UNITED STATES DEPARTMENT OF AGRICULTURE

REPORT ON THE AGRICULTURAL EXPERIMENT STATIONS, 1940

PREPARED BY THE

OFFICE OF EXPERIMENT STATIONS

For sale by the Superintendent of Documents, Washington, D. C. - - - - - - - - - Price 25 cents

OFFICE OF EXPERIMENT STATIONS

James T. Jardine, Chief
R. W. Trullinger, Assistant Chief

ADMINISTRATION OF GRANTS TO STATES AND COORDINATION OF RESEARCH

J. T. Jardine, R. W. Trullinger, F. Andre, H. P. Barss, E. C. Elting, F. D. Fromme, G. Haines, F. G. Harden, H. C. Knoblauch, H. W. Marston, Sybil L. Smith, H. M. Steece, J. W. Wellington, R. Y. Winters, B. Youngblood

DIVISION OF INSULAR STATIONS

James T. Jardine, Chief

Puerto Rico: Atherton Lee, Director.

CONTRIBUTORS TO THIS REPORT

Agricultural Economics—F. G. Harden.
Agricultural Engineering—R. W. Trullinger.
Agricultural Soils and Plant Nutrition—H. C. Knoblauch and H. C. Waterman.
Animal Production, Products, Diseases, and Disorders—H. W. Marston, G. Haines, E. C. Elting, and W. A. Hooker.
Field Crops, Pastures and Ranges, and Weed Control—H. M. Steece.
Home Resources for Defense—Sybil L. Smith and Georgian Adams.
Horticulture and Forestry—J. W. Wellington.
Plant Diseases and Insect Pests—H. P. Barss, F. V. Rand, and F. Andre.
Rural Sociology—B. Youngblood.
Statistics—F. G. Harden.
Manuscript Supervision—Katharine A. Nau.

UNITED STATES DEPARTMENT OF AGRICULTURE
OFFICE OF EXPERIMENT STATIONS
Washington, D. C. July, 1941

REPORT ON THE AGRICULTURAL EXPERIMENT STATIONS, 1940

By J. T. Jardine, F. D. Fromme, and H. L. Knight[1]

CONTENTS

INTRODUCTION

For many years there has been included in the acts making appropriations for the support of the Federal Department of Agriculture a provision requiring the Secretary of Agriculture to report to Congress on the work and expenditures of the State agricultural experiment stations established under the Hatch Act of 1887 and supplementary legislation. The present report extends the series thus provided for and covers the fiscal year ended June 30, 1940.

During this period the research work of the stations proceeded for the most part along well established lines. More than 8,500 projects were under way and many new and significant contributions to the improvement of agriculture and rural life resulted from these investigations. The printed record of these studies embraced more than 43,000 pages in station publications and scientific journals.

The direct support for these extensive programs was derived from Federal, State, and supplemental sources and amounted to $21,216,748.61. Approximately one-third ($6,848,750), came from Federal-grant funds authorized by the Hatch, Adams, Purnell, title I of the Bankhead-Jones Act of June 29, 1935, and supplemental acts, and two-thirds ($14,367,998.61) from State appropriations and supplemental income derived from endowments, fellowships, fees, sales, and other sources.

[1] With the collaboration of other members of the Office staff.

In addition to these direct sources of support the research work of the stations was aided and augmented by cooperation with the Department of Agriculture. Information derived from Department investigations contributed to the progress of much of the station work, and in like measure and manner the work of the stations contributed to the progress of Department studies. This supplementing of resources of men and facilities in these cooperative undertakings has contributed to economy of effort and expenditures, helped to avoid unnecessary duplication and waste, and expedited solution of problems.

Another important factor in the close integration that exists in agricultural research in the United States is interstation cooperation. Much of this cooperation is informal and difficult to compute, but in the aggregate it adds considerably to the effectiveness of these research agencies.

Still another development is a noticeable increase in the coordination of work within the station organization. This may be both informally between individuals or in response, in whole or in part, to administrative suggestions and stimulus. An indication of what is going on more and more in this direction is revealed by the following extract from a recent summary of the activities of the New Jersey experiment station:

> On various occasions in the past attention has been called to the efforts we are making to integrate and coordinate research work on problems which cut across departmental lines. This line of approach to many-sided problems has been aptly termed the "research team" plan. Instead of assigning various phases of the work to appropriate departments which then proceed more or less independently, a committee is formed representing every department which can make a contribution. The chairman of the committee corresponds to the captain of a team, keeping in touch with the work of the other members and calling the group together at suitable intervals for interchange of results and suggestions.
>
> Naturally, this does not mean that departments can be abolished. Many of our objects fall entirely within the province of single departments, and efficient administration as well as research and teaching requirements make the departmental organization essential. The change is rather in our way of thinking, and in the organization of investigations into some of the State's larger agricultural problems. The State studies the soil, insects, plant and animal diseases, not primarily for the sake of knowledge as such, but in order to apply this knowledge to the production of better crops, better livestock, and a higher standard of living for its citizens.

THE COORDINATION OF AGRICULTURAL RESEARCH

ADMINISTRATIVE AIDS TO COORDINATION

The Office of Experiment Stations again acted as a central agency to promote cooperation in the planning and conduct of research between the stations and the Department. As Director of Research, the Chief of the Office performed a similar function with respect to research work within the Department. On the one hand, the coordination of the research of the Department and that of the stations was furthered by assisting the stations to obtain scientific advice and suggestions, as well as active cooperative help from the Department, and on the other by assisting agencies of the Department to develop the most effective cooperation with one or more stations.

In addition to a large amount of such assistance rendered informally, especially in connection with the administration of the Federal grants to the States for research, the Office examined, approved, and recorded

nearly 1,400 new or revised formal memoranda of understanding covering cooperative research between bureaus of the Department and the State stations, and involving nearly 1,200 major research undertakings. These undertakings covered practical field problems of nearly every major aspect of farm production and rural life. All of the State stations, all of the research bureaus of the Department, and at least 3 of the action agencies of the Department whose programs are based upon well-defined needs for adjustments in land use and rural-life practices participated in this broad cooperative program. The cooperative agreements of the stations with Department bureaus varied from 7 to 53 per station.

Stations cooperated in the national land use planning enterprise, which involves cooperation of organized groups of farmers, State extension services, the Bureau of Agricultural Economics, and the major action and operating agencies of the Department. This was actively participated in by the experiment stations in 45 States on a formal basis and by the stations in the other 3 States and the Territorial and insular possessions on at least an informal basis. State extension, research, and special planning agencies in every State were participating in this movement, which had reached a stage of organization where the research needs of the land-planning program were becoming apparent in terms of specific problems for study. The Office assisted in this activity in the planning, coordination, and prosecution of the essential pertinent research by the stations and Department bureaus concerned.

Typical of the social science research pertinent to land use planning and active during the year was that on farm population and farm population movements which was gotten actively under way at 14 State stations under the over-all cooperative guidance of the Bureau of Agricultural Economics. Examples of pertinent biological research essential to the program of land use planning concerned cereal crop improvement in 20 States, forage crop improvement in 10 States, and grass breeding and improvement in 11 States, all under the cooperative guidance and leadership of the Bureau of Plant Industry. The grass and forage crop improvement research was especially pertinent in connection with the widespread "back to grass and pasture" movement which is assuming such importance in the conservation aspects of land use planning. Data were available for immediate use in planning in 7 States where these cooperative studies were completed during the year. The cooperative vegetable variety and standardization studies in 8 States and the corn improvement studies in 6 States, both under the over-all guidance of the Bureau of Plant Industry, were continued as essential to plans for adjustment in the use of row crop land. In 9 States both the vegetable crop and corn improvement studies were completed and the data were being put to immediate use in planning. Cooperative soil erosion control studies, begun on a limited basis in 1936, were active in 47 States during the year, and the continuous flow of practical results was being made one of the major bases for procedure in land use planning.

The experiment stations also worked more closely with other State agencies, with local organized groups, with each other in regional groups, and with the U. S. Department of Agriculture in efforts to coordinate their research along the most effective lines. Evidence that this effort was fruitful was reflected in the fact that 28 States com-

pleted work in the cooperative study of farming adjustments by regions and type-of-farming areas and the results were being used in land use planning. Some 33 active adjustment studies were being continued in 20 States in order to bring to early completion this foundation material for Nation-wide land use planning.

Another outstanding recent accomplishment was the completion of a study of New England milk marketing, dealing particularly with the Boston milkshed. This broadly cooperative study, sponsored by the Northeastern Directors' Association, which includes the directors of the 12 northeastern stations and has functioned informally but effectively since 1884 in coordinating research of community interest and application, grew out of an acute need in the region for stabilization of milk marketing procedure. Worth-while completion was accomplished not only by effective pooling of the resources of the various State stations concerned but by the eventual enlistment of assistance from the Bureau of Agricultural Economics, which provided over-all leadership and help. On completion, this study was immediately followed by a regional program of agricultural economics research in New England which involves all the States in the area and the Bureau of Agricultural Economics in an organized effort to establish a pattern of basic principles of agricultural economy.

BANKHEAD-JONES REGIONAL LABORATORIES

No new laboratories were established in 1940, but the 9 previously set up have continued to cooperate with from 12 to 25 experiment stations each. Thus, the vegetable-breeding laboratory at Charleston, S. C., gave particular emphasis to determining the genetic principles underlying the inheritance of desired characteristics in vegetables for the southeastern region, and distributed material, for further selection of strains best suited to local conditions, to the 13 cooperating experiment stations of the southeastern region. Following this procedure, promising strains of garden peas and beans were released for wider trial in the region, the peas possessing wilt resistance or cold tolerance, or both, and the beans showing bacterial blight resistance and hardiness under adverse weather conditions.

The research program of the pasture research laboratory at State College, Pa., is of primary importance to livestock production, particularly the dairy industry, in the 12 Northeastern States, and also has direct application to problems of soil erosion and watershed protection. Thousands of pasture plants have been assembled, grown, tested, and hybridized at the laboratory, and its breeding program has advanced to the stage where certain plant materials are being tested under varying soil and climatic conditions at six of the experiment stations. Individual plants of orchard grass having distinct plant characteristics were collected in Maryland and are being grown at both the laboratory and the Maryland station for future breeding trials looking toward the production of strains of orchard grass superior to those now available. Six different strains of Kentucky bluegrass have been supplied to the Pennsylvania station for growing in plats where relative yields will be determined by clippings. The West Virginia station obtained individual plants of Kentucky bluegrass to establish breeding plats. Some 1,500 or 2,000 individual bentgrass plants are being collected in Rhode Island by the laboratory in co-

operation with the experiment station as a basis for future breeding. During the winter the laboratory made crosses of several of the more promising white clover plants selected by the New Jersey station, which is testing the hybrids and, in addition, 40 individual plants of white clover developed by the laboratory. Individual plants of white clover were supplied to the Delaware station by the laboratory.

The program of the soybean laboratory at Urbana, Ill., was participated in by the Bureaus of Agricultural Chemistry and Engineering and Plant Industry of the Department and the agricultural experiment stations of the 12 North Central States. As a result of cooperation between the laboratory and the experiment stations two new high-yielding varieties, Mt. Carmel and Patoka, particularly adapted to southern Corn Belt conditions and with special characteristics for industrial utilization, have been released to growers.

Active participation in the program of the laboratory for swine improvement through breeding is in progress at the Illinois, Iowa, Minnesota, Mississippi, Nebraska, and Oklahoma experiment stations. The work as a whole is in close cooperation with 13 stations and is designed to develop inbred lines of swine for the purpose of increasing the productiveness of sows, growth rate of pigs, economy of gains, increased physical vigor, and desired quality of carcass. The results achieved so far in the program compare favorably with the progress made in the early development of hybrid corn, the ultimate success of which has been spectacular.

The program of the laboratory at Dubois, Idaho, for sheep improvement through breeding is designed to develop and improve mutton type, longer staple wool, and the open-face characteristics so important on the range. The availability of lines developed by the 12 cooperating stations will make possible the use of a larger number of sheep upon which to base conclusions and a wider choice of lines for combining to obtain desirable qualities. Range rams have been loaned by the laboratory to the Arizona station to determine their adaptability for lamb production and ranch ewe replacement with a commercial band of ewes under range conditions.

In planning the program for the animal disease laboratory at Auburn, Ala., representatives of the Department and of the 13 cooperating Southeastern experiment stations have recommended that the first work should deal with Johne's disease of cattle and internal parasites of cattle. The laboratory has worked out methods for producing satisfactory quantities of johnin, the product used for testing live animals for the presence of Johne's disease, and investigations are under way to determine its quality when used in the field as a diagnostic agent. Examination at time of death of 35 reacting dairy cows showed that all of them were infected with Johne's disease, thus affording encouraging evidence of the satisfactory performance of this product as a diagnostic agent.

Assisting in various phases of the program of the laboratory at East Lansing, Mich., for the improvement of poultry viability are the cooperative studies at a number of the 25 State stations of the northeastern and north central regions which compose the cooperating groups. The North Dakota, Ohio, and Oklahoma stations are testing the livability of chicks produced by the laboratory under different environments and varying kinds of exposure to infection. Breeding studies to determine the interdependence of vigor and resistance to pullorum disease

and fowl paralysis are being conducted by the Illinois and Maryland stations. The Massachusetts and Pennsylvania stations are working on the effectiveness of selective breeding to reduce mortality from fowl paralysis in the Rhode Island Red and White Leghorn breeds, respectively. Studies of the effect of diet on susceptibility to fowl paralysis are under way at the Indiana and Michigan stations. At the Iowa station an investigation is being made of the transmission of the iritis type of paralysis through the egg by the sperm or by artificial inoculation with diseased tissues and, in addition, an attempt is being made to determine the association of the so-called nonspecific enteritis of chickens and fowl paralysis. Studies of the pathological changes due to fowl paralysis have been undertaken by the Connecticut (Storrs), Indiana, and Iowa stations, and investigations of the cause and transmission of the disease are being made at the Connecticut (Storrs) and Iowa stations. Particular attention is being given in the Connecticut work to the development of specific methods of diagnosis of the disease.

The research program of the laboratory at Riverside, Calif., for the study of salinity of irrigation waters was organized in cooperation with 13 States. Progress was made in the development of new research techniques and in the securing of data from experiments.

The research program of the special research laboratory recently organized at Ithaca, N. Y., for the study of relation of soils to plant, animal, and human nutrition is recognized as of national rather than regional significance. It is, however, primarily sponsored by the experiment stations in the 12 North Central States and involves cooperation with them as well as with other agencies.

SPECIAL RESEARCH FUND PROJECTS

Under the provisions of the Bankhead-Jones Act a special research fund is provided for studies by agencies of the Department. Many of these projects, assigned for leadership to the subject-matter bureaus of the Department most directly concerned, are carried on in cooperation with other agencies, including the experiment stations. Among such cooperative investigations is one of input as related to output of milk production, which has been under way with the participation of the Bureaus of Agricultural Economics and Dairy Industry of the Department and 10 experiment stations. While the results to date indicate that responses in increased milk production to increased feeding above the standard ration are only half as great as previously assumed, the additional return from an extra unit of feed falls off very slowly even when feeding is increased to quite high levels. There is, therefore, a much wider degree of elasticity in dairy returns than was heretofore supposed. The studies have also shown that while the cows of modern dairy breeds gained a little in weight when heavily fed, the principal response to increased levels of feeding was in the form of higher milk production rather than in gains of body weight. They indicate that the commonly used feeding standards for dairy cattle are approximately 25 percent too low for most economical milk production. The results obtained in this investigation will be useful in the formation of national agricultural programs. They also can

be applied directly by dairy farmers who are endeavoring to adjust acreage of various feed crops and the feeding of dairy herds to changing market demands for dairy products.

UTILIZATION-OF-FARM-PRODUCTS REGIONAL LABORATORIES

Work under the authorization of section 202 of the Agricultural Adjustment Act of 1938 for the establishment and maintenance of four regional research laboratories on new and extended uses for surplus farm commodities included (1) the completion of technical organizations appropriate to the peculiar functions of each of the laboratories, (2) fair progress in the construction of buildings, (3) the completion of plans and specifications for technical equipment, and (4) the preparation of research programs covering each of the commodities designated for initial research attention. These commodities as assigned to the respective laboratories were as follows: Northern Regional Laboratory, Peoria, Ill.: Agricultural residues, corn, wheat; Eastern Regional Laboratory, Philadelphia, Pa.: Animal fats and oils, apples, milk products, potatoes, tanning materials, hides, skins, leather, tobacco, vegetables; Southern Regional Laboratory, New Orleans, La.: Cotton, peanuts, sweetpotatoes; and Western Regional Laboratory, San Francisco, Calif.: Alfalfa, apples, fruits, potatoes, poultry products and byproducts, vegetables, wheat.

In cooperation with the bureaus and other agencies of the Department, steps were taken to coordinate the proposed work of the laboratories with other active work. In this connection copies of the proposed programs were supplied the experiment stations and conferences were held in each of the four regions to formulate policies of coordination between the Department and the stations. Mutual agreement as to the organization for continuous consideration of relationships has been reached in each of the regions and the programs proposed for each of the laboratories have been approved. The detailed work projects of the laboratories are being used as a basis for further coordination in the Department and with the States.

PROGRESS OF AGRICULTURAL AND RURAL LIFE RESEARCH

The summary which follows of the experiment station research carried on in 1940 is based mainly on the publications issued during the year by the 50 State stations, the Alaska, Hawaii, and Puerto Rico stations, and the Federal Puerto Rico station. The printed record for these institutions has also been supplemented as source material by special reports from their directors as to significant accomplishments of the year.

As stated earlier, the publications of the stations in 1940 comprised more than 43,000 pages. This summary, therefore, does not attempt to cover all of the research projects active during the year and is necessarily incomplete as to details of the experimental work accomplished and the results obtained. The aim has been to make selection within the several fields to depict the wide range of the subjects studied and the findings having greatest significance in the solution of current problems.

PLANT PRODUCTION, PRODUCTS, DISEASES, AND INSECT PESTS

FIELD CROPS, PASTURES AND RANGES, AND WEED CONTROL

CONTENTS

New and better crop varieties, improved cultural methods and field practices, more exact and economical use of fertilizers, and higher qualities of farm products; effective ways to use and conserve meadows, pastures, and ranges; and improved measures for weed control are definite products of agronomic research on current problems of American agriculture. Many of the discoveries and developments in the State experiment station investigations, often cooperative with the Department and other agencies, are of such nature that without further refinement they may be employed at once in farm practice.

Examples of advances in crop improvement are the development and expansion of one-variety cotton communities involving use of superior varieties of cotton; the continued phenomenal increase in the growing of hybrid corn—concurrent with the production by the stations of new hybrid combinations; creation of new wheats, combining resistance to plant diseases and to insects, as hessian fly, with good milling and baking qualities; and the development of soybeans and sweetpotatoes suitable for special industrial uses; early and cold-resistant sugarcanes which prolong the milling season; and alfalfa strains outstanding in resistance to bacterial wilt and cold and in production of forage and seed. The stations also have developed productive new kinds of oats, barley, rice, flax, potatoes, tobacco, sorghums, clovers, and grasses.

Profitable modifications of cropping practices seem certain to result from findings which point to the use of depth of soil moisture at seeding time as a criterion of prospective yields of spring wheat; the wider application of foliar diagnosis to determine needs of crops for plant foods; better formulas and more effective placements of fertilizers for corn, potatoes, truck, and other crops; the use of electricity, as in the economical production of sweetpotato plants in electrically heated hotbeds; and well-planned rotations which take into account crop behavior, as the favorable response of tobacco to weed fallow and sugar beets to preceding crops. Maintenance and improvement of quality of product may be assured by the application of results of studies indicating proper storage conditions for wheat and soybeans; the optimum time for harvesting these crops, corn, and Havana tobacco; conditions for the curing and handling of Burley tobacco to obtain a superior product; the best stage for cutting alfalfa and meadows in general; and by giving proper attention to the fertilization of potatoes, tobacco, and other crops.

Conspicuous examples of pasture research were the profitable use of a grain-lespedeza 1-year rotation for beef pasture, and grazing management of native and tame pastures for greater carrying capacity and increased beef production; development of better pasture plants for definite purposes and particular situations; and the response of pasture to renovation and fertilization. Research on range improvement dealt with changes in range vegetation and the restoration of depleted range and abandoned cropland; grazing management; and improved range plants and ways to establish them. Useful information was gained in weed research, especially on effective eradication measures, control of pasture shrubs as an improvement practice, and the economic utilization of weed plants.

Examples of accomplishments in agronomic research, particularly those of more or less immediate practical application, are given in the following pages.

COTTON

Research on cotton problems by the stations was similar in scope to that of previous years and often proceeded in cooperation with the Department. Varieties and their improvement, development and progress of one-variety communities, and fertilizers are features of current reports.

Varieties.—Additions to new cottons of merit, already in the hands of growers, include superior strains of Acala, No. 1064 in the Pecos Valley and No. 1517 primarily in the Rio Grande Valley, both developed by the New Mexico station cooperating with the Department (B.P.I.). These strains came into commercial production on a large scale in 1939 and showed advantages in earliness and yield over the widely grown ordinary Acala. By selfing selected Stoneville plants the Oklahoma station bred a uniform type of cotton adapted to eastern Oklahoma conditions. Uniformity of Oklahoma Triumph was improved likewise. Improvement work of the Arkansas station, cooperative with the Department (B.P.I.), revealed that varieties were very nonuniform, particularly as to fiber characteristics. Many types, however, segregated by inbreeding became relatively uniform after from two to three generations, and inbred lines always were much more uniform than parent varieties.

Variety tests have shown the relative merits and adaptations of new cottons. Leaders in money value per acre in Georgia station tests in north Georgia included Stoneville 2B, Coker 100, and D. and P. L. 11A, and in south Georgia tests, Coker Clevewilt 7, Coker 4-in-1, Wannamaker Wilt Resistant Cleveland, and Stoneville 2B. Stoneville 2B excelled except where wilt was unusually severe and might profitably replace Stoneville 2A in one-variety communities. The two best wilt-resistants for south Georgia staple from 1 to $1\frac{1}{16}$ inches and differ very little in value for wilt lands. Variety is the major factor influencing lint length, yet environment, location, and season also affected the staple of all varieties. Boll size and ginning percentage likewise were affected by both variety and environment.

Deltapine (D. and P. L. 11A), Stoneville 2B, and Ambassador (Stoneville 4B) were outstanding in Missouri station tests. In eastern and central portions of the Oklahoma Cotton Belt, the Oklahoma station cooperating with the Department (B.P.I.) observed that Deltapine and Stoneville strains or types were perhaps the best producers

of acceptable staple, and Rowden types were satisfactory. In southwestern Oklahoma, Mebane types were rather outstanding in these respects, with Acala 5 and Acala 8 types also of merit. Half-and-Half types, in general, were good producers, but their staples were perhaps too short for best market demand.

One-variety communities.—Stations in cotton-growing States continued to cooperate with the Department (B.P.I., B.A.E., and A.M.S.) in the development of one-variety community production of cotton, an activity closely linked with variety testing and improvement programs. Efforts within States were supplemented and stimulated to a greater accomplishment in a number of ways, among them the National One-Variety Export program in which the stations and extension services cooperated with the Surplus Marketing Administration and other branches of the Department.

In Georgia, for example, the one-variety cotton community plan began in 1931 when the Georgia station, cooperating with the Department (B.P.I.), placed about 4 tons of seed of Stoneville No. 2 in the Orchard Hill community in Spalding County. The program had grown by 1939 to 183 active communities in 78 counties which produced 182,729 bales. Increases in yields and premiums estimated at $2,130,032 were realized in 1939 by Georgia cotton growers through planting improved varieties in such communities. Economic aspects of one-variety cotton communities were appraised by the Tennessee station, which reports that since 1931 the enterprise had grown until in 1939 there were 125 communities in the State with an estimated acreage of 200,000. In one community 82 percent of the bales in 1939 graded White Middling and better and 77 percent 1 inch and longer. About 87 percent of the cotton grown by the community was purchased by the ginner on the same day ginned, and he resold over half the cotton bought in from 1 to 5 days and held none longer than 15 days. The prices he paid growers were generally in line with the central market at Memphis. A number of farm management and community betterments, as well as social improvements, also might be attributed to the plan.

Fertilizers.—The needs of cotton for plant foods and economical ways to supply them received the usual attention. Addition by the Mississippi station, cooperating with the Tennessee Valley Authority, of about 500 pounds of dolomitic limestone to 1 ton of otherwise acid-forming 4–8–4 fertilizer at an added cost of about 30 cents per acre, on sandy soils resulted in an average gain of 90 pounds of seed cotton, worth, at 3 cents per pound, $2.70. Little or no increase occurred on silt and clay soil. Exclusive use of neutral fertilizers on soils of sandy texture, the station estimated, probably would result in an increased profit of from $1,000,000 to $2,000,000 annually to Mississippi farmers. In studying fertilizer practices of growers, the Tennessee station observed that farmers of the western two-thirds of west Tennessee might use to advantage fertilizers with more emphasis upon nitrates, and those of the eastern third fertilizers of mixed requirements or with greater emphasis on phosphates.

Placement of fertilizer for cotton in bands 2.5 inches to each side of and 3 inches below the seed level gave most satisfactory results on soils at the Sandhill substation, the South Carolina station concluded from experimentation in cooperation with the Department (B.P.I.

and B.A.C. and E.). Fertilizer so applied in a single operation at planting gave better results than when applied 10 days before.

Effects of calcium arsenate, used extensively for control of insects, upon the yield of cotton have been studied by several stations. Yields on four representative Cotton Belt soils were not affected by even as much as 1,600 pounds per acre but were reduced greatly on Ruston sandy loam, reports the Mississippi station cooperating with the Department (B.E. and P.Q.) Beneficial nutritional effects were obtained from light applications and detrimental effects from heavy ones, but the arsenic toxicity was reduced with time. Evidently there is little danger of reducing cotton yields on these soils with calcium arsenate in the average annual application, which seldom exceeds 30 pounds per acre.

CORN

Hybrid corn.—Farmers in the Corn Belt States grew about 25,000,000 acres of hybrid corn in 1940, or more than half of the total corn plantings of 49,544,000 acres in the 12 North Central States, according to Department (A.M.S.) estimates. The spectacular increase in acreage of hybrids throughout the Corn Belt from a mere beginning in 1936 to 12,000,000 acres in 1938 and 21,000,000 in 1939 has been a noteworthy development in recent years. Furthermore, production of hybrid corn extends far beyond the Corn Belt. According to a special yield survey, hybrids outyielded other varieties in 1939 by 10 to 30 percent, depending on the section of the country. Even if hybrids have increased yields by no more than 10 percent, the net effect has been to increase corn production by many millions of bushels without expanding acreage. Higher quality of market corn is also attributed to the widespread planting of hybrids, and their improvement is still continuing as typical activities of several stations, often in cooperation with the Department (B.P.I.) and other agencies.

The survey revealed that 88 percent of Iowa's total corn acreage was planted to hybrids in 1940. In the long ripening season of 1939, hybrid corn averaged 14 percent more than open-pollinated varieties in yield tests in which the Iowa station, the Department (B.P.I.), and others cooperated. It was realized, however, that many hybrids performing well in northern Iowa might be unsatisfactory with a less favorable autumn, and the station again cautioned against planting such hybrids in sections where they normally would be too late.

Of the 1940 corn acreage in Illinois, it was estimated that 77 percent was planted to hybrid corn. The 5 best hybrids on the 10 test fields of the Illinois station in 1939 averaged 16.5 bushels of sound corn per acre above the 5 open-pollinated varieties, and also excelled in erect plants. Hybrid corn on very fertile soil, the station finds, will produce very high yields, and, in fact, respond better than open-pollinated corns to good fertility practices. Hybrids, however, do not perform even relatively as well on poor soils. The Indiana station attributed rapid increase in hybrid popularity mainly to economy of production and better standing ability, and also to more certain production in adverse seasons and to better grain quality. An early hybrid, Ind. 210, particularly adapted to short-season sections of northern Indiana, was released in 1940. It is estimated that 66 percent of all corn planted in Indiana in 1940 was hybrid.

In the spring of 1939 the Ohio station and the Department (B.P.I.) brought out as part of the cooperative corn-breeding program 30 new hybrids adapted to the range of climatic and soil conditions of Ohio. These were produced commercially in a limited way in 1940. Higher yield, less breakage, and less lodging were major objectives, and there also was evidence that greater tolerance to European corn borer and less susceptibility to aphids, smut, stalk rot, and leaf blight has been achieved in certain combinations.

Sixteen new double crosses made by the Minnesota station showing promise of adaptability to the several sections of the State outyield recommended hybrids currently grown and are resistant to smut and to lodging. Hybridization of Japanese Hull-less popcorn resulted in 16 percent better yield and 29 percent greater popping volume. This cross, Minhybrid 250, ripens earlier than open-pollinated corn and is less susceptible to smut. The Michigan station also reported more extensive trials of corn hybrids and varieties in 1938 and 1939 which provided a basis for a maturity classification of hybrids for the eight corn-growing zones of the State.

Several new white corn hybrids produced chiefly from Kentucky station inbreds were superior to the commercially grown older station hybrids in yield, quality of grain, and strength of stalk, and definitely outyielded the best open-pollinated corns grown in Kentucky. New inbred lines were being developed and new combinations tested by the West Virginia station to find hybrids suitable for soil and climatic conditions in West Virginia, where farmers have shown increased interest in hybrid corn.

Nebraska 1939 corn variety and hybrids tests demonstrated advantages of locally adapted hybrids—in 10 tests hybrids in general averaged 17 percent over varieties, and the 10 highest-yielding hybrids 32 percent more. Distinct progress has been made in developing superior hybrids involving new Nebraska lines. Adapted superior hybrids have been available for the eastern fifth of Nebraska for a number of years, and also for irrigated sections of central and western Nebraska.

The Kansas Station cooperating with the Department (B.P.I.) expanded the corn-testing program begun in 1923 by adding corn-performance tests in 1939 to increase hybrid-testing facilities. Preliminary results indicated that some hybrids developed in this program surpass varieties and hybrids currently available to farmers. These cooperators found that drought resistance is inherited, and that reliable drought-resistant corn probably can be assured by controlled crossing of inbred lines that previously had produced drought-resistant hybrid seed. This is one practical application of the earlier discovery at this station that a fair criterion of drought resistance in corn can be had by exposing 10- to 14-day-old seedling plants for 5 hours at about 130° F. in a chamber with relative humidity about 30 percent. Seedlings surviving such treatment and recovering from its effects come from strains that prove highly resistant to both heat and limited soil moisture in field plantings.

Success with hybrid corn has been obtained also in the Mountain States. In Colorado station tests several hybrids have substantially outyielded the standard Minnesota No. 13 at the station and Reid Yellow Dent (Moore strain) at Rocky Ford. Tendency to plant hybrids materially later than standard adapted corns in a locality is discouraged. Large increases in yields of shelled corn and green and

dry forage could be obtained by use of adapted hybrids at altitudes below 6,000 feet on irrigated land, the Wyoming station showed, but it doubted whether hybrids would be adapted to the cool climate and variations in killing frosts above 6,000 feet.

In line with results in Corn Belt States, the Louisiana station showed that locally developed hybrids outyield open-pollinated corns by 10 to 30 percent, are of good quality, and are especially weevil resistant. The station feels, however, that success with hybrids may not be as great in Louisiana and elsewhere in the South, for on the average southern corn yields are much lower. Performance in North Carolina station tests indicated that Corn Belt and northern hybrids are generally unadapted to North Carolina conditions. Farmers were advised to continue growing varieties recommended for their respective sections. Early varieties compared very favorably with hybrids of the same period of development in Oklahoma station tests. The Oklahoma farmer, it appeared, had been planting varieties rather late for average weather conditions, and by growing a slightly earlier corn farmers can produce their own seed or use locally adapted seed and save the cost of the more expensive hybrid. Hybrid corn developed by the Tennessee station in cooperation with the Department (B.P.I.) and used by Tennessee farmers for the first time in 1939 outyielded standard varieties by about 15 percent. The improved mass-selected Mayorbela corn was outyielded by 8 of 90 hybrids tested by the Puerto Rico University station. Ordinary field corn averaged about 500 pounds per acre, Mayorbela 800, and one of the hybrids about 1,000 pounds. With better cultural operations, this hybrid might return much higher yields and make corn growing a profitable enterprise.

Measuring the loss which might result from careless detasseling in the commercial production of hybrid corn, the Illinois station determined that pulling one leaf with the tassel reduced the grain yield 8.3 percent, two leaves 15.3, three leaves 18.1, and pulling four leaves 29.2 percent, while detasseling without removing leaves resulted in a gain of 1.4 percent over nondetasseled plants.

Adaptations and performances of standard and new varieties were studied by several stations. State-wide tests by the Arkansas station showed that in northwestern Arkansas, Neal Paymaster and the western varieties were superior, in southwestern Arkansas the western corns, and in eastern and central Arkansas prolifics were in the lead. Neal Paymaster, Pride of Saline, Delta Prolific, Surcropper, Mexican June, and Thatcher Golden Dent proved dependable in all parts of the State. Neal Paymaster, Jellicorse, Cocke Prolific, and College Hybrid 47 were generally outstanding in Mississippi station studies. Other good sorts were Laguna, Mosby Prolific, and Hastings Prolific. Florident White and Florident Yellow varieties, originated at the Florida station, upon which mass field selection was being continued, were currently the highest-yielding corns for Florida and surpassed older productive varieties in weevil resistance. Leading corns in extended tests of the New Mexico station included Mexican June, Golden June, and Mexican June × Reid at Las Cruces, Union County White and Hays Golden at Clayton, Minnesota No. 13 and Swadley at Mosquero, White Flint at Capulin, and Surcropper, Mexican June, Reese Drought Resister, and Colby Bloody Butcher at Tucumcari.

Cultural practice.—Better production practices, largely results of experimental findings, were reported by several stations. The Louisiana station in popular circulars indicated suitable varieties, thorough seedbed preparation, appropriate fertilizers, timely dates and proper rates of planting, and the needed cultivation for corn in the alluvial and hill lands and other sections of the State. Tests by the Arkansas station suggested a range of planting dates from April 15 to June 15 in different sections of the State. Planting part of the corn early and the remainder at a later date may avoid heavy losses from adverse weather. It was found that any reasonable method of cultivating and keeping down weeds was as good as another, although delay in starting cultivation, terminating the work too soon, or utter neglect of the crop would cause decreased yields. Early plantings, about April 1, have yielded better than late plantings, about June 1, in Mississippi station tests. The Illinois station and the Department (S.C.S.) determined that on land limed and planted to clover for 2 years preceding, corn on the contour yielded 69.3 bushels per acre and that in rows up and down a 5-percent slope 61.5 bushels. Similar differences were noted on manured and on untreated land.

Fertilizers.—Nitrogen is rapidly becoming a major limiting factor in Corn Belt soils, the Indiana station states, although legume production for nitrogen maintenance has been stressed. Wheat and other small grains may be supplied easily and profitably with commercial nitrogen, yet the usual methods have failed to supply the needs of corn. In current experiments, plowing under nitrogen, i. e., ammonium sulfate, to supply 80 pounds of nitrogen, when preparing the land has resulted in noteworthy increases. This method promises to reduce the production cost per bushel of corn in a large section of the Corn Belt.

Making further use of foliar diagnosis, the Pennsylvania station studied the effects, on the nutrition of corn, of nitrogen carriers, including manure plus lime and complete fertilizer supplying nitrogen in the form of dried blood or sodium nitrate. Uptake and use of nitrogen and phosphorus were best and at a higher plane of nutrition with manure plus lime and least and at a low level with the dried blood mixture. Sodium nitrate hindered absorption of potassium more than did dried blood but less than lime, an influence found in the soil and not in the plant.

In preliminary studies of the value of coal as a fertilizer and soil amendment, the Utah station noted that it does not improve growth of corn. Coal-tar dyes, sold as plant stimulants, did not show beneficial effects and, indeed, appeared to depress yield in the presence of adequate nutrients.

On cornland protected by straw applied between the rows, the Nebraska station and the Department (S.C.S.) found that the gain in stored soil moisture and in acre yields of air-dry fodder over yields from plowing and basin listing increased as the straw rate rose from 2 to 4 to 8 tons per acre. Leaving crop residues on the soil surface appeared to be a very effective and practicable method of conserving soil and soil moisture in the Great Plains, greatly increasing infiltration and reducing run-off and evaporation from the surface soil and minimizing water and wind erosion.

Maturity.—Corn is not ripe, i. e., not through growing, until the grain contains not more than 40 percent of moisture, according to

studies by the Michigan and Ohio stations. Maximum yield of dry matter in condition to harvest for silage did not occur in Michigan until the grain had begun to dent and contained about 50 percent of moisture. That too early cutting may cause great loss in yield was shown by the Ohio station. Corn cut and shocked at dough or well-dented stages averaged 47 bushels an acre, cut 2 weeks later at the glazed stage, 56 bushels, and cut when mature, 61 bushels. For maximum yield corn should not be cut before the kernels are glazed and really hard—when the lower leaves begin to die and the husks are usually brown.

WHEAT

Improvement.—Additional varieties and strains of wheat were undergoing final tests or had been released recently to growers. Sanford, a new wheat resembling Purplestraw, was originated by the Georgia station in cooperation with the Department (B.P.I.) by crossing Purplestraw × Kanred with Purplestraw several times. It is resistant to leaf rust and has outyielded the old Purplestraw variety. Wabash, a new soft red winter wheat highly resistant to leaf rust and mosaic, developed by the Indiana station cooperating with the Department (B.P.I.) and released in 1938, has outyielded other smooth varieties of its type in station tests. Purdue No. 6 and No. 7, productive new soft red winter wheat varieties developed by this station and being multiplied for more extensive testing combine high winter hardiness, good standing ability, a high resistance to leaf rust and to scab, and almost complete resistance to loose smut and mosaic, wide adaptation in Indiana, and excellent quality for pastry. Current results of this station's research indicated the possibility of producing strains resistant to all of the important diseases of wheat, with the possible exception of scab.

Prairie, a productive new soft winter wheat brought out by the Illinois station, is very winter-hardy, resistant to lodging, highly resistant to mosaic, and of fair resistance to leaf and stem rust. Marmin, a new wheat obtained by the Minnesota station in cooperation with the Department (B.P.I.), combines the weight and milling qualities of Marquis with the rust resistance and winter hardiness of Minturki, and, moreover, produces a whiter loaf of bread. White Federation 38 and Baart 38, stem rust- and bunt-resistant wheats released in the fall of 1939 after development by the California station and the Department (B.P.I.), were received enthusiastically throughout California since the State had been experiencing a record stem rust epidemic. These wheats were almost untouched, whereas losses in susceptible varieties ran from 60 to 100 percent in the Imperial Valley and from 15 to 60 percent in the San Joaquin Valley.

The average yield per acre of winter wheat for the United States as a whole has been slightly downward over the past 44 years, while in Illinois, according to the Illinois station, acre-yields have trended upward from about 11 bushels for 1895–98 to about 17 bushels for 1935–38, varietal improvement being indicated as an important contributing factor. Corresponding yields for the Nation were 14.7 and 12.9 bushels. Leaders on the main test fields included Kawvale, Tenmarq, Brill, Ioturk, Minturki, Wabash, Fulcaster, and Nabob. Varietal improvement may be responsible also for changes in the cropping system. For example, spring wheat constituted more than

80 percent of the total wheat acreage grown in Nebraska before 1900. Since then, the Nebraska station reports, the proportion has changed until currently winter wheat makes up more than 90 percent of the wheat acreage. The change was primarily due to introduction of Turkey and development of other adapted hard red winter wheats, such as Nebraska No. 60, Cheyenne, and Nebred, recommended from their outstanding performance.

Adaptation of new varieties to particular areas and conditions also presents a problem. The South Dakota station finds that Thatcher is the outstanding hard red spring wheat in eastern South Dakota where rust may be a serious hazard, and may also be grown in a transitional area farther west. However, Ceres is indicated for the western half of South Dakota or wherever grasshoppers, heat, and drought are more serious than black stem rust. Reward, more susceptible to grasshoppers, may be grown as an early-maturing wheat in certain hard red spring districts where stem rust epidemics are not likely to occur. Mindum is the leading durum, although Arnautka and Kubanka also may be grown to advantage in the same districts as Reward. Thatcher is considered first choice by the North Dakota station because it resists stem rust satisfactorily, is high in baking quality, and seed is readily available. Ceres may also be grown where stem rust is not serious. Rival and Pilot, distributed in 1939, now are regarded as supplements for Thatcher as they are equal to it in stem rust resistance and are also resistant to leaf rust.

Hazards.—Studying resistance of wheat varieties to heat when plants are about 3 weeks old, the Kansas station found winter wheats as a class to be more resistant than spring wheats, suggesting one reason for the low yields of the latter in Kansas. That certain badly rusted spring wheats were injured more than others by grasshoppers was observed by the North Dakota station and the Department (B.P.I.). Cereal crops at Dickinson, in extent of grasshopper injury, ranked in the descending order barley, oats, wheat, corn, and sorghum.

Under the limited precipitation of the Great Plains the initial water content of the soil, approximated by the depth to which the soil is wet, has been a strong determinant of the yield of spring wheat. This was concluded from an analytical study of data obtained in prolonged experiments by the Department (B.P.I.) in cooperation with five State stations involving different methods of preparation. Frequent failures, low average yields, and infrequent good yields from spring wheat sown on soil wet to only 1 foot deep or less show that planting is not warranted under such conditions. Two feet of wet soil may provide a satisfactory margin of safety in some localities but not in others. Good yields have been best assured by an initial condition of 3 feet or more of wet soil, found much oftener on fallowed land than on land cropped the previous year.

Quality.—Wheat harvested properly may endure prolonged storage under good conditions without deterioration in quality. Turkey wheat combined in 1927 and stored until 1938 in a 1,000-bushel farm steel bin, under good conditions in western Kansas, when studied by the Kansas station in cooperation with the Department (B.P.I.) showed no signs of heating, insect or other damage, was of good quality, gave favorable milling and baking results, and when planted

produced as good a stand as new-grown Turkey seed. When Marquis and Kanred wheat of 1921–29 crops were stored in a dry, unheated room for up to 17 years, the Colorado station, working with the Department (B.P.I. and A.M.S.), observed a definite and fairly regular increase in fat acidity, indicating a certain progressive deterioration on storage. However, satisfactory flour yields were obtained in all cases and all lots made satisfactory bread, with no indications of decline in baking quality.

From milling and baking tests, the Oklahoma station grouped wheat varieties tested in 1938 as follows: Tenmarq and Turkey as of excellent quality; Blackhull, Cheyenne, Eagle Chief, and Smoothhead as intermediate to good in quality; and Chiefkan, Early Blackhull, Sibley 81, and Superhard Blackhull as poor in quality.

Protein content varies more among the hard spring wheats of the Northwest than among the soft winter wheats of the Central States, according to Minnesota station findings in technological studies. Farinograms were no more dependable in predicting baking strength of flour than was protein content for varieties of like general characteristics. In the 1939 crop Thatcher wheat rated higher in baking properties than Newmarq, Premier, Merit, Brandon 123, and Renown Selection. In malting studies, amylase activity increased with germination time much faster than protease activity, and durum wheat produced malts of lower amylase and higher protease activity than hard red spring wheat of the same protein content.

Spring wheat (7 varieties) grown for a number of years by the Utah station on a deep dry-farm clay loam soil carried greater percentages of ash, calcium, magnesium, potassium, iron, phosphorus, and sulfur than did winter wheat (17 varieties). The calcium content of winter wheats differed significantly, and several mineral constituents varied widely from year to year. Green manures added to the soil caused a noteworthy variation in ash content and a significant difference in calcium and phosphorus and material increase in the phosphorus content of wheat.

OATS

Improvement.—New productive oats varieties, developed by stations cooperating with the Department (B.P.I.) and released during the year, included Marida (from Markton × Idamine), smut-resistant and stiff-strawed, by the Idaho station; Huron, medium-early, high-test, smut-resistant, stiff-strawed (derived from Markton × Victory), by the Michigan station; and three crown rust- and smut-resistant oats by the Texas station, including Ranger, a medium-early winter type also resistant to drought, Rustler, an early winter oats often escaping stem rust, and Fultex, a variety adapted for either fall or spring seeding and with marked resistance to lodging, making it of value for combining. Bridger (Markton × Victory (C. I. 2611)), a white-seeded oats strain developed by the Montana station in cooperation with the Department (B.P.I.) and of promise for irrigated land, has equaled its parents in yield and lodging resistance and surpasses Victory in resistance to smut and halo blight.

Oats strains found by the Oklahoma station to be superior in winter hardiness for northern Oklahoma are Winter Fulghum (C. I. 2500),

developed by the Department (B.P.I.), which averaged 55.3 bushels per acre versus 42 bushels from the best spring oats, and Oklahoma Selection 1–32–1446, which was 11 percent hardier than Winter Turf and exceptionally productive from fall seeding.

Adaptations and production practices.—A gradual decline in oats production in Mississippi has been reversed in quite recent years. In 1940 there were increases of about 150 percent in oats acreage in Mississippi over the period 1929–38 and of more than 250 percent in average yield. Numerous experiments by the Mississippi station, including varieties, fertilization, and time of planting, demonstrated that under approved farming methods, at least in the Delta and brown loam areas, 60 bushels and more per acre may be expected. Varietal leaders in its Delta substation tests over long periods comprised Red Rustproof oat strains, including Ferguson 922, Nortex, Delta station selection, Hastings 100 Bushel, Appler, and Baylis, and among the earlier oats Fulgrain, Fulghum, and Kanota.

Extensive Nebraska station tests, cooperative with the Department (B.P.I.), indicate Brunker for central and western Nebraska, Iogold and Otoe (Burt selection (Nebr. No. 518)) for the southeastern section and in irrigated areas, and Otoe and Kanota for early seeding in central and northeastern Nebraska. Columbia oats, a Missouri station selection from Fulghum, outyielded other superior varieties, such as Fulghum and Burt, at the Middle Tennessee substation. The Mississippi and Tennessee stations also have indicated appropriate planting and fertilizer practices from their test results.

Clipping oats, i. e., removal of tip end of the hull, which improves weight and appearance of lightweight oats, the Indiana station finds does not affect seed viability. This has been supported by results at the Tennessee station, which, however, reports that viability may be impaired greatly by mechanical dehulling, the loss of germination being due largely to injury at the junction of glume, kernel, and peduncle. A practical suggestion is that threshers or combines should be so adjusted as to keep the percentage of dehulled oats at a minimum.

BARLEY

Improvement.—Reno, a new high-yielding winter barley offered by the Kansas station, has a relatively high resistance to winter killing and rather stiff straw and is rapidly replacing other barleys on Kansas farms. Wintex, a new barley developed by the Texas station, can be grown from either fall or spring seeding and has given high yields throughout Texas and in parts of nearby States. Its culture is spreading rapidly in Texas where it may replace other barleys, particularly in the north-central section. Composite Cross, a new two-rowed semi-smooth-awned barley produced at the Montana station and found superior to varieties now recommended for dry land, resembles Horn, ripens 4 to 7 days earlier, and the plants are 2 to 5 inches shorter and much more resistant to grasshopper attack. The foregoing three barleys were developed in cooperation with the Department (B.P.I.).

A recent increase in barley acreage, in Nebraska, concurrent with reduction in acreage of oats, is attributed by the Nebraska station to superior varieties and recognition of the higher productivity of barley. Varieties indicated by test results were Spartan, Short Comfort, Trebi, and Club Mariout. Manchuria and Tenkow barleys, the Oklahoma station reports, make abundant pasture when sown

in late September or early October. Manchuria may be planted in either fall or spring and has seldom frozen out under northern Oklahoma conditions.

From barley experiments, 1913–38, cooperative with the Department (B.P.I.) and other agencies, the Washington station reports that Rufflyn, Flynn Selection, and Coast strains 1 and 2 have outyielded the widely grown six-rowed spring Beldi Giant. Hannchen 2911, surpassing other two-row strains, has ranked with Beldi Giant. White Winter, a six-rowed club, and Olympia, six-rowed lax, both outstanding winter strains, have ranked high as malting barley, as have the Atlas, Blue, Hannchen, and Rufflyn varieties. Barleys introduced, bred, or developed by the Oregon station cooperating with the Department (B.P.I.) and replacing older sorts include the Hannchen, O.A.C. 6 and 7, and Santiam varieties in western Oregon. Union Beardless, a hooded variety developed by the station, has wide adaptation and is outstanding in eastern Oregon.

RICE

Varieties.—Zenith, a new rice developed in cooperative work by the Arkansas station and the Department (B.P.I.) as a selection from Early Prolific, matures about the same time as the parent, is more resistant to leaf spot diseases, has broader leaves, coarser stems, lighter foliage, and slightly smaller kernels, and possesses better table quality. The merits of Zenith were confirmed in similar cooperation at the Louisiana station. Calady Selection 100, a new medium-grained rice developed by the California station, was expected to extend greatly the profitable production of this type in the State. The rice farmer may profitably grow more than one variety of rice, and combinations suggested from experiments by the Arkansas station and the Department (B.P.I.) are Zenith and Nira or Supreme Blue Rose with (1) Caloro or Acadia or (2) Arkansas Fortuna.

Fertilizers.—Caloro rice grown, 1925–37, on Stockton adobe clay by the Department (B.P.I.) cooperating with the California station, made its highest average yield of 4,561 pounds from the 150-pound acre rate of ammonium sulfate, 987 pounds above the check, and also the highest net return, $9.76 per acre. For Colusa rice, the respective figures were for ammonium sulfate 200 pounds, the average (1927–34) 1,370 pounds and $10.88 per acre. Ammonium sulfate (150 pounds) at planting increased yields more effectively than when applied during tillering or heading. It was the most profitable nitrogen carrier. Plowing under a moderate growth of bur-clover also resulted in increased yields, while superphosphate and potassium sulfate either alone or in combinations were ineffective. Drilling in fertilizers with the rice in Texas station experiments has increased the grain yield 17 percent over that from the common practice of applying fertilizer on top of the soil at planting, and has not injured germination of seed.

FLAX

Flax has good possibilities as a cash crop in western Oregon, in the Blue Mountain region, and in some irrigated districts, according to the Oregon station, but is not recommended for the Columbia

Basin section. Seed flax is adapted to most soil types in Oregon, except very sandy soils. Experimental results suggest planting on well-prepared seedbed after a legume, or, when flax worm is present, after a cultivated crop, and at acre rates of from 30 to 35 pounds in the Willamette Valley and in eastern Oregon and from 40 to 50 pounds on irrigated land along the Lower Columbia. Bison flax is indicated for western Oregon, Rio for eastern Oregon, and Redwing for diked lands along the Columbia. Oregon flaxseed has been comparable in oil content to that grown elsewhere in the United States but excelled in drying power.

That seed flax could be fall planted in south Georgia where it would withstand winter was observed by the Georgia station cooperating with other agencies. An acre production of 5,040 pounds of unthreshed flax yielding 11.7 bushels of seed was reported. The crop is not yet on a commercial basis in the State, but experiments in both north and south Georgia have given encouraging results.

The first improved hybrid varieties of flax in the United States, represented by two selections of crosses of Bison with other flaxes made by the Minnesota station cooperating with the Department (B.P.I.), were being increased for distribution. Approaching Bison in seed size and oil content, they have the high iodine number and oil quality of the other parent.

Studying time and temperature relations of germinating flax, a worker of the North Carolina station observed that with both Bison and Albidum (an Indian variety) seed flaxes 31° C. was most favorable for early production of seedlings, an optimum range being 26° to 34.5°. Low and high temperatures slowed down germination, Bison appearing more sensitive to heat.

POTATOES

The record demand for and sale of Maine potato seed in 1940, according to the Maine station, was largely a result of cooperative research with the Department (B.P.I.). The methods of producing high-yielding, disease-free seed worked out assure an annual income of several million dollars to the potato industry of the State and aid to outside potato areas using Maine-grown seed stock. Foundation seed stocks, the station advises, should be planted early by the tuber-unit method in rigidly isolated areas, rogued early and carefully, kept weed-free, and sprayed thoroughly with a spray not masking symptoms of virus diseases. Seed should be so stored as to avoid other diseases, as bacterial wilt.

The Katahdin potato, introduced by the Florida station in 1933 after it was developed by the Department (B.P.I.), is established as the leading variety in the Hastings and LaCrosse sections, where by 1940 it had replaced more than 80 percent of the acreage planted to Spaulding Rose and consistently produced heavier yields of higher-quality tubers. As a part of the national potato breeding project the Sequoia, a new variety developed by the North Carolina station and the Department (B.P.I.) and resistant to virus diseases, late blight, leafhoppers, and flea beetles, was released during 1940 for general introduction. It averaged over 400 bushels per acre in mountain sections and was an outstanding producer in limited tests elsewhere in the United States. Desert, a new potato highly re-

sistant to blight, developed by the New York (Cornell) station by crossing commercial varieties with a wild potato species from Tropical America, was to be released to seed growers if it held its record for 1 year longer.

Clonal strains of Triumph potatoes very early to very late in maturity have been tested during 10 years by the Nebraska station and in cooperation with stations in several Southern and Central States. Midseason strains appeared to be most desirable on dry land and under irrigation in western Nebraska. Only the earliest strain appeared desirable in eastern and central Nebraska with or without irrigation, and it seldom equaled other early varieties, as Warba or Irish Cobbler. The second early or midseason strains seemed more suitable for general use in the South. To obtain high-yielding clonal lines of potatoes, the Louisiana station cooperating with the Department (B.P.I.) found it desirable under Louisiana conditions to select first-year seedling segregates having tuberous to slightly stoloniferous types of stolon growth, which are associated closely with maximum plant height and earliness of maturity.

Seed and planting practices.—Treatments of seed potatoes with ethylene-chlorohydrin by the Hawaii station resulted in much faster germination and growth of dormant seed and an increase in number of sprouts per seed piece and also in the yield for fully dormant and for germinating seed. Commercial application of these findings with seed from the mainland is expected to influence materially the continued development of the winter potato industry. Seed potatoes grown during winter in Hawaii and stored at 38° F. until the next fall were found as productive as newly imported stocks. The relation of these observations is obvious, for growers need seed for planting at a time when mainland seed does not germinate well without special treatment. In plantings by the New York (Cornell) station, plants of sprouted tubers came up first, and from 43 to 64 days after planting were taller than those of desprouted tubers and of dormant tubers in order. Plants of desprouted seed produced more tubers than those of sprouted and of dormant seed, but yield in weight of tubers was larger from sprouted seed. Seed tubers exposed to light seemed no better than those kept in darkness under like conditions.

Fertilizers.—Potato yields obtained by the Alabama station on five soil series and in five localities indicated that, in general, fertilizer providing nitrogen 60 pounds, phosphoric acid 150, and potash 90 pounds per acre—4, 10, and 6 percent, respectively—on a 1,500-pound per acre basis, would be adequate. Yield responses, however, suggest increasing potash to 120 pounds and nitrogen on certain soils to 90 pounds and on new land to 135 pounds the first year after clearing and 90 pounds later. In south Alabama continued use of a summer legume after potatoes was shown to result in a higher production level and a smaller need for commercial nitrogen.

The merits of phosphates in potato production were again confirmed by the Montana station. The program of phosphate application indicated for the industry appeared to have an average value of a 25-percent yield increase plus a 50-percent gain in grade value, adding materially to the crop value and reducing unit cost of production. Although potatoes grown at Aberdeen by the Idaho station continued to respond more in yield, especially No. 1's, to fertilizers

containing nitrogen than to phosphorus alone, phosphate produced heavier netting of tubers and a higher percentage of No. 1's.

Tendencies of soils to lose organic carbon under the common 3-year rotations of potatoes, oats, and hay, the New Hampshire station found, could be corrected in measure more by a light application of lime than by fertilizers. Emphasis on the need for maintenance of organic matter to avoid erosion and yield decline is of current significance because of the trend to shorter potato rotations to avoid insects and quackgrass.

Quality.—Causes of the rise and fall in prominence of the principal potato-growing districts of Colorado, according to studies by the Colorado station, did not seem to be chemical and climatic factors. Its tests indicated that heredity and environmental conditions, especially moisture and sunshine, affect the starch content of mature tubers. Starch content rose and fell with total dry matter and increased with maturity. On dry land early varieties matured well and produced as much starch as under irrigation, while the later sorts did not ripen properly and were stunted and low in starch. Starch content and high yields appeared to be conditioned on an ample and well-distributed moisture supply. In general, irrigated potatoes showed higher starch content.

Moisture relations during the growing season also affected both quantity and quality of tuber ash. Mineral shortages were limited largely to a lack of phosphorus. Supply of this element, besides increasing yields, tended to produce rather thick, well-russeted skins, resistant to abrasion. A middle planting date (May 18–25) gave best yields and most uniform-sized tubers, yet planting date had little effect on mineral composition or starch content.

Conditions favorable to high specific gravity and mealiness of tubers indicative of better cooking quality, the New York (Cornell) station reports, included growing potatoes after potatoes unfertilized and without a cover crop and on soils of pH 7.88, whereas too heavy a rate or unsuitable formula of fertilizer, soils with a reaction of pH 6.36, growing the crop after soybeans for hay, and periodic shading were prejudicial to these qualities. Shading on land receiving nitrogen also increased incidence of blackening after cooking.

SWEETPOTATOES AND TARO

The method developed in breeding research by the Louisiana station of overwintering sweetpotato vines in the greenhouse in pots which are shifted to the field in early spring, training to a wire trellis, and then girdling has produced seed in satisfactory numbers by crosses of and selfs from standard varieties. Seasonal differences in seed setting among varieties were observed. An associated study revealed that high moisture content of sweetpotatoes has meant relatively low carbohydrate content, and the sums of the two percentages have been fairly constant. Thus, the starch may be readily estimated from the moisture content.

On growing Porto Rico sweetpotato plants in electrically heated hotbeds, the South Carolina station observed that muslin was unsatisfactory as a cover, and that insulating materials, as pine straw or cinders and soil, failed to conserve electricity materially. Nar-

row spacing of the soil heating cable produced more plants per kilowatt-hour than relatively wide spacing. A comparatively high temperature, 78° to 80° F., was more profitable than a lower temperature, 68° to 70°. Crowded bedding of the roots produced more plants per unit of bedding space and only slightly fewer per bushel of seed. The station obtained high yields of longer and better-shaped roots from beds 10 to 12 inches high.

Sweetpotatoes grown on Buckner coarse sand by the Iowa station responded to complete fertilizers in yield increases. At most, 2 percent of nitrogen was required, and probably this could be omitted on a fairly fertile soil with a legume in the rotation. Superphosphate was needed up to 10 percent, and potash up to 12 percent gave profitable yield increases. Sweetpotatoes receiving complete fertilizer containing an adequate supply of potash kept better in storage than the unfertilized crop.

Even at the low price of 20 to 25 cents per bushel for sweetpotatoes, the Alabama station reports that returns from an acre for starch or stock feed compare favorably with those from other crops. The average yield in eight localities was 246 bushels per acre, making gross returns at 25 cents per bushel $61.50 per acre and the net value above materials and labor through harvesting $34.08. Gross returns from cotton, both lint and seed, on the same farms approximated $45 and from corn averaging 34 bushels per acre $20.40.

Taro in Hawaii.—Descriptions of 84 distinct forms of taro (*Colocasia esculenta*), including 69 varieties native to Hawaii and other Pacific islands and Asia and information on origin and name, distribution, and uses, were published by the Hawaii station cooperating with the Department (B.P.I.).

TOBACCO

Varieties.—Because of a period of drought years and low prices, a large proportion of the coarser yet higher-yielding Big Seed varieties has been grown in Wisconsin chiefly for the stemming market, but current prospects for tobacco leaf appear more favorable in the cigar-binder market where Havana Seed varieties, productive of the best quality, are in greatest demand. Since Big Seed varieties often have given better yields only because they are more resistant to black root rot than Comstock Spanish or Havana No. 38, the Wisconsin station has endeavored to introduce such resistance into Havana Seed. Certain strains of this type, e. g., Havana Nos. 142 and 211, have been grown extensively, and more improvement in this direction is in prospect.

A new rot-resistant strain, No. 16, developed by the Kentucky station from a cross between Burley and a northern dark cigar tobacco, makes a better plant than average, produces a heavier acre yield, and brings a higher price. Another type that looks, smells, and tastes like Burley but averages only about 0.02 percent of nicotine has been also developed by the station. Ordinary Burley contains about 2 percent of nicotine, and dark tobacco averages from 3 to 4 percent and runs as high as 7.

Rotation.—Tobacco properly fertilized and grown after natural weed fallow of sufficient duration was observed by the Department (B.P.I.), working with the Maryland and South Carolina stations,

to possess in the main the desirable characteristics noted in the crop grown on virgin land. Tobacco grown after bare fallow declined rapidly in yield and gross value, being surpassed markedly by that after ragweed and horseweed. Weed fallow promoted a quick start and very rapid and uniform growth of tobacco from transplanting to maturity, a result associated within normal limits with a uniformly high market value per acre and high average price per pound.

Fertilizers.—For best growth of tobacco the Kentucky station found that the soil should contain at least 325 pounds of replaceable potassium per acre and possibly more if the nitrogen level is high. The level of replaceable potassium of a soil in tobacco usually falls from 10 to 40 percent during the growing season and even more at maximum growth. Additional potash is suggested for better growth and quality, especially where leaf symptoms indicate potash deficiency. That a proper balance between the potassium and magnesium in the soil is essential for the best quality of tobacco leaf was observed by the Indiana station, which indicates the optimum potassium-magnesium ratio as about 4:1. Burley tobacco took 25 percent more potassium from potassium metaphosphate than from potassium sulfate in Tennesse station experiments, cooperative with the Tennessee Valley Authority, suggesting a superiority in fertilizer value of the metaphosphate.

Quality.—Havana Seed tobacco under normal conditions, the Connecticut (State) station reports, should remain in the field at least 3 and often 4 weeks after topping. Beside gains in weight and in grading during each successive week, late harvest accelerates speed of curing, shortens the period of danger from shed troubles, and also gives characteristics of "ripeness" favored by the trade.

In curing burley tobacco in air-conditioned chambers, the Kentucky station determined that good leaf can be cured at 60° to 90° F. provided the relative humidity is about 65 to 75 percent. Too high a relative humidity tends to produce darker tobacco, and Burley cured at too low a relative humidity often is mottled. Split tobacco has lost weight faster during curing than tobacco not split. Cured tobacco should not be exposed to a relative humidity above 75 percent for longer than needed to bring the leaf into case for stripping, or damage may occur. The rate of damage increases rapidly as relative humidity rises.

Treatment with yeast up to 1 percent by the Connecticut (State) station benefited greatly the grade of Havana Seed binder tobacco known as "darks," treated leaf having a more completely fermented appearance and a more pleasant aroma. Smoking test results overwhelmingly favored cigars with treated binders. Seconds also were improved by the treatment. Leaf-by-leaf analysis of Havana Seed tobacco by this station revealed that total ash, calcium, and magnesium were highest in the lower leaves and regularly declined toward the top of the plant, whereas the contents of potassium (highest in ninth to twelfth leaves) and total and protein nitrogen, as well as acidity of leaf, showed a reverse trend. Total volatile bases increased rapidly from bottom to top leaves. Nicotine was more than three times as high and ammonia 25 to 60 times as high in the top leaves as in the bottom leaves.

SUGAR CROPS

Sugar beets.—That crop-sequence effects should be considered in planning a rotation including sugar beets was ascertained by the Michigan station, cooperating with the Department (B.P.I.) and other agencies. Certain sequences could entail no important increase and might even lower costs of producing sugar beets. Following corn on Brookston loam, sugar beets produced an average of 2,753 pounds of indicated-available sugar per acre, after beans 2,604, barley 2,340, and after oats 2,292 pounds. Acre yields of roots, numbers of marketable roots, and indicated-available sugar per acre closely followed similar trends. Rotations and other cultural practices, varieties, and soil and climatic needs of sugar beets, published by the Minnesota station, were based largely on its cooperative research with the Department (B.P.I.).

A high nitrate level is essential for beets during the growing season, the Colorado station determined, but the supply must be practically exhausted by harvest in order that the beets may have a high content of sugar. Percentage of sugar was negatively correlated with nitrate content in beets at harvesttime.

The 14,000,000 pounds of sugar beet seed produced in the United States in 1939 were worth, according to the New Mexico station, about $1,100,000 to farmers of the southwestern United States. This industry began in research at the station, carried on in cooperation with the Department (B.P.I.). In further experiments it was noted that alfalfa is much superior to cotton to precede sugar beets grown for seed. Sudan grass as a preceding growth has been found to lower the yields and also to injure the seed crop.

Sugarcane.—Extensive planting of sugarcane varieties developed by the Florida station has permitted the milling season in that State to open in late October, earlier than ever before. These earlier canes provide for a longer milling season and thereby increase the capacity of the equipment. The value of early-maturing cane was also emphasized by a severe freeze early in 1940. The highest-yielding variety, F31–762, exhibited superior cold resistance, greatly exceeding that of Cayana, C. P. 807, C. P. 29–116, or Co. 290.

Research on factors affecting germination of sugarcane by the Hawaii station and Hawaiian Sugar Planters station suggested determination of soil temperatures before planting, 68° to 69° F. being minimum and 90° to 95° optimum, and adjusting practices to unfavorable conditions, e. g., shallow planting of previously treated top seed pieces, and careful planting on heavy soils tending to puddle. Seed pieces need have not more than three buds and should be free from trash and planted to avoid placing buds in a down position. Soaking seed pieces in a warm 1-percent solution of calcium nitrate before planting, particularly under unfavorable conditions, assures an improved stand and vigor.

Increasing amounts of nitrogen applied to sugarcane above a certain minimum optimum, the Hawaiian Sugar Planters station noted earlier, have a depressing effect upon quality of juice. Current results show that control of nitrogen fertilization, important both in cultural practice and related economic aspects, may be achieved by collecting leaf-punch samples at progressive intervals, obtaining their

total nitrogen content by a rapid chemical method and estimating the nitrogen requirement from platted data. Proper proportioning and timing of the total nitrogen application for sugarcane was found essential for greatest efficiency.

That differences in amounts of nutrients removed from the soil exist among sugarcane varieties was shown by the Puerto Rico University station. B. H. (10–12) cane responded to nitrogen up to a certain point; with 100 and 200 pounds it outyielded others, but with 400 pounds no differences were noted between varieties. The same relation was found with phosphorus. M–28 and B. H. (10–12) seemed to use potash better than did P. O. J. 2878. Determination of such differences appears essential for economic application of fertilizers.

SORGHUMS

Information on growing sorghums, based extensively on station research, was published by the Colorado station in cooperation with the Department (B.P.I.) and by the Nebraska station. The Nebraska tests demonstrated the superiority for grain yield in southeastern Nebraska of Early Kalo, Sooner, Kalo, and Day milo and, under chinch-bug infestation, Club and Western Blackhull kafir. Atlas, Leoti, Kansas Orange, Early Sumac, and Black Amber sorgos excelled in forage yields. In Colorado, Leoti, Black Amber, and Fremont were leading sorgos for altitudes less than 5,000 feet and Dakota and Minnesota Amber for altitudes above 5,000 feet and for late planting at lower elevations. Highland and Improved Coes were the best adapted for grain, and Sooner, Pygmy, Colby, and Day milo were the best combine types. In both States adapted grain sorghums have yielded more than twice as much grain as corn, and, in general, superior sorgos have made forage yields two or three times those from corn.

Texas milo, a new Texas station strain that is productive and highly resistant to *Pythium* root rot which has caused heavy losses in western Texas, now is widely grown in the State. Two milos resistant to this root rot also have been released to growers by the California station. Colby milo, the early-maturing combine type developed by the Kansas station cooperating with the Department (B.P.I.) and released in 1938, has been in great demand by farmers.

Sirup.—Growing sorgo for sirup is a profitable enterprise in many localities. From its experiments, partly in cooperation with the Department (B.P.I.) and the Tennessee Valley Authority, the Georgia station published information on sorgo varieties (Blue Ribbon being currently the choice), cultural methods and field practices, and on handling and canning sirup. Land in Breathitt County treated with complete fertilizer by the Kentucky station averaged 219 pails per acre of sorgo sirup compared with 209 from that receiving nitrate and phosphate only and 154 pails on untreated soil. Limestone or manure in addition to fertilizer lowered quality without further increasing the yield. William, a productive local sorgo, has made the best sirup, has shown resistance to red spot, and its foliage remains green until harvest.

SOYBEANS

Maintaining to a large extent the record acreage and production attained in 1939, the soybean crop continued to provide many oppor-

tunities for profitable research in both production and utilization for the stations and cooperating divisions of the Department.

Improvement.—Seneca, a new yellow-seed soybean to be made available to growers by the New York (Cornell) station in 1941, yields about 30 percent more than the currently popular black seed Cayuga, grows taller and is easier to harvest, has a growing season 10 to 14 days longer, and can be raised in western New York and the Hudson and Mohawk Valleys. Chief, a new soybean developed from a cross between Illini and a Manchu strain by the Illinois station and first distributed in 1940, has outyielded Illini. Chief has proved best adapted to central and south-central Illinois. Cooperating State stations and the United States Regional Soybean Industrial Products Laboratory have released to farmers the high-yielding Mt. Carmel and Patoka varieties adapted to southern Corn Belt conditions and possessing special characteristics for industrial use. Two new yellow-seed soybeans suitable for processing, developed by the Indiana station particularly for southwestern Indiana and being multiplied for release, outyield varieties now grown in that section and contain from 3 to 4 percent more oil.

Limitations.—Soybeans have extended rapidly into many sections but may have definite limitations. Although the crop proved relatively well adapted to eastern Nebraska, the Nebraska station reports that farm trials during 35 years failed to bring about a large acreage because alfalfa and clover proved superior for forage production and threshed-bean prices had been too low. Grain yields from standard adapted varieties at the station, 1909–38, were much higher for corn and small grains than for soybeans. Soybeans grown by the Utah station on good irrigated land under favorable conditions have made from 22 to 27 bushels per acre, worth from $27.50 to $33.75, yet have been limited by few adapted varieties, no local market, and the probability that they could not compete with alfalfa for forage. Colorado station tests suggested that at current prices soybeans do not yield enough to be recommended to replace any other legume in general culture on irrigated farms in the State.

The value of soybeans as an emergency forage, suitable for both hay and silage and able to grow when ordinary hay crops wilt and pastures burn, was demonstrated by the New Jersey station during the abnormal drought of the summer of 1939. The crop is also gaining in popularity as a green manure. Indicating varieties and cultural practices, the Rhode Island station stated that soybeans probably will find their main place on Rhode Island farms as a higher protein emergency hay crop or for seed as a high-protein dairy concentrate. Fair crops have been made in certain Maine localities, yet the Maine station does not indicate soybeans as profitable under its conditions.

Varieties and production.—Reports of the Illinois and Mississippi stations, both in important producing areas, gave examples of current trends. Soybeans recommended for grain by Illinois tests included certain Manchu selections, Black Eyebrow, Illini, Dunfield, Manchuria 13–177, Morse Selection 230, Scioto, Mansoy, and Macoupin. Strictly hay soybeans usually did not yield either more or better hay than did grain types. Varieties at the best stage for hay, i. e., pods well-filled but leaves not yet starting to fall, averaged about one-third each of leaves, stems, and pods dry weight. During field-curing and harvesting for hay, about 74 percent of the dry weight of leaves, 77 of stems, and 89 percent of pods were saved. Leaders in the Missis-

sippi Delta included Laredo, Avoyelles, and Otootan for hay, and Mamloxi, Delsta, Tokio, Mamredo, and Mammoth Yellow for grain.

In Illinois, Illini soybeans gave higher acre yields in 24-inch rows, where a 50- to 70-pound rate was best, than in 8-inch drills, where 90 to 130 pounds of seed slightly excelled other rates. Grain yields from May plantings surpassed those from June seedings. Mississippi station experiments indicated planting from April 15 to June 1, unless earlier with corn, the rate for grain being about one seed per inch in 30- to 42-inch rows at a rate varying according to seed size, and for hay planting at about 3 times the rate for grain, the heavier rates making finer hay.

Growing soybeans in cultivated rows was found superior by the Arkansas station, especially in droughty seasons. Failures were much greater from the drill and broadcast methods. Respective average acre yields, 1925–36, from the 36-inch rows were for Laredo, 11.7 bushels of seed and 1.91 tons of hay, and for Mammoth Yellow, 10.44 bushels of seed and 1.8 tons of hay. Seeding Mammoth Yellow in rows at a rate of 21 pounds per acre and Laredo at 14 pounds was economical and productive for both grain and hay.

Fertilizers.—Soybean fertilization, the North Carolina station determined, includes proper liming, inoculation when needed, use of phosphate and potassium and of nitrogen on certain well-drained lighter soils, and harvesting so as not to deplete soil fertility. The Mississippi station recommended appropriate rates of phosphorus and potassium for soybeans on hill land. It found that placing a mixture of dolomite and superphosphate 2 inches to one side and 2 to 3 inches below soybean seed gave better hay yields than contact placement. The best placement was dolomite in contact with and superphosphate below and to the side of the seed.

When the seed was stored by the Illinois Station indoors in metal cans, soybeans grown from seed planted the next spring after harvest made slightly higher grain yields than those planted 1, 2, and 3 years afterward. Sharply reduced grain yields followed storage 4 years or longer. Soybeans from the upper levels in an outdoor test crib absorbed water faster, lost vitality sooner, and had greater acidity than those at the lower levels. However, depth of storage did not especially affect most of the chemical constituents.

ALFALFA

New varieties.—Cooperating with stations in 40 States, the Department (B.P.I.) has been making extensive tests of alfalfas, and several strains have been selected which are strongly resistant to bacterial wilt, a serious disease causing alfalfa to die out in two to three years in many areas. Intensive studies of these tests have resulted in the designation of 5 strains outstanding in resistance to cold and bacterial wilt, and apparently equal in forage and seed production to the best commercial strains and rather similar in adaptation. Seed of these strains has been composited and used in establishing foundation fields in several States. Observation of over 10,000 individuals studied at the Nebraska station indicated that hybrid vigor is manifest in seed yields as well as in forage production. During the last 2 years, Orestan, a Turkistan introduction resistant to bacterial wilt increased by the Oregon station, has gone into commercial pro-

duction. Wilt resistance in alfalfa also is being increased by rigid selection and inbred lines at the Colorado station.

Alfalfa in the Mississippi Delta.—That poor surface drainage, unadapted seed, poor seedbeds, improper seeding dates, failure to cut at the proper growth stage, and insects and diseases are factors in Delta alfalfa failures was confirmed by the Department (B.P.I.) working in cooperation with the Mississippi station. Lack of surface drainage, responsible for most failures, has been remedied by building up the field into lands with surface ditches spaced at regular intervals with the grader or the tailboard scraper-leveler. Seedbed preparation should begin well before planting, leaving the upper 2 inches well-pulverized and the subsurface settled and firm, and seeding from September 15 to October 15 at the rate of 12 to 20 pounds per acre.

Cutting alfalfa.—The general practice in Michigan of making two cuttings in the bloom stage is desirable, according to recent Michigan station experiments. For maximum yields in two cuttings, the first should be when in bloom and the second about August 15 in most of Michigan. Acre yield may be increased by cuttings after the first killing frost, but in cutting three times good management is necessary. That alfalfa cut at one-half and later bloom stages gave best yields although at some sacrifice in quality was reported by the Mississippi station cooperating with the Department (B.P.I.)

Alfalfa remained vigorous in other Michigan station studies when cut back to a 6-inch level every 2 weeks or monthly or to a 9-inch level weekly or biweekly, whereas cutting often and close to the crown depleted reserves and reduced hay yield and vigor and cutting frequently at 12 inches resulted in decreased yields owing to lack of vegetative growth and to loss of leaves due to maturity of the plant. The Colorado station found that frequent cutting reduced yield and the crude fiber percentage in alfalfa but increased the protein content in the forage. Noting the differential response of alfalfa varieties to time of cutting, the Department (B.P.I.) and the Nebraska station cooperating suggest that for optimum production Ladak evidently should grow somewhat longer for the first cutting and between later cuttings than is usual with common or Grimm.

CLOVERS AND OTHER LEGUMES

Clover.—On examining commercial and native strains of white clover, the New Jersey station observed a high degree of variability in all characteristics studied, due primarily to heredity. Ladino (giant) and Kent (dwarf) to a lesser degree represented distinct morphological types, while other strains did not differ essentially in form but had variations ranging from giant to dwarf. Ability to spread rapidly was associated with increased size of all plant organs. When grown in a permanent pasture mixture, Kent increased in abundance and in yield when cut at 2-week intervals, as in close grazing, but decreased in these respects when cut 4 to 6 inches high, while Ladino responded with a reverse treatment. High productivity was associated with a large percentage of white clover in the vegetation under mineral fertilization. Lime and pH values, it appeared, may be more important than phosphate and potash for white clover on poor soils. Strain differences also were noted in response to the different treatments.

White clover strains differed in adaptability in Wisconsin station and Department (B.P.I.) tests, those from Louisiana and New Zealand being killed almost completely during a severe winter. Domestic red clovers were decidedly superior to European strains in ability to produce a good stand in the year of seeding when drought and high temperatures prevailed. A local strain of Graham mammoth appeared hardier under adverse conditions than medium or the double-cut types.

In a study of the relations of clover-seed color to germination and other characters, the Oregon station determined that in total germination on blotters yellow or yellowish seeds led in red clover, darker colors in alsike, and yellow in white clover. Germination in soil was similar, although for red clover color differences in germination were slight.

The Alabama station, in studying soil and water losses from cultivated plats with slopes ranging from 2 to 20 percent found that crimson clover surpasses hairy vetch as a soil-conserving crop. The water run-off from clover plats was consistently the lower, and cotton yields were 5 to 20 percent higher than on vetch plats. The Oregon station, cooperating with the Department (B.P.I.), brought forward several improved strains of crimson clover having greater resistance to stem rot and better winter hardiness, and also developed a seed-producing strain of zigzag clover.

Strawberry clover was found by the Utah station to be promising for planting in wet locations, including those with considerable alkali, but it was not indicated for better land except for seed purposes. The Oregon station also found this clover the most satisfactory legume for saline soils. California bur, black medic, and sweetclover gave good results in several counties in southern Florida for the first time, the Florida station reported. California bur-clover appears to be more generally adapted to the State and tolerant of drier soils than White Dutch clover and also furnishes early feed.

The rapid spread of Korean lespedeza, with its easy and abundant production of nutritious feed and beneficial soil relations, according to the Missouri station is a remarkable development in Missouri agriculture. It was grown on 166,000 farms in Missouri or on about 2 of every 3 farms in 1939, and on 80,000 farms was produced in the continuous 1-year rotation of grain-lespedeza. On 40 acres of wheat-lespedeza, 56 head of long yearling beef cattle grazed from April 27 until October 20 with no supplementary feed and little relief pasture and gained 279 pounds per head for the season.

Sweetclover.—That current emphasis on legumes such as sweetclover and alfalfa in soil conservation may accentuate the importance of soil potash supplies and require more attention to potash fertilizers or to return of crop residues as straw and stover was shown by the Ohio station. In a 2-year fertilized rotation of corn and oats, including sweetclover as a green manure, substantial increases in corn yields resulted from sweetclover alone, yet such benefits as resistance of cornstalks to breakage, increases in their sugar content, and higher grain yields from either potash or residues increased with time. Continual use of nitrogenous green manures without added potash, it appears, may lead to a limitation of yields by a lack of potash for normal photosynthesis. Effects of plowing under sweetclover growth or stubble upon small grain following, the Minnesota station reported, result

primarily from tillage involved rather than from decomposed sweetclover put into the soil. By planting small grain in wide rows the Oklahoma station found it possible to obtain good stands of sweetclover without appreciable decrease in grain yield.

No low-temperature storage treatment, 5° or −10° C., moist or dry, caused seed of sweetclover and smooth vetch to show higher germination percentages than seed stored dry at room temperature (average 22°) at the Oregon station. Moist storage under various low and alternating temperatures was harmful, while dry storage did not affect germination. Hard seeds of sweetclover after from 1 to 10 months' storage were not softened much by treatments which were effective with smooth vetch.

Vetch.—Willamette, a strain of common vetch developed by the Department (B.P.I.) and the Oregon station cooperating, is vigorous, hardy, and disease resistant, and has given excellent results at the Alabama station. It equaled or exceeded hairy vetch in tonnage per acre, and its seed production was about double. The Texas station reports, however, that hairy vetch was the most dependable winter legume for sandy soils of eastern Texas. Plowing under vetch and applying 100 to 200 pounds of superphosphate per acre increased average cotton yields from 34 to 42 percent and those of corn as much as 65 percent. These experiments have resulted in a rapid increase in the use of hairy vetch in eastern Texas.

Corn after vetch turned under averaged 3.1 bushels per acre, after vetch with tops removed 23.3 bushels, and without vetch 15.9 bushels, at the Mississippi station. Vetch roots contained 35 percent of the nitrogen in the whole plant. Vetch cut for hay or grazed by livestock may leave half of its fertility value in and on the soil for corn production. The station observed that soils producing a good vetch crop without addition of lime in the drill do not need inoculation for another crop of vetch. Liming soils low in calcium content in Louisiana station experiments enabled common vetch to use more of the phosphorus from superphosphate. Lime alone produced an increase in calcium percentage only, while lime with superphosphate resulted in higher contents of phosphorus and nitrogen also.

Winter legumes.—Illustrative of the very large expansion in the acreage of winter legumes planted in the South for soil improvement is the planting of more than 30,000,000 pounds of seed in Mississippi in 1939, covering a sizeable percentage of the cultivated acreage. Mississippi station experiments indicated that in certain Delta areas the average crop of winter legumes might equal in increased cotton production as much as 55 pounds of commercial nitrogen and in hill sections about 24 pounds. On sandy soils, the Alabama station observed that without winter legumes about 20 percent of the potassium applied under field conditions during 8 years had leached into the subsoil, whereas growth of winter legumes minimized the loss, aiding in potash conservation and improving soil fertility.

A partridge-pea (*Chamaecrista fasciculata*), the Alabama station indicated, has possibilities as a ground cover and for soil improvement, especially on rather poor soils where it grows well. It yielded 10,437 pounds green weight per acre when planted April 15. The crop reseeds freely, making planting after the first year unnecessary. *Indigofera hirsuta* in tests by the Florida station cooperating with the Department (B.P.I.) has made good yields, reseeded in corn as a

cover crop, competed well with grasses, recovered after timely cutting, has been palatable to cattle, and could endure controlled grazing and be used for fall grazing after pastures become short. It has produced late-maturing seed in abundance. Seed of three strains of pigeonpeas (*Cajanus indicus*) selected by these cooperators as early-maturing, reasonably resistant to root knot, and heavy seeders was being increased for distribution.

Kudzu.—Kudzu, a perennial drought-resistant legume found in Alabama station experiments to be valuable for hay, temporary grazing, cutting and feeding green, soil improvement, and for preventing erosion has averaged over 2 tons of hay per acre and has supplemented permanent pasture for beef and dairy cows with no harmful effect on flavor or odor of milk or butter. The crop may be grazed by hogs to partly replace protein supplements but will not fatten them without other feed. It excels for poultry, either hand-fed or grazed, from May until frost.

Field beans.—The pinto, the most widely grown field bean in New Mexico, is brown and white mottled and has a distinctive flavor. Its variable color markings affect the market price. Several selections by the New Mexico station for plant type, early maturity, and uniformity of pod setting and color markings showed superiority in irrigated sections and an early-maturing strain in dry-farming sections. Eleven of 63 high-yielding white bean selections by the Puerto Rico University station definitely outyielded the unselected native variety, one by 45.3 percent. If sustained in future crops, such increase may make bean growing a profitable enterprise in Puerto Rico.

Peanuts.—Improved varieties of peanuts are being developed by several southern experiment stations. The North Carolina station made extensive tests with selections of Virginia Bunch and Jumbo runner peanuts, and the Virginia station and the Department (B.P.I.) carried forward strains of large-seeded Virginia-type nuts. Productive lines promising in yield, earliness, and seed quality were anticipated by the Florida station from a hybrid strain. As a part of its comprehensive peanut program, the Georgia station in 1940 planted 1,350 new strains and selections for yield tests and had sent the most-promising selections to other States. *Arachis glabrata*, a perennial stolon-producing wild peanut from South America, survived the severe winter of 1939-40 and is expected by the Florida station to be a valuable pasture plant for certain lands in Florida.

Experiments of a number of stations have led to practical recommendations. A recent bulletin of the Mississippi station, based largely on reports on investigation by various stations, covers many phases of production. Based on its experiments, the North Carolina station has published appropriate recommendations on soils, lime, gypsum, and fertilizers. When the Alabama station added magnesium sulfate to poor sandy soils, yields of peanuts were greatly increased, and it seemed probable that on very sandy soils magnesium sulfate should be used with phosphate for maximum yields. Profitable responses of peanuts to superphosphate in yield increases in certain producing districts and to potassium chloride in another district were observed by the Florida station. Comparative effects of digging and hogging peanuts on subsequent yields of fertilized cotton led the Alabama station to suggest that in the interests of soil fertility peanuts should be harvested seldom but hogged off as often as possible.

GRASSES AND HAY

Angleton grass.—Culture of Angleton grass (*Andropogon annulatus*), an introduction from India and productive and nutritious in the humid Gulf Coast region of Texas, has been limited to propagation by cuttings because seed could not be produced in the region. Recent Texas station experiments have proved that viable seed is set in abundance under drier conditions, and the crop evidently may be so grown for planting in more humid regions.

Bluegrass.—Under the rather long days of late spring and early summer and on plants illuminated 18 hours daily, the Department (B.P.I.) and the Ohio station observed that shoots were nearly upright on both Kentucky and Canada bluegrass, internodes became elongated, and inflorescences developed on some shoots. Plants under the shorter days of fall or 8.5 hours daily illumination tended to have decumbent shoots, shorter stem internodes, and few or no inflorescences. Kentucky bluegrass tended to develop more rhizomes under the longer days and Canada bluegrass under short days. The Kentucky station found little difference between Kentucky and Missouri-Iowa-grown bluegrass in adaptability to Kentucky, although lots from old fields in both regions differ significantly in productiveness and appearance.

That harmful root interactions might occur between species of pasture grasses and legumes was indicated to the Wisconsin station by reduced dry weights and in some cases root weight of grasses. In one experiment Kentucky bluegrass was practically eliminated when grown in association with clovers, while bromegrass strains and timothy were not affected. Average plant weights of Kentucky and Canada bluegrass were also reduced in cultures with other grasses. At the Kentucky station, however, bluegrass-legume mixtures produced about 4 times as much dry matter in 1939 as plats without legumes for 11 years, and yield difference seemed to be increasing. The weed content of herbage produced by bluegrass alone was about twice that in bluegrass-legume herbage.

Brome.—Brome receiving nitrogen (ammonium sulfate), the Ohio station and the Department (B.P.I.) report, gained in several aboveground parts and dry weight of tops, but decreased in number of rhizomes and weight of the underground parts. Artificial shade, like associated growth of alfalfa, lowered numbers of brome shoots and rhizomes and dry weight of all plant parts, and shade also increased the number of elongated internodes and plant height. Nitrogen-treated and check plants at bloom were low in nitrogen and high in carbohydrates, while the reverse held for shaded plants. Phosphorus- and potassium-deficiency symptoms in carpet grass on a Bladen fine sandy soil were established by the Florida station. Treating carpet grass with superphosphate, lime, potash, and nitrogen doubled the phosphorus, calcium, and potassium contents of plants when compared to nitrogen applied alone.

Crested wheatgrass.—That good stands of crested wheatgrass were closely related to favorable moisture conditions at seeding, especially when planting in September and October, was reported by the Montana station. Sown in the native prairie, crested wheatgrass established itself better than any of 36 grass species tried, indicating greater agressiveness. A 5-year-old stand of crested wheatgrass treated with

200 pounds of ammoniated phosphate fertilizer per acre by the Oregon station produced 602 pounds of recleaned seed and the check only 314 pounds.

Napier grass.—Four strains of Napier grass, selected by the Florida station cooperating with the Department (B.P.I.) and found resistant to eyespot, adapted to sandy soils, and productive of abundant forage with a high percentage of leaf to stalk, were being increased for general distribution. Some of the large perennials, such as Napier grass, are ideally adapted to Hawaiian conditions and often yield 100 tons of green forage per acre. Management of such grasses in short rotation, supplemented with molasses and protein for beef fattening, was being tested with success by the Hawaii station. When high yield, quality, and persistence were considered, the station determined it to be desirable to cut Napier grass every 8 weeks. A 10-week cutting interval might be used to advantage during winter when growth is slower.

Ryegrasses.—Data on characteristics, adaptations, production practices, and uses of Italian, perennial, and common ryegrasses were published by the Department (B.P.I.) cooperating with the Oregon station.

Sudan grass.—Sorghums, including Sudan grass, and several other species under certain conditions produce hydrocyanic acid in quantities often lethal to grazing animals, a problem under study by several stations. Differences among strains of Sudan grass and the effect of available nitrogen in the soil were observed by the Colorado station. High nitrates during seedling development have tended to create a higher hydrocyanic acid level in the plant, a condition of importance from its bearing on tillage problems. While both high and low hydrocyanic acid strains at certain growth stages seem to increase in hydrocyanic acid content as the soil nitrates rise, the low strains remain lower in content than the high strains under nitrate fertilization.

Meadows and hay.—Improvement of the hay crop of the Upper Peninsula was the objective of Michigan station experiments which demonstrated that seeding rate was less important as a factor in bettering stands than variety, lime, inoculation, seedbed, and planting depth. Alfalfa was suggested for soils well supplied with lime or which have produced excellent stands of alfalfa and a mixture preferably including alfalfa on more acid soil. The results also indicated an 8-pound seeding rate, cutting earlier in growth, and plowing up meadows after a few years and keeping them in the regular rotation.

It is desirable in Ohio to cut or clip new seedings of alfalfa or red clover sometime in August, but the Ohio station has determined that first-year sweetclover should not be cut at that time unless it is needed for hay or because weeds are certain to kill it. Red clover ought not be cut after September 1 and young alfalfa not after September 10—a summer seeding should not be cut the first year. Sweetclover has been injured most by cutting in early September. Before then it should be cut high and early, but after that time injury lessens with delay and height of cutting is not important.

Curing tests in the Delta by the Department (B.P.I.) and the Mississippi station indicated that in April and May alfalfa should be raked into single windrows from 4 to 6 hours after cutting or into double windrows at least 6 hours after. During June, July, and August the hay may be raked into single windrows as soon as cut or 2

hours after or into double windrows from 2 to 4 hours later, depending upon yield and weather.

The merits of oats, millet, Sudan grass, corn, and sorgo as emergency forage crops, especially to offset drought-stricken stands of alfalfa and grasses, have been shown by the North Dakota station.

Lawn and sport-field grasses.—Demands for information on turf problems have been Nation-wide. Practical instructions on turf making and lawn management, renovation, and diseases and insect pests in Rhode Island, based extensively on its research, were published by the Rhode Island station. The use of buffalo grass for lawns was described in a Nebraska station circular and the establishment and care of velvet bentgrass for putting greens and fine turf in a New Jersey station publication, both based on station research.

The apparent uniformity of plants in a Kentucky bluegrass lawn contributes to its beauty and to the ease with which it can be kept smooth and attractive. Selection and separate culture of individual plants have demonstrated, however, that considerable variation exists, enough to encourage further improvement research. Bluegrass seedlings derived from single plant selections at the Wisconsin station have varied little from each other or from the parent plant, supporting the view that bluegrass ordinarily sets seeds without pollination.

A standard 10–6–4 fertilizer carrying a mixture of organic nitrogen—3 parts of activated sludge, 5 parts of ammonium sulfate, and 2 parts of sodium nitrate—was most suitable for bentgrass fertilization at the Rhode Island station and very satisfactory on a comparative cost basis. The different fertilizers have had little effect on resistance to the brown patch and dollar spot diseases.

Seed and germination.—The maximum pure-seed crop of Piper velvet bent at the Rhode Island station, as with Rhode Island Colonial bent, was produced with a complete (6–6–1) fertilizer at the rate of 1,000 pounds per acre. Although production on the acre basis is similar, returns from sale of Piper velvet bent are much greater per pound, making it more valuable as a crop for the region. Another outcome of the station's grass work and a benefit to agriculture was the development of a law and a system of grass-seed certification initiated in 1939.

Planting Sudan grass in 7-inch drill rows at from 20 to 25 pounds of seed per acre produced the largest seed crop for the Michigan station, gave less trouble with weeds, required no cultivation, and resulted in plants fine enough to be harvested with a binder and threshed with the grain separator. Stacking is best delayed until stems have dried thoroughly to avoid heating and injury to seed viability.

A number of important native grasses, useful in soil conservation and for range cover, have seed characters, such as long awns, various types of pubescence, and appendages, that make them hard to clean and difficult to plant with standard drills. The Department (S.C.S.) cooperating with the Washington station successfully processed bluebunch wheatgrass, blue, Canada, and Siberian wild-ryes, tall oatgrass, bulbous barley, squirreltail, alfileria, and virgins-bower, species adapted to the Pacific Northwest, by milling the threshed seed in a hammer mill and cleaning it with a seed cleaner.

Buffalo grass seed was harvested by the Texas station, cooperating with the Department (S.C.S.), in late June at the rate of about 1 pound per man-hour cleaned unhulled weight by the use of a modi-

fied lawn mower. The station determined that buffalo grass seed swept from accumulations around red ant hills and run through a commercial cleaner (netting about 200 pounds in 2 days) germinates about as well as seed gathered in the usual way. Crested wheatgrass seed harvested in the early-dough stage may have high viability, as shown in Washington station tests, but vigorous plants can hardly be expected from seed gathered before the hard-dough stage, which in turn may be slightly inferior to more mature seed.

Seed germination of grass species used in pasture improvement is of great importance to ranchers in Hawaii. The Hawaii station increased germination of *Paspalum prolutum* from 0.2 to 39 percent by soaking seed in water for 3 days, of *P. notatum* from 0.2 to 73 percent by scarification with concentrated sulfuric acid for 30 to 35 minutes, of *Pennisetum ciliare* from 60 to 80 percent by similar scarification for 10 minutes, and of *P. setosum* from 52 to 92 percent after 24 hours in a 1-percent solution of ammonium sulfocyanide.

PASTURES AND RANGES

Progress in pasture improvement may be illustrated by recent results from fertilization of pastures and its effects on composition of herbage, cultivation and renovation practices, and grazing management.

Fertilizer.—Response of pasture sods to fertilizers and lime, as seen by the New Hampshire station, seemed to be governed by moisture relationships of the soil. The lighter, drier soils responded mainly to nitrogen, and the heavier, moister soils to all the nutrients and lime because wild white clover is a component of sod on such soils under proper treatment. In the Connecticut Valley results in both pasture and hay production tests suggest that potash more than any other material is beneficial to clover. Nitrogen consistently has produced more forage on both light and heavy soils, the main response to spring application coming soon after treatment and in early summer. Soil moisture, the Massachusetts station likewise determined, is the major factor influencing prevalence of natural white clover in permanent pasture sods. The supply of available mineral plant food and competition from associated grasses are also important, yet secondary.

On permanent pasture at the New Jersey station, lime plus complete fertilizer (5–10–8) produced an annual yield of 2,280 pounds of dried herbage per acre, while omission of nitrogen from the treatment resulted in 1,920 pounds, with respective protein percentages of 18.7 and 18.8. Dried herbage costs were $16.15 and $12.60 per ton, and the cost of feed produced was less than half that of commercial rations. Lime and complete fertilizer produced more early growth but less midseason and fall growth than did lime and minerals, which stimulated clover.

Trials on native pastures distributed over the State on the more important soil types demonstrated to the Michigan station that 500 pounds per acre of a fertilizer relatively high in nitrogen (e. g., 10–6–4) brought about increases of about 100 percent in yield, obtained largely during May, June, and July. The enhanced yield was accompanied by substantial increases in nitrogen content of the herbage. On pastures treated with fertilizers containing treble super-

phosphate or ammonium sulfate, or with manure, the Utah station obtained a worth-while increase in herbage production. Forage from phosphated pasture contained more phosphorus and nitrogen and included more clover than that from other treatments.

Composition.—Growing grasses on Everglades organic soils, the Florida station determined that phosphate enough to make good yields also assures a phosphorus content exceeding that found in the grass of Florida ranges where healthy cattle are raised, i. e., 0.31 percent and above. Carpet and Dallis grasses responded markedly to the phosphate and potash, as contained in 500 pounds of 0–6–12 mixture. Sharp decline in hay yields from Dallis grass after omission of fertilizer was indicative of rapid depletion of reserves of available plant food in these soils.

The greatest improvements in major nutritional characteristics of northeastern pasture species grown by the Connecticut (Storrs) station were caused by superphosphate (as 500 pounds of 16-percent) and included a 25-percent increase in protein, a 50-percent increase in phosphorus, and a 5-percent decrease in fiber. In these respects, further advances were attributed to adding limestone and/or nitrogenous fertilizers with superphosphate. Bromegrass at the Illinois station yielded more dry forage and total digestible nutrients per acre than reed canary grass, orchard grass, and Kentucky bluegrass, although the latter usually contained the most digestible nutrients per pound.

Improvement.—Excellent stands of clover were established by the Texas station on bottom-land pastures in east Texas consisting of carpet, Dallis, and Bermuda grasses. Of the predominating clovers, White Dutch grows best on bottom lands, while hop clover prefers higher, better-drained, and less fertile lands. These clovers are largely responsible for remarkable improvement in the pastures, which carry an average of a cow and a calf on 1.5 acres from early March to late November. Their establishment has made it possible to furnish good grazing from 30 to 60 days earlier than native grass pastures. They also improved the quality and increased the amount of pasturage furnished by the three grasses, which extend the grazing after clovers cease growth in early summer.

The wide adaptation of annual lespedeza and Dallis grass has permitted their growth in many sections of Mississippi, and *Lespedeza sericea* has been especially valuable on soils too sandy or droughty for annual lespedeza. The best returns on pastures, according to the Mississippi station, were had from phosphate or phosphate and lime treatments made at the low cost of $2 to $4 per acre. Yields of desirable pasturage often were increased from 50 to 100 percent, and usually the total protein content of forage was doubled by fertilizer. Mowing has doubled the grazing and greatly increased the protein content of herbage.

Grazing management.—A deferred bluestem pasture of the Kansas station during 12 years provided 54.8 days of grazing per acre annually and produced an average of 65.1 pounds of beef per acre. Two pastures grazed season-long averaged 32.2 and 45.2 days of grazing, respectively, making only 37.4 and 42.5 pounds of beef.

Rotation grazing of bluegrass gave striking returns near Kansas City, Mo., where the Missouri station cooperates with the Department (B.P.I.). Rotated pasture gave slightly smaller live-weight

gains of beef cattle per acre from 1931 to 1933 than did continuous grazing where the grass at first was naturally in better condition and more productive. For the next 3 years the two systems were practically equal, but in 1937–39 rotation grazing was much superior. Cattle gains per acre in 1939 for the bluegrass season were rotation grazing 174.5 pounds and continuous grazing 131.5 pounds. The grass under rotation grazing was improved in vigor, uniformity, and purity.

Rotation pasture of alfalfa-brome mixture, shown by the Indiana station to be important in a dairy-pasture program, made exceptional yields of good-quality forage and is being widely used in dairy farm operations in Indiana.

Renovation.—Establishment of dry-weather legumes in permanent bluegrass pastures without plowing or destroying the grasses, termed renovation by the Wisconsin station, has been effective in controlling weeds and white grubs (*Phyllophaga* sp.) for the first 2 or 3 years after renovation. Further duration of such benefits has depended on managerial treatment, being aided by moderate grazing. Pasture renovation, including liming, disking, and reseeding, has increased yields in both the first and second year at the Minnesota station. Grazing off the small-grain companion crop gave better results than allowing it to mature. Careful and controlled grazing of mixed stands of pasture grasses and legumes have been essential to high yields.

When native grass pastures with a cover consisting primarily of buffalo grass were solid-listed 3 inches deep on contours by the Texas station and the Department (S.C.S.), grass yields increased nearly fourfold and there was a large reinforcement in buffalo grass cover. Gains in available soil moisture and depth of penetration were reflected in higher grass yields, greater basal cover, and a tendency of listed areas to remain green longer during drought. Studying the influence of grazing upon conditions in farm woodlands in central New York, the New York (Cornell) station ascertained that contents of soil organic matter and soil moisture, moisture equivalent, and relative humidity were higher on ungrazed soils, and volume weight, air and soil temperatures, and amount of light penetrating forest canopy were higher on grazed soils; but no significant differences were noted in the pH of the surface soil.

Range.—Improvement and management of range, changes in range vegetation, and restoration of depleted range and abandoned cropland continued to be problems of vital importance in the Western States, challenging the specialists of their experiment stations.

Succession of vegetation after abandonment of farm lands in western Nebraska was found by the Nebraska station to be broadly limited by climatic and soil conditions and influenced in the first 3 years by the previous cropping system. Annual forbs, first to occupy the land, are followed by annual grasses, which predominate in the third year, after which perennial grasses, led by western wheatgrass, increase rapidly. At 10 to 15 years the cover is composed largely of perennial grasses, with the buffalo and blue grama grasses constituting 14 percent of the total. After 5 years the yield of hay on abandoned lands often exceeds 0.75 ton per acre in moderately wet seasons. Natural revegetation of abandoned land has been a slow

process, according to the Wyoming station, even after 6 years showing only one-third the carrying capacity of nearby virgin range. Ways to restore Great Plains range pastures, abandoned croplands, and depleted mountain ranges have been described by the Colorado station, which gave particular attention to seedbed preparation and seeding practices, and recommended species with desirable characteristics, adaptations, and cultural needs.

Surveying the vegetative composition and grazing capacity of typical sandhill range land, the Nebraska station determined that decided changes had occurred during the past two or three decades. Little bluestem and needle-and-thread, previously important grasses on dune sand, and turkeyfoot, an earlier dominant, have decreased in abundance. Hairy grama and sand dropseed, of minor importance in earlier years, increased considerably and rank second and third, respectively, in density after *Calamovilfa longifolia.*

Changes in species composition and in density on open and protected range areas were recorded during 9 years by the Arizona station. Increases in amounts of perennial grasses for 2 years after 1931, a year of high rainfall, were noted on all areas. Since 1934 the grass cover under all grazing conditions has decreased, due chiefly to low rainfall. Of the most important perennials, cotton grass tended to decrease, while poverty grass, a poor forage, increased. Rothrock grama increased more when open to grazing, and black grama developed best under complete protection. Fertilization resulted in greater forage production and higher seed germination, and together with protection increased plant density greatly.

Bunch wheatgrass not grazed during the spring, in studies by the Utah station, was greatly superior in density, seed production, and weight of root systems to that of the same grass on a range heavily grazed throughout the growing season. Root systems of the earlier-grazed plants contained only 93 pounds of sugar and starch per ton of root material as compared with 141 pounds from the later-grazed, the available sugar and starch of which was over nine times as much as for early-grazed. Density of native vegetation has varied as much as 100 percent between drought and wet years, the Wyoming station noted, adding that reports on range conditions from observations in 1- or 2-year periods may not be reliable. Removal of sagebrush has not increased the amount of palatable forage per acre.

Grazing, even when conservative or on a deferred-rotation basis, affects the better range forage plants in drought years, according to the Colorado station. Improvement of depleted ranges, it observed, may be accomplished only with return of better precipitation years and by continuation of better management practices.

Sheep and cattle consistently grazed certain strains within a grass species at the Montana station and repeatedly refused other apparently similar selections. Some crested wheatgrass selections hardly recovered after the first grazing, while others produced forage satisfactorily during the entire grazing season. This station, cooperating with the Department (B.P.I.), has published descriptions including distribution and relative values for important grasses and other common plants on Montana ranges.

Rothrock grama and three lovegrasses (*Eragrostis* spp.) under test by the New Mexico station, with the development of suitable cultural methods, promise to be valuable on thousands of acres of denuded range lands in arid sections of the Southwest. Annual bromegrasses which cover many thousands of square miles of range in the northern intermountain region, the Nevada station finds, can compete with native grasses under many conditions of grazing, soil, climate, and topography. Bromegrasses bind the soil and retard erosion, furnish ample grazing in years of normal spring rainfall, and are valuable in carrying sheep through the winter.

WEED CONTROL

Effective control measures and programs were major objectives in the continued campaign of experiment stations and cooperating institutions against weeds, the serious farm problem manifested in lower crop yields, lower grade and often unmarketable farm products, and reduced land values. Progress in phases of weed-control research is evident in the following comments on current findings in physiological and chemical studies, cultivation, grazing and other practical measures, and in tests of herbicides.

Bindweed.—In a study of organic reserves in bindweed, the Colorado station determined that cultivating every 2 weeks held total sugar and starch contents in roots to about 1 percent each, and also checked accumulation of colloidal nitrogen. Cultivation was better than sodium chlorate in reducing reserves, and the merits of early cultivation were evident. Fall applications of sodium chlorate were more effective than early ones in reducing reserves and controlling the weed.

An eradication method suggested by Iowa station research includes three applications per season of sodium chlorate, 1 pound per gallon of water plus 4 grams of powdered animal glue and 3 cubic centimeters of concentrated sulfuric acid, sprayed in June and August-October, preferably when the humidity is high enough for dew at night and especially on a heavy development of leaf surface. Plants emerging in the next year should be sprayed twice or exterminated. Sodium chlorate gave the best results on bindweed growing in small grain or in a smother crop. Winter rye followed by alfalfa sown in August suppressed bindweed effectively, and soybeans, millet, cane, and Sudan grass were valuable as smother crops.

Chess or cheat.—For control of chess, a winter annual grass, the Michigan station advised chiefly preventive measures which involve planting chess-free seed of winter grains, eradication of chess plants by the use of hay or spring-sown crops, and using chess-infested manure just before a spring-sown crop only.

Johnson grass.—In controlling Johnson grass along ditches and fences, the New Mexico station demonstrated that burning with a kerosene burner was as effective as frequent hoeings and more economical.

Nutgrass.—Control experiments by the Alabama station on nine soils indicated that infestation of nutgrass may be reduced greatly by plowing at 3-week or shorter intervals during one growing season, and nearly or completely eradicated by such plowing during two growing seasons.

Perennial peppergrass.—Spraying unmowed plats of perennial peppergrass seemed to give the best control with either sodium chlorate or Atlacide at the North Dakota station. Applications of 8 to 10 pounds were usually needed for satisfactory control. Dry sodium chlorate gave excellent control with 10 pounds and fair control with 8 pounds per square rod. This weed appeared very resistant to chlorates.

Pricklypear.—Rapid spread of pricklypear cactus in western Kansas during the past 7 years of drought has caused much concern. The real cause of the spread was not known until the Kansas station, cooperating with the Department (B.P.I.), discovered that jackrabbits feed heavily upon ripened fruits of the cactus and that germination of the seeds is increased and speeded up by passage through rabbits.

Russian knapweed.—Excellent control of Russian knapweed was obtained by the North Dakota station with sodium chlorate and Atlacide applied either in solution or dry at rates varying from 2 to 6 pounds per application per square rod, usually in one spring and one fall treatment. The extent of the root system suggested that this plant could store large quantities of reserves.

Whitetop.—That whitetop on grassland can be controlled by cultivation followed by heavy seeding to adapted cultivated grasses was shown by the Nevada station in cooperation with the Department (B.P.I.). Heavy grazing with sheep to weaken the stand is followed by planting the area to bluegrass and white clover for pasture. Subsequent grazing by sheep, together with the choking effect of the grass sod, eliminates the weed. Since cow droppings containing the seed may spread the weeds far and wide, quarantine for 10 days or longer before moving cattle to clean fields is advised.

In Utah station weed-control research, carbon bisulfide proved of merit for whitetop, whereas chlorates seemed more economical in the eradication of morning-glory, Canada thistle, and perennial sowthistle. Burning may be used along ditch banks to clean out weed growth, but its effects are only temporary. Clean cultivation for 2 years is a most economical control method on areas where infestation makes it difficult to establish crops.

The weed-seed problem.—Soil samples taken from farms in the Upper Peninsula by the Michigan station contained viable weed seed averaging for pastures 126 per square foot, grain fields 116, and cultivated fields 39 on clean farms, and 296, 183, and 155 seeds, respectively, on weedy farms, differences attributable to cropping practice. This observation and the weed-seed contents of seed stocks revealed a serious weed problem in the region, perpetuated by planting weedy grain and hay-crop seeds. The New York State station, examining samples of home-grown seed obtained on 1,000 farms during the clover-planting season, found a substantial percentage objectionable because of weed seed.

Pasture shrubs.—Methods of improving permanent pastures or maintaining them at a high level—removal of brush and weeds, application of lime and superphosphate, and continuous heavy grazing to prevent regrowth of brush—must, reports the New Hampshire station, take place concurrently for best results. Burning, pulling, or cutting have been equally effective for clearing off hardhack or juniper, although burning also destroys juniper seed. Burning birch seemed effective—the new shoots are browsed off by continued pastur-

ing—providing almost complete control. Cutting birch has induced excessive sprouting, requiring heavy grazing to control regrowth. Sweet fern has been most difficult to control. On farms with a heavy stand of this weed mixed with hardhack and meadowsweet, pulling required 57.7 hours per acre, cutting 56.6 hours, and burning 42.5 hours. Under these circumstances, with better control of brush and no standing brush left, pulling offered the best opportunity for control.

Herbicides.—Sodium chlorate in solution sprayed on bindweed at the Iowa station gave more consistent results than when applied on the soil as a dry salt. It was more effective when placed in the soil. Potassium chlorate was about as effective as sodium chlorate. Sulfuric acid, C. K. (creosote-kerosene) 10–90 spray, and sodium chloride had definite limitations. Ammonium thiocyanate in quantities of 8 to 12 pounds per square rod applied in 1 year was promising for small areas. When used by the Minnesota station on soil in quantities comparable to field practice in weed control, ammonium thiocyanate increased the number of bacteria and even in excess did not harm soil algae or protozoa.

Sinox, a new selective spray having as its active agent the dye sodium dinitrocresylate, according to the California station cooperating with the Department (B.P.I.) has been highly effective against weeds on which the spray can spread and penetrate, and it will not injure a number of crops that do not retain it on their surfaces. It was effective for weed control in cereals, silage, corn, flax, alfalfa, field and garden peas, garlic, onions, fenugreek, and seed carrots. The spray could be made more penetrating by addition of sodium bisulfate. Relatively nontoxic to man and animals, it does not corrode or otherwise injure sprayer parts. As a result of recommendations, more than 25,000 acres of weed-infested grain and flax were sprayed with Sinox during 1940.

Kerosene, clear-colored or water-white, applied at the rate of 1.5 gallons per square rod of area in late September has been found fairly effective by the Montana station for control of dandelions in lawns. Kills of 80 to 95 percent were possible with this method. Similar results have been reported by the Iowa station (see 1938 report, page 43).

Uses of weed plants.—Even troublesome weed pests may have potential economic values. The Montana station found Russian-thistles to equal alfalfa in protein and fat content and to surpass it in carbohydrate:crude fiber ratio. Thistles were high in minerals, particularly potash, and the high content of phosphorus might enhance their feeding value in areas known to produce phosphorus-deficient forages. Good silage could be prepared with the addition of either 3 percent of sugar or 1 percent of phosphoric acid, but poor silage would probably result from untreated thistles. Artificial manure made by composting water hyacinths at the Florida station resembled and could be substituted for barnyard manure, suggesting a practical use for the vast quantities of this weed available in Florida. A protein-digesting enzyme, termed solanain, has been found in horse nettle by the University of California. This enzyme resembles pepsin in its action but is even more like the digestive compound found in the subtropical fruit papaya and known as papain.

HORTICULTURE AND FORESTRY

CONTENTS

Spectacular discoveries in the field of research are of necessity rare. Occasionally, however, something of immediate interest to an industry is revealed. In 1940, the Department (B.P.I.), working jointly with the New York (Cornell) station, confirmed on an orchard scale the rather amazing possibilities suggested by earlier work of the Department in reducing preharvest fruit dropping in the apple by the application of dilute solutions of certain growth-promoting substances, such as naphthaleneacetic acid. These materials apparently retarded the normal abscission processes in the fruit spurs and permitted the apples to remain attached to the tree until well colored. The findings had wide significance and were immediately taken up by commercial manufacturers, who are already offering materials to the growers under various trade names. The new spraying technique is of major importance with certain apples, such as McIntosh, which are peculiarly susceptible to preharvest dropping.

FRUITS AND NUTS

Varietal improvement.—The California station, in cooperation with the Department (B.P.I.), continued its promising work in the breeding of peach varieties that would flower and fruit under the mild temperature conditions of southern California. Five new varieties, Rosy, Hermosa, Golden State, and Sun Glow (freestones) and Ramona (clingstone), were named and disseminated for use in that region. The South Dakota station released three pears—Okolo, Sungari, and Ilya; four crabapples—Keo, South Dakota Eda, Nebo, and Sonla; and two bush cherries—Checkpa and Kasota. A high-quality apple, Prairie Spy, and a hardy, blight-resistant pear, Bantam, were named and made available for distribution by the Minnesota station.

As reported by the New Jersey station, the Sunrise red raspberry, originated from a cross between Latham and Ranere made by the Department (B.P.I.) at Glenn Dale, Md., in 1920, has proved of commercial value in southern New Jersey. The Tennessee Supreme strawberry, originated by the Tennessee station from a cross of Missionary with Howard 17, was reported to be disease-resistant, productive, and well adapted for freezing preservation. An outstanding characteristic of the new variety is the high percentage of U. S. grade No. 1 fruit produced throughout the season.

Breeding and genetic studies.—Progress was reported by the Virginia station in apple-breeding studies, with two of the resulting

seedlings showing promise for the grower. With respect to cedar rust inheritance, the cross Jonathan × Rome Beauty produced seedlings of which all were susceptible to cedar rust, while the crosses Arkansas Black × Mother and Arkansas Black × Delicious produced seedlings about half of which were resistant. Winesap × Delicious produced about three resistant to one rust-susceptible seedling.

A count of 68 chromosomes was recorded by the Maryland station in root tips of "self-rooted" Hibernal apples obtained from the Iowa station and from layers of Hibernal. Unguarded seedlings of Nevis and certain other specimens of *Malus ioensis* had 34 chromosomes. Unguarded seedlings of Waziya and Wetanka had 34 and Wecota 51 chromosomes. Northwestern Greening, the pollen parent of Waziya, Wetanka, and Wecota, had 34 chromosomes in the root tips of layers.

Observations by the New York State station on the autumn fruiting of various red raspberries revealed, in a planting of seedlings of N. Y. 1950 × Lloyd George, three autumn bearers, one of which was sufficiently valuable to be named. In crosses between this variety, Indian Summer, and its sibs, other Lloyd George seedlings, and other non-autumn-bearing varieties, the autumn-fruiting characteristics were observed in many of the seedlings. Some were superior to Indian Summer, indicating that Lloyd George and its offspring are the best sources yet discovered for the breeding of desirable autumn-fruiting red raspberries.

Single fertilization (gametic fusion with either the egg or fusion nucleus) is suggested by the Illinois station as the most probable cause of button fruits in the peach. J. H. Hale and a few other varieties are apparently sensitive to adverse weather during the critical growth stages, centering around pollination and fertilization; and the retardation of growth processes, or the diminished pollen transfer during unfavorable weather, appears to be an important factor in button production. Apparently, the growth stimulus to the fruit as a whole derived from fertilization occurs soon after gametic fusion and continues with or without the seed. The stimulus appears to be fractionated in single fertilization such as takes place in button formation. Restricted planting of varieties showing frequent button formation is advised as a practical measure.

Ontario, a cross of Winchell × Diamond grape, was reported by the New York State station as an excellent parent for producing high-quality progeny. Particularly favorable results were secured from crosses of Ontario × Mills and Keuka (one-half Mills). Among promising new grapes with Ontario parentage obtained by the station are Seneca, Watkins, Wayne, Yates, Eden, and Buffalo.

Cultural methods.—The use of salt-marsh hay as a mulch for Latham red raspberries growing on Sassafras sandy loam underlaid with a gravelly subsoil was found by the New Jersey station to be beneficial with respect to growth and yield, particularly where the basic fertilizer treatment was supplemented each spring with an additional 1,000 pounds per acre of 5–10–5 material plus 200 pounds of sodium nitrate each autumn. Both the number and the size of canes were notably larger in the mulched plants, and soil temperatures during midafternoon in July were lower. Studies of root distribution showed more roots in the surface 2 inches under mulch than under cultivation. In the case of the Ranere variety there were

more roots per cane in the cultivated area than under mulch, but in Latham there were somewhat more roots under the mulch.

Observations by the Arkansas station on the behavior of mulched and nonmulched plants of 19 strawberry varieties showed significantly more severe winter killing of plants and crowns and greater flower killing by late frosts and freezes in the nonmulched plants. Varieties which showed the greatest benefit in 1939 from mulching, from the standpoint of crown survival, were Fairfax, McClintock, Grand Champion, Howard 17, and Catskill. The greatest yield gains from mulching were recorded in the three early-blooming varieties Fairfax, Howard 17, and Dorsett. It was apparent that mulch did not protect all varieties in the same manner or to the same degree.

Of various materials tested by the Illinois station for covering Dunlap plants, corn stover soon became water-soaked and ineffective. Wheat straw gave good protection when in sufficient depth. Soybean refuse was also reasonably effective but encouraged mice in search of the scattered beans. Early covering (October 24) caused smothering injury, November 9 treatments giving much better results. Howard 17 was most resistant to crown injury, followed in order by Dorsett, Aroma, Redheart, Catskill, and Fairfax. Of the three materials used, wheat straw was the most efficient in reducing winter injury to the crowns.

As indicated in studies by the Maryland station, spacing was highly effective in increasing dry-weight production of strawberry plants, but not to the extent of spacing plus fertilizer. Similar results were secured by the New Jersey station with Fairfax strawberry plants set from 18 to 20 inches apart in 4-foot rows and spaced during the summer so that the runners stood from 7 to 9 inches apart. The spaced plants produced more fruit the succeeding spring than did nonspaced plants, despite the fact that the number of plants was less. Furthermore, the average size of berries was consistently larger in the spaced plants. The proper spacing distance was found to vary with varieties, depending on the length of the runners. Records taken by the North Carolina station, working cooperatively with the Department (B.P.I.) on spaced plants growing in single-, double-, and triple-row beds showed an increase in the number of flowers per plant for each increase in size of plant, as measured by the number of leaves present on the preceding November 15. Apparently, plants averaging seven or eight leaves were the most efficient flower producers under the conditions of the study. The effect of age of plant appeared to be chiefly a matter of plant size, as measured by the number of leaves.

As reported by the Indiana station on the basis of an orchard soil-management study that had been in operation for 25 years, none of the cover crops used had maintained the amount of soil nitrogen present at the initiation of the experiment. Millet, early-sown rye, and vetch were the most effective species, but permitted a loss of approximately 20 percent of the original nitrogen. Where nitrogen fertilizers had been used in addition to mulch, the nitrogen content of the soil had been built up to a point much higher than originally present.

The capacity for young apple trees to recover from drastic cutting back was shown by the Missouri station in an experiment with sev-

eral varieties. Almost invariably the cut-back trees produced lower and better-placed branches with wider angles than did the control trees, and within from 4 to 5 years the trees cut back when young were practically as large as and in some cases larger than the controls.

As part of an experiment conducted by the California station on the irrigation of the French prune, ratios between the weight of the harvested fruit and the weight following drying were determined. On the average, only relatively small differences in drying ratios were found among the various irrigation treatments in any one year, and in several cases the drying ratios of the fruits from unirrigated plats were equal to or greater than those from irrigated plats. Apparently, a close relationship existed between yields and drying ratios, suggesting that in years of small crops the trees may have sufficient leaf area to produce fruits with a low drying ratio, while in years of heavy production this was not the case. This hypothesis was confirmed by severe thinning of certain trees, the fruits of which had lower drying ratios than those of the controls.

Observations on soil samples obtained before and after irrigation in a 9-year-old navel orange orchard located on Ramona sandy loam soil led the California station to report that the average pH value of the rather dry soil before irrigation is lower and therefore more acid than that of samples taken after irrigation. The results suggest the need of considering soil-moisture content in studies involving the pH values of soil.

Nutritional investigations.—That apple seedlings are tolerant to H-ion concentrations over a wide range was indicated in New York (Cornell) station experiments in which seedlings of McIntosh and Delicious, grown in sand supplied with nutrient solutions, the pH values of which varied widely, showed essentially the same growth throughout the series. Determinations of the total nitrogen content of the seedlings showed little effect of the reaction differences on this constituent. Apparently, the amounts of phosphate buffer added to maintain the different pH levels were not sufficient to interfere with normal growth.

Studies by the New York State station on the deep placement of manures or fertilizer in a McIntosh apple orchard indicated this practice to be of little value. A differential response of apple varieties to fertilizer treatment was observed. There was some indication that excessive nitrogen applications in McIntosh orchards may result in a serious reduction in color of the fruit and an increase in dropping during the preharvest period.

No material benefits in yield were obtained by the Washington station from the application of various forms of nitrogen fertilizer in a mature Rome Beauty orchard on Cashmere sandy loam. The orchard had a good alfalfa cover crop in the beginning which was gradually killed by heavy disking and was replaced by grass and weeds. The form of nitrogen appeared to be of little significance, leading to the practical suggestion that the most economical material at hand be used. The depressing effects of nitrogen on red color development were not as evident in Rome Beauty as in Jonathan.

Working in the Hudson River Valley, the New York (Cornell) station obtained rather conclusive evidence that heavy applications of nitrogenous fertilizer increased the tendency to preharvest dropping in the McIntosh apple. The tendency for nitrogen to increase drop-

ping was greater during years of excessive rainfall than in comparatively dry seasons.

Stating that the premature dropping of McIntosh is a serious problem for Massachusetts growers, reaching at times 50 percent or more of the crop, the Massachusetts station reported that dropping was more extensive under cultural conditions that made for abundant soil nitrates, particularly late in the season. Heavy mulching, organic or mineral nitrogen applications, late cultivation, and injections of nitrogen into the tree all tended to increase the percentage of drop in the preharvest period. In many cases, dropping was found to increase with larger crops per tree.

Rubel blueberry plants, set in pails of soil collected by the Michigan station from a portion of a field where there was a complete loss of plants within 5 years after planting, responded markedly to applications of ground limestone sufficient to raise the pH from 3.2 to 3.9. Control plants which received the same applications of nitrogen, phosphorus, and potassium made little or no growth and by the latter part of August were practically defoliated.

As reported by the Arkansas station, nitrogen fertilizers increased the growth and yield of Concord and Campbell Early grapes growing on light soils, with even greater increments from the use of complete fertilizers. On Clarksville silt loam, neither fertilizers nor manures gave profitable increments in the yield of Concord. Fertilizer did not influence the quality of the fruit. The use of vigorous rootstocks, such as Cynthiana, tended to increase the production of Campbell Early, Concord, and Moore Early.

At the Mississippi station it was observed that muscadine grapevines receiving potash in their fertilizer treatment showed marked improvement in growth, while those receiving only nitrogen continued to decrease in vigor. Of 50 vines on the nitrate plats, 90 percent were affected with scorch and yellowing. Of 96 vines on the plats receiving potash, only 27.3 percent were affected.

In pecan studies by the Florida station variety was found to be an important factor in fertilizer and cover-crop responses, the high-producing kinds showing the greater responses. In general, the best results were secured where fertilizer and cover-crop treatments were combined.

Propagation.—Of certain English apple rootstocks tested by the West Virginia station and the Department (B.P.I.) at Kearneysville, Malling IX produced dwarfed trees when budded with York Imperial, Gallia Beauty, Staymared, and Starking. Apparently, Malling IX has no commercial possibilities in the Cumberland-Shenandoah Valley, although it may be found useful for certain special purposes. Malling II is worthy of further trial on deep, fertile soils as a stock inducing some degree of dwarfing with the prospect of yielding a profitable quantity of fruit.

In other studies at Kearneysville, rootstocks had in many instances considerable influence on the behavior of varieties propagated thereon. A study of variability in the top weights of York Imperial and Gallia Beauty trees on seedlings and on clonal stocks showed no material difference except that Gallia Beauty on seedlings was significantly more variable than when on the stock T–200. However, when trunk circumferences were compared, trees on seedling roots were considerably more variable. The station concludes that certain

environmental factors, such as soil type, may be more potent in determining uniformity than are clonal rootstocks.

That rootstocks have rather definite requirements or rather preferences with regard to soil moisture was shown by the New York State station in studies with uniform, well-rooted 1-year-old trees planted individually in glazed crocks of 10-liter capacity and supplied with water to simulate (1) dry-midsummer, (2) favorable-moisture, and (3) excessive-moisture conditions. In general, growth was greater under high- than under low-moisture conditions, with a variation in the response of different clones.

Stimulated by an interest in the Northeast in apple trees smaller than the so-called standards, the New York State station measured the comparative development at the end of the seventh growing season in orchards at Geneva and Ithaca of five varieties—Baldwin, Delicious, Early McIntosh, McIntosh, and Northern Spy—on various clonal rootstocks and on French crab seedlings. Apparently, several factors, environmental as well as inherent, were concerned, but there was evident a general tendency with all varieties for a certain rootstock to produce consistently small trees, while USDA 227 produced consistently large trees. Malling I and XIII tended to produce intermediate trees.

The need of careful consideration of the compatibility of stock and scion combinations before making general conclusions was indicated as the result of extensive and long-continued studies by the Iowa station. Apple varieties, in practically all cases, made more growth and yielded more fruit on Virginia Crab than on Hibernal. Records taken on Jonathan trees on various stocks, including the conventional French crab seedlings, showed considerable variability in growth and production related to the stocks. That intermediate stocks may exert a profound influence on the tree was shown in the case of trees with Virginia Crab as an intermediate.

Utilizing an extensive collection of apple materials, the Maryland station found that only 1 of 287 kinds failed to form roots on the daughter plants when propagated by the trench-layer method. Variation in the number, size, texture, and point of initiation of the roots produced by the clones was such that it was possible to classify them into 6 root types. Roots were always found in one or more of 4 positions in relation to the bud, directly above the bud, directly below, or at each side a little below the bud.

Working with Siberian crab apple, highly desirable as a rootstock for the apple in South Dakota but little used because of low percentage germination and slow growth of the seedlings, the South Dakota station found that treatment with various fungicides before stratification failed to give significant benefits in germination or in stimulating the development of seedlings. Extensive experiments conducted by the Maine station with summer cuttings of *Vaccinium corymbosum* and using various growth-promoting substances led to the conclusion that the use of such materials for stimulating the rooting in the blueberry is not a worth-while practice.

As observed by the Colorado station, Montmorency cherry trees on mazzard rootstocks showed significantly greater mortality at the end of five seasons than those on mahaleb roots. Based on trunk measurements, the mahaleb-rooted trees had made significantly greater growth, and chlorosis was more evident in the mazzard-

rooted trees. Marked superiority of mahaleb over mazzard as a rootstock for sweet cherries also was reported by the Utah station. The mahaleb-rooted trees made approximately 45 percent more growth than those mazzard-rooted. Trees on Stockton morello roots grew better than those on mazzard but were surpassed by mahaleb-rooted trees.

The submission by the Indiana station of stem and root cuttings of different rootstock materials to uniform temperatures revealed marked differences in the capacity to withstand low temperature. Florida peach (probably Peento) grown from pits exhibited the most serious injury of any of the materials. Elberta seedlings also showed little resistance. Considerable variation was noted in materials grown from southern natural seedlings. Myrobalan plum was more resistant than any of the peach materials except that *Prunus davidiana* was slightly more hardy than Myrobalan in the top tissue. *P. americana* was the hardiest of all the stocks tested. On the whole, there was a close correlation in the behavior of the roots and tops of any given material.

As observed by the South Carolina station, the growth and yield of grapes grafted on certain rootstocks were outstanding when compared with those of vines produced on their own roots. Delaware, a notoriously weak grower although otherwise well adapted to the South, was trebled in yield and growth by understocks. In general, the quality of the fruit of many varieties on understocks was superior with regard to color, size, and compactness of bunches. Dog Ridge proved especially good as a stock and was relatively immune to attacks of root nematodes. Rupestris St. George was also very satisfactory.

Measurements taken by the California station on Eureka lemons and navel and Valencia oranges on their own roots and propagated on grapefruit and sweet orange, respectively, showed that the lemon trees grew more rapidly when on their own roots than when on grapefruit. In the navel orange the results were practically neutral, with slight superiority for own roots in one plat. A similar inconsistency was exhibited by the Valencia trees, indicating that environmental factors may be more potent than the inherent nature of the rootstock in determining response of certain stock-scion combinations.

Considerable progress was reported by the Puerto Rico University station on the use so-called plant-growth substances in the stimulation of rooting of coffee cuttings. With an effective medium, peat moss and shredded fern stems, and a bottom heat of 95° F., treated cuttings formed callus in less than 4 weeks. The successful development of a method of vegetative propagation would make possible the rapid increase of productive and desirable types of coffee.

Physiological studies.—In the case of 1-year-old budded McIntosh and Delicious apple trees growing in 2-gallon glazed porcelain crocks with tight covers to permit the control of gas exchange, the New York (Cornell) station noted at soil temperatures between 55° and 70° F. a marked decrease in the formation of new rootlets as the oxygen level of the soil was reduced below 16 percent, particularly when the percentage of carbon dioxide was increased in compensating amounts. When the oxygen level dropped below 10 percent and

the carbon dioxide increased to between 5 and 10 percent, so few rootlets were formed that top growth was markedly reduced. The deleterious effect of root pruning on root development was particularly evident in plants with low oxygen supply, suggesting that a higher oxygen level is necessary for the production of new rootlets than for the maintenance of life in existing roots. The results suggest the need of providing good aeration for newly planted trees.

Tests of a hormone spray, naphthaleneacetic acid, conducted by the New York (Cornell) station in cooperation with the Department (B.P.I.) in several commercial orchards in the fall of 1939 showed very striking effects in reducing preharvest drop of McIntosh apples. The effects of the spray depended somewhat upon the nutritional condition of the tree, especially with respect to its nitrogen status. Using α-naphthaleneacetic acid and α-naphthaleneacetamide sprays, the Missouri station secured, in both Delicious and Stayman Winesap, material reduction of the preharvest fruit dropping. In one orchard of Delicious a drop of 24 percent was recorded on the treated trees as compared with 84.4 percent in the controls. There was some indication that the acetamide was more effective than the naphthaleneacetic acid.

Samples of leaves collected throughout the very dry summer of 1939 from the New York (Cornell) station orchard showed the amount of potash to be rather constant until about September 1, when migration of the element from the leaves began. The percentage of potash in the dry matter decreased fairly uniformly throughout the entire summer. In analyses of samples of leaves collected in 36 McIntosh orchards, considerable variation was found in the percentage of potash in the foliage of apparently normal trees. Where samples of foliage were taken from McIntosh trees affected with some degree of marginal scorch and staining, the percentage of potash in the dry matter was very low.

Analyses by the Michigan station for free reducing substances, starch, and polysaccharides other than starch in samples of spurs taken at intervals from June to August from a barren and a normal Montmorency cherry tree showed that the normal spurs ran higher in free-reducing substances and starch and lower in polysaccharides other than starch. There was a relatively low rate for photosynthetic activity and for the production and accumulation of starch, both prior and subsequent to fruit-bud formation, in the barren tree. Photosynthesis determination made on samples of leaf tissue collected by the leaf-punch method led to the inference that barren mutants in the Montmorency cherry are, as compared with normal trees, photosynthetically deficient during the period of fruit-bud initiation, differentiation, and early development, but not so with respect to the later part of the season or the season as a whole. Apparently in the barren tree there is some basic peculiarity of the genetic composition that causes the nutrient supply to be utilized directly and completely for vegetative growth.

Observations on small apple trees growing in the greenhouse at the Kansas station indicated that of the three varieties used, York Imperial accumulated the least, Jonathan intermediate, and Wealthy the greatest amount of total dry matter per unit meter of leaf surface. No significant difference in chlorophyll content between varieties was found. There was a much closer relationship between the

internally exposed surface and photosynthetic activity than between chlorophyll content and photosynthetic activity, indicating that the extent of the internally exposed surface is more important than chlorophyll content as a factor partially governing photosynthetic activity.

Heavy fall applications of nitrogenous fertilizer may increase the susceptibility of apple trees to low-temperature injury, according to observations of the New Hampshire station on samples of wood taken October 28, 1938, from McIntosh trees that had received varying amounts of nitrogenous fertilizer the preceding autumn. There was an absence of severe frost rings in the control trees, and in individual trees there was a greater number of frost rings on the north side of the tree.

That certain disorders, such as cork, can be produced experimentally in apples was shown by the New York (Cornell) station. When excessive irrigation of Northern Spy trees was continued into the second year there was curling of the leaves, and by the middle of June the fruits showed the characteristic early symptoms of surface cork. Internal corky tissue was also observed. The leaves later showed pronounced scorch, with some abscission. Not all the fruits or all the leaves were affected, but at least half of the branches bore injured fruits.

That the time of fruit thinning of the apple is an important consideration in determining its effect on flower production the succeeding year was indicated in studies by the Ohio station with Stayman Winesap, Delicious, and Northern Spy trees which had been bearing alternately for at least 10 years. One-half of each tree was thinned 21 days and the other half 42 days after petal fall. In all cases, early thinning sharply reduced the crop of the year of thinning and greatly increased the crop of the succeeding year as compared with late thinning. In the third year the tree halves given the original early thinning produced a somewhat smaller crop in most instances.

The long life of certain fruit pollens when stored under favorable conditions was shown by the New York State station. Some germination of apple pollen was recorded after more than 4 years of storage under optimum conditions. One sample of Seckel pear pollen survived 4.5 years, indicating a similar life span for the pollen of the apple and pear. The pollen of Grand Duke plum reached the 4.5-year stage. Peach and apricot pollens were not so lasting, showing marked degeneration after 2 years. Montmorency cherry pollen was alive after 5.5 years.

A definite association between temperatures prevailing during the growing season and the ripening period and quality of the fruit of the Tokay grape was established by the California station. In years in which quality was rated acid or very acid, heat summations for the growing period fell below 2,100 day-degrees. Heat summations for the ripening period, however, were not consistently correlated with quality as were those for the longer period. The value of heat summations for supplementing the present Balling standards as indications of the proper stage for harvesting Tokay grapes is discussed.

In greenhouse tests of forty-odd varieties of peaches, the budwood of which was obtained from different localities, the Texas station observed that the locality where grown had a marked influence on the

response of any given variety to temperature conditions. For example, in Elberta budwood grown at Winter Haven and in the Wichita Valley, development was more rapid in the southern material. There was evidently a progressive development of fruit buds toward flowering condition, influenced by both "cool" and "warm" temperatures.

That the injury to strawberry plants attributed to ice smothering during the winter is more likely the result of low temperatures or excessive water at the time of growth resumption or of disease was concluded from investigations by the Minnesota station in which plants were coated with ice or enclosed in ice-covered cylinders or in sealed jars, the internal atmosphere of which was altered with respect to carbon dioxide and oxygen. Plants sealed in jars and exposed at 26.6° F. for 1 week to concentrations of carbon dioxide ranging from 2.7 to 7.3 percent showed some retardation of growth when placed in a warm greenhouse but soon assumed vigorous development. Since a coating of ice or of frozen water-saturated soil was found highly impermeable to gases, it is thought that plants in the field are exposed frequently under natural conditions to abnormal atmospheres without apparent serious injury.

That fertility conditions have an important bearing on the behavior of citrus trees during exposure to severe cold was reported by the Florida station. Plants receiving correct fertilizer treatment, including control of the soil reaction, and necessary lesser elements, such as zinc, magnesium, and manganese, came through the freeze of January 1940 with little damage; while adjoining trees with the usual commercial-fertilizer treatment suffered severe injury. Correction of soil deficiencies was also found to increase the acid and sugar content of the fruit and thereby improve its eating qualities.

The generally accepted assumption that citrus groves thrive under a rather wide range of pH values was disproved by the California station. In a series of carefully conducted laboratory and field studies it was shown that citrus and walnut trees, although tolerant of low and high hydrogen-ion concentrations, made their best growth in acid rather than alkaline solutions or soils.

Studies by the Hawaii station of the physiological development of macadamia fruits collected at five intervals from flowering to maturity from five selected seedling trees showed two well-defined periods. The first occurred from flowering to the end of 90 days, during which very little oil was formed and the embryo did not enlarge sufficiently for analysis. The second period covered the 90-day stage to maturity, embracing about 125 days, during which oil was formed and the major expansion of the embryo took place. The total-sugars content increased during the early oil formation but decreased as maturity was reached.

In comparing sweet- with flat-tasting papaya fruits, the Florida station observed almost negligible differences in acid, moisture, and ash contents. There was a definitely higher percentage of total sugars in the sweet fruits, due largely to the appreciably higher percentage content of hydrolyzable sugars. The ratio of free reducing to hydrolyzable sugars is considered an indication of sweetness.

Handling and storage.—Fruits picked August 17 from two McIntosh apple trees in the Delaware station orchards and placed on straw spread beneath the trees had increased markedly in color by August 25. The 8 days on the straw did not soften the apples to

the point of decreasing their marketability. However, McIntosh apples harvested September 18 from trees in the Rhode Island station orchards scalded badly when placed beneath one layer of cheesecloth. No scalding occurred in another lot of apples under five layers of cloth and markedly improved color was secured. Favorable results were also secured with Cortland, Baldwin, and Northern Spy. Oilcloth proved a better light-reflecting medium for placing beneath the coloring frames than did either gravel, paper, or grass.

That certain modifications in the storage atmosphere favor the keeping life of McIntosh apples was evident in studies at the New York (Cornell) station. A reduction in the rate of respiration to a desired minimum occurred in an atmosphere containing 5 percent of carbon dioxide and 2 percent of oxygen at 40° F. Firmness and crispness, as indicated by the pressure test, were greater in fruits with slow rates of respiration. No physiological injury occurred in the fruits stored in an atmosphere containing 5 percent of carbon dioxide and 2 percent of oxygen at 40°, and this environment produced the longest storage life and the longest period of marketability.

The use of special storage atmospheres was found by the California station to lengthen the storage life of Bartlett pears. A concentration of 10 percent of carbon dioxide was apparently the optimum, and it was particularly effective when the oxygen was reduced to 5 percent. Fruit held in nitrogen without carbon dioxide or with only 2.5 percent of carbon dioxide was delayed in maturity but often developed undesirable flavors.

Modification of the storage atmosphere so that there was less than 6 percent of carbon dioxide and between 5 and 10 percent of oxygen was found by the Florida station to be beneficial in the storage of citrus fruits. Storage in carbon dioxide or nitrogen alone was unsatisfactory. Pliofilm, a rubber hydrochloride product, proved to be the best wrapper yet tried for citrus and avocados, giving good results both at cool-storage and at room temperatures.

In using wax emulsions of different concentrations for covering fruit, the California station found the principal benefit to be the reduction of water loss. Benefits were greatest in fruits with thin cuticles, with the possible exception of the apricot. Waxing did not overcome, and in fact aggravated, decay in some instances. The inclusion of a fungicide, such as borax, proved of doubtful value. As observed by the New York (Cornell) station, the coating of Golden Delicious apples with wax emulsion materially checked the rate of shriveling. Heating the emulsion to 90° F. reduced weight loss slightly, apparently by providing a better covering. Certain wax emulsions had a slight retarding effect on the development of scald and bitter pit in Rhode Island Greening, while other waxes were of no benefit or actually increased the trouble. Wax emulsions enhanced appearance and, in certain varieties such as McIntosh, helped retain the aroma. Treatment of Grimes Golden and Golden Delicious apples with a water-miscible wax, following a week's period of ripening at 70° F. before cold storage, was shown by the Maryland station to be a practical way to prevent scald and shriveling of these varieties.

In investigations with six varieties of apple, the Minnesota station observed a general correspondence between the course of respiration activity and that of ethylene content in stored apples. Varieties with naturally longer storage life were characterized by lesser ca-

pacities to produce ethylene. The fundamental function of ethylene during the ripening process is believed to be concerned with the hydrolytic processes, although this function probably is not any simple effect on the hydrolytic enzymes.

By treating fruit with carbon dioxide at temperatures of from 55° to 60° F. and at a relative humidity of from 80 to 90 percent, the Minnesota station found it possible to extend significantly the time that red raspberries and strawberries could be held in good market condition. An initial concentration of 30 percent carbon dioxide was found to be most practicable, and no advantage was found in using a constantly maintained concentration of the gas. The same station, in studies with fruit frozen with sugar or sirup at a temperature of about −10° F., found the Beaver, Culver, Dorsett, Gem, and Wayzata strawberries and the Chief, Latham, and Viking red raspberries well adapted for freezing preservation.

Studies by the Hawaii station on the tolerance of the papaya and mango to methyl bromide fumigation showed that injury occurs in some cases. Methyl bromide appears to decrease the natural resistance of the fruit to fungus attack. It was found that papaya and mango fruits cannot be stored below 50° F. without manifesting a "chilling" effect which seriously affects their market quality.

VEGETABLES

Varietal improvement.—Confronted by a loss of resistance to downy mildew by the recently developed cantaloup No. 45 because of the appearance of a new type of the fungus, the California station and the Department (B.P.I.) succeeded in producing a new melon, No. 8, prossessing resistance to both types of mildew. Seed stocks were increased rapidly, with the confident expectation of again saving the highly important melon industry of southern California.

Promising results were reported by the Puerto Rico University station in the development of a new variety of cucumber resistant to downy mildew. The new variety is productive, and its fruits are of satisfactory size and appearance.

A small-seeded variety of lima bean developed by the Oklahoma station and well adapted for use in canning and frozen-food trade was distributed to commercial seedsmen and growers. The Minnesota station named and released for trial the Midget cucumber, the Greengold squash, the Mingold tomato, and the Duluth snap bean. By individual plant selection from an old-established variety, the New York State station developed a new squash, Geneva Delicata, characterized by uniformity of type, high baking quality, and resistance to mosaic.

Genetic investigations.—Working cooperatively, the Texas and Wisconsin stations observed that in Marion Market cabbage grown in Wisconsin and Texas from the same lot of seed, the heads of the Wisconsin-grown plants were somewhat flattened and those of Texas distinctly elongated. It was evident that plants selected in a given locality to the point of apparent stability may become unstable when transferred to an entirely different environment, and that new varieties should be developed in the region where they are to be grown.

Crossing cucumber varieties differing from each other in height, growth habits, spine characters, fruit color, etc., the Minnesota station

found certain characters to be closely associated or possibly the expression of the same genes. For example, large fruit size appeared to be associated with white spines, coarse spines, few spines, no netting, and cream-colored fruit. A high degree of association was found between the time of production of the first female flower and the maturity of the fruit.

The possibilities in utilizing F_1 hybrid seed in the commerial production of summer squash were demonstrated by the Connecticut (State) station. The hybrid between two horticultural varieties produced female flowers some 10 days earlier than either parent, and the fruits of the hybrid were more numerous and considerably larger.

Cutting asparagus until July 15 each year shortened materially the profitable life of Mary Washington plantings growing at the Iowa station. Cutting until June 15 gave the greatest yields over the 10-year period. Rows 3 feet apart were satisfactory when the distance between plants in the rows was greater than 1 foot. In the case of asparagus crowns set 2, 4, 6, and 8 inches deep, the Massachusetts station observed no significant differences in yield associated with depth, but there was a greater mortality in the deeply planted crowns. Records taken by the California station over a 12-year period on Palmetto and Mary Washington plants graded into three sizes at the time of setting in 1924 showed the superiority of large plants, although there was no significant difference between crown grades in the mean number of spears harvested per plant for Palmetto over the 12 years. In Mary Washington, the large- and medium-sized crown grades produced significantly more spears than did the small grade. Over the 12 years, Mary Washington outyielded Palmetto.

The New Jersey station found that applying fertilizer in liquid form to different vegetable crops is much more efficient than dry application, and suggested that considerable increases in yield may be possible with a number of crops without any increase in the total outlay for fertilizer. In studies with lettuce grown on raised beds under irrigation, the Arizona station found that, compared with broadcasting or drilling prior to making the raised beds, band placement of fertilizers gave highly significant increases in yield. The most efficient placement was a single band 1.5 inches toward the furrow side from the seed row and 3 inches deep. This procedure permitted lateral movement of the phosphates under the plant row as a result of repeated furrow irrigations and finally developed a wide band well placed for nutrient absorption by the roots.

The temperature at which lettuce seed is held from time of harvest to planting was found of major importance in studies by the Arizona station with new crop seed planted the autumn of the year harvested. The highest field germination was recorded in seeds stored at from 75° to 88° F. The first seeds harvested in the Salt River Valley in the spring were larger and gave higher field germination and greater seedling vigor than seeds from later harvests.

The practice of setting onion bulbs in the field in late fall gave better results, according to the Idaho station, than did storage through the winter. Straw mulches were beneficial but not essential. Large bulbs were better than small, producing more seedstalks and larger total yields of seed.

That fire roasting or oil scalding of pimiento fruits to remove the skins has a disastrous effect on the germination of the seed of pimiento

peppers was indicated in investigations by the Georgia station. The heat treatments reduced viability to approximately 14 percent. Furthermore, the seedlings from the heat-treated lots were often stunted or showed other abnormalities, such as adhering seed coats, baldheads, or single cotyledons.

Pruning of unstaked tomato plants to either 1 or 2 stems was indicated to be a profitable practice in results obtained over a 3-year period by the Texas station at Winter Haven. In terms of marketable fruit harvested per acre during the first 4 pickings, covering a period of about 2 weeks, the average yields for the 3 years for unpruned, one-stem, and two-stem plants were 580, 2,504, and 2,155 pounds, respectively. For the entire season of 11 pickings, the average yields were 12,860, 13,030, and 15,356 pounds, respectively.

The Missouri station observed that thinning watermelons failed to increase the total yield per acre as compared with no treatment. The largest and the greatest number of melons per acre exceeding 26 pounds were secured when the fruits were thinned to two per vine. The maximum total yield in pounds per acre was secured with no thinning.

Nutritional studies.—The exacting nutrient requirements of the lima bean were shown in studies by the New Jersey station. Application of hydrated lime to soil with less than 500 pounds per acre of replaceable calcium increased germination of Fordhook lima beans from 20 percent on the untreated to 80 percent on the limed area. An increase of the calcium in nutrient solutions stimulated normal development and setting of the later flowers. Of different sources of nitrogen used, tankage and calcium nitrate gave the best results on a soil of pH 6.0. Among varieties, Fordhook showed the most striking response to nitrogen fertilization, apparently having special need for an abundant supply and generally being given inadequate nitrogen under field conditions in New Jersey.

Boron may be beneficial on some soils used for the growing of canning beets, according to studies by the Michigan station. Certain abnormalities, such as black, corky areas within the root tissue, surface cankers on the roots, an intensified reddening of the leaves, twisted and nonsymmetrical leaves, cross-checked leaf petioles, and numerous small leaves, were corrected by the application of small amounts of boron. In a field study, borax did not increase total yields but did increase the percentage of marketable beets by reducing the number of roots showing internal break-down.

That calcium is of primary importance in the nutrition of the carrot was indicated in experiments conducted by the Missouri station with plants grown in a colloidal clay culture and at a uniform pH value and constant level of all nutrients except calcium. The plants without calcium lived for only 6 weeks and developed only a single tiny true leaf. Successively better growth was made as the calcium increased from 2 to 6 milligram-equivalents per plant. The leaves were particularly responsive to changes in the calcium supply.

Studies conducted by the New York (Cornell) station indicated that magnesium may become a potent factor in certain soils in the successful production of cauliflower. A distinct form of chlorosis, manifested in a mottling of the lower leaves, was eliminated in a cauliflower field where the preceding crop was a complete failure. In another trial, even where no chlorosis was evident significant in-

creases in the number and weight of salable heads were obtained from the use of dolomitic hydrated limes containing magnesium. The field results were confirmed in greenhouse experiments with soil brought from a magnesium-deficient region.

The large nutrient requirements of celery grown under intensive cultural conditions were shown in studies by the Virginia truck station. In Golden Plume celery grown to maturity in frames, 2 tons of 6–6–5 fertilizer were insufficient to produce maximum growth and optimum foliage color. A supplementary treatment with 300 pounds of nitrogen per acre, applied in six applications at weekly intervals in the irrigation water, proved more effective and economical than either 100 or 600 pounds.

Favorable results with respect to total yield and percentage of No. 1 pickle cucumbers were secured by the Mississippi station from applications of commercial fertilizers. On a moderately fertile soil, from 800 to 1,000 pounds of a 4–8–6 or 6–8–6 material gave good results. On a newly prepared field of Ruston sandy loam, economical results were obtained with up to 1,000 pounds per acre of a 6–8–8 material.

Head size in lettuce was influenced by nitrogen more than by any other fertilizer element, according to the results of studies conducted by the Florida station. On areas low in potassium there was a definite response to applied potassium provided adequate nitrogen was also present.

The application by the New York (Cornell) station in early June of manganese sulfate and borax as aqueous solutions at the rate of 100 pounds per acre of each to onions which had a yellow color and were dying at the tips resulted, within a week, in the resumption of green color and of vigorous growth. Since the addition of borax to manganese sulfate had little benefit, the station suggests that borax was not a factor in increasing growth. By far the most serious condition with respect to manganese deficiency occurred on shallow peat underlaid with marl.

Of four crops, onion sets, sweet corn, cabbage, and pickle cucumbers, grown by the Illinois station in a 4-year rotation which included three green-manure crops and various combinations of fertilizing materials, sweet corn was the least responsive to fertilizer treatments. Cucumbers responded better to manure, while onions, corn, and cabbage yielded better with commercial fertilizers. Unit costs of increased yields were much lower with a complete 4–8–4 fertilizer mixture than with stable manure.

The need of tomato plants supplied with abundant ammonium or nitrate nitrogen for adequate supplies of potassic nutrients was shown in studies conducted by the New Jersey station with tomato seedlings growing in white quartz sand and supplied with nutrient solutions. The plants with adequate nitrogen and potassium grew luxuriantly throughout the experiment, while those without sufficient potassium showed early deficiency symptoms. Apparently, in the ammonium nitrogen lot without potassium the comparatively high concentration of ammonium nitrogen in the plants was responsible for the rapid deterioration and collapse of the leaf tissues. The lack of potassium apparently prevented the ammonium nitrogen from being converted into amino and protein nitrogen.

The addition of nutrients to the water used at time of setting

tomato plants in the field was found by the Indiana station not particularly beneficial in the case of the Indiana Baltimore variety. There was, in one instance, a slightly significant gain from the treatment in the first picking. When total yields were analyzed, the gains from nutrient starters were of no significance as compared with water alone. At no time during the season was there sufficient difference in growth to distinguish the plats from one another.

On the other hand, the inclusion of quickly available fertilizer materials in the water applied to tomato plants at the time of setting in the field was found beneficial in studies by the New York State station. Nutrient solutions containing nitrogen, phosphorus, and potash were more effective than those lacking any one of these ingredients. Starter solutions assisted the plants to become established quickly, with earlier maturity as a result. Treatments were particularly useful for southern-grown plants or local plants grown under crowded conditions which resulted in a depleted nutrient condition.

Investigations conducted by the Rhode Island station in the field and in concrete frames showed nitrogen to be the only fertilizer ingredient to increase yields of tomatoes consistently. There was a tendency for plants receiving the high-nitrogen fertilizer to produce a greater percentage of fruit of No. 1 grade. Where stable manure, green manure, and fairly liberal applications of mixed fertilizers were used, phosphorus and potassium seldom limited production either of tomatoes or of other vegetables.

In Wenatchee soils from which there had recently been removed mature apple trees that in their bearing years had been heavily sprayed with arsenic-containing sprays, the Washington station observed that rye made excellent growth but oats much slower development. Potatoes appeared to be fairly satisfactory for planting on newly reclaimed orchard soils. Tomatoes were stunted badly during the early part of the season but recovered later to produce a crop of green fruits. Legumes, such as peas and beans, appeared most adversely effected by soil toxicity. The longer the period following the removal of the trees, the better was the development of the crops.

Physiological studies.—Studies by the South Carolina station indicated that the superior capacity of the Henderson lima bean to produce fruit under adverse heat and drought conditions is due to its more extensive and numerous roots. The broad leaves and large blossoms of Fordhook and other large-seeded kinds resulted in a greater loss than intake of water during dry, hot weather and may account in part for the differences in root development, which, in turn, depends on photosynthetic processes. Under controlled greenhouse conditions, Fordhook and McCrea (large-seeded varieties) were characterized by a low and Henderson (small-seeded) by a high root : top ratio. Baby Fordhook, a cross between Fordhook and Henderson, had a root : top ratio intermediate between those of its parents. Temperature had a profound influence on root growth, with varieties responding differently.

In experiments conducted with mature plants and seedlings of the Detroit Dark Red variety of beet, the New York (Cornell) station noted that when grown at 65° F. few seedstalks developed from mature field-grown roots regardless of photoperiod. When shifted to 55°, the same plants produced a high percentage of seedstalks. Plants grown in continuous darkness from mature roots produced no seed-

stalks at 55°, but when shifted to continuous light 80 percent developed flowers and seed. Exposure of plants to light intensities of approximately 500 footcandles resulted in slightly more seedstalk formation than exposure to 200 footcandles intensity, and exposure to continuous light resulted in still greater seedstalk response. Two weeks' exposure of seedlings in total darkness at 50° appeared to stimulate seedstalk formation more than a similar length of exposure to continuous light of 500 footcandles intensity at 55° when both were subsequently grown in continuous light at 55°. In general, plants from 33 to 47 days old at the initiation of the cold and light treatments responded more quickly and to a greater degree than plants either older or younger.

Noting that cucumbers grown in the greenhouse in late autumn frequently show injury as cool weather commences, the Missouri station grew plants in crocks set in tanks of water the temperature of which was controlled. The critical temperature for water movement through the cucumber root was between 60° and 70° F., and the leaf and fruit injury observed in fall crops is attributed to a deficiency of water resulting from a set of conditions wherein transpiration is in excess of the amount of water supplied through the roots. In general, the more vigorous the plant and the more rapid the temperature change, the more severe was the injury. A soil temperature of 70° is apparently the most practical for growing greenhouse cucumbers.

Observations by the New York (Cornell) station on Long Standing Bloomsdale spinach plants sown April 26 outdoors in drums of soil, part of which were supplied with nitrate of soda in divided applications and part given no nitrate, showed the nitrated plants to be slower in beginning seedstalk elongation. The large quantity of nitrate of soda, 6 tons per acre, delayed seedstalk initiation and development, and indicated the need of considering the level of fertility in photoperiodic experiments. The nitrated plants were stockier, with thicker leaves of a darker green color and with more savoying.

Chemicals, such as indolebutyric acid, applied to tomato flowers in the greenhouse during the winter season when fruit development is greatly retarded because of low light and a relatively high nitrogen content of the soil were found by the Ohio station to result, in a very large proportion of the flowers which reached full bloom, in the setting of fruit with locules well filled with gelatinous material.

From determinations of the total soluble solids and sugars in important commercial varieties of watermelons and in certain hybrids, the California station concluded that factors for sugar content are heritable but that environmental conditions may affect total soluble solids and sugars of genetically pure strains. High quality was largely dependent upon high sugar content, with deep-red color and pleasant texture of the edible flesh also important. The various Klondike types were consistently higher in sugar content than the more important eastern United States varieties. Of the wilt-resistant kinds, Klondike R16 and Klondike R7 excelled in sugar content. Trends for total soluble solids and total sugars were essentially alike, and approximately 85 percent of the total soluble solids was sugar. A refractometer reading on two or three drops of juice taken from the center of one-half of a fully mature fruit gave approximately

the same result as when a composite sample was taken from the entire edible tissue. Studies by the same station of the expressed juice taken from systematically cut cross and longitudinal sections of cantaloups and honeydew melons showed that the concentration of solids varies somewhat in different portions of the fruits. In cross-section pieces, the stem-end quarters were always lowest and either the middle-blossom quarter or the blossom quarter highest in percentage of soluble solids. When the flesh of a single section was divided into thirds from the placenta outward, the inner third was always highest in soluble solids. Following storage at room temperature for 6.5 days, cantaloups were lower in soluble solids, while honeydews were slightly higher. Storage had little effect on the relative ratings of different sections of a given melon.

Of the three degrees of defoliation practiced by the Missouri station with watermelons, the greatest inhibition to fruit setting accompanied the severest treatment. When nitrate of soda was applied as a side dressing, it appeared to delay and decrease the fruit set. The setting of fruits tended to check terminal growth and to interfere with the development of fruits setting subsequently.

Storage and handling.—Of various methods of handling iceberg types of lettuce, none was found by the New York (Cornell) station to equal package-icing in effectiveness. However, the Boston variety cannot be satisfactorily package-iced, leaving precooling as the only practical means of handling this type. The rate of reheating of iced packages was found to be slow, permitting the product to continue in good condition for some time after the lettuce reaches the market. Package-iced New York grown lettuce of the iceberg type sold on a favorable basis with the California product.

That different varieties and strains of sweet corn respond differently to storage temperature was indicated in studies by the Indiana station in cooperation with the Department (B.P.I.). Inbred lines and hybrids varied markedly as to their initial sugar contents and the rate at which the sugar disappeared during storage.

Studies by the Utah station on the adaptability of various varieties of vegetables for freezing preservation indicated that Gradus and Thomas Laxton early peas, Onward, Morse Market, and Morse 2286 midseason peas, and Stratagem and Dwarf Alderman late peas are valuable for freezing. Among lima beans, Burpee Improved bush, Baby Potato, and Baby Fordhook were found desirable.

ORNAMENTALS

Varieties.—Three new chrysanthemums—Daisymum, Sioux, and Winona—were distributed by the Minnesota station.

Cultural studies.—At the Ohio station, carnation plants grown in either sand or gravel and subirrigated with nutrient solutions produced more flowers with longer stems than comparable plants in soil. Favorable results were secured with roses and lilies. An increase in the potash content of the nutrient solution increased the yield of the Lucile Hill rose. An attempt to supply additional carbohydrates by adding glucose during cloudy weather in February and March gave no strikingly positive results. In the case of sweet peas, glucose additions resulted in earlier germination, due probably to bacterial action on the hard seed coats.

A soil-peat moss mixture of medium moisture content gave fine re-

sults with roses at the New York State station. The addition of peat moss was distinctly beneficial, especially with the low and medium moisture cultures. In the presence of peat moss, the root systems formed dense masses of fine, actively growing laterals. Gains in weight of shoot growth and flower production were greatest in plants in the soil-peat mixture of medium moisture content.

That the incorporation of sand in the soil medium used for growing roses is a highly beneficial procedure was demonstrated by the Pennsylvania station in greenhouse experiments with the Better Times variety. Plants in media containing sand produced consistently more flowers than those in clay or loam.

Treatment with steam or with hot water was found by the Illinois station to restore the productivity of soil which had for 3 years been utilized for the growing of greenhouse roses. The results compared very favorably with those secured on new soil. Favorable results were secured also from treatment of old soil used for the production of carnations.

The drying of freesia corms for from 3 to 4 weeks prior to planting, according to the Massachusetts station, increased flower production and lessened the number of days required to reach the flowering stage, as compared with no treatment. Subjecting the corms to a temperature of 40° F. for from 1 to 4 weeks prior to planting had no stimulative effect on blooming.

Propagation.—A successful method developed by the New Jersey station for propagating hybrid varieties of rhododendron included the use of a stratified root medium, a special type of propagating frame, the orientation of these frames with respect to north light, and the reflection of an adequate amount of light into the frames. Cuttings were made between July 1 and November 15, preferably from tip growth sufficiently mature to possess dark-green leaves.

Storage and handling.—As a result of trials with a number of peony varieties cut at different stages of bud development and held for from 2 to 4 weeks in cold storage under known temperature conditions, the Indiana station found that certain varieties are better adapted than others to this method of handling. The following varieties gave the most satisfactory response: Edulis Superba, Felix Crousse, Festiva Maxima, Floral Treasure, and Monsieur Jules Elie. As to time of cutting, the buds of the full, double-flowering varieties need to be more fully expanded and to show more color than do single or partly double varieties. Buds of red varieties should be more fully expanded than those of white varieties. Dry-packing proved less expensive and more satisfactory than moisture application prior to storage.

Nutritional factors.—Budded Better Times roses grown by the Ohio station in a combination of burned shale and clay supplied with a nutrient solution were benefited by small amounts of boron or zinc in concentrations below toxicity. Copper applications decreased total production and caused greater percentages of short-stemmed blooms. Results with small amounts of ammonium sulfate indicated that some ammonium is necessary for optimum rose production, particularly during periods of high carbohydrate production in the spring and fall.

That the application of sulfur may be beneficial to roses growing in alkaline soils was indicated in studies conducted by the Texas station in central Texas on a black calcareous prairie soil. The three varieties used, Red Radiance, Talisman, and Joanna Hill, responded somewhat

differently. When sulfur was used in amounts greater than from 10 to 15 pounds per acre the nitrate concentration in the soil was reduced to zero, but under the conditions of the experiment there was no evidence that nitrate deficiency resulted in any material decrease in flower production. In studies of the effect of varying calcium and phosphorus concentrations of the nutrient solution maintained at different pH levels on growth and composition of Briarcliff rose plants, the New Jersey station found that the ratio of calcium: phosphorus is of significance. The effective ratio extended over a range easily obtainable in practice. Apparently, the need of calcium as a direct nutrient for the rose is moderate, but phosphorus seemed to be needed in greater concentrations than by the peach, apple, and other horticultural plants.

Physiological studies.—Intermittent artificial light was shown by the Indiana station to be more effective in plant growth proportionate to the amount of energy used than continuous light. Apparently, the photochemical mechanism in photoperiodism is limited by a dark reaction which can accumulate products available for the light reaction at a slow rate and in relatively small quantities. As the daylight intensity was decreased, flowering was delayed in both long- and short-day plants.

Environmental factors, such as length of day and temperature, were found by the Wisconsin station to be highly important in determining the growth responses of plant materials. Cuttings of *Antirrhinum*, *Centaurea*, and *Petunia* responded differently to photoperiod and temperature than did seedlings. The different response of cuttings from nonflowering and flowering plants to a single environment was associated with differences in the anatomical structure of the original cuttings.

The ethylene gas emanating from ripe apples when the fruit was confined in airtight chambers was found effective, by the Oregon station, in defoliating nursery rose plants. Where 50 percent or more of the space was occupied with rose bushes, the heat liberated by the plants, once the defoliation process was started, was adequate to maintain the necessary temperature. For most varieties, from 3 to 5 days was sufficient to complete removal of the leaves. The treatment had no apparent significance in its effect upon subsequent growth.

The effect of night temperatures on chrysanthemums, gardenias, and poinsettias was studied by the New York (Cornell) station. The subjection of young chrysanthemum plants to low night temperatures interfered with flower-bud formation, delayed flowering, and decreased the number of buds per stem as compared with holding plants at high night temperatures. Plants given low intensity and high temperature did not form flower buds as freely as those given high light intensity. Shoots that failed to form flowers during the early fall at high temperatures remained blind during the winter, even though the temperature was increased. Late pinching and late planting may delay bud formation until the temperature has dropped to the point where it inhibits flower-bud formation. Bud formation in the gardenia occurred equally well at a night temperature of 60° F. as at 55°, but was seriously curtailed when the night temperature was 70°. Supplementary illumination did not consistently increase the number of buds formed in all treatments. Bud abscission was in-

creased at a night temperature of 70°. Poinsettias were found to have exacting temperature requirements for the development of the large, colored bracts, and a night temperature above 65° F. inhibited their development. However, under the high light intensity of summer, poinsettias developed bracts at much higher night temperatures than when grown with short days.

The production of vegetative shoots by leaf-bud cuttings of *Leucothoë catesbaei*, *Rhododendron ponticum*, and *R. roseum elegans* was found by the same station to be stimulated by either high temperatures or long days. A temperature of from 75° to 80° F., regardless of day length, resulted in a high percentage of shoot growth. Maximum elongation of shoots from leaf-bud cuttings occurred under conditions of high temperature and continuous light. The length of vegetative shoots of mature plants of azaleas and rhodendrons was affected more by day length than by temperature.

FORESTRY

Silvicultural studies.—The value of thinning dense stands of red pine was shown by the Minnesota station in studies on 4 one-tenth acre thinning plats established in 1927 in a 15-year-old stand in the Cloquet National Forest. On remeasurement in 1932, there was some advantage, as indicated in diameter measurements, for the 7-by-7-foot plat. This advantage was maintained through the second 5-year period. All the thinned plats showed considerably better growth than the check and suffered less damage in a very severe sleet storm occurring in 1935.

One-year-old seedlings of hardy catalpa, green ash, hackberry, black locust, and American elm, root pruned to various degrees before planting in April, were found by the Kansas station to respond differently to the pruning treatment. When dug in the autumn, the trees showed that root pruning had not significantly affected the amount of top growth of catalpa, ash, or locust, but had definitely reduced the amount of growth in hackberry and American elm.

The extended use of black locust as a soil erosion control plant led the Indiana station to conduct an investigation in which no difference was noted in survival on fertilized or unfertilized areas but marked differences were recorded in growth rate. The fertilized trees were about twice as tall and twice as thick at the base. Nodule formation was also more evident in the fertilized plats.

In forests of southeastern Iowa, the volume loss from all types of defects averaged, according to the Iowa station, 8.5 percent of the total volume of trees in the merchantable size class, 5.2 percent of the total volume of large poles, and 6.2 percent of the total volume of saplings. In white oak, the most important species represented, the percentage of defective volume decreased with increasing diameter. Slightly over 60 percent of the trees were partially defective from one or more causes. Eight percent of all trees bore fire scars, and 50 percent of the scarred trees were defective.

Microscopic examination by the Minnesota station of sections made from the seedlings of five forest species—*Pinus strobus*, *P. resinosa*, *Picea canadensis*, *Ulmus americana*, and *Catalpa speciosa*—exposed under controlled conditions to different temperatures indicated that the several species do not vary greatly in their relative heat resis-

tance. The cortical parenchyma cells of all five species were killed in 30 minutes when exposed to temperatures between 57° and 59° C.

Stating that approximately 56 percent of the area of Connecticut is in forest and brushland and that the predominant forest type is oak, the Connecticut (State) station reports that in even-aged second-growth oak stands the five principal species were white, red, black, scarlet, and chestnut oaks, with a few swamp white and pin oaks. High water table or seepage from higher ground was, in some cases, apparently of greater consequence than the soil itself in controlling tree growth. With certain unusual plats discarded, there was a low but significant positive correlation between site index and total nitrogen. Topography came into the picture only as it influenced soil moisture and exposure to wind and sun. On sandy soils, gray birch, red maple, and oak were fairly abundant; and on compact subsoils, black cherry and sassafras were more abundant than most other species. Except for a few species, ground cover proved of little value in indicating site quality.

If growth at maturity is taken as a good index to site quality, according to the New York (Cornell) station the hardwood type is the most favorable for sugar maple, beech, and yellow birch; the spruce-hardwood type for spruce and balsam fir; and northern white cedar for the spruce flat type. Measured by specific gravity, sugar maple and balsam were slightly heavier when growing on the spruce-hardwood type, while yellow birch was heavier on the hardwood type. Spruce produced heavier wood on the spruce flat and balsam fir in the spruce swamp.

The New York (Cornell) station also found that the organic-matter content of ungrazed woodland soils averaged 8.5 percent as compared with 6.4 percent for grazed areas. Air and soil temperatures were lower, and light intensity at ground level much lower, on ungrazed areas.

The application of different amounts of nitrogenous fertilizers, according to cooperative studies by the same station and the Black Rock Forest, resulted in an increase in both radial growth and in foliage nitrogen contents. The leaves of all species on the fertilized plats were from 30 to 150 percent larger and much darker green than those on the control non-nitrogen-supplied plats. The various species differed considerably in their response to nitrogen, yellow poplar, white ash, and basswood apparently being particularly nitrogen-requiring.

Of all the exchangeable ions, potash is said by the Wisconsin station to present the greatest interest from the standpoint of nursery soil fertility. Except for a negligible amount in the soil solution, available potash occurs in the form of an exchangeable ion, making the content of available potash retained in the soil despite leaching dependent directly on the level of base-exchange capacity. In case the base-exchange capacity of a nursery soil is low and there is need for a high level of available potash, its maintenance is possible through the use of catch crops, composts, or liquid manures. The inclusion of peat or other matter of high base-exchange capacity may be helpful.

On a somewhat alkaline soil, aluminum sulfate, sodium nitrate, and a 2–12–6 mixture were all found by the Iowa station to stimulate the top growth of white pine seedlings. Of the three treatments, only

aluminum sulfate increased root growth. In greenhouse trials, Norway pine and white spruce responded well to a combination of superphosphate, muriate of potash, and sodium nitrate, and good results were secured in the case of white and jack pines from the application of superphosphate, steamed bonemeal, or a combination of superphosphate and muriate of potash. A combination of fertilizers containing nitrogen, phosphorus, and potassium was, in general, more effective in the nursery than any single element.

Observations by the Michigan station on the development of 2-year-old seedlings of European larch, white pine, red pine, white spruce, and jack pine planted in the fall of 1936 on areas the dominant ground covers of which were quackgrass, dewberry, and polytrichum moss, respectively, showed the best average growth rate for all species on the dewberry type. Red pine and white spruce made slightly better growth on the quackgrass soil, and the jack pine made its best growth on the moss type. Site differences were probably correlated with water-table differences.

Distinguishing three types of glei soil, (1) alpha, (2) beta, and (3) gamma, the Wisconsin station states that the alpha is a semi-swamp type supporting stands of water-enduring species, with mosses and sedges the characteristic ground cover. The beta glei soils are transitional and suitable for the survival but not the successful growth of both upland and lowland species. Gamma glei soils are characterized by the occurrence of more exacting species than are found on upland soils of similar texture. Sufficient depth of aerated soil, availability of nutrients, and accessibility of ground water resulted in exceptionally rapid growth of trees and their general stability.

AGRICULTURAL SOILS AND PLANT NUTRITION

CONTENTS

The application of the findings of soil- and plant-science research is of fundamental importance in achieving a permanent and profitable agriculture. In the formulation of any satisfactory system of land management it is essential to have information on the characteristics of the soils and plants to be used. Results from the experiment stations each year contribute much toward a better understanding of the nature and properties of soils under various conditions and treatments.

The continued production of sufficient food and fiber from our soils may be considered as a major economic problem when observed from a national viewpoint. However, from the soil-science perspective the problem presents several seemingly complex and interrelated factors involving a study of soil and plant relationships. Some of the factors may require long periods of field and laboratory study before a satisfactory method of handling a soil under a given set of

conditions is worked out. Further, the soil is a dynamic body, making it necessary for research to be constantly alert and continually moving forward.

During the past year, progress has been reported in working out practical means of soil and water conservation under Great Plains conditions, the action of soil micro-organisms in soil conservation, and the effect of tillage practices on soil conservation. Knowledge of the condition of plant nutrients in the soil, how the nutrients become available, and a possible method of entry of nutrients into the plant has been greatly advanced.

The role of soil organic matter in soil conservation, plant nutrition, and soil moisture relationships was investigated further at several of the stations. Developments were made in fertilizer practice through the extension of the use of non-acid-forming fertilizers, the use of fertilizers of higher plant-food content, and including in the fertilizer mixture minor elements found to be essential for healthy plant growth.

The above, along with many other findings of research in soil science, are reported in the following pages:

SOIL REACTION AND ITS CONTROL

One of the most important phases of soil-reaction control recently taken up is that of the introduction of non-acid-forming fertilizers. The Rhode Island, Vermont, and other stations now report each fertilizer mixture analyzed as acid-forming or non-acid-forming. Progress is being made toward the general adoption of non-acid-forming commercial fertilizer mixtures. The Vermont station, for example, has shown that 526 tons of limestone would be required to neutralize the potential acidity of the 7,821 tons of complete fertilizer sold in Vermont in 1939. The Tennessee station has found that superphosphates made from phosphate rock of normal fluoride content returned to an insoluble and relatively unavailable condition on the addition of the lining materials used to render the fertilizer non-acid forming. However, superphosphate that will not become unavailable can be made from phosphate rock of low fluoride content.

In regions of alkaline soils an opposite need may be encountered. The acid-forming tendency of ordinary fertilizer mixtures may be insufficient to overcome the alkaline soil reaction to a degree such that plant roots can feed normally. The Arizona station, pointing out that plant roots must develop a slightly acid film between root and soil particles in order to dissolve the required nutrients, has made an acidulated fertilizer by adding small proportions of sulfur to the mixture and using finely ground manure instead of sand as a filler. A soil pH value of 7.6 appeared, at this station, to be about the upper limit for the normal root-feeding processes.

Certain forest soils studied at the Minnesota station were found to be acid not only in the surface layer but, to a decreasing degree, throughout their entire depth. From about three-tenths to seven-tenths of their exchangeable base content had been displaced by acidity. In work by the Nebraska station on the perennial problem of "slick spots," both slick-spot and normal soils showed the greatest alkalinity where the highest exchangeable sodium and potassium content was found. An alkaline raw humus was found by the Wisconsin station to have developed, over calcareous outcrops on the

Door Peninsula, from remains of white cedar, balsam fir, and ground vegetation usually associated with strongly acid soils. This material had a reaction definitely on the alkaline side of neutrality, and it had the rather notable lime content of 5.9 percent, together with a very low available phosphate supply. In rice-soil work at the Louisiana station, flooding an uncropped Crowley soil with distilled water, in a laboratory experiment, made the soil more alkaline and increased the soluble sodium and magnesium contents.

Means for the more accurate determination of the lime requirements of acid soils are being studied at many of the stations. A method developed by the Indiana station has been adopted by the Virginia station and found to be the most satisfactory procedure for actual field use.

MINERAL NUTRIENTS, AVAILABILITY, FIXATION, AND BASE EXCHANGE

An important effort, in which an increasing number of the stations are taking part, is that directed toward the use of fertilizers of higher plant-food content. Modification of the fertilizer law to require a fairly high content of actual plant food has been secured in a number of States. Progress toward still further elimination of inert fillers has also been made. Of 181 samples taken by the Rhode Island station, for example, 47 were guaranteed to contain 20 percent or more of plant food, and 10 guaranteed 40 percent or more. This station notes that many farmers have materially reduced their expenditures by the use of high-analysis brands. The New Jersey station is advising the user to think in terms of ratios as well as grades, pointing out that the 4–8–8 and 5–10–10 analyses have the same ratio, but 1,600 pounds of the higher grade is usually a little cheaper than 2,000 pounds of the lower grade and provides exactly the same quantities of nitrogen, phosphorus, and potassium. Treble superphosphate has been successfully used by the Montana station, which found that this highly concentrated phosphate could be applied at the time of planting with the seed of wheat and sugar beets without ill effect on germination or stand. The South Carolina station calls attention to the fact that farmers of that State have been paying about $1,000,000 annually for sand and other inert fillers because of their purchase of low-grade fertilizers. The State fertilizer law has been revised to require a minimum of 16 percent plant-food content. The tendency to revert to cheaper and often inadequate fertilizers in a year following a very bad crop has been observed by the Mississippi station. This station has tried to remedy such unwise practice by recommending fertilizer mixtures which lower the cost without sacrificing the necessary minimum of deficient plant-food elements.

Means for the rapid estimation of the fertilizer requirements of soils have received much study. The New York (Cornell) station worked out practical methods of determining the calcium, magnesium, and phosphate content of soils. A method involving leaf analysis, developed at the Pennsylvania station, has been shown to indicate the differences between nonuniform soil plats receiving identical experimental fertilizer treatment—a matter of obvious significance in field-plat fertilizer experiments. Good agreement with field results was obtained from a commercial testing set and from

a laboratory method at the Louisiana station, although the station does not yet recommend routine sampling, testing, and interpretation of the results by persons unfamiliar with the technique of the methods and the nature of the soils and crops involved. A study at the California station upon the causes of the frequent failures to establish a correlation between acid-extracted soil phosphates ("available" phosphate) and actual field growth of plants has revealed what chemical characteristics and components of the soil must be known and reckoned with if a dependable estimate of the phosphate requirements is to be made from chemical data. At the Arizona station it has been shown that the ordinary type of rapid chemical tests for available phosphates cannot be applied because of the alkaline reaction of the soils of Arizona. A method using carbon dioxide gas dissolved in water proved useful, as did also the use of small seedlings to test for phosphate availability.

A wide variety of work on soil and fertilizer phosphates has been recorded. At the Nevada station further work has been done on penetration of the soil by certain organic phosphate compounds. Temporary fixation in an organic form produced by micro-organisms appears in the work of the New Jersey station. In early stages of decomposition of plant material in the soil, much of the phosphate content of the soil was taken into organic combination. Adding a soluble phosphate markedly increased the rate of decomposition of straw and other organic residues. In later stages the phosphate taken up was gradually mineralized again. The stage of growth at which the plant material was added to the soil strongly influenced the behavior of the phosphate. Young plant material required distinctly less phosphate for its decomposition than did straw. At the California station metaphosphate was found to penetrate to the lower soil layers, whereas the ordinary fertilizer phosphate (an orthophosphate) was all retained in the upper layer. The metaphosphate was a satisfactory source of phosphorus for plants, as were also certain soluble, penetrating organic phosphates. The soil-penetrating properties and availability of metaphosphates have also been revealed by the Delaware station. Fertilizer properties of a calcium metaphosphate made by passing hot elementary phosphorus into phosphate rock were also investigated at the Tennessee station. Metaphosphate seemed much more completely absorbed by soils and subsoils than is the ordinary phosphate. A rather probable explanation of the fixation of large quantities of phosphate by soils of high iron content has been offered by the North Carolina station.

Study of potassium as a plant food and of the supply and fixation of this element in the soil has continued along established lines of attack, and new studies have been begun. At the New Hampshire station it has been shown that a suitable potassium-nitrogen balance is necessary for good plant growth. At the Ohio station quantities of potassium salts, amounting to about 2 ounces each, were placed in the lower foot of 18-inch borings located in 12- and 9-foot circles about apple trees to determine the extent of the lateral movement of the fertilizer. From somewhat more than 22 cubic feet to a little over 35 cubic feet of soil within 13 feet of the trunks of the trees was changed from very low to very high available potassium content as a result of this treatment. This indicates that potassium salt

fertilizers may be dropped behind a deep tillage tool, such as a Killifer disk or coulter, to a depth of 16 to 18 inches, a practical operation placing the potassium within the absorbing zone in most eastern orchard soils and below the layer in which potassium is subject to fixation by alternate wetting and drying. Such fixation has been studied at the New Jersey station, which reported some decrease in base-exchange capacity in the lower layers of the soil, though not in the top layer, when potassium is fixed in this way. The Illinois station reported the release of potassium from nonreplaceable (fixed) forms when the soil was kept moist and when all or a part of the original replaceable potassium content had been removed. When no potassium had been added or removed, release of the fixed potassium occurred only to a very small extent. Adding a potassium fertilizer resulted in a part of the replaceable potassium being changed over into a nonreplaceable state of combination. This work is considered to indicate that fixed potassium should be regarded as difficultly replaceable rather than as nonreplaceable. In studying certain unproductive soils of high lime content, the Iowa station found productive soils from some fields to carry from about one-third more to over seven times as much exchangeable potassium as did the unproductive soils. The unproductive soils averaged 151 pounds per acre, and the productive 396 pounds of exchangeable potassium. It appeared that the soils of high lime content required more exchangeable potassium for good crop growth than did the normally acid soils of the same region. Fixed, or difficultly exchangeable, potassium has been found in experiments with tomato plants at the New Jersey station to be utilized much less readily than potassium in the exchangeable state. Fixed, as well as replaceable, potassium was lost by leaching from soils studied by the Virginia Truck station, where fixation varied markedly from month to month under natural conditions though it remained constant under controlled conditions.

Irrigation water has been found, at the New Mexico station, to supply annually quantities of potassium ranging from 92 to 545 pounds of "potash" per acre. Leaching losses of potassium fertilizer compounds were no greater, at the Hawaii Sugar Planters' Station, when such fertilizers were applied with ammonium sulfate than when they were applied after the sulfate had been converted to nitrate in the soil. From uncropped soil, potassium carbonate was leached out less than was potassium chloride, but from soil cropped to cane the losses were but little different. Potassium fertilizer applied in excess of crop needs appeared to be largely lost in any event.

Magnesium has been shown by a number of the stations to be needed in the fertilizer application and in quantities greater than those of the trace-requirement elements properly so called. The New Hampshire station reported magnesium as one of the guaranteed elements in 17 of 109 brands in 1939. The Oklahoma station has devised a method, found to be accurate, for determining the exchangeable magnesium of soils, together with a quick test suitable for approximate estimates of soil-magnesium needs. The light, sandy soils of citrus groves studied by the Florida station were found mostly to be very deficient with respect to magnesium. Calcined dolomitic limestones, if ground to 80-mesh size or finer and of the quality used by the North Carolina station in experiments on

dolomitic limestone decomposition in the soil, should supply at least a large part of the magnesium needs of plants. In general, the work on this element indicates very wide differences from one region to another in the need for added magnesium.

A study at the New York (Cornell) station of the effects of forest cover on base-exchange properties has shown that on soils of similar mineral origin the sugar maple-beech-yellow birch forest type produced a less leached out and less acid soil with a higher percentage of its exchange capacity saturated with bases (including the potassium, calcium, magnesium, and some other basic elements essential to plant nutrition) than did a forest cover consisting of red spruce, sugar maple, and beech, or mainly of red spruce type. The difference seemed largely due to the difference in the calcium content of the leaves. A large part of the base-exchange capacity of such soils apeared to be that of the organic matter. At the Illinois station also, the exchange capacity of the organic matter played an important part in the storage of plant nutrients as exchangeable bases, the organic matter contributing from 6.8 to 43.4 percent of the total base-exchange capacity of the agricultural soils studied. Means for determining such percentages were developed at the same station. From a technical study of "contact exchange" at the California station, information likely to be of considerable practical importance in plant feeding has been obtained. Plant roots in contact with clay particles both gain and lose nutrients. The study of this complex natural process has an obvious bearing upon the understanding and control of the behavior of both native and added plant-food elements.

SOIL DEFICIENCIES AND TOXICITIES, AND PLANT DISORDERS CAUSED BY THEM

The practical importance of the trace-requirement elements—plant poisons, yet essential, in minute quantities, to the normal growth and even the life of plants—has become widely recognized as more and more instances of local deficiency in one or another of these elements have been discovered. In the fertilizer-analysis data of the Maine station for 1939, for example, both boron and manganese, in addition to magnesium, appear as fertilizer components guaranteed by manufacturers and determined in the regulatory analyses. Illustrative instances of the numerous studies on deficiencies and toxicities traced to individual elements of this group will be found in the following paragraphs.

The Vermont station, in further research upon a form of overliming injury ascribed to substances produced from the soil organic matter of strongly acid soils by excessive liming, has now shown that the injurious effect of these organic substances may result from their power of rendering the normal boron supply of the soil unavailable to crop plants. A boron deficiency has been found by the Idaho station to be the cause of alfalfa "yellows." Suitable applications of borax relieved this disorder. The Oregon station treated "yellowtop" of alfalfa successfully with a boron compound, 30 pounds per acre of boric acid serving to control the disease. The effects of treatment with boron compounds upon crop growth have also been studied at the Delaware station. At the Montana station, the potato disorders known as "haywire" and "witches'-broom" yielded to treat-

ment with from 3 to 5 pounds of boric acid per acre, the last-named quantity giving the best results. At application rates of from 10 to 15 pounds per acre of boric acid, definitely toxic effects appeared.

A manganese deficiency has been shown by the New York (Cornell) station to have resulted from the plowing up of marl underlying intensively cultivated shallow mucks. Manganese sulfate at the rate of 100 pounds per acre furnished an effective and inexpensive remedy, restoring the high productivity of these soils. The station further showed that the application of manganese sulfate could be deferred until June (at which time the unproductive spots become clearly defined) without loss of benefit to the crop.

The effects of the soil zinc content have been studied at the New York (Cornell) station with respect to the growth of oats seedlings on a Westmoreland silt loam. When this soil was of an acidity greater than pH 6, a few hundred parts per million of zinc in the soil had a toxic effect. The injuries caused by as much as 800 parts per million of zinc were prevented, however, by adding enough calcium carbonate (limestone) to bring down the soil acidity to that represented by pH 6. The concentration of zinc compounds in the soil solution approached its minimum when the acidity was further lowered to that corresponding to pH 6.5. Zinc was found by the California station to be present, in small quantities, in almost all soils. This station has worked out a method for determining minute quantities of zinc, and in a survey of the State it was found that the soil zinc is easily fixed, both by the mineral and by the organic components of the soils, in a difficultly soluble form, and that it is not easily replaceable by other basic elements. From 451 to 902 pounds per acre of replaceable zinc showed toxicity to corn on Norfolk sand, according to the Florida station, but considerably larger quantities were not discovered to have any injurious effect in Orangeburg fine sandy loam or in Greenville clay loam. Moderate to heavy applications of phosphate to the Orangeburg and Greenville soils failed to increase the zinc tolerance of corn or cowpeas. Calcium carbonate at the rate of 1,000 pounds per acre on the Norfolk and at 4,000 pounds per acre on the other two soils, did, however, increase the zinc tolerance and greatly alleviated the toxic effect.

Molybdenum has been shown by the California station to be essential—though in the exceptionally minute quantity of 1 part in 100,000,000—for the healthy growth of tomato plants. However, a deficiency in this element has not thus far been detected in any natural soil.

The distribution of selenium, toxic to many plants though apparently essential to some weeds found only where the selenium content of the soil is dangerously high, has been studied by the South Dakota station. Greenhouse investigations and laboratory work on the forms of selenium in soils and rocks were also carried out by this station.

Work on the elimination of arsenic residues from the soil has been reported by the New Jersey station. The Washington station has studied the accumulation of arsenical spray residues in orchard soils. The various crops tested at the Mississippi station showed differences in sensitivity to calcium arsenate, and the quantity required to build up a toxic concentration varied with the soil. According to this station, toxic concentrations are not likely to be developed

by the average application of calcium arsenate for insect control. Arsenic in this form, when present in very small quantities, appeared to stimulate the soil bacteria.

An estimation of the iodine content of soils has been reported upon by the Texas station. This station has studied the iodine content of samples of 146 soil types, finding more of this element in heavy- than in light-textured soils.

Soil salinity and alkalinity continue under investigation at a number of the stations. A tract of saline land, once highly productive but so injured by high ground water and salt accumulation as to bring about its abandonment in 1930, has been reclaimed by the Washington station in cooperation with the Department (B.P.I.). Copious irrigation after suitable corrugations reduced the salinity to a point where sugar beets yielded 24.2 tons per acre the following year. Soil salinity has also been studied at the California station, where it was shown that the replacement of desirable bases in the soil-exchange complex by sodium from irrigation water depends not only upon the concentration of sodium salts in the water but also upon the ratio of sodium to calcium or calcium plus magnesium. When the sodium: calcium ratio is not greater than 2:1, little sodium will be taken up (that is, conversion of a normal soil into a saline or saline-alkaline soil will not occur), but since some of the calcium will be precipitated in the soil and some will be absorbed and used by the crop grown, unless the irrigation water has a very low total salt concentration the ratio of sodium to calcium plus magnesium should not be greater than 1:1.

ORGANIC MATTER AND NITROGEN

The Texas station found that the addition of calcium carbonate to sodium nitrite was effective in preventing losses of nitrogen from acid soils through the decomposition of nitrites. When 100 parts of nitrogen were added to 1,000,000 parts of an acid soil in the form of sodium nitrite there was an average nitrogen loss of 47 parts in the first 2 days, 55 in 4 days, and 63 parts in 8 days, but when calcium carbonate was added to the nitrite the losses were only 5, 8, and 9 parts in 2, 4, and 8 days, respectively. There was no loss of nitrogen that could be accounted for by the formation and decomposition of nitrites during the nitrification of ammonium sulfate in 23 of 24 soils which require additions of calcium carbonate for good nitrification, but there was some loss with one of the subsurface soils.

Loss of nitrogen as nitrate nitrogen from various fertilizers under different soil types was reported from a series of lysimeter studies by the Connecticut station. When the nitrogen fertilizer is not added in the nitrate form, it must undergo nitrification before it is materially affected by leaching. Urea was found to be more rapidly leached from the soil than either sulfate of ammonia or cottonseed meal. Sulfate of ammonia and cottonseed meal are similar in their rate of nitrification, but a given quantity of nitrogen in the form of cottonseed meal develops a much smaller amount of nitrate nitrogen in the course of a year. In these studies less than two-thirds of the nitrogen from cottonseed meal has become available in the soil in the form of nitrates. In seasons of abundant but not excessive rainfall, the use of 200 pounds of nitrogen per acre, supplying 40 pounds im-

mediately available as nitrates and the remainder as organic nitrogen, provides nitrates in desirable quantity during the period of most rapid demand by the tobacco crop, with little left in the soil at harvesttime. Applying nitrate nitrogen before planting may often lead to loss by leaching during early summer rains, but unless the leaching is severe during July the organic nitrogen will build up a favorable level by the time the crop needs it most. Summer rains of less than 1 inch rarely cause leaching unless the soil is very wet. After a week or more of dry weather, a 2-inch rainfall causes little or no leaching on loam soils but may frequently deplete the nitrogen supply in sandy soils. Storms with a rainfall of 4 inches or more within a 3-day period remove from 50 to 75 percent of the nitrate nitrogen from loamy soils and from 75 to 90 percent from the sandier soils, so that in case of severe leaching the supply of nitrates must be replenished as quickly as possible if injury to the crop is to be avoided.

A good crop of winter legumes turned under was found by the Mississippi station to be approximately equal for cotton to from 24 to 32 pounds of nitrogen per acre from commercial fertilizers. Summer legumes when interplanted had little soil-improving value but when not interplanted seemed to be of some value. The cost of nitrogen from the legumes was found to be about the same as equivalent quantities obtained from commercial sources, but their use as green-manure crops is considered as having other advantages.

Green crotalaria and green Natal grass harvested at two stages of growth decomposed more rapidly and more completely in soils slightly acid or neutral than in more acid soils, according to results from the Florida station. The slowing down of decomposition because of acidity was more marked for the Natal grass-treated soils than for those receiving crotalaria. The decreased activity in the soil may have been caused by a deficiency of available calcium for the soil micro-organism bringing about the nitrification process.

The Vermont station found that the mixing of caustic forms of lime with fresh cow manure may help save the nitrogen. The caustic lime temporarily retards ammonia production so that less nitrogen is subject to loss by field drying. In order to be effective in decreasing the loss of nitrogen, the lime must come in direct contact with the fresh manure. Ground limestone may be spread with either fresh or fermented manure on the loaded spreader with little loss of nitrogen, since it comes in contact with only a small portion of the manure.

The Oklahoma station reported that where natural gas escaped from leaking pipe lines there was a marked increase in total nitrogen in the soil. This is explained by the fact that anaerobic micro-organisms fixing nitrogen were present where the leaks occurred.

SOIL MICROBIOLOGY

The effect of chloropicrin (tear gas), used in soil sterilization, on nitrification and ammonification in soils was investigated at the Rhode Island station. Small treatments of chloropicrin had little effect on nitrate formation, but an increased dosage has inhibited nitrification for a period dependent upon the dosage. Ammonification was not inhibited, and in some instances the inhibition of nitrification resulted in an accumulation of ammonium nitrogen. The use of high dosages

was the only treatment that materially increased the total amount of nitrogen available for plant growth. It thus seems that increases in plant growth obtained from low dosages of chloropicrin cannot be accounted for by the hypothesis of increases in available nitrogen.

The amount of atmospheric nitrogen fixed by *Azotobacter* at the Kansas station when using colloidal clay as the basic medium was influenced by the kind and quantity of ions adsorbed by the clay. Addition of colloidal clay to an aqueous medium with minerals increased the ability of *Azotobacter* to fix atmospheric nitrogen. Colloidal material with a base-exchange capacity was more effective than suspended soil material. Nitrogen fixation by *Azotobacter* was studied at the Utah station to determine the influence of various amino acids and proteins on the process. A chroococcum was grown on a synthetic medium to which were added various amino acids and proteins. Cystine and *dl-methionine* increased nitrogen fixation about 20 percent. Casein and albumin also increased nitrogen fixation by *Azotobacter*, but gelatin greatly retarded fixation. Work at the Arizona station was directed toward determining the distribution and activity of *Azotobacter* under range- and cultivated-soil conditions. Cultivated soils contained *Azotobacter* in 87 percent of the soils studied, whereas range soils showed the presence of *Azotobacter* in about 23 percent of the soils. The organisms were generally active under cultivated conditions whereas under range conditions they were inactive. At the New Jersey station, the survival of *Azotobacter* in soil was investigated with results which indicated that different soils varied in their ability to support *Azotobacter* even when the reaction was favorable and readily available sources of energy were supplied. The inability of *Azotobacter* to survive may be due to competition with other microflora and microfauna, the presence of toxic substances, and the absence of certain nutrients, such as phosphate and potassium.

Soil moisture had a marked effect on the growth of algae at the New Jersey station. Changes in pH from 4.2 to 7.6 caused an increase in the algal growth on the surface soil. Additions of organic matter in the presence of light partially or completely inhibited algal growth during the period of decomposition of the organic matter by the bacteria and actinomycetes when soil bacteria, fungi, and actinomycetes were inoculated into five soils of varying organic-matter content and pH values and their survival studied. All the introduced organisms decreased in number, and three disappeared completely. Attempts were made through special soil treatments to establish the organisms that disappeared. Correction of reaction and additions of organic materials brought about survival of some of the organisms, while others reacted unfavorably to treatment.

Long-time cropping and fertilizer effects on the biological activity of the soil have been investigated by the Missouri and Illinois stations. The Missouri station considers that differences in organic-matter content of a soil under various treatments represent differences in the rate of consumption of organic residue by micro-organisms. This is given as an explanation of the various deficiencies in bacterial nutrient requirements under various soil treatments. Where the organic matter is not breaking down, it is because mineral elements are too deficient in the soil for microbiological activity, and they are also limiting elements in plant growth. At the Illinois station plats growing corn continuously and without soil treatment produced the lowest yield of

corn and contained the smallest number of soil micro-organisms. A plat receiving a treatment of manure, limestone, and phosphate in a corn, oats, and clover rotation produced the highest yield of corn and ranked at the top in the activity of its soil micro-organisms.

SOIL CONSERVATION AND LAND USE

Cooperative studies by the Nebraska station and the Department (S.C.S.) showed that leaving crop residues on the surface of the ground is a very effective and practical method of conserving soil and soil moisture in the Great Plains. Crop residues used in this way increase infiltration and thus decrease run-off, evaporation from the soil, and water and wind erosion. Working the decayed part of the residue and any undecomposed material into the soil may aid in maintaining soil fertility, but in these tests had little effect on the storage of soil moisture.

In erosion studies by the Arkansas station, high soil moisture resulted in higher soil and water losses. A good Bermuda grass sod reduced losses to less than 0.3 percent of the total rainfall during 3 years of experimentation. A 3-year rotation of corn, oats, and clover provided ground protection except for from 5 to 6 months. The permeability of the soil was increased as a result of plowing. A winter-plowed plat showed no appreciable run-off from January to March 25, 1938, although there were in that time 13 rains which caused run-off from fallow unplowed land. Run-off losses from a plat from which 6 inches of surface soil had been removed exceeded those from any cultivated plat.

The Kansas station found that, in comparison with areas in sod, cultivation across the slope with cropping has brought about a loss of carbon and nitrogen amounting to 37 and 32 percent, respectively, for the surface 7 inches of soil and 25 and 20 percent in the 7- and 20-inch layers. Considering only data from the relatively humid eastern section of the State, carbon loss was reduced 31.2 percent by cultivation across the slope. Further studies made cooperatively by the New York State station and the Department (S.C.S.) showed on soils from Clarinda, Iowa, and Bethany, Mo., a correlation between the depletion of soil organic matter and the extent of erosion. It was indicated that losses heretofore attributed to oxidation may have been the result of erosion. For a fallow plat, where the greatest erosion occurred, it was estimated that erosion had increased the depletion of organic matter 18 times that normally lost by oxidation, and that to maintain organic matter at the original level it would be necessary to apply as much as 9.2 tons per acre of clover hay annually.

The importance of conserving topsoil because of its higher content of available phosphate was shown in experiments reported by the Colorado station. While the total phosphate content of the topsoil does not vary greatly from that found in the subsoil, the available phosphate content of the subsoil is usually much less. On a number of surface soils and subsoils, corn showed much less growth on the subsoil than on the surface soil, and alfalfa made very little growth on the subsoil. Leaching studies on Sassafras sand at the Delaware station indicate that approximately one-third of the potash applied to the soil was lost by leaching with water equivalent to a 2½-inch rain, but that very little phosphorus was lost. In order to decrease this

waste of potash and to supply the plants more effectively with that element, it is suggested that smaller amounts be applied more frequently, while with phosphorus the entire amount might be added in one application.

With a view to better land use, the Oregon station has prepared a rating for soils of the Willamette Valley, together with a preliminary fertility balance sheet, including suggestions for conservation of soil fertility.

SOIL MOISTURE AND WATER MOVEMENT

Many of the stations continued research on methods of obtaining a continuous record of soil moisture under field conditions. At the Michigan station an electrical-resistance method was developed for measuring soil moisture in situ. Porous blocks cast about pairs of electrodes are imbedded in the soil. The moisture content of the absorbent blocks varies with that of the soil, and the electrical resistance varies inversely as the moisture content. The electrical resistance can be easily measured in the field as well as in the laboratory in a few seconds, and the results provide a rapid and accurate moisture determination. An apparatus for measuring heat conductivity as an index of soil moisture was developed at the Ohio station. Changes in the salt content of the soil solution do not materially affect the conductivity. The use of the tensiometer (a porous clay cup connected to a mercury manometer) for measuring soil moisture tension was further extended by the development by the Iowa station of a compact manometer for use in 1-gallon crocks, with very satisfactory results for moisture control.

Using various organic materials and several soil types, the Michigan station found that a high percentage of organic matter markedly increases the available water capacity of light soils and to a lesser degree that of heavier soils. The percentage of water present in the soil when plants wilted was also increased but not as rapidly in proportion as the water retention with added organic matter. The Georgia station, in a study of three forest soils of the Duke Forest, reported that moisture-equivalent values for the lower soil horizons appear to be directly correlated with colloid content. In the surface layers the organic-matter content seems to be the dominant factor. Although the wilting-percentage values were much lower than the moisture-equivalent values, they followed the same trend.

Subsoil moisture in connection with wheat production was studied at the Kansas station. Within the zone of root development of the wheat plant in semiarid regions the soil is usually dry at harvest-time, but if loss of moisture from weed growth after harvest is prevented, there will be an accumulation until the growth of the spring crop requires more moisture than that obtained from precipitation. The usual annual cycle of charge and discharge is confined to only a part of the zone where roots develop freely, and no water reaches the underlying subsoil. Under exceptional conditions, the entire root zone fills with water and small quantities go beyond the reach of the wheat roots. Fallowing thus lengthens the period of water accumulation and increases the times when water reaches the subsoil. At the Kentucky station it was found that Maury silt loam soil contained approximately its maximum field capacity of moisture at depths below 4 to 5 feet. Above 4 to 5 feet, the moisture decreased

toward the surface. Decreases below 2 to 3 feet were no different under cropped or uncropped areas, but above 2 to 3 feet the decrease was much greater in the cropped areas. This indicates that the crops grown obtained water mainly from the top 2 or 3 feet. Root-penetration studies showed that crops did not root effectively below the 2- or 3-foot depth. In pot experiments, 12 percent of water in the surface soil and from 23 to 24 percent in the subsoil was unavailable to corn plants, so that even if an extensive root system was developed at the lower depths, the amount of water obtained would not be great.

PHYSICAL STRUCTURE AND CONDITION OF SOILS

The peat and muck deposits of Connecticut to an average depth of 6 feet have been estimated by the Connecticut (State) station to be capable of providing soil-improvement material to a total of about 500,000,000 cubic yards. The greater part of these deposits is of a woody type, found to increase the capacity of the soil for holding water in a form available to the crop and to improve the tilth of soils which are stiff and sticky when wet, hard when dry, or both. The peat furnishes an organic component more stable, and therefore a more permanent contribution to good physical condition, than organic matter from manures or organic fertilizers. The peat deposits, in swamplands otherwise of very little value, give these lands a potential productiveness of from 2 to 2.5 billion dollars.

At the Nebraska station manure applications had no appreciable effect on the consistency of soils, their behavior with reference to moisture, their volume weight (density), or state of aggregation (crumbiness). Sharp differences between cultivated and uncultivated soils were found, the most marked difference being in the degree of aggregation, which for the cultivated was only 73 percent of that for the uncultivated soil. Of aggregates larger than 0.5 millimeter the cultivated soil had only 12.8 percent of the proportion found in the uncultivated. The maximum water capacity of the cultivated was 16.2 percent of that of the uncultivated soil.

A method for measuring accurately the changes in size distribution of aggregates and the density of soils, developed at the California station, provides a means for a study of the effects of various plowing and harrowing practices. In general, plowing decreased the cloddiness and volume weight unless it was done at excessive moisture contents. Harrowing usually reduced cloddiness somewhat, the disk and spring-tooth machines being rather more effective than the spike-tooth machines. Rolling and leveling increased the volume weight of the soil. These operations pulverized very dry soils to some degree but usually increased the cloddiness of moderately moist soils. Thoroughly pulverized soils showed greatly increased cloddiness after irrigation, often exceeding that existing before any tillage operation had been performed. Tilled areas left cloddy also showed some increase in cloddiness after irrigation but not as much as that of soils that had been thoroughly pulverized. Winter rains appeared often to have as great an effect upon the size distribution of aggregates as did tillage and irrigation.

Experiments of the West Virginia station show that organic matter must be decomposed before it can affect soil structure. In a study of

the effects of 12 types of organic matter on distribution of aggregates, rate of water percolation, and other properties, the effect of rapidly decomposing organic matter was observable after 1 week, whereas peat moss, which decomposes very slowly, had very little effect on the physical properties of the soils to which it had been added during 1 year from the time of its addition. With the cooperation of the Department (S.C.S.), the South Carolina station found the soil bacteria to have a quite marked effectiveness in producing aggregation or granulation of soils.

Pore space in soils, important in its influence on water movement, erosion, root penetration, etc., has been studied by several stations. The New York (Cornell) station has found the most promising method for determining this structural characteristic of the soil to be that based on the simple principle of filling the pores with water and then withdrawing the water at successively increasing tensions. Any given degree of tension will empty the pore space down to a size having sufficient capillary "suction" to hold the water against the force tending to withdraw it, and so the pore space of any given size can be quickly and easily determined. An apparatus for making this measurement was devised. To complete, for practical purposes, the picture of the physical condition of a soil, measurements of the force required to change the physical state were also shown to be needed and to be attainable by the use of a dynamometer, an instrument already in use for measuring plow draft. Average pore size was successfully determined by a somewhat different method at the California station in a study of water percolation through water-saturated soils.

The soil minerals are known to differ in their power of supplying and absorbing or fixing mineral crop nutrients and in their rates of physical and chemical change, so that a knowledge of the mineral composition of a soil is of obvious practical significance. The Wisconsin station has reported upon an improved means for separating the various minerals of which soils are made up. This method was found not only accurate with respect to separation of minerals of the sand, silt, and coarser clay portions of the soil but also to show promise of useful separations of the minerals present in the form of the extremely minute particles of the finer clay. Soil slips, of frequent occurrence in some sections of West Virginia, appear, according to the West Virginia station, to be due to subsoils derived from micaceous shale minerals. Such material has produced the most easily displaced subsoils and, therefore, those that are most likely to start soil slips. Marked variations in water level within relatively short distances, indicating little lateral movement of water within the soil, were also associated with soil slipping. The downward movement of water following rains was quite rapid in these soils. Work of the California station on the minerals constituting the finer clay (colloid) soil material has shown that all of the soil colloids studied are crystalline and can be identified as to their mineral type.

The puddling of alkaline soils of high lime content has been studied by the Arizona station in its relation to the decomposition of added organic matter (alfalfa). Erosibility and degree of aggregation have been associated with soil reaction in a Clarksville loam studied by the Virginia station, which found that the addition of ground limestone to the point of neutrality definitely improved both the physical

condition of the soil and its resistance to erosion. Increasing quantities of soluble aluminum in the soil, usually associated with increasing acidity, were accompanied by decreasing quantities of silt and clay aggregates of a size larger than silt.

PLANT DISEASES AND INSECT PESTS

CONTENTS

The extensive changes in American agricultural practices during recent years have resulted in new insect and plant-disease problems. Furthermore, unbalanced climatic conditions during part of this period were responsible directly or indirectly for widespread outbreaks of serious diseases and pests such as bacterial wilt of corn, tobacco downy mildew, grasshoppers, Mormon crickets, and chinch bugs. To the problems created by old enemies are added those caused by new invasions and by further advances of introduced diseases and pests like potato ring rot. strawberry red stele, white-fringed beetle, and the berseem weevil. Such problems have necessitated, more than at any previous time, coordinated effort between State experiment stations and the Department so that sounder recommendations for preventive practices could be worked out. Among the visible major changes in such research, a marked improvement in the organization of investigational work with the various diseases and pests has taken place, particularly in the careful design of experiments leading toward a better interpretation of results, and in the extension of research along important new lines which had received little or no attention previously.

With the current rate of progress and expansion in entomological and phytopathological research, it is not possible to chronicle and evaluate all that should be mentioned, but the following comprise some of the important results of projects carried on or reported on during the fiscal year at the various experiment stations, often in cooperation with the Department.

GRAIN DISEASES

Grain diseases and pests are probably the most serious causes, aside from unfavorable weather, of low yields and quality and consequently of high bushel-production costs for the grain farmer. In view of the present national and international situation the problem of reducing these costs assumes major importance. To aid the cereal producer nearly all the States are carrying forward intensive research on the major grain parasites and are breeding up, as rapidly as

possible, high-yielding, high-quality varieties which show inherent resistance to various diseases. In this work the Department (B.P.I.) has long cooperated with the experiment stations.

Stinking smut or bunt of wheat.—Due apparently for the most part to the wide adoption by growers of bunt-resistant wheat varieties developed cooperatively and to the use of improved seed treatments worked out by research, the percentage of cars of wheat grading smutty dropped from 50 in 1924–25 to about 5.6 in 1939 from all carlots received at Pacific Northwest terminal points. Even greater reduction in field losses took place. The new varieties include Ridit, Albit, and Hymar from Washington; Oro, Rio, and Rex from Oregon; and Relief from Utah. The California station reports the release of two varieties, White Federation 38 and Baart 38, resistant to bunt and also rust resistant. More bunt-resistant varieties are being increased for release in 1944. When these become available, all commercially valuable varieties of wheat grown in California are expected to be bunt resistant.

A comparatively new type of bunt discovered in Montana is considered more serious than ordinary bunt because not controlled by the usual seed treatments. The Montana station, in cooperative tests of about 100 varieties of winter wheat in the infested area, found some to be highly resistant to this form, thus solving the problem for the local growers. The Idaho station in cooperative work used 10 strains of stinking smut to find out whether repeated reinfection of a resistant variety of wheat with the same race of smut would increase its infecting power on that variety. The results indicated that such was fortunately not the case. The Kansas station reported on cooperative work in which, in the greenhouse, bunt-infected spring and winter wheats could almost invariably be detected long before heading by a peculiar mottling of the leaves. The breeding program for smut resistance will now be speeded up since infected and bunt-free plants can be distinguished early.

Treating machine for loose smut.—The Oklahoma station developed a new type of hot-water-treating machine to disinfect wheat and barley containing loose smut. Its speed, with automatic control of time and semiautomatic control of temperature, insures high effectiveness for large-scale use, whereas previous methods were too troublesome for wide adoption on the farm.

Storage of treated grain.—To answer the question whether treatment with the widely used ethyl mercuric phosphate dust would result in injury of the grain during storage, the New York State station experimented with five seed stocks of wheat, oats, and barley. Only an insignificant amount of injury was noted following treatment and 3 to 15 months' storage. Greenhouse tests after 2½ years of storage showed that the treated grain produced more and heavier seedlings in disease-infested soil than similar untreated seed. It was also found that timely aeration may benefit seed that must be held in storage for several months. Properly treated grain could thus be held over safely from one year to the next in sacks in the barn.

Grain rusts.—Released in the fall of 1939, the stem rust-resistant White Federation 38 and Baart 38 wheats developed by the California station and the Department (B.P.I.) went straightway, almost uninjured, through the most widespread and destructive stem rust

epidemic California had experienced in 25 years. Six susceptible varieties at the same time showed losses of 60 to 100 percent in the Imperial Valley and 15 to 60 percent in the San Joaquin Valley. Cooperative work by the Minnesota station showed that population shifts may be expected in physiologic races of stem rust in the United States, and that rusts overwintering in northern Mexico may become a menace to United States grain fields. It was also discovered that certain wheat varieties highly resistant to particular races of stem rust at low temperatures were far more susceptible at high temperatures. This points to the necessity of developing resistant varieties for different climatic areas. To this end the station conducted studies which showed how different genetic factors for resistance are influenced differently by environment in respect to various races of stem rust, bunt, and flag smut of wheat. The Georgia station developed a useful technique for insuring heavy rust infections in the field in connection with experimental plats used for breeding rust-resistant varieties. The Kansas station met with success in its preliminary trials with hard red winter wheat crosses which have been bred up for combined resistance to leaf rust, stem rust, bunt, and hessian fly, the major pests of the crop in that State.

Research by the Oklahoma station showed that the races of orange leaf rust include many mere environmental variants, a fact that simplifies the breeding problem. Fifty rust-resistant hybrids were being multiplied and tested by that station. The leaf rust was found not to carry over the summer in Oklahoma. Airplane spore-trapping showed that it is blown in from the north in autumn. The economic importance of leaf rust was shown by Minnesota station tests where reductions in yield and quality from this parasite were found equivalent to losses of $9 per acre.

Take-all disease of cereals.—The Kansas station and the Department (B.P.I.), studying this root-infecting disease, found that its establishment in a new location is slow and uncertain and that infestation often apparently disappears from take-all spots in the field. Infected roots of living plants appeared probably the most important means in the spread and establishment of this disease, thus explaining the control value of crop rotation. That insect attacks may predispose cereals and grasses to root rots was established by the Minnesota station.

Resistance to wheat mosaic.—Prairie, a new wheat from the breeding plats of the Illinois station, was being increased because it is outstanding for its combination of important characters. Highly resistant to the mosaic disease, very winter hardy, and above average in resistance to lodging, it shows fair resistance also to the leaf and stem rusts and is a high yielder.

Milo root rot.—This destructive disease, recognized in California only since 1935 but now widespread, no longer threatens to eliminate production of grain sorghum in that State. Selection for resistance, begun by the California station in 1936, gave superior, highly resistant strains of the three types of grain sorghum grown in the State. These are making rapid headway. In Texas, after the third year in growers' hands, a million pounds of seed of root rot-resistant Texas milo were grown. This is enough to replace the old susceptible milo on half a million acres with this Texas station strain.

309632—41——6

Sorghum smut.—The great variability of the sorghum smut fungus was disclosed by Minnesota station research. Knowledge of this kind is essential to the success of any program of breeding sorghums for smut resistance.

Oat diseases.—The Wisconsin station and the Department (B.P.I.) announced the development of a variety of oats, Vicland, which 5 years of tests show to be resistant to loose smut, covered smut, crown rust, and stem rust, and to outyield the best varieties previously grown in most parts of that State The Minnesota station found that resistance of oat varieties is highly variable and depends in part upon the physical and chemical evironment. The Louisiana station, studying the crown rust disease, reported that the germination of the spores that produce infection is strongly influenced by temperature. In a 3-year test Victoria was found to be the most highly resistant variety under both Louisiana and Minnesota conditions. It contains a substance which, when extracted, interferes with the normal development of infection threads from the crown rust spores.

Both crown rust and stem rust infection were found by the Iowa station and Department (B.P.I.) to reduce the capacity for cold resistance in young plants. The relative hardiness of different varieties and selections was tested out by means of important techniques developed for the purpose.

Corn diseases.—Hitherto unsuspected as a serious parasite, a species of *Helminthosporium* is reported by the Indiana station to have caused widespread damage for 2 years to the inbred Pr corn in Indiana. The station is working to produce from selected parents a strain of corn similar to Pr but resistant to the disease. A peculiar sterile condition in corn as well as in certain grasses was studied by the Illinois station and found to result from the development of leafy shoots in place of male and female flowers in the tassels and ears, respectively. Although the abnormality was always associated with low spots in fields, the precise cause was not discovered. The kinds of weeds and volunteer grasses that grow on "rested" land were found by the Florida station to absorb much larger proportions of zinc than planted crops. When plowed under this vegetation makes available sufficient zinc to prevent the serious "white bud" trouble in corn due to zinc deficiency.

Heat treatment reduction of seed-borne diseases.—Artificial drying of corn at 120° to 130° F., if considerable moisture was present, improved its germination, presumably by destroying certain fungi associated with the seed. The Indiana station, while studying this method, learned that, on the other hand, most fungi were able to survive a temperature as high as 140° under extremely dry conditions. The station is working to find the safe effective heat limit for different corn varieties and hybrids.

Rice diseases.—In tests by the Arkansas station and the Department (B.P.I.) differences were found in the susceptibility of various rice varieties to leaf disease caused by the fungi *Cercospora* and *Helminthosporium*. An extensive breeding program to develop resistant types has therefore been started. In an effort to determine the cause of the serious rice-leaf injury called by growers "white tip," the Texas station found that lack of sufficient available magnesium produced this type of symptom. The trouble was corrected by giving the rice plants

additional magnesium. Under the conditions of the test, lime also had to be added. Otherwise the magnesium caused injury.

GRAIN INSECTS

European corn borer.—The Virginia Truck station, cooperating with the Department (B.E. and P.Q), has found on the Eastern Shore that this pest has three generations per year, the first infesting potato stems chiefly but the majority of the second and third developing in corn. During the 4-year period reported upon, corn planted between May 15 and June 10 produced consistently higher yields than did corn planted before or after these dates. The investigations demonstrated that winter and early spring mortality due to weather conditions was negligible, but that hot winds and drought caused high mortalities to eggs and small larvae. Of the farm practices which may affect borer abundance, that of cutting the stalks low in fields and feeding them in pounds has been found to kill many borers. At least one of the six parasites liberated on the Eastern Shore has become established.

As the corn borer has reached important proportions in some regions of Indiana during the past 2 years and is definitely becoming two-brooded, the Indiana station is giving more emphasis to research on this insect. Its studies include varietal resistance and tolerance, date of planting as it relates to both one- and two-brooded borers, the single-farm husker-shredder as it relates to corn borer destruction, and the use of attractive lights for the destruction of corn borer moths. Particularly important are the studies on resistance and tolerance of various strains of hybrids, since they show that, although some are definitely susceptible, in general hybrid strains are more resistant than open-pollinated varieties and stand up better under attack. The R–4 inbred strain, for instance, when used in certain combinations, has given a relatively high degree of resistance.

The Ohio station, in cooperation with the Department (B.E. and P.Q.), has described and identified the areas of Ohio that appear most favorable to the corn borer. Investigations during a 15-year period show that the avoidance of abnormally early planting on well-drained fertile soil and the use of resistant and tolerant strains of corn are the best defenses. Not only is borer survival higher on early- than on late-planted corn, but it is also higher in early- than in late-season strains.

Preliminary studies with different types of electric lights by the Indiana station demonstrated that moths are definitely attracted to certain kinds of lights in sufficient numbers to reduce, but not to eliminate, corn borer populations in areas where lights are used. For example, 10 such trap lights in a 10-acre field of corn destroyed 11,176 borers, 60.7 percent of which were gravid females. The data from this field indicate a 75-percent reduction in borer population.

Corn aphids.—Control work during a 4-year period on the soil experiment fields of the Illinois station at Clayton showed that heavier infestations of the corn root aphid (*Anuraphis maidi-radicis* (Forbes)) occurred in fields plowed the first half of April and not worked until just prior to corn planting, than in fields plowed a week prior to corn planting and thoroughly cultivated in the meantime. These results led the investigators to recommend that plowing be

delayed until just prior to corn planting if the control of this pest is the only factor to be considered.

Differences ranging from complete immunity to extreme susceptibility to the corn leaf aphid have been found in inbred lines and single crosses of corn by the Indiana station. Plantings are being made at the Auburn branch station to study the reported correlation of corn leaf aphid resistance and European corn borer resistance.

Chinch bug.—A discussion of plant breeding and selection for insect resistence, including the discovery of resistant varieties of sorghum, has been published by the Oklahoma station cooperating with the Department (B. E. and P.Q., B.P.I.). Studies to determine the genetic character of chinch bug resistance in certain varieties of sorghums revealed indications that resistance is a dominant characteristic. Atlas sorgo and several kafirs have been shown to be sufficiently resistant and well enough adapted to southwestern Oklahoma to be recommended for that area, where resistant varieties are particularly needed because the seasonal history of the chinch bug in that area is such that the barrier-type defense used elsewhere is not effective. The determination of the inheritance of chinch bug resistance in sorghums through measuring the injury to the plants was found difficult because of the frequent occurrence of hybrid vigor that enables plants to escape serious injury. When chinch bugs were confined on the stems of field-grown plants of susceptible sorghum varieties by means of small celluloid cages, more eggs were laid than by those similarly confined on resistant varieties. Egg counts obtained by this method tend to demonstrate in the F_1 generation the crosses that offer the greatest promise for resistance. Data from 11 F_1 sorghum hybrids indicated that in most of the crosses resistance was dominant to susceptibility.

Hessian fly.—Experiments by the Indiana station and the Department (B.E. and P.Q.) have further demonstrated that early-seeded wheat is most heavily infested, and that seeding after the safe date produced better yields in years of severe infestation. It is recommended that general adherence be given to the safe seeding dates each year if losses are to be avoided, since this insect can build up to extremely high and injurious infestations within a single year.

Studies by the Kansas station and the Department (B.E. and P.Q., B.P.I.) on the resistance of crop plants to insect attack have demonstrated that hybrids made in 1931 between hessian fly-resistant Marquillo spring and winter wheats, especially Oro, Tenmarq, Kawvale, and Minturki, continued to show desirable resistance to this pest both in the hard- and soft-wheat belts. Some selections showed resistance to the wheat jointworm (*Harmolita tritici* (Fitch)). Resistance to these hazards of wheat production were combined for the first time in winter wheats which in addition showed promise of yielding ability.

Grasshoppers and Mormon crickets.—The Montana station has investigated the resistance of different barley varieties to grasshopper attack. Composite Cross C. I. 5438 was found more resistant to grasshoppers than the present Montana-recommended barley varieties. In an examination of 112 fields after a very even and large hatch of the lesser migratory locust, the station found that types of tillage early in the season have a marked effect on reducing the number of little hoppers which actually hatch. Considering untreated idle fields

as 100 percent, the following observations were made: Stubbled-in, 68.7 percent hatch; disking, 54.0; duckfoot cultivating, 29.1; and plowing, 8.1 percent hatch. This indicates that where plowing can be done in infested fields nearly 92 percent of the eggs can be kept from hatching.

Trials by the North Dakota station at the Edgeley and Langdon substations have also demonstrated that soil tillage may have an important bearing on grasshopper control. Experiments designed to test the effects of spring tillage operations, including plowing, disking, and duckfoot cultivating, showed that moldboard plowing ranked first as an aid to grasshopper control. Plowing in this manner served to bury most of the egg pods below their normal level in the soil and prevented the grasshoppers from reaching the surface. The one-way disking, or disk plowing, rated second to moldboard plowing. Though the disk plow (sometimes referred to as the "wheatland plow") did not bury the pods as well as the moldboard plow, it proved satisfactory for destroying weed growth and other vegetative cover. Disk plowing, it was concluded insofar as spring tillage is concerned, is decidedly unsatisfactory for preventing grasshopper development, while results with the duckfoot varied considerably.

The Montana station, while investigating the effects of insecticides on Mormon crickets, noted the lack of adequate dusting equipment and developed a new type of duster which it considers more efficient than anything yet on the market.

Fall armyworm.—The New York State station has published notes on this pest (*Laphygma frugiperda* (S. and A.)). This insect overwinters in the South and migrates farther northward with each generation in the season, reaching New York in mid-August.

Grain aphids.—Two species of aphids have been reported by the Colorado station as heavily infesting wheat fields in northeastern Colorado, southern Nebraska, and adjacent parts of Kansas. Neither species appears to have been previously reported from this country, and one is apparently *Rhopalosiphum splendens* (Theob.), first described from wheat in Egypt in 1915 and later reported on wheat and grasses in Morocco.

Use of an airplane enabled entomologists of the Oklahoma station to detect greenbug infestations and to classify them as heavy, medium, and light. Most of the State was surveyed in 2½ days and the limits of the infestation determined. The airplane method is more rapid and economical then any devised heretofore.

COTTON DISEASES

Research of recent years has brought about progressive reduction of losses from a number of cotton diseases. Costs of production have been correspondingly lowered for many thousands of cotton farmers. Further benefits may be expected to result from current cotton-disease investigations. In the main these are conducted cooperatively by various experiment stations and the Department (B.P.I.) Such joint effort is facilitated by a voluntary organization of research workers, the Cotton Disease Council, which meets annually to consider new findings and plan future work.

Cottonseed treatment.—Seed- and soil-borne infections seriously cut down the stands of plants in bad seasons and reduce final yields of cotton. Experiment station work has shown the value of seed treatment to lessen seedling losses from such causes, and as a consequence both delinting and chemical dusting of seed have been adopted extensively. The stations, however, have continued to work for improved seed-treatment methods and on the conditions affecting their success. The Mississippi station tried to find out whether ethyl mercury dust would cause injury if seed treated with it were kept in storage for a considerable period afterward. The tests demonstrated that even 17 months following treatment the dusted seed sprouted better than seed of the same lot left untreated, whether kept during all that time under outdoor conditions or inside a laboratory. How profitable such treatment may be was indicated by the average 25-percent increase in both emergence and yields. In experiments by the Georgia station cottonseed treated with the mercurial dust, but not delinted, gave an increase of 200 pounds of seed cotton per acre over the same grade of untreated fuzzy seed, while cottonseed merely machine-delinted without chemical treatment gave a yield within 56 pounds of that produced by the same delinted seed treated with the mercury dust. The economic results of the work of the Arizona station with the sulfuric acid-delinting of cottonseed to reduce the amount of black arm and angular leaf spot carried with the seed are reported as outstanding. During a recent season approximately 500 tons of planting seed, enough for over 50,000 acres, were treated in the State. Under irrigation the delinting process has made possible, with good seedbeds, a substantial reduction in the planting rate per acre. Thus more seed can be sold for oil production. A combination method of delinting and flotation grading of cottonseed increased cotton stands in Oklahoma station trials and also increased the yields. Cost was more than offset by savings of seed and labor and by yield increase. That different types of disease-producing organisms are carried with the seed in different cotton-growing regions has often been found by station workers, hence the stations are working out methods of treatment applicable to each area.

Fusarium wilt of cotton.—The South Carolina station discovered unexpectedly that the widely prevalent fungus causing common cotton wilt also attacks tobacco. Prior to this it had been the general opinion that each crop was attacked by a different species of *Fusarium*. Previous station research had shown that soil applications of potash often increase resistance to wilt in cotton varieties, but the station discovered that moderately large applications may sometimes bring about a severe magnesium deficiency so injurious as to counteract the beneficial effects of the potash. The same station conducted work for 3 years with 18 varieties of cotton at 3 different places where wilt appeared to behave differently, to find out whether the difference was due to the presence of different strains of the wilt fungus, but no evidence of different strains was found. Breeding cotton for wilt resistance would be badly complicated if there were fusarium strains that are unlike in their parasitic behavior. Investigations of chemical characteristics were also conducted with 2 cotton varieties, 1 susceptible and 1 resistant. The susceptible variety tended to have a higher percentage of nitrogen in its tissues than the resistant variety. Furthermore, infected plants usually lived longer when the

level of nitrogen was low than when high. This information may give valuable clues to improved control by breeding or cultural methods.

Root knot nematode and cotton wilt.—Previous station work has indicated that the presence of the microscopic root knot eelworm greatly aggravates the severity of fusarium wilt. In comparing 31 varieties and strains of cotton, including the major upland and introduced types and hybrids, the Mississippi station discovered that in land heavily infested with both organisms, those upland types that showed highest wilt resistance were, as a group, relatively low in root knot infection. Those of intermediate wilt resistance showed more root knot attack, while those extremely susceptible to wilt were also extremely susceptible to the nematode. One sea-island variety that had never shown a trace of wilt sustained the least root knot of all cottons in the test, but another sea-island strain with rather low resistance to wilt showed considerable root knot. Of 2 Hopi varieties, both of which showed very high nematode attack, one had a low percentage of wilt while the other became 100-percent infected. Such research shows the possibilities and lays the foundation for developing high resistance to both parasites in the various cotton types.

Sore shin of cotton.—Caused by a widespread and persistent soil-borne fungus, *Rhizoctonia*, this disease has been a serious cause of damage to seedling cotton in the eastern Cotton Belt. Successful control may eventually result from clues obtained from intimate study of the causal organism. In this type of study, conducted cooperatively by the South Carolina station and the Department (B.P.I.), the investigator obtained for the first time the complete life cycle of the fungus through inducing spore production in artificial cultures.

COTTON INSECTS

Bollweevil, bollworm, and flea hoppers.—Good control of the bollweevil with very little difference between treatments was observed at the Mississippi station, in cooperative tests with the Department (B.E. and P.Q.), when $\frac{1}{10}$-acre plats were dusted with a 1:2 or 1:1 mixture of calcium arsenate and sulfur, or with calcium arsenate alone, each replicated 12 times. Although heavy weevil damage occurred in untreated plats, large plats of late-planted cotton treated with a 1:1 mixture of calcium arsenate and sulfur and with calcium arsenate alone gave large gains and profits in both cases, with slightly better results from the mixture than from calcium arsenate alone.

Tests reported by the Texas station indicated that calcium arsenate alone and with 5 to 10 percent of paris green, cube containing 0.8 percent of rotenone, and 50-percent sulfur were equally effective against the bollworm when the quantity of calcium arsenate included was applied at the rate of 7.76 to 9 pounds per acre. When the calcium arsenate content was reduced to 7 pounds per acre, the yield was reduced. Pyrethrum dust, containing 0.09 percent pyrethrins I and II and with sulfur as a carrier, did not prove effective against the bollworm.

Data from the Mississippi station show that it is apparently unnecessary to poison bollweevils or flea hoppers before the first or second week in July, if the cotton is well protected after that time.

Growers are advised to wait until plants are large and fruiting heavily, and if infestation counts then show that 10 to 25 percent of the squares on heavily fruiting plants are being punctured, applications of calcium arsenate should be applied.

Aphids.—The South Carolina station, reporting on cooperative work with the Department (B.E. and P.Q.), has found that increase in cotton leaf aphids following the use of calcium arsenate dust for bollweevil control can be prevented by the addition of a small amount of derris to the dusts. Also effective against the cotton boll-weevil, yet not causing an increase in plant lice, were mixtures containing equal parts of calcium arsenate and sulfur, and calcium arsenate and diatomaceous earth, to which enough ground derris root was added to make each mixture contain 0.5 percent of rotenone and applied at the rate of 8 to 10 pounds per acre per application.

A method of control for the cotton root louse has been worked out at the same station. Actually, control is directed against the cornfield ant, since it is responsible for the presence of lice on the cotton, and consists of the use of a poison bait composed of cane sirup, sugar, and tartar emetic, mixed with water and boiled. Cottonseed hulls are thoroughly soaked in this mixture and small handfuls placed about 10 feet apart in each third row.

Thrips.—A study by the Texas station on the effect of thrips injury on production in cotton revealed that attack results in a smaller size of boll, a smaller number of bolls per plant, and late opening of the bolls. Loss in bottomland fields was calculated at from 107 to 358 pounds of seed cotton per acre; two upland fields suffered an average loss of 61 pounds per acre.

TOBACCO DISEASES

Tobacco downy mildew or blue mold.—Rapid progress has been made in developing the use of copper-oil spray or of vapors of benzol and paradichlorobenzene to control this destructive disease in tobacco seedbeds. Practical growers are now adopting these methods, developed through extensive experiments by the experiment stations in tobacco-growing States and by the Department and Duke University cooperating with them. These agencies have devoted further attention to the way the disease acts under various conditions to give a basis for more accurate and economical control. They have studied how the spray chemicals behave when used in different concentrations and in different ways. The idea is to devise measures of greatest practical efficiency and lowest practicable cost. The Florida station found that the disease may be successfully controlled in beds by use of paradichlorobenzene applied as soon as the disease appears, perhaps at less expense over a period of years than by preventive spraying several times each year. In the spring of 1940 the South Carolina station tried out a wide range of spray and vapor treatments, finding that paradichlorobenzene used every fourth night gave as good mildew control during the mild attack of that year as treating on alternate nights. Flea beetles unfortunately survived. The Virginia station in cooperation with Duke University showed that vaporization will kill out the mildew parasite even after it has become established inside the leaf tissues. This would appear to lay the foundation for a wide range of new possibilities in the way of eradicating plant parasites by use of penetrant gases.

Tobacco mosaic and yellow ring spot.—The first of these troubles is caused by a world-wide, long-lived virus the study of which has given better insight into the nature of the peculiar and destructive ultra-microscopic substances that affect plants and animals. Persistent and difficult work is continuing in the hope that the finding of facts about the chemical nature of viruses will pave the way to more effective methods of prevention or control. X-ray experiments at the Iowa station tended to confirm the idea that the tobacco mosaic protein molecule is large, with a molecular weight of 16 to 20 million, and capable of reproducing itself if the larger portion of the molecule remains unmodified. Missouri station findings indicated that this impression of large size may be due to the method of preparation of the virus, and a different method was devised which may lead to improved accuracy in such studies. The New York (Cornell) station also contributed much to a fundamental knowledge of the nature and characteristics of the mosaic virus. The yellow ring spot, another tobacco virus, was found by the Kentucky station to be capable of being carried through the seed from generation to generation without showing the typical ring-like markings and to survive 5½ years. These important facts have a bearing on successful control of the disease.

Tobacco blackfire and wildfire.—These bacterial leaf-spot diseases, which sweep destructively through many a tobacco-growing area in a bad year, have been most difficult to deal with, defying at times the best control practices science has thus far devised. Each year, however, sees added results of research that may eventually conquer these troubles even when conditions favor an epidemic. The Pennsylvania station reported evidence that unbalanced environmental and nutritional conditions influence tobacco susceptibility. The wildfire organism was present on all tobacco seedlings when taken from the beds, and whether serious field damage follows or not was thought to depend upon the development of conditions of susceptibility in the tobacco plants. The Kentucky station found that spraying of seedbed plants with bordeaux mixture usually prevented the two diseases from appearing in the beds, and no damage was found in any field set out from treated beds. Extensive damage, however, was experienced in many untreated beds and in fields set from plants from them. Water soaking of leaves, reported to favor epidemic wildfire and blackfire, was found by the same station to result in extensive injury to dark tobacco even in the absence of bacterial infection. Such information may help to clarify a complex disease situation which has been confusing to growers and scientists alike.

Tobacco bed rot.—Vapors of benzol and paradichlorobenzene were found in preliminary tests by the Connecticut State station to be effective in the control of damping-off or bed rot due to soil fungi. This extension of the use of gases in plant-disease control points to the probability that there are still further possibilities of value to farmers and greenhouse men to be worked out in the future.

TOBACCO INSECTS

Flea beetles.—Of significance to tobacco growers are studies reported on the overwintering habits and seasonal life history of the tobacco flea beetle (*Epitrix parvula* (F.)), as carried on by the Virginia station at Chatham, Va. In 1938, emergence from overwintering

quarters began on March 19 and continued until May 28. Adults were found in dead leaves and forest litter near tobacco fields on September 21, although other adults were noted still feeding as late as November 1. In the insectary four generations were reared, and the length of the various stages were summarized.

The Pennsylvania station reported that, of the 11 species of flea beetles found on tobacco or upon plants growing in tobacco or adjacent fields, *Epitrix cucumeris* (Harris) was the most abundant species during April, May, and June. The foliage of tobacco plants in seedbeds or those recently transplanted was severely injured. *E. cucumeris* was also observed feeding on potato and tomato plants during the same period.

SUGAR BEET DISEASES

Sugar beet seedling diseases.—These diseases, usually referred to as "black root" and characterized by rotting of the young beet roots, are said to have occurred commonly in rotation plats at Huntley, Mont., and also in all the sugar beet growing areas of the State. Phosphate deficiency was also important, especially where beets followed alfalfa, and fusarium wilt assumed dangerous proportions wherever sugar beets were planted continuously on the same ground or in 1-, 2-, and 3-year rotations. In greenhouse tests by the Montana station soil treatments proved most important for control, but seed treatments were also of some benefit. The smallest amounts of disease occurred in the flats with soil that received applications of nitrates, phosphates, and manure, and with soil sterilized by steam or disinfected by formaldehyde. In 3 years' field trials seed treatments alone were only slightly beneficial, while soil treatments were highly successful. It was concluded that seedling diseases can be efficiently controlled and good stands and high yields obtained by the use of a complete and well-balanced fertilizer, by the improvement of the physical condition of the soil, and under some conditions by treating the seed.

The Washington station learned from an extensive 2 years' study involving 31 different fungi isolated from affected sugar beet roots throughout the Puget Sound district that the fungus most frequently found and the only one capable of inducing black root was *Phoma betae*, which is carried in the beet seed balls. None of the treatments tested gave significant control where the soil was severely infested, but where there was very little present Ceresan and New Improved Ceresan gave some protection against the preemergence stage. Crop rotation and use of domestic seed, together with seed treatment, are recommended.

Sugar beet root rots.—The Minnesota station with the Department (B.P.I.) made comparisons of the appearance and growth requirements of the *Rhizoctonia* strains inducing dry rot cankers of the roots with those causing crown rot of beets and those attacking potatoes. The dry rot canker strains from sugar beets differed in many respects from the crown rot strains, and the sugar beet and potato strains as to optimum temperatures. The dry rot canker forms proved most active in causing decay of sugar beet roots at 30° to 35° C., and were favored by relatively low soil moistures. The New Mexico station has reported studies of a serious root rot of sugar beets grown for

seed which was extremely prevalent in widely separated fields and found to be associated with both *Rhizoctonia* and *Fusarium*.

SUGAR PLANT INSECTS

The Idaho station cooperating with the Department (B.E. and P.Q.) found only one insecticide to be specific for the beet leafhopper—pyrethrum. The results indicated that 50:1 and 40:1 ratios of oil to pyrethrum are too large; best results were obtained at 25:1 and 30:1. In general, the percentage of kill increased as the pyrethrum content increased and as the per-acre application was raised from 5–6 to 7–8 gallons, but disease counts showed no significant difference between the various treated and untreated plats. The results did not show a correlation between yield obtained and the spray applied, but this was expected since the beet leafhoppers were found to redistribute themselves over the plants following each spray application. A satisfactory yield under heavy infestations was produced by U. S. 12, one of the resistant varieties. Movement during the spring to cultivated areas was noted over a 12- to 36-day period, and this migration coincided well with the seedling stage, at which age the plant is most susceptible.

FORAGE AND COVER-CROP DISEASES

Grasses resistant to disease.—The increasing importance of diseases in forage-crop production was shown by the South Dakota station in connection with variety tests and an investigation of adaptation and date of seeding in which, because of seedling blight or foot rot, it was found difficult to secure stands of grasses. This serious condition led to the initiation of seed- and soil-treatment trials for controlling these foot rot diseases on crested wheat, Russian wild-rye, and bromegrasses. Individual selections were also made of plants appearing either to have escaped or to be resistant to infection. These have been planted on badly infested soil with the view to building up strains of grasses more resistant to the foot rots.

Alfalfa wilt.—In a survey of the State, bacterial wilt (*Phytomonas insidiosa*) was found by the Washington station to be generally prevalent and to be playing an especially important part in gradually reducing the stands of alfalfa in the Yakima and Okanogan valleys. Records taken on 25 varieties to show the percentage of stand, the percentage of bacterial wilt, and the yield in tons per acre revealed Ladak, Hardistan, and Turkistan as exhibiting the highest resistance both to winter injury and to wilt.

Hairy vetch leaf spot.—In studying the incidence and longevity of the leaf spot fungus (*Ascochyta pisi*) in seeds of hairy vetch, the New York State station demonstrated its presence in 1934 in only 1 of 181 lots of seed imported in 1929–30 and in 16 of 110 lots imported in 1931–32. Of a total of 224 samples representative of both the domestic and foreign crops of 1931–37, tested immediately on receipt, 149 were internally infected, but during storage in a warm, dry laboratory for 1 to 5 years the number of fungus-infected seeds decreased continuously though the viability of the seeds remained nearly constant for 4 years or more. This suggests the value of prolonged seed storage as a means

of controlling attacks by this parasite. The fungus and its spores were less affected by hot-water or hot-air treatments than were the vetch seeds, but infections in seed stocks treated with New Improved Ceresan decreased significantly during 2 years' storage. This parasite was also present in seeds of various other species of vetches, but was never found in those of common vetch.

Leaf spot of forage legumes not related to a tomato disease.—There has been considerable question as to whether the fungus *Macrosporium sarcinaeforme* causing leaf spots on various species of legumes and one, *Pleospora lycopersici*, inducing a fruit rot of tomato might not in reality be different stages of the same parasite. To settle this point the California and Missouri stations, in separate tests, inoculated each fungus into tomato, alfalfa, and white sweetclover, and also into red, white, and alsike clovers. The tomato fungus readily infected the fruits, leaves, and flowers of tomato, but gave no evidence of being able to attack any of the leguminous crops tested. On the other hand, the legume fungus failed entirely to infect tomato but readily attacked all the leguminous crops in the test. The two fungi also differed in various other characters as shown by growth in pure cultures. Thus, so far as this fruit rot is concerned, tomatoes may follow forage legumes in the rotation. The fruit rot probably originates from floral infection by way of spores (conidia) developed on leaf spots of the tomato plant itself.

Sweetclover diseases.—An early spring fungus root rot of sweetclover (due to *Phytophthora megasperma*) is reported to occur from Ohio northward into Wisconsin. In general it has been most abundant in low, wet portions of fields, where, during seasons of heavy spring rainfall, it may rapidly destroy almost all plants. Search was instituted by the Wisconsin station with the Department (B.P.I.) for individual plants showing resistance to infection, and while thus far all common white sweetclover plants from roadsides or commercial fields have proved susceptible, occasional resistant individuals were obtained from a few selected strains of white sweetclover and a foreign selection yielded many of them. Progenies from selfed seeds from some of these resistant selections have given 50 to 75 percent of healthy plants as compared with 10 percent from unselected seeds.

A search under the same cooperative arrangement for the stem-blight fungus (*Ascochyta caulicola*) in sweetclover seed resulted not only in its isolation but also that of three other fungus parasites of this crop plant. The evidence seems to indicate that stem blight is chiefly a seed-borne disease.

A cowpea pod rot.—In the fall of 1937 at Experiment, Ga., a fungus was found causing a decay of about 5 percent of the pods of Groit cowpeas. The following year the same fungus was observed in the locality, causing very little damage on account of the dry season, but, even under these adverse conditions, revealing one or more infected pods to the rod of row in nine cowpea varieties. Further studies by the Georgia station identified the fungus as *Choanephora cucurbitarum*, a form frequently encountered developing on cut leaves of grasses under moist conditions in this and neighboring regions. Inoculations showed the parasite capable of attacking the green as well as the more mature pods, though less readily. It appears that the fungus is a weak parasite on this crop and may be considered a storage

rot which might cause damage in transit to cowpeas picked and shipped in the pods.

Peanut leaf spots.—In further investigations of the two *Cercospora* (*Mycosphaerella*) leaf spots of peanuts, important technical studies of the fungus parasites by the Georgia station have made it possible to distinguish easily and quickly between the 2 species as well as between the symptoms which they induce. This should make it more readily feasible to test the effectiveness of plant breeding for resistance or chemical control methods for each disease. The North Carolina station reported that in 70 demonstrations in 13 eastern counties of the State during the past 3 years sulfur dusting of peanuts for the control of leaf spot has increased the average value of the crop per acre by nearly $7 at least. The treatment increased the yield of nuts by an average of 265 pounds per acre and the hay yield by 412 pounds. As a result of these demonstrations, based on previous experimental work, the practice of applying sulfur dust to control peanut leaf spot is recommended unquestionably for commercial use.

FORAGE AND COVER-CROP INSECTS

White grubs.—Thirty-six species of white grubs, which are the larvae of May beetles (*Phyllophaga* sp.), occur in Kentucky. Life-history studies by the Kentucky station indicate that white grubs in the State have 2- or 3-year life cycles, and hibernation studies show that they spend at least the first part of the winter in their pupal cells, some species beginning to burrow toward the surface in January and February. *Phyllophaga ephilida* (Say) was found to differ from most other grubs in that it overwintered in the soil at a depth of only 3 inches. The presence and prevalence of the species of white grubs were found to vary with the physical regions of the State. For example, in the inner bluegrass region most of the stripping of oaks in May is done by *P. hirticula* (Knoch), the dominant species in that region.

The New Jersey station has published a practical account of white grubs in lawns and golf courses. Observations by the Kansas station indicate that the wheat white grub (*P. lanceolata* (Say)) is a potential golf-course pest in central Kansas.

Sod webworms.—Three species—the bluegrass sod webworm (*Crambus teterrellus* Zinck.), the striped sod webworm (*C. mutabilis* Clem.), and the leather-colored sod webworm (*C. trisectus* Wlk.)—are commonly found in bluegrass sod in Kentucky. According to observations at lights, two broods and a possible third are indicated for *C. teterrellus*, but two broods only for the other two species. Since 1934 the Kentucky station has been working on their control, particularly in lawns. While a spray containing pyrethrum was most effective in bluegrass sod, a kerosene emulsion consisting of ½ pound of hard soap, 1 gallon of water, and 2 gallons of kerosene diluted at the rate of 1 part to 10 of water and applied at the rate of 2 gallons to 20 square feet also gave good results. Two pounds of lead arsenate in 20 gallons of water was fairly effective when applied at the rate of 2½ pounds to 1,000 square feet.

Wireworms.—The Idaho station continued cooperating with the Department (B.E. and P.Q.) in investigations for cultural controls

of wireworms. The following crop rotation is being tried in field plat studies: Alfalfa, first 4 years; early potatoes, fifth year, followed by plowing land August 1; wheat without legume, seventh year, again plowing land August 1. The alfalfa is included to maintain soil fertility, as well as to reduce wireworms, and plowing the land August 1 is expected to destroy a large percentage of transforming adults. Though these studies are in but their third season, a substantial reduction in wireworm numbers has occurred in the alfalfa plats.

The Kentucky station has published technical descriptions of four species of wireworms that live in bluegrass sod in Kentucky.

Legume weevil.—New to the United States, this pest (*Hypera brunneipennis* Boh.), closely related to the alfalfa weevil (*H. postica* Gyllenhal) which is now generally distributed throughout the Great Basin States, was discovered at Yuma, Ariz., in April 1939 by entomological workers from the Arizona station. A survey conducted by the Department (B.E. and P.Q.) and cooperating stations disclosed that it is present in limited parts of the Yuma Valley in Arizona and California. This weevil is a minor pest in its native habitat in northern Africa and in Egypt but is held in check there by cultural practices. It is apparently adapted to a subtropical environment. It has been found on bur-clover (*Medicago hispada* Gaertn.) and alfalfa (*Medicago sativa* L.), but sour clover (*Melilotus indica* All.) is apparently the favored food plant.

Tarnished plant bugs.—According to the Utah station, the most abundant insect inhabitants of alfalfa-seed fields during the bloom period, with the exception of thrips, were *Lygus hesperus* Knight and *L. elisus* Van Duzee. They were responsible for a significant increase of blasted buds, blossom drop, and shriveled seed during the production of an alfalfa-seed crop, the degree of injury generally varying with the intensity of the infestation. Although no insecticide has been found effective in either destroying or repelling these insects, it is noted that some measure of control may be obtained by keeping ditchbanks, fence lines, roadways, waste places, and all cultivated land free from weeds and crop litter. Further, it is pointed out that a seed-growing community should adopt a uniform practice of selecting either all first- or all second-growth alfalfa for the production of seed, since simultaneous occurrence of both first- and second-crop alfalfa provides *Lygus* bugs with favorable conditions for multiplication.

Cowpea curculio.—In recent years canners have shown increased interest in canning cowpeas for human food, but wormy peas caused by the cowpea curculio have been a difficult problem. Studies by the Georgia station indicate that the use of poisonous sprays is not practicable. Selections of varieties for resistance to the curculio have shown a variation from 2.1 to 12 percent of infestation.

Observations on this pest by the Mississippi station showed that two or three generations occur annually. Four larval instars were noted, three and a part of the fourth being passed in the seed and the remainder of the fourth in the soil. Adults emerged 20 to 30 days after egg deposition under favorable conditions. Except for the last generation, which delays oviposition until the following spring, adults began oviposition about 10 days after emergence.

POTATO AND SWEETPOTATO DISEASES

Bacterial ring rot of potato.—Gratifying progress is reported in the Nation-wide research on this disease, a recent invader which has spread with disconcerting speed. A committee of experiment station and Department representatives has assisted. Studies by the Maine station indicated that soil water is probably one means of rapid spread of infection in the field. Neither former methods of tuber examination at the time of planting nor seed-plat methods and field examination, with removal of suspected plants, eliminated the disease completely. Planting of whole seed gave partial control, but the only practical method demonstrated in these experiments was the use of disease-free seed. The Florida station showed that the disease developed in infected tubers rapidly at 70° to 95° F. but slowly at 37°. By elimination of most infected seed stocks, losses in the Hastings, Fla., potato area were reduced from 5 percent to 0.5 percent in 2 years. The Minnesota and Montana stations demonstrated that ultraviolet light is useful in rapid and positive detection of ring rot, since infected tubers show a blue-green fluorescence not present in healthy tubers. Potato growers will probably be able to use this method themselves in eliminating ring rot tubers from planting stock. The Colorado station reported a program under way to produce disease-free seed foundation stock of the varieties most generally grown in the State. The smear-stain test method for detecting the bacteria, with other methods gave promise for eliminating infected stock.

Potato late blight.—The Maine station with the Department (B.P.I.) studied the relative severity of attack by this disease at Presque Isle on eight new and old potato varieties. Green Mountain was the only one showing a profit from spraying in 1937, while in 1938 spraying was profitable for all the varieties. The New York (Cornell) station, continuing studies with certain hybrids, found them immune to the late blight fungus obtained from commercial potato fields but susceptible to a strain built up artificially to high virulence. To develop total immunity to all strains, persistence will therefore be necessary.

Blackleg of potato.—The Maine station reported studies of 62 bacterial strains associated with potato blackleg, seed-piece decay, and other soft rot diseases derived from widely different sources. It was concluded that they were all strains of one species, *Erwinia carotovora*. The blackleg organism was found to remain alive over winter in the pupal case of the cabbage maggot. This work throws helpful light on a frequently destructive type of disease which it has proved difficult to control.

Potato scab.—Four pounds of yellow oxide of mercury or of calomel added to each ton of fertilizer mixture were found by the New York State station, in its Long Island investigations, to reduce the amount of potato scab in soils that showed a reaction of pH 5.5 or below, the oxide being the more effective. Larger amounts gave no better control and sometimes decreased yields.

Black scurf (Rhizoctonia) of potato.—This soil- and tuber-borne cause of potato losses throughout the United States has proved very difficult to control. The New Jersey station has obtained a strain

of *Bacillus simplex* capable of producing in the soil a material toxic to the fungus of the disease. If further work shows that this germ can be used in a practical way to suppress the fungus, great benefit may result, since the parasite attacks not only potatoes but a wide variety of other crops.

Potato seed treatment.—The Maine station, studying various methods of treating seed potatoes to destroy surface-borne scab and *Rhizoctonia* found that 1 percent of hydrochloric acid added to the usual mercuric chloride solution retards the usual rapid loss of potency so that it is retained even after 25 dips. Acetic acid proved to be equally effective and also much less hazardous to handle. Cost of materials is reduced to about one-fifth of the former cost.

Virus diseases of potatoes.—Among the most difficult of potato troubles to deal with are those caused by viruses. It has been hard to find out how certain of these troubles spread in nature. The Minnesota station reported that the perplexing purple top disease had been produced artificially by exposing potato plants to the feeding of aster leafhoppers carrying the virus of aster yellows, a virus which is widespread in the United States. With this information it should be possible to protect potato fields from hitherto unsuspected sources of infection. Yellow dwarf is potentially one of the most serious virus diseases affecting potatoes over an important area of the United States, but the New York (Cornell) station has found that the Katahdin potato escapes this infection to a large extent as compared with the Green Mountain variety. Yellow dwarf is carried from clover to potatoes, but recent tests have indicated significantly more spread from alsike than from medium red and mammoth clovers. These findings will guide growers in avoiding attacks. The Wisconsin station found that plants often do not emerge from seed tubers affected with yellow dwarf when soil temperatures are high. Clover leafhopper abundance was associated with extensive spread of yellow dwarf in 1937, but evidence covering 7 years indicated that in some places other sources of the virus beside red clover plantings are probably important. Russet Burbank tended to escape infection in a section of Wisconsin where 18 other kinds of potatoes became heavily infected.

Microscopic tests for potato diseases.—Extensive microchemical tests on the corky substances in diseased parts of potato tubers affected by six different types of disease were reported by the West Virginia station. Optical properties distinguishing cutin, suberin, suberized deposits, and cellulose proved useful in studying the disease conditions and will undoubtedly aid in diagnosis.

Stem blight disease of sweetpotato.—The Florida station found that soil treatment with ethyl mercury phosphate resulted in practical control of the fungus causing this disease, *Sclerotium rolfsii*, without introducing any detectable poisonous substance into the tubers.

Deficiency diseases of sweetpotato.—The South Carolina station studied the effect on deficiencies in nitrogen, phosphate, potash, magnesium, and calcium on the Porto Rico variety of sweetpotato. Symptoms were established which will be useful in diagnosing these different types of crop malnutrition so that proper corrective measures can be used.

POTATO INSECTS

Potato psyllid.—The New Mexico station has developed two effective insecticidal dusts for control of the potato psyllid (*Paratrioza cockerelli* (Sulc)). The most efficient consists of 60 percent of yellow dusting sulfur, 30 percent of talc, and 10 percent of Dry Pyrocide. The second contains 40 percent of yellow dusting sulfur, 40 percent of monohydrated copper sulfate, and 20 percent of hydrated lime. Both produced yields superior to those obtained from applications of either dusting sulfur alone or liquid sulfur. Statistical analysis indicated a significant superiority of the sulfur-Dry Pyrocide mixture in total yield and freedom from psyllid yellows. To be effective, these dusts should be applied in quantities of not less than 40 pounds per acre and at 10-day intervals, commencing when the first blossom buds appear and continuing until the plants are mature.

The effect of certain temperatures and combinations of temperature on the egg deposition, egg hatch, and nymphal development of the potato psyllid was studied by the Colorado station. An account of the biology and control of this insect, the most serious pest of potatoes and tomatoes in Colorado, has been published by the station. The application of a liquid lime-sulfur spray twice each season or three times during epidemic years is recommended in the permanent program of psyllid control urged for Colorado potato growers.

The Montana station reports, as a result of studies on the insecticidal activity of various toxic materials on the potato psyllid, that there is a marked reduction in effciency of most insecticides to last-instar nymphs, indicating the importance of timing treatments and more careful consideration of experimental data.

Potato leafhopper.—Studies by the Wisconsin station demonstrate that varieties of potatoes definitely exhibit variability in susceptibility to the hopperburn disease. In general, early-maturing varieties are more susceptible than late-maturing varieties.

Wireworms.—In a study of the effect of planting dates on wireworm injury to potatoes, the New York (Cornell) station found that in western New York the crop should be planted as late in the planting period as economically feasible. Late-planted potatoes do not set tubers until late August and thus are not subject to wireworm attack for as long a period as are early-planted potatoes, which set tubers about a month earlier. Rotating potatoes with such crops as clover, timothy, alfalfa, sweetclover, and wheat will result in lower infestations of the eastern field wireworm (*Limonius ectypus* (Say)) than when rotated with oats. In studies upon the varietal susceptibility of potatoes, it has been found that Warba is less susceptible to wireworm injury than other early and midseason varieties.

Stinkbugs.—According to the Colorado station a new potato disease resembling psyllid yellows but caused by the feeding of Say's stinkbug was discovered in northeastern Colorado. Medium early plantings showed 15 to 20 percent of diseased plants, while in late plantings 50 to 60 percent were affected. A definite correlation was found between the number of insects on each plant and the severity of the disease.

Sprays.—The New York (Cornell) station in reporting upon extensive tests as to possible modifications in potato spraying or dusting

practices mentioned the need for more detailed basic, quantitative measurements of the complex relations between plants, organisms, and spray materials. Potato yields suggested that some species of insects, though present in smaller numbers, may be more injurious. A brief review of the potato spraying-dusting program was published by this station.

Workers at the Virginia Truck station concluded that potato growers would benefit materially by making the application of calcium arsenate-bordeaux (2–4–6–50) a standard practice. When properly applied, this spray will control not only the potato flea beetle but also the Colorado potato beetle, the potato leafhopper, and early and late blight.

TRUCK-CROP DISEASES

Progress in the development of resistant varieties.—The remarkable achievement by State experiment stations and the United States Department of Agriculture in meeting serious vegetable-disease problems through the selection and development of resistant varieties has been brought to focus through the publication of a recent survey by the North Carolina station, which lists a total of 186 varieties of vegetables resistant to 47 different plant diseases that have been placed in the hands of growers as effective means of defense against some of the most troublesome of all truck-crop hazards. This development has taken place almost entirely within the past 25 years. Although incomplete and failing to show the large number of resistant varieties introduced since 1936, this list is representative of the progress made.

Sweet corn bacterial wilt.—Bacteriophages—literally "eaters of bacteria," those ultramicroscopic viruslike agents considered by some to be living parasites and by others to be enzymatic in nature—have been studied for the most part in their relations to bacterial diseases of man and the lower animals. However, during the past 2 years the Ohio station has revealed that bacteriophages (phages) are also developed in plants as a reaction directed against invading bacteria. In this investigation the organism used was *Phytomonas stewartii*, the parasite causing bacterial wilt of sweet and field corn. A phage precursor differing from the phage itself was shown to be present in many plants. It was found that resistant corn plants quickly set up a reaction against the invading parasite, resulting in the development of a phage from this precursor which, in turn, dissolves the bacteria or renders them innocuous. Furthermore, a method for testing corn hybrids to determine whether or not they possess the phage precursor has been developed which should greatly simplify the finding and development of resistant varieties. As a result of this investigation, we now have a more concrete idea of the nature of at least one type of resistance in plants and of how it functions.

In recent tests by the New Jersey station of 13 varieties of sweet corn at 5 points where wilt was severe enough to give reliable data, Whipcross P–39, Whipcross C–6.2, Golden Cross Bantam, Bancross P–39, and Charlevoix C–2 gave the best yields, and the first 3 proved also very resistant to wilt. A summary of the performance of 45 varieties and strains planted at New Brunswick, as to wilt, smut, yield, etc., showed that Early Bancross P–39, Whipcross P–39, and Golden Cross Bantam

again stood at the top rank. Among the very early types, Marcross 13–6 proved highly resistant.

Near-wilt of pea.—Although this fungus disease appears to be much more widespread in the United States than wilt, it has never become so acutely destructive, usually being found on occasional plants widely scattered in a field. The Wisconsin station has recently reported on an investigation which seemed particularly important in view of the attention now being given to the development of near-wilt-resistant varieties suitable for commercial production. Although wilt and near-wilt have closely related causes (different species of *Fusarium*) and certain symptoms in common, plants and varieties fell into two very distinct and separated groups with respect to resistance and susceptibility to wilt, whereas in relation to near-wilt all plants of resistant forms slowly but eventually succumbed under conditions favorable to the disease. This relative slowness of near-wilt development, regardless of variety, was outstanding and probably important in determining the fact that although it is more widespread it is generally less destructive than wilt. The fact that optimum soil temperatures for near-wilt proved somewhat higher than for wilt is held unlikely to become very important, and air temperatures had but little influence on near-wilt. In the resistant varieties used the wilting was most rapid in medium-moist soil, but here again the rate in all soils was sufficiently rapid to indicate but little checking of the disease by dry seasons.

Virus diseases of beans.—The program for the development of varieties resistant to the serious bean diseases of the State has been continued by the Idaho station on a basis similar to that of previous years. Three mosaic-resistant varieties of Great Northern beans developed by this station represented almost the entire 92,000,000-pound Idaho crop of that variety in 1939, which was about 11 percent of the total bean crop of the United States. Such replacement of varieties susceptible to this Nation-wide disease took place within 10 years after the first selection work for resistance began, and the once serious losses from mosaic are now practically nil. The most recent results indicate that many hybrid selections grown on the trial grounds now are resistant to some of the most important bean diseases found in Idaho. The varieties under study and for which an active program is now carried on to develop resistant strains include Great Northern, Red Mexican, Red Kidney, Pinto, and many wax and green-pod type garden-bean selections, all of which are important to the seed trade. Crosses have been made in the greenhouse where 2 generations can be obtained, thus permitting more rapid development of promising selections. The most recent selection of a disease-resistant variety resulting from the bean-breeding program was introduced. Great Northern U. I. 15, resistant to the viruses of both common bean mosaic and curly top, will be grown on a few seed farms, after which it will be ready for general distribution. It is believed that this variety will have special value when grown on farms near the breeding grounds of the beet leafhopper, carrier of the curly top virus. From various fields in the northern Idaho bean-growing area, 300 selections of small flat white beans (the principal commercial variety in northern Idaho) have been made, 3 of which have proved of the desired seed type. These have now been crossed with Norida, a mosaic-resistant medium-sized white bean.

During 1939 the yield records obtained by the New York State station from commercial fields and from replicated experimental plats showed that the common mosaic-resistant hybrid types, Idaho Refugee and U. S. No. 5, continue to outyield the mosaic-susceptible Stringless Green Refugee bean. In commercial fields no common mosaic was found in the resistant types, whereas the susceptible types exhibited almost 100 percent infection. From both yield and mosaic standpoints it appears that the resistant types now on the market are far superior to the nonresistant types.

Bacterial blights of beans.—Plants grown by the New York State station from Geneva infected seed of Stringless Green Refugee, Idaho Refugee, and U. S. No. 5 became badly cankered, resulting in some cases in complete crop losses. On the other hand, plants from Idaho healthy seed of these three varieties grown in the same plats showed that, while the leaves of practically all plants had some infection, less severe stem cankering had taken place. The evidence appears to indicate that with seed free from the organisms of both common and halo bacterial blights on land not in beans for at least 1 year previously, injury can be kept at a minimum and excellent commercial yields obtained.

Bean rust.—This is said to be a serious disease in Hawaii, where the variety Lualualei, though the most popular market bean now grown there, is also probably the most susceptible. It has been found by the Hawaii station that two strains of Kentucky Wonder Rust Resistant Brown Seeded and Rust Resistant Morse 191 beans are highly resistant to rust in this area. These varieties are recommended as substitutes for Lualualei, which some sections have already discontinued growing.

Lettuce yellows.—Having found that this disease (due to the same virus as aster yellows) could be experimentally controlled or prevented in the late lettuce crop by controlling the six-spotted leafhopper, which spreads it, and that insecticides were effective in reducing the numbers of this insect, the New Jersey station carried its studies further by means of controlled dusting tests, field demonstrations, and observations obtained through growers who dusted on a commercial scale for this purpose. Tests with nine different dusting materials and mixtures on experimental plats indicated that mixtures of pyrethrum, sulfur, and talc and of derris root, sulfur, and talc were the most effective in controlling the leafhopper and that the number of disease-free plants at harvest was increased with decrease in the leafhopper population. Field demonstrations confirmed the results thus obtained.

Pink root rot of onion.—The New Mexico station has continued its studies on the cause and prevention of this disease. Several different fungi were isolated from diseased onions in various parts of the State, but the ones most frequently encountered were *Fusarium* and *Phoma*. In control tests onion plants were given chemical treatments before and after transplanting to the field. Copper carbonate proved extremely toxic to the young plants, and those treated with borax showed no reduction in pink root rot. However, the disease was reduced to some extent by mercuric chloride, organic mercury, sulfur, copper sulfate dust, bordeaux mixture, and formalin, in decreasing order of effectiveness.

Mildews of cucumber and cataloup.—Through studies of the seasonal development and control of downy mildew by the South Carolina station, it was demonstrated that a prediction of the seasonal date of first appearance of infection in the State, based on analysis of climatological data and the northward advance of the disease from Florida, is essential to the proper timing of control measures. Frequent and properly timed applications of dust fungicides, in which one of several proprietary copper compounds was the active ingredient, proved effective in controlling downy mildew on both cucumber and cantaloup. In seasons when the disease is severe, the protection afforded by copper dusts provides normal maturity of fruits and extends the harvest period, resulting in improved quality and increased yields.

California's Imperial Valley ranks as one of the leading cantaloup-growing sections of the United States, the annual shipment running to around 25,000 carloads. In 1923 this industry was threatened by the appearance of powdery mildew, which spread through the valley until annual losses of more than 30 percent became common. The California station with the Department (B.P.I.) produced a mildew-resistant cantaloup, No. 45, which effectively saved the industry from this first attack. Shortly after introduction, however, a new form of mildew to which this variety proved susceptible gained a foothold in the valley and has caused heavy losses during the past 2 years. As the result of further cooperative breeding work, a new cantaloup, No. 8, has now been brought out which is resistant to both types of mildew. Seed of this variety will be available for the 1941 plantings. Thus the threat of this new powdery mildew has been effectively met.

Watermelon wilt.—This disease is reported by the Idaho station to have become increasingly important in the watermelon-growing areas of the State, and in certain sections it is the limiting factor in production. Tests conducted during the past two seasons have shown that the wilt-resistant Klondike R7 developed by the California station is adaptable to Idaho conditions, where it has proved to be 90 to 98 percent resistant.

Cabbage mosaic.—This disease, apparently differing from any virus infection of cruciferous plants (cabbage family) observed elsewhere, has recently been reported by the Wisconsin station as extremely destructive in the southeastern part of the State. All the cultivated and wild members of the cabbage family tested, as well as many non-cruciferous plants, have proved susceptible. Three species of aphids, all common in commercial fields were shown to be carriers of the virus, which was also successfully transmitted by mechanical means. Overwintering cruciferous weeds were found to be an important source of infection in southeastern Wisconsin. Preliminary trials confirmed field observations that certain cabbage varieties are more tolerant to the disease than others.

Cabbage clubroot.—In 2-year trials, a small amount of mercuric chloride in the transplanting water was found by the Wisconsin station to offer an effective means of controlling this fungus infection. For example, in one test on infected muck soil, using mercuric chloride at a cost of $2.61 per acre increased the cabbage yield by about 4.5 tons per acre. This new method holds the fungus in check so that a normal root system develops. Later in the season the roots may

become infected at some points, but the critical period then is past and enough of the root system will keep functioning to produce a good cabbage. Experiments by the New Jersey station have confirmed the common opinion that soils with an acid reaction favor the development of this disease and that a hydrogen-ion concentration of 7.3 is approximately the critical point. Salts of calcium, potassium, and magnesium were tried with about equal success where they increased the soil alkalinity to this point or higher, indicating that the beneficial effect is more directly associated with the soil reaction than with the chemical nature of the material used.

Tomato defoliation diseases.—The Ohio station reported that investigations involving both laboratory and field studies of various types of dust and spray mixtures and of machinery for applying them have led to definite progress in developing practical control measures for these troubles. The laboratory work on dust preparations has been particularly significant, involving studies on compatibility between the fungicidal element and the other ingredients of the mixture, as well as various tests on the influence of density and particle fineness on the way in which different mixtures flow, float, separate, and adhere to foliage. Use of these new methods and materials is said to have increased the tomato crop income by from $10 to $30 per acre in years when diseases were of moderate or greater severity.

The Indiana station states that the defoliation diseases, due primarily to septoria blight, early blight, and bacterial spot, are probably the major limiting factors in the production of high-quality canning tomatoes in the State, and that they constitute a very real threat to the tomato canning industry. Of approximately 250 accessions of tomatoes tested in the field against early blight and septoria blight, a few were found to possess some degree of resistance to one or both of these diseases. Of this resistant group, an unidentified species proved particularly resistant to septoria and also showed some resistance to early blight in field tests. From over 1,000 attempts to obtain a hybrid between this strain and 30 other tomato types, a single hybrid with Indiana Baltimore was finally secured. Furthermore, several accessions of the *Lycopersicum hirsutum* group have been repeatedly inoculated with this septoria without evidence of infection, and 12 hybrids with the Rutgers tomato have been obtained and are now available for breeding work. The results already secured by these and similar studies suggest that it will be possible eventually to produce defoliation-resistant canning tomatoes.

Tomato wilt diseases.—One of the most valuable investigations conducted by the Missouri station dealt with the breeding of tomatoes resistant to fusarium wilt. In the fall of 1939, 150 progenies from open-pollinated flowers were tested for wilt resistance, some remaining unharmed under conditions resulting in nearly 100 percent infection of commercial varieties within 30 days. It is anticipated that within a reasonable time wilt-resistant commercial varieties will be available. Since 1918, the Indiana station has been interested in the development and maintenance of the Indiana Baltimore tomato. In addition to supplying stock seed for multiplication, 45 different varieties and strains have been tested for yield and desirable plant characteristics, and 73 selections and crosses have been tested on badly wilt-infested soil. Seed was saved from all wilt-resistant selections and crosses, and one selection proved almost immune to wilt.

A large number of crosses between this and the wilt-immune Red Currant tomato have been tested, and the results are said to indicate that it will be possible to produce a good tomato with high resistance to wilt. The Texas station has developed a rapid and reliable method for testing resistance of tomatoes to this wilt, involving immersion of the young plants in liquid cultures of the *Fusarium* fungus prior to transplanting in trays or coldframes.

A related disease, the verticillium wilt, is particularly severe in the cooler regions of the Pacific coast where, in some localities, it has rendered the profitable production of tomatoes impossible. During the past year, however, cooperative breeding work of the California station with the Department (B.P.I.) has culminated in the development of a new resistant heavy-producing long-season variety of favorable size for canning. An ample supply of seed of this variety, known as the Essar tomato, was expected to be on hand for the 1941 planting.

Other tomato diseases.—The Hawaii station reported that yellow spot or pineapple virus, cause of a serious tomato disease, has been found to resemble the spotted wilt virus in symptoms induced, ease of mechanical transmission, and failure of seed transmission. The evidence at hand points to the belief that the two viruses are identical.

The tomato puffing fruit defect, said to cause annual losses of 8 to 15 percent of the Texas crop, was found by the Texas station to begin in the embryonic stage of fruit development, progressing to the most prominent symptoms at full maturity. While the cause is still unknown, the condition was found to be influenced by certain fertilizers, by soil moisture, and by some other surrounding conditions. Irrigated fields produced a higher percentage of puffed fruits than the nonirrigated.

In Texas tomato seedlings are grown in coldframes or hotbeds under cloth or sometimes in the field under sheeting. These young plants are very susceptible to the *Pythium* and *Rhizoctonia* forms of damping-off. The Texas station found that such cloth covers reduced the sunlight intensity from 1,000 footcandles to 100 to 300 footcandles, and laboratory tests showed the pronounced effect of such light reductions on increasing the susceptibility to damping-off. Higher light intensities were proved necessary to the growing of normal tomato seedlings. Dusting the seed with various fungicides also decreased the incidence of the disease under conditions strongly favoring its development, and certain fungicides—particularly formaldehyde and chloropicrin—applied as soil treatments proved very effective against postemergence phases of damping-off.

Vegetable problems in the greenhouse.—The Ohio station has reported on the recognition and treatment of the common greenhouse diseases of vegetables, with special reference to viruses, and has described two diseases new to Ohio greenhouse plants, namely, the virus-induced Australian spotted wilt and the bacterial stalk rot of tomato.

The accumulation of ammonium carbonate following soil sterilization—very injurious to many plants grown in the greenhouse—was shown by the Ohio station to be preventable by application of calcium sulfate.

New equipment and materials for controlling vegetable diseases.—Progress in the designing and construction of a much-needed small power-driven spraying and dusting equipment for vegetable growers

operating 5 to 10 acres is reported by the Ohio station. The work on vegetable-disease control has also involved comparisons of the insoluble copper compounds with one another and with bordeaux mixture, and progress along these lines has been made.

TRUCK-CROP INSECTS

Corn earworm.—This insect, which also goes under the name "bollworm," is charged by some conservative estimates with a 4-percent loss in the annual corn crop of the Nation. In parts of the South sweet corn as a crop has been generally abandoned because of this pest. Desilking sweet corn will reduce the amount of corn earworm damage, according to results of experiments on 4 sweet corn varieties by the Virginia Truck station. Desilking at 5-day intervals was almost as effective as at 3-day intervals. This method, however, probably would not pay on a large commercial scale unless used in a locality where labor is cheap. In tests made on 64 varieties of sweet and field corn to compare the resistance of some of the newer varieties, wide variations in the severity of injury occurred, but in general freedom from injury seemed to be associated with thick, close-fitting husks and late maturity.

Populations of the corn earworm occurring in southern Connecticut during August and September could be traced to natural increases from annual populations found in the earliest sweet corn during June or July, according to work by the Connecticut (State) station in cooperation with the Department (B.E. and P.Q.). The studies indicated that winter survival of pupae in certain environments in southern New England in at least some years would account for the occurrence of annual infestations in Connecticut.

The New Jersey station, seeking a practical method of corn earworm control more effective than desilking, tested several insecticides in white oil with encouraging results. For example, six cooperating growers applied oil containing 1.5 percent dichloroethyl ether and oil containing 0.1 percent pyrethrins at the rate of 0.75 cubic centimeter per ear. In the harvested ears approximately 95 percent were found free of corn earworm larvae as compared with 70 percent in the desilked plats and no clean ears in the untreated check plats on the same fields. The cost of this treatment is approximately 7 man-hours per acre and material amounting to $1.31 for each acre. With pyrethrins the cost is about 50 cents per acre higher. No difference in flavor was noted between the treated and nontreated ears.

The application of cryolite dust or sprays has appreciably reduced the corn earworm damage to Fordhook lima beans in experiments conducted during a 3-year period by the Virginia Truck station. A bait consisting of 1 pound of cryolite to 25 pounds of corn meal, broadcast evenly over the leaves of the plants at the same time intervals as for dust or spray applications, has also been effective for control of the corn earworm on beans.

Cutworms.—The New York (Cornell) station has developed an economical premixed cutworm bait which is now available to New York State vegetable growers. The poison in this bait consists of sodium fluosilicate and paris green; wheat bran is used as the carrier, and the entire mixture is colored green or red. It can be marketed at a low price, yet its efficiency in the control of cutworms is extremely high.

Aphids.—Severe aphid infestations on peas cause not only a reduc-

tion in yield but also in the average size of the shelled peas, which are hard and of poor quality. The first season's results of a 5-year experiment being conducted by the Maryland station at its Ridgely substation on control of this pest showed that one application of an insecticide was not sufficient during severe and extended infestations.

A good method for controlling the cabbage aphid was discovered by the Virginia Truck station at Tidewater, Va., that of dipping the plants before planting in a nicotine-soap solution containing 1 gallon of nicotine sulfate, 2.5 gallons of soap, and 500 gallons of water at a temperature of 65° to 70° F. Nicotine dust (3-percent) and vaporized nicotine gave very high kills of this aphid, although both failed to reach all of the aphids that were protected in close-fitting broccoli heads. The same dust and vaporized nicotine were about equally effective in controlling the spinach aphid on spinach. Dipping cut spinach in a dilute pyrethrum-soap solution was effective in killing this aphid, and washing the spinach before marketing removed the dead insects. Under field conditions vaporized nicotine applied while the plants were dry gave the most satisfactory control of the pea aphid. Derris and cube sprays have given good control in experimental tests, although satisfactory results were not obtained in some field trials by growers.

Another plan for pea aphid control, suggested by the New York State station, is that of timing. The Wisconsin station also has obtained data which indicate the feasibility of timing as a control. It reports that aphid-susceptible canning peas become uncongenial hosts to those aphids which produce alate forms at about the time the peas come into blossom. When the aphids are destroyed at that time, the uncongenial nature of the peas inhibit normal increases of subsequent infestations. Moreover, if the aphid infestation is destroyed after the fourth week before the usual canning stage, the aphids will not have time to increase to destructive numbers before the peas are harvested for canning.

Pea weevil.—The acreage in pea production as a cash crop has expanded rapidly in eastern Oregon because it offers the only suitable crop to rotate with wheat on a large scale in the better lands of Umatilla County. According to the Oregon station, cooperating with the Department (B.E. and P.Q.), the discovery that 0.75-percent strength rotenone dust is effective in killing adult pea weevils, and the development of a practical machine for applying this dust on large acreages now makes it possible to control this insect, which threatened the destruction of Oregon's several-million-dollar pea crop. Controlling the weevil not only restored the market but saved the thousands of acres now devoted to peas from reverting to the production of crops in which there are already mounting surpluses.

Mexican bean beetle.—This pest first made its appearance in South Carolina in 1921. The South Carolina station has reported from its studies that emergence from hibernation is greatest following periods of rainfall and high temperature; snap beans, lima beans, cowpeas, and soybeans are the preferred hosts; predators were rather abundant in the bean fields; rotenone and associated compounds have given the best control; and although magnesium arsenate and cryolite (either synthetic or natural) may be used in control, they leave a harmful residue and should not be applied after formation of the pod.

Striped cucumber beetle and cowpea curculio.—According to the

Indiana station the striped cucumber beetle is the most destructive pest of cucurbits in home and commercial gardens. Studies conducted during a 4-year period have demonstrated the superior efficiency of a calcium arsenate-insoluble copper dust. This mixture was recommended for the first time last year but has been widely adopted. For example, the Indiana Farm Bureau Cooperative reported the sale of several tons of the dust the first year, and the station received reports of almost universal success.

During 4 winters the Georgia station searched samples of 20 kinds of vegetation for hibernating stages of the spotted cucumber beetle and cowpea curculio. Broomsedge (*Andropogon virginicus* L.) held the highest concentration of each insect, but 8 other plants also harbored the cucumber beetle and 7 others the cowpea curculio. The curculios enter winter quarters about October 15 and begin to leave during April or early May, with the emergence period extending into July. Burning broomsedge seemed to kill the cucumber beetle readily, but only 23 percent of the curculios succumbed.

Wireworms.—A 100-percent control of wireworms without damage to plants of the cabbage family may be attained by applying dichloroethyl ether at the rate of 1 cubic centimeter per hill, according to a report of the New Jersey station. The cost of the material for the treatment should not exceed $8 per acre. When applied with water, dichloroethyl ether acts as a contact insecticide. Baits, repellents, and stomach poisons proved ineffective for wireworm control.

Harlequin bug.—Studies by the Virginia Truck station on the control of the harlequin bug show that spraying the infested plants with a mixture of 4 pounds of derris or cube powder (5- or 6-percent rotenone) and a good spreader to 50 gallons of water will give satisfactory control. A commercial product containing derris extract, emulsified in 50 parts of water, as well as concentrated derris extract plus soap thoroughly applied also gave good control. Two or three applications of spray at weekly intervals are necessary on large plants where the bugs are well protected.

Cabbageworms.—The Ohio station reported that the residue on cabbage resulting from the application of a dust consisting of 1 pound of paris green and 9 pounds of talc for control of cabbageworms was well within a tolerance of 0.01 grain per pound. The only approach to this tolerance occurred after four applications had been made.

Tomato psyllid.—Spraying with lime-sulfur or wettable sulfur and dusting with sulfur definitely repels adults of the tomato psyllid, according to work of the Colorado station. During 2 seasons, tests with dry and liquid lime-sulfurs, wettable sulfur, 300-mesh dusting sulfur, and gas-house dusting sulfur failed to show any difference in effectiveness of these materials in killing nymphs, a high percentage of nymphs being killed by each. Sulfur deposits from sprays and dusts were noted to kill settling nymphs 16 days after being applied. Liquid lime-sulfur, 1 pint to 50 pints of water, or dry lime-sulfur, 1 pound to 10 gallons of water, seriously retarded plant growth and this was evidenced in fruit yields. In some instances an almost complete tomato crop failure resulted on untreated plantings.

Six-spotted leafhopper.—Fencing lettuce to protect it from attack by this insect, responsible for transmitting the virus of lettuce yel-

lows, was found successful by the New Jersey station. Only 1 percent of the protected lettuce showed symptoms of the disease as compared with 31.8 percent of the unprotected checks. Experiments with insecticides on small plats during 2 years showed a high degree of leafhopper control, but the decrease in disease was slight. Large-plat experiments with rotenone and pyrethrum dusts not only gave good control of the leafhopper, but the amount of virus was reduced so that a commercial crop of lettuce was harvested. Roguing has given approximately a 50-percent reduction in lettuce yellows.

Carrot weevil.—An effective means of control of this insect (*Listronotus latiusculus* (Boh.)) in celery consists of broadcasting over the celery field dried apple pomace coated with an arsenical or one of the fluorine compounds. The New Jersey station, which discovered the control with celery, believes that the same method will eradicate the pest on carrots.

ORCHARD DISEASES

Apple scab.—This fungus infection, which probably causes the most serious and extensive losses of all American apple diseases, has been brought under control in the past largely through the use of lime-sulfur spray, which earlier experiment station and Department investigations had shown to be superior in effectiveness to other materials then known. This scab spray along with codling moth sprays undoubtedly have made it possible for apple growers in many sections to continue in the business, but in many seasons and in many localities the lime-sulfur has exerted a prolonged detrimental effect on yields as a consequence of an injurious effect on the foliage and occasionally on the fruit. Carefully controlled greenhouse tests employing ingenious and rather complicated apparatus have been made to determine why this material produces such damage and what other old or new materials are better or worse. The New York (Cornell) station has found that dilute lime-sulfur sprayed on the leaves cut down the rate at which they produced food for the tree and fruit by photosynthesis. At 70° to 85° F. the reduction amounted to about 10 percent, while when the temperature went up to 100° the reduction was about 25 percent. A product known as flotation sulfur as well as other wettable sulfurs caused far less interference with normal leaf activity, and dusting sulfur also showed but little effect. Bordeaux mixture causes less interference than any of the sulfurs, but is objectionable because of its well-known tendency to russet fruit. The Ohio station found that the reduction in photosynthesis caused by dilute lime-sulfur may persist at least 3 to 5 days after application even though no visible leaf burning occurs.

Renewed attacks by experiment stations on the problem of finding less harmful materials capable of effective scab control are bringing encouraging results. The New York (Cornell) station in experiments in commercial orchards proved that flotation sulfur could serve as a satisfactory substitute for lime-sulfur, reducing the amount of fruit and foliage injury and increasing yields. The Missouri station obtained scab control with flotation sulfur in paste or powder form comparable to that obtained with lime-sulfur. However, lime-sulfur was found by the New Jersey station to have certain advan-

tages, being able to check infection if applied within 4 days after the start of a period of wet weather conducive to infection, while the wettable-sulfur types did not have this power but were useful only to prevent infection and hence would have to be applied before an infection period.

Progress is reported by several stations in working out the possibilities of a new line of approach to the better control of a number of orchard and small-fruit diseases through destroying the overwintering stage of the causal fungi carried from season to season in the fallen leaves. Apple scab is one of these. A proprietary sodium salt of dinitro-orthocresol, used as a spray in one test, reduced the discharge of spores of the disease from old leaves by almost 100 percent at the Wisconsin station. The New York State station obtained promising results with ground sprays of the same material applied before the disease first started in the spring. Monocalcium arsenate and nitrate of soda likewise gave beneficial results, but further experiments are held necessary before general use of these eradicant sprays can be advised. When two of the above-mentioned chemicals were employed as eradicant sprays in trials by the Illinois station in severely infested Illinois orchards, at the time the blossoms fell there were 94 percent fewer leaf infections than in a nearby orchard, used as a check, which had no eradicant spray. Summer sulfur sprays were applied in all cases, but where the eradicant spray had been used before the start of the season the amount of scab on the fruit at harvest was from about 70 to 90 percent less, depending upon the variety, than in the trees not receiving this early spraying of the orchard floor.

Fire blight of apple and pear.—Ten years of experimental work by the Tennessee station indicated that the spraying of apple and pear trees in full bloom with 1–3–50 bordeaux mixture will give sufficient reduction of blossom blight under Tennessee conditions to assure a fruit crop. Without such protection the disease frequently ruins the set of fruit in bad years. There has been fear among growers and specialists that spraying in bloom would prevent full setting of fruit, but experiments at the New York (Cornell) station have shown that in spite of the fact that copper compounds will prevent pollen from germinating in the laboratory, copper-lime dust and bordeaux spray can be applied to blooming apple trees without seriously reducing the fruit set.

Apple rots.—The Washington station summarized for the benefit of growers the results of experiments extending over many years on the blue and gray molds, black rots, and anthracnoses affecting apples in storage in the Pacific Northwest. The methods of prevention or reduction of infection worked out over the years have been applied with success by a large number of growers and fruit-packing establishments in that section of the country, and have served greatly to reduce former large losses from fruit decay.

Collar rot of apple trees.—The Indiana station has found the cause of this widespread tree-killing disease to be an organism that invades the trunk near the soil line and penetrates all the bark tissues. In tests made with pure cultures of the fungus to determine the relative susceptibility of seven important commercial varieties of apples, 2- to 4-year-old Grimes Golden trees were resistant to infection, while trees 8 to 30 years old were highly susceptible. Cherry, peach, and

plum trees, as well as flax and peony, were found subject to attack from one or more strains of this fungus. Bordeaux mixture gave promise of partial control, and sodium arsenite in alcohol appeared capable of checking the advance of established cankers.

Boron deficiency in apples.—Continued experiments in the Champlain Valley with treatments for the apple fruit damage known as "cork" and "drought spot" showed common borax to be best adapted to commercial use, being not only effective but easy to procure and cheap. The New York (Cornell) station found that, of the various methods tested for overcoming boron deficiency, soil application seemed best adapted to commercial conditions. The Idaho station likewise greatly reduced the incidence of drought spot and corky core through soil applications of borax in orchard tests in northern Idaho.

Cedar apple rust.—In those sections of the United States where cedars grow close to apple orchards, the latter are often severely attacked by the rust fungus which winters over in galls on the native cedars, and sometimes the entire crop is ruined. The Michigan station recently tested a sodium salt of dinitro-orthocresol applied as a spray when the cedar galls were actively developing their spores in the spring. This apparently resulted in completely preventing discharge of the infective spores without injuring the trees. Whether this method is commercially practicable or not remains to be seen, but it opens up, at any rate, new possibilities in controlling types of tree diseases that are carried over winter in infected bark tissues.

Wood rot.—Fungus decay in the trunk and branches was found by the Minnesota station to contribute definitely to senescence and death of apple trees. This fact, suspected but not adequately proved in the past, should lead to better treatment of tree wounds that allow the entrance of decay.

Stone-fruit viruses.—Each year reveals new complexity in the virus-disease problems among peaches, prunes, apricots, cherries, and related trees. To aid in the eradication campaign, the Colorado station studied and mapped the different kinds that are capable of carrying the peach mosaic virus in the western part of the State. In cooperation with the Department (B.P.I.), the California station found cherry mosaic to exist widely in the State and proved it to be transmissible to peach and other stone fruits. The virus infection known as almond calico was successfully transferred to sweet cherry and peach. At least two mosaics were discovered in Japanese plum, and one was successfully transmitted to peach. Two mosaics were also found on prunes, and one was transmitted to peach. The disease known as the Winters peach mosaic, which also occurs naturally on apricots, was successfully transmitted by grafting to wild desert peach, apricot, sweet cherry, plum, rose, and *Kerria japonica*. These proofs that numerous viruses are capable of being harbored in various related plants will be taken into consideration in all efforts to eliminate virus diseases from commercial producing areas. A grotesque fruit disfigurement, peach wart, increasingly prevalent in Idaho, was traced by the Idaho station in a number of instances back to certain sources of nursery stock. Cleaning up the trouble at the source will probably simplify eradication. A start toward control of a serious defoliating and devitalizing leaf spot of Italian prune, common in Idaho for many years, is made possible by the discovery

by the station that it may be of virus origin. Experiments showed that it could be perpetuated by budding. Likewise, an affliction of the sour cherry known as physiological yellow leaf, widespread in Wisconsin, was found by the station in that State to be transmissible by budding and hence that it is possibly caused by a virus.

Cherry leaf spot.—This disease having become one of the limiting factors in cherry production, the West Virginia station recently compared several different types of sprays as to their effectiveness under local climatic conditions. Although the widely recommended sulfur sprays gave very good control during the early part of the season, copper sprays gave much better protection during the latter half. These results, if confirmed in further tests, should bring about a change in spray practices with increased profits for cherry growers. In tests by the Ohio station extending over 2 years, standard liquid lime-sulfur not only failed to control the leaf spot but also dwarfed the leaves. Fixed copper compounds, however, proved effective and with lime added was safe. The Indiana station found about 4 times as many leaf spot infections on the under sides as on the upper sides of the leaves, indicating that particular care must be taken to spray under surfaces thoroughly. On the sweet cherry, both bordeaux mixture and copper phosphate gave good control without injury.

Brown rot.—A survey of the serious twig- and blossom-blighting European type of brown rot and of the American form chiefly responsible for fruit rotting, conducted by the California station throughout the fruit districts of that State, enables growers of apricots, almonds, and other stone fruits to know where control practices for each type will be worth while. A fungus related to brown rot was found responsible for a seedling blight of the valuable wild black cherry of the East through cooperative work between the Arkansas station and the Department (B.P.I.). The disease, which is known to occur in both Georgia and Arkansas, apparently has restricted the multiplication of this tree in the South.

Bacterial canker of stone fruits.—In extensive studies by the California station on this cause of gumming and death of branches in cherries, apricots, plums, and other stone fruits, it was revealed that leaf, fruit, and green-shoot infections commonly start from previous twig and bud infections. This information may provide a clue to more successful control than has been possible hitherto. In connection with extensive inoculation tests by the same station which showed that cankers began to extend in the fall and stopped in the spring, it was found that moderately cankered trees on sandy loam soils were benefited by the use of ammonium sulfate as a fertilizer, which seemingly increased the ability of the trees to repair damage from the disease.

Bacterial spot of peach.—Attempts to control this trouble, one of the most erratic and perplexing among the major peach diseases of the United States, have largely failed because handicapped by lack of essential information as to how the disease is carried over from one season to the next. Recent findings of the Illinois station indicate that the disease starts on twigs, and from the twigs spreads to the new foliage. The critical time for twig infection was found to be September and October. Beside studying the disease, the station is making progress in breeding and selecting for resistance to it. The Arkansas station, working with the Department (B.P.I.), dis-

covered abnormal leaf symptoms produced by this bacterial disorder, particularly where beans had been interplanted the year before.

Powdery mildew of peach.—The California station proved that although botanically related, the powdery mildew disease on peach is not identical with that on rose. Infected roses therefore can be no menace to peach orchards and vice versa. Both, however, live over winter in infected buds, a fact of importance in control.

Peach shot-hole disease.—Surveys by the Idaho station in fruit districts in the southern part of the State showed that a peculiar trouble, producing leaf spots that drop out, leaving holes and making the foliage fall prematurely, commonly occurs on soils from which apple trees have been removed. This seems to indicate another phase of the problem arising from soils rendered toxic by sprays previously used.

Peach blight.—Inoculation experiments with the western peach blight fungus, conducted by the Idaho station, have shown that the disease is carried by a number of different kinds of fruits, including peach, apricot, wild cherry, sweet cherry, and prune. Control practices must therefore include not only the peach but these other fruits as well.

Peach rust.—Five native species of plum were found by the California station to be attacked by peach and prune rust infection. Thus native trees may form a reservoir of disease and perhaps complicate the problem of control. Two native species were not successfully inoculated. The possibility therefore exists that they may prove useful in a breeding program to introduce rust resistance into desirable commercial types.

Boron deficiency in prune.—Work by the Idaho station indicated that the common and frequently serious spot form of so-called "drought injury" to prunes may be related to a deficiency in boron. Affected fruits showed a lower boron content than normal ones.

Virus diseases of citrus.—The discovery by the California station of the virus origin of scaly bark of citrus trees, the presence of leaf symptoms, and the long incubation period have furnished a basis for practical control through a system of testing trees from which it is desired to obtain bud wood for the presence or absence of the virus. By propagating from healthy stock only, it is expected that this costly disease will eventually become rare. The same station has discovered that a condition of lemon leaves resembling certain variegations on ornamental plants is capable of being transmitted by budding to sour orange. This indicates probable virus origin and points the way to practices necessary for control. Tahiti lime trees in Florida sometimes turn yellow and become stunted, but the nature of the disease was in doubt until the Florida station discovered that it could be transmitted by budding, which indicates that it is probably of virus origin.

Citrus deficiency disease.—The Florida station has extensively studied the diseased conditions of citrus fruits associated with a lack in the soil of sufficient available copper, zinc, manganese, magnesium, boron, iron, and other elements. These investigations have disclosed the symptoms by which each kind of deficiency may be detected. Armed with this information a grower can now correct the difficulty in his own planting at insignificant cost by small applications of the proper chemical. The symptoms of toxicity from excess of

boron have likewise been studied and described. With some of these elements, correction of deficiency has been found to raise the sugar and acid content in the fruit as much as 25 to 50 percent. Control measures have also been developed by the same station for zinc deficiency in mango and for copper and zinc deficiency in avocado. The California station has revealed the fact that availability of manganese to oranges is restricted when the soil is neutral or alkaline under certain conditions related probably to the mineral composition of the soil. A study of the symptoms has made it possible to recognize manganese deficiency and correct its decline-producing effects in both lemon and orange groves.

Water spot of navel orange.—Continued work by the California station on this fruit disfigurement showed that the structure of the rind and properties of the cells are important factors in the development of the condition, while internal liberation of toxic rind oil and decay by blue and green molds are important in bringing about ultimate break-down of the fruit.

Citrus scab.—Experiments conducted by the Florida station for 6 years on the control of scab on grapefruit, tangelo, and King oranges showed the best scab control followed spraying with bordeaux mixture just before the spring flush of growth. Certain proprietary copper sprays also gave good control, while lime-sulfur with added wettable sulfur gave only partial control, and mercury oil emulsions proved to be unreliable. Scale insects were more abundant and difficult to control after bordeaux than after the so-called insoluble copper sprays. For this reason, oil emulsion or wettable sulfur should be combined with the early copper spray, especially if red scale is prevalent. In older trees with both scab and melanose, two sprayings with copper fungicides were found necessary for effective control.

Bacterial blight of walnut.—Although experiments and field usage in California and Oregon have shown that bordeaux spray will control this serious disease, many growers hesitate to use it because it sometimes burns the foliage. Large-scale experiments by the California station have led to a substitute spray that is slightly cheaper, easier to prepare, and much safer to use. In this spray red cuprous oxide is used with a commercial emulsion. Although bordeaux is more efficient in preventing the blight, the safety of the new spray argues for its substitution in orchards where bordeaux burn has been experienced.

ORCHARD INSECTS

Codling moth.—Field comparisons by the New Mexico station of lead arsenate and lead arsenate substitutes in the southern part of the State showed a high and consistent degree of freedom from infestation only with lead arsenate. Where five cover sprays in addition to a calyx spray were used, 85 to 95 percent of sound fruit was secured. When arsenate of lead was used in the first three applications and an organic insecticide such as oil-nicotine or phenothiazine constituted the last three cover sprays, the control was reduced to 67 to 75 percent, and one application of lead arsenate as a calyx and one as a cover spray resulted in only 50 to 65 percent of sound fruit. Next to lead arsenate, cryolite was the most promising insecticide tested. Some promise was found in the use of spreaders. The effi-

ciency of organic insecticides such as oil-nicotine and phenothiazine is apparently hindered by weather conditions, particularly dry, hot summers.

That spraying procedure may be greatly simplified is indicated in experiments at the Missouri station. The dry-mix method of preparing nicotine-bentonite combinations used in spraying apples produced a material that was fully as effective as lead arsenate in controlling codling moth. Further, the combinations left no apparent residue on the fruit.

Temperature and rainfall have a direct relationship to codling moth infestation in two major fruit areas of New York, the Hudson Valley and the Lake Ontario plain, according to studies by the New York State station. Weather directly or indirectly has a dominant influence on fluctuations in the activity from year to year and on long-range trends of this pest, although other factors such as the development of an insecticide-hardy race, the concentration of orchards in certain areas, and the abundance of shaggy bark in old orchards which provide overwintering quarters for the larvae must also be considered.

From data on emergence recorded by the Delaware station during the last 10 years, growers can now determine just when sprays should be applied for effective control of the first brood of codling moth. Both maximum emergence and 50-percent emergence of the spring brood of moths have occurred on May 20 with a range of but ±4 days. The date of application for the usual petal-fall spray on apples is approximately the date of first emergence, and normally emergence continues thereafter for about 45 days, with the peak approximately 10 days following petal fall. An apple-spraying program worked out by the station includes prebloom applications of liquid lime-sulfur, with flotation sulfur, lead arsenate, and hydrated lime in the petal-fall and first-cover sprays, followed by successive applications of a relatively weak bordeaux mixture with lead arsenate. This seems best designed for Delaware conditions and does not seriously injure foliage or fruit.

In experiments by the New Jersey station over a 2-year period with a triple spray of nicotine sulfate, oil and lead arsenate, or fixed nicotine, directed toward reducing the first brood of codling moth to such a low point that little or no second-brood spraying will be necessary, the addition of a pint of nicotine sulfate to 100 gallons of a spray mixture containing an ovicide and larvicide definitely improved the control. Spraying from the outside of the tree through multiple-nozzle rods as opposed to spraying from the ground with single-nozzle guns tended to trap the adult moths in the trees, thus increasing the adult moth kill and resulting in better control.

The Virginia station found, upon removal of codling moth bands from apple trees in a heavily infested orchard, that 70 percent of the worms on such trees had cocooned in the bands. More than 50 percent of the worms in the branches were in pruning wounds and in cracks in dead wood. As about three-fourths of the worms on the older trees are to be found on the branches, the importance of scraping those parts as a control measure is emphasized. Studies in Albemarle, Augusta, and Patrick Counties indicate that a bait consisting of 1 part of stock sirup to 20 parts of water, to which 1 cubic centi-

meter of anethol per quart was added, is the most constant attrahent of codling moths. The catches were increased slightly by the addition of a small amount of sodium benzoate during the summer months. Largest catches of moths were noted in new unpainted traps, and the second largest in traps painted with aluminum paints. When 3 traps were used, the trap suspended in the top of the tree captured more moths than the other 2 combined. During 1938, 60 percent of the catch were females and less than 5 percent had deposited their full quota of eggs. Bands on trees in untreated blocks caught approximately 6 times as many larvae as similar bands in treated blocks of the same orchard. Bait traps should be suspended about May 1 in central and April 20 in southern Virginia.

In connection with the spray-residue problem on fruit, the New York (Cornell) station has given further attention to the development of nicotine compounds suitable for controlling codling moth and other fruit insects. During the past season a nicotine peat used on codling moth larvae gave kills under laboratory conditions at only 0.0125 percent of nicotine comparable to the standard nicotine bentonite at 4 times that concentration. Nicotine peat is now being tried in commercial orchards.

Prune thrips.—In Oregon prune thrips have caused serious losses to the prune industry by blighting the fruit buds and reducing the yield and quality of the fruit. The Oregon station cooperating with the Department (B.E. and P.Q.) is now able to control them by sprays consisting of either 3 gallons of lime-sulfur and 1 pint of nicotine sulfate mixed with 100 gallons of water or 2 percent miscible-oil emulsion and nicotine sulfate, 1 pint to 100 gallons of water. Thrips-infested trees sprayed experimentally with these mixtures yielded from 62 to 4,000 percent more fruit than those in the unsprayed plats.

Cherry casebearer.—This pest was first discovered in Oregon in 1937, but has since become the source of rather heavy damage in apple orchards near Salem. Two hymenopterous parasites have been reared from it at the Oregon station.

Citrus thrips.—Research by the California station has demonstrated that one of the important pests of lemons, the citrus thrips (*Scirtothrips citri* (Moulton)), can be successfully controlled by spraying with 1 pound of tartar emetic and 2 pounds of sucrose per 100 gallons of spray. Thousands of acres of California citrus trees have been sprayed with this material with excellent results.

Black scale.—Although rotenone sprays containing 1 percent of petroleum oil are effective against this insect, the oil is harmful to the foliage and fruit. In an effort to reduce the petroleum content the California station found a solvent, 2(4-tertiary-butylphenoxyl) ethanol, which dissolves rotenone into oil to produce sprays that will control black scale with oil dosages as low as 0.25 to 0.5 percent.

Woolly apple aphid.—According to research conducted by the Virginia station either carbon disulfide emulsion 1:1,600 or dichloroethyl ether in solution 1:800 when applied at the rate of 1 gallon to the square foot of soil gave satisfactory control for this aphid (*Eriosoma lanigerum* Hausm.) without perceptible injury to the roots of apple trees. When carbon disulfide was applied at the above dilutions at the rate of 2 and 3 gallons to the square foot of soil, the roots were burned and in some instances the trees were killed.

Oriental fruit moth.—Several years ago *Macrocentrus ancylivorus* Rohwer, the imported parasite of the oriental fruit moth, was introduced into the Piedmont section of South Carolina and 2 years ago into orchards of the Ridge section. Surveys made in July in Spartanburg County in the Piedmont section indicated that 94-percent parasitism had been reached. At Clemson the native parasite (*Macrocentrus delicatus* Cress.) was found parasitizing 70 percent of the larvae.

Plum curculio.—The Delaware station, in puncturing fruit artificially to imitate the egg-laying punctures of the female plum curculio beetles, found that peach and apple fruits showed little if any inclination to fall prematurely because of the mechanical injury.

SMALL-FRUIT DISEASES

Strawberry red stele root disease.—Maryland, with an annual income of nearly $1,500,000 from strawberries, is among the States concerned over the destructive recent invader known as the red stele disease, caused by a soil-borne fungus. The Maryland station with the Department (B.P.I.) during 2 years has tested all named varieties obtainable and about 5,000 hybrid lines, and found over 1,800 lines apparently resistant or immune. It can therefore be expected that, before the disease has reached its maximum extent and destructiveness in this country, through plant breeding all important susceptible varieties will be replaced by equally satisfactory immune sorts.

Strawberry leaf-disease resistance.—The New Jersey station reported encouraging progress in testing strawberry types for resistance to leaf scorch, powdery mildew, and June yellows in connection with strawberry-breeding projects. These diseases have caused serious losses in various parts of the country.

Blakemore "yellows" of strawberry.—Widespread decrease in productivity in Blakemore and certain related strains of strawberry was found by the Indiana station, as well as others, to be perpetuated by propagation from runner plants derived from affected parents. This is a fact that cannot safely be overlooked by nurserymen or growers in dealing with troubles of this sort.

Currant anthracnose.—That this common and destructive infection can be relegated to eventual insignificance through selection of resistant lines is indicated by the finding of the Michigan station that the Prince Albert variety appeared to sustain no appreciable injury from it while the President Wilder lost its leaves heavily. No such differences in susceptibility between these sorts were noted, however, for another fungus pest, the *Mycosphaerella* leaf spot.

Miscellaneous small-fruit troubles.—The New York State station summarized, for the benefit of growers, farm advisers, and technical workers, its progress in the study of such troubles as winter injury, mosaic, wilt or bluestem and spur blight of raspberries, black rot and mildew of grapes, leaf spots and powdery mildew of gooseberries, and winter injury, root rot, leaf spot, and red stele of strawberries. In a similar way there were published methods of control for strawberry diseases due to viruses, fungi, eelworms, etc., worked out by the Oregon station for conditions in the Pacific Northwest.

SMALL-FRUIT INSECTS

Strawberry weevil.—This pest, sometimes called "clipper," does its damage by cutting the stems of buds in which the eggs had been laid. According to the Delaware station, the strawberry growers in that State have experienced serious losses, especially in 1938, when from 40 to 100 percent of different plantings of the crop was destroyed. Of considerable value to farmers in combating this pest have been the results of experiments with arsenicals, arsenical substitutes, and diluents for the same. Three applications of either calcium arsenate or lead arsenate and sulfur at a 1–5 dilution and at a rate of 20 to 40 pounds per acre are usually necessary to insure a satisfactory crop.

American strawberry leaf roller.—The Kansas station found the most effective spray to be that of 40-percent nicotine sulfate, or 50-percent free nicotine, in combination with summer oil emulsion, if applied during the time interval between the first hatched larvae and the first rolled leaves; this efficiency remained constant for all three broods when spraying was properly timed and applied three times at 5-day intervals. Beginning with the second brood, lead arsenate sprays or cryolite in combination with a proprietary neutral soluble fish oil gave controls nearly equal to 40-percent nicotine sulfate or 50-percent free nicotine spray, again the best results being obtained when these sprays were timed for broods and applied often enough to protect newly unfurled foliage. A strong pyrethrum dust (0.8 percent) appeared to be 96.8-percent effective against larvae in rolled leaves.

Other strawberry insects.—Insect and mite enemies of major importance to the strawberry in Oregon are spittle bugs, strawberry root weevils, the strawberry fruitworm, the strawberry and western strawberry leaf roller, the strawberry crown moth, the strawberry crown miner, the strawberry aphid, and the cyclamen mite. These were noted in an account published by the Oregon station, which also includes methods of control. Topping and covering the plants after harvest gave a high degree of protection against oviposition of moths of the western strawberry leaf roller (*Anacampsis fragariella* Busck).

Raspberry insects.—A practical account of control measures against insects attacking the canes and foliage of the raspberry has been issued by the Michigan station. The Washington station has reported that the cane-feeding aphid (*Amphorophora rubicumberlandi* Knowlton and Allen) is responsible for the transmission of black-raspberry mosaic.

Grape plume moth.—The history of this insect (*Oxyptilus periscelidactylus* (Fitch)) has been completely worked out for the first time by the Massachusetts station. Only one generation occurs annually in that locality. The eggs, previously undescribed, are laid singly at the axil of a branch or bud on the older canes. Experiments based on this information led to the discovery that a dormant application of either 1-percent sodium dinitrocresylate or oil emulsion diluted to contain 3 percent of actual oil gave satisfactory control without injury to the vines, the first record of an efficient control applicable for either home plantings or commercial vineyards.

Coffee leaf miner.—One of the most serious pests of coffee is the coffee leaf miner, so it is of considerable significance that the Puerto Rico University station has found an Arabian coffee (*Coffea steno-*

phylla) that has proved immune to attacks by this insect under favorable greenhouse conditions. Eggs were laid normally on the leaves, but most of the caterpillars either failed to penetrate the leaf or died soon after eating portions of the tissues. The discovery of this immunity may lead to hybridization for the development of resistant commercial strains of coffee.

ORNAMENTAL PLANT DISEASES

Rose diseases.—The California station has discovered three distinct mosaic diseases of roses in the State and has worked out methods for differentiating them. In addition, roses were shown to be susceptible to apple mosaic and to Winters peach mosaic. Use of affected buds for propagation proved an important means of introducing these virus diseases. One of the three rose viruses survived heat treatments near the limit of tolerance for rose cuttings, while a second withstood exposure to 30° C. for 11 days. A black mold disease of rose grafts due to a fungus (*Chalaropsis thielavioides*) not hitherto known to attack roses has been reported by the New York (Cornell) station. The New Jersey station has found a type of boron deficiency in greenhouse roses believed not to have been described before. The disease first becomes evident through the dying back of the stem tips, flower shoots, and tips of the leaves in late September when the plants are growing most rapidly, and the development of small abnormally thick leaves is one of the most characteristic of the later symptoms. Soil treatment at the rate of 2 parts per million of boron resulted in prompt recovery.

Dieffenbachia picta leaf spot.—A yellowish-brown leaf spot of this popular foliage plant has been found by the New Jersey station with the Department (B.P.I.) to be caused by a new bacterial species (*Bacterium dieffenbachiae*), which is fully described together with the disfiguring symptoms induced. The bacteria enter the tissues through the breathing pores (stomata) of the leaves.

Virus diseases of narcissus.—White streak, a new and readily transmissible virus disease of narcissus, has been studied and described by the New York (Cornell) station. It is found to differ in symptoms from the previously known mosaic. The only control methods as yet known consist in eradicating infected plants and isolating the healthy ones.

Botrytis blight of Antirrhinum.—In greenhouse plantings of two varieties of snapdragons it was found by the Oregon station that this mold parasite can enter the tissues through glandular hairs wet by watering or spraying operations, primary infection in all cases corresponding with locations where the surfaces of the stems changed from the smooth to the hairy condition. The glandular hairs in these areas were full of the fungus, and infections were seen starting through them.

Stem-and-bulb nematode on Amsinckia.—This nematode has a recently described new variety attacking *A. intermedia*, a very common annual herbaceous wild flower of central California. The parasite was found by the Texas station to display a peculiar specialization in its selection of the tissues to be invaded. Initial infestation always occurs among the leaves at the growing tip of the plant. From this point the nematodes attack the developing flowers, where a tumorlike growth is stimulated, resulting in the complete enclosure of enormous

numbers of the parasite and the formation of a gall much larger than the normal fruit. Finally, these galls fall to the ground, leaving the rest of the plant uninvaded. Another variety of the same nematode attacking a plant commonly known as cat's-ear (*Hypochaeris*) is disseminated by means of wind-blown tufted seeds, resulting in a wide geographical distribution of the disease. In the *Amsinckia* variety, however, dissemination depends entirely on the survival of nematodes from fallen galls, and the range of this disease is correspondingly limited to small local areas.

TREE DISEASES

Maple tree diseases.—Many hundreds of Norway maples are said to have died in New Jersey during the past 2 years, and similar losses have been reported from the New England States, notably Rhode Island. As a result of experimental work by the New Jersey station, these deaths have been traced to infection by a fungus parasite of the *Phytophthora cambivora* group. Several years ago the station found the same fungus responsible for a disease in rhododendrons, and in Europe it has done extensive damage among beeches and sweet chestnuts. It is believed that this is the first report of its attacking maples, but since the maple is one of the most widely planted street and shade trees in New Jersey and elsewhere, the disease is of grave concern. No spontaneously infected trees have been known to recover, and the best recommendation at present is the prompt location and destruction of all such trees.

Nursery seedlings of Oregon maples in California were found suffering from a bacterial spotting of the leaves, which investigation by the California station proved to be due to a new species described as *Phytomonas aceris*. Five other maples also were shown to be susceptible. Cool, damp weather favors infection, and in serious cases development of cankers may follow.

Dutch elm disease.—Studying the relation of wounds and rain water to infection, the New York (Cornell) station discovered that spore masses of the fungus parasite may develop in somewhat exposed places on the trees and that rain water from the trunk surfaces of diseased trees may yield spores capable of infection. Furthermore, infection followed introduction of spores into fresh wounds of many kinds and on different parts of the tree provided these wounds reached the sap-conducting vessels, and root, trunk, and branch wounds up to 2 weeks old readily admitted the fungus. Invasion was more extensive and destructive when infection occurred during the period of rapid growth, and the incidence was greater under high moisture conditions.

Elm wilt or die-back.—A State-wide survey of elm diseases made by the Massachusetts station and extending over several years, revealed a fungus (*Cephalosporium*) wilt disease to be generally distributed throughout the State and seriously affecting the trees. Infection early in the season resulted in greater destruction than that occurring in later summer or fall. The evidence indicates that the trouble may be kept fairly well in check by maintaining tree vigor, accompanied by general sanitation. The presence of this disease in New Jersey has assumed more prominence because of its resemblance to the Dutch elm disease.

Texas root rot.—The treatment of trees and shrubs attacked by *Phymatotrichum* root rot has been continued by the New Mexico station with satisfactory results provided the disease had not progressed too far beforehand. Pursuing further its work on the basis of parasitism by this fungus, the Texas station isolated three alkaloids from bloodroot, a plant known to be highly resistant to infection, one of which was shown experimentally to prevent growth of the parasite at a concentration of 2.5 parts per million. This evidence, together with previous results, is believed to indicate that alkaloids play an important role in resistance to this root rot.

Poplar tree diseases.—The Georgia station has recently reported on studies of two diseases of poplars found to be caused by new species of fungi. One is a canker disease of balsam poplar, quaking aspen, and large-toothed aspen due to *Neofabraea populi*, and the other a leaf blight of balsam poplar caused by *Linospora tetraspora*. The New York (Cornell) station has found the eastern and western forms of a sclerotial disease of quaking aspen to be caused by two different species of *Sclerotinia* rather than by one species as formerly supposed. The two fungi were named and described.

Palm tree diseases.—The California Citrus station has studied three diseases of ornamental palms—leaf base rot of the canary date palm, bud rot of the California Washington palm, and trunk canker of the *Cocos plumosa* palm. All were shown to be caused by one fungus (*Penicillium vermoeseni*) and to occur in a rather narrow strip of land along the California coast. Planting of the California Washington palm in coastal regions is discouraged, but the Mexican Washington palm may be substituted for it. The canary date palm is attacked less frequently. On the *Cocos* palm the malady can be controlled by early removal of the trunk cankers.

Laurel oak leprosis.—Lesions closely resembling the leprosis bark disease on citrus trees were reported by the California Citrus and Florida stations in several locations, in each case occurring in proximity to the citrus disease. It is suggested that this bark malady on oak and citrus may be due to the same cause, probably a virus.

Wood-destroying fungi.—The Ohio station conducted physiological studies of a fungus parasite (*Stereum gausapatum*) known to be the most important cause of basal decay in oaks of sprout origin throughout the eastern part of the United States. Although oak is its common host, it also attacks many other deciduous trees. Very little growth of the parasite was found to occur at either relatively low or high temperatures or in the absence of oxygen, and growth was prevented under conditions of high acidity or alkalinity. The wood constituent lignin, various carbohydrates, and tannins were readily fed upon by the fungus. The spores, which initiate new infections in wood, gave 85 percent germination after 4 months, but after 6 months only an occasional one was still alive, and after 7 months all were dead. These results furnish necessary steps to an understanding of the way in which wood is attacked and to the development of means of control. The Pennsylvania station has made a study of these wood destroyers as they occur in that State, describing some 27 species and presenting a key for their identification.

Fungi causing malformations.—A group of parasitic fungi of the genus *Taphrina* are responsible for various malformations such as the witches'-broom, leaf blister, and leaf curl diseases. The New

York (Cornell) station is making a comprehensive study of these parasites and has recently published a paper on the 10 species found attacking the alder and stone-fruit trees of North America. Four of these—two on each host-tree group—are described as new species.

White-pine blister rust.—Because a million dollars a year is being spent for reforestation in Wisconsin, it is a matter of concern that the stock being planted is largely an unknown quantity so far as disease resistance and other qualities are concerned. White pines and poplars, two of the most useful species, in particular fall easy victims to disease. The Wisconsin station has found that in areas where blister rust is severe there are a few white pine trees that remain unattacked. Probably not more than 1 out of 300 to 500 young trees remains undamaged under severe conditions, but the fact that a number have been able to do so for 15 to 20 years indicated that at least some of them are disease-resistant. The station has selected 163 such apparently healthy trees, numbered them, collected and planted the seed, and made veneer grafts from 40 of them. By testing the progeny in this fashion it should be possible to learn within 5 years which of these parent trees are able to transmit disease resistance, and to begin incorporating their use in the reforestation program.

Much of the present control of white-pine blister rust is based on eradicating plants of the currant group (*Ribes*), which are the alternate hosts of the fungus parasite. To facilitate the recognition of these plants at all seasons of the year, the Michigan station has worked out and published winter and summer keys for their identification, based, respectively, on stem and twig characteristics and on leaves, flowers, and fruits. Descriptions of some 14 species of *Ribes* are included, and extensive investigations are said to have shown that practically all the species occurring in this region are susceptible to attack.

TREE INSECTS

Bark beetles.—Field keys to the galleries of 64 scolytid species occurring in Minnesota have been published by the Minnesota station along with an account of their economic importance, control measures, natural control, life history, and habits. Keys to genera and species are also included.

From a count made of cast larval skins in several galleries of the native elm bark beetle (*Hylurgopinus rufipes* (Eich.)), the Massachusetts station believes that there may be a variation in the number of stadia of this pest.

Studies by the New York (Cornell) station indicate that *H. rufipes* and *Scolytus multistriatus* Marsham infest logs near the ground as readily as those high above it.

The New York State station, in summarizing results of several years' investigations of the plant tolerance of conifers to dormant and summer sprays and the toxicity of these materials to certain insects, has demonstrated that lubricating oil containing 2 or 4 percent of dinitro-*o*-cyclohexylphenol and a proprietary compound at concentrations greater than 1 gallon in 100 gallons of spray mixture is apt to cause serious injury to evergreen conifers.

A new so-called "trough method" of treating nondurable green pine posts with water-soluble preservatives to make them resistant

to insects and decays was developed by the South Carolina station. This is not complicated or expensive, and its use is expected to help in relieving the present shortage of fence-post timber.

White-spotted sawyer and white pine weevil.—The Michigan station has called attention to the fact that red pine nursery stock is damaged by the white-spotted sawyer not only through the adults' feeding on the green bark of twigs during the flight period but by their chewing away the bark and cambium tissues along one side of the leader. The same station reports that the white pine weevil causes more widespread damage in Norway spruce than in white pine, since it does not confine its damage in spruce to leaders but sometimes extends to 3- to 5-year-old growth. Also, since the tendency toward axial growth is apparently not so pronounced in Norway spruce as in white pine, the damage to the main stem is much more difficult to overcome. For these reasons pure plantations of Norway spruce should never be established in close proximity to stands of white pine without serious consideration of white pine weevil damage.

Japanese beetle.—To protect the foliage of American elm trees against the Japanese beetle, the Delaware station recommends either ground derris (4 pounds) or tetramethylthiuram disulfide (5 pounds) combined with a suitable adhesive such as rosin-residue emulsion. An application should be made prior to any heavy invasion by this insect and should be repeated as soon as any reinfestation is noted.

Forest tent caterpillar.—Studies on *Malacosoma disstria* Hbn. and one of its parasites (*Sarcophaga aldrichi* Parker) by the Minnesota station have shown that the flies are ready to larviposit when the first cocoons of the tent caterpillar appear in the field. Only one generation of the parasite occurs each year, and it enters into direct competition with other parasites and destroys them when they chance to occur in the same host. Since it will breed in carrion, mashed caterpillars, and other organic material, it is classed as a facultative parasite (one bridging the ground between a specialized parasite and an exclusive scavenger).

Five species of egg parasites were reared from egg masses of the forest tent caterpillar by the same station. Although three of these species were found in nearly all the collections of eggs studied, the low rate of egg parasitism was attributed to factors associated with oviposition and egg-mass construction rather than to other influences. These three parasites were found well adapted to the life cycle of the host and widely distributed.

MISCELLANEOUS DISEASES

Crown gall of plants.—The physiology of crown gall development has been the subject of numerous studies in the general field of abnormal cell growths, and the recent work with plant hormones or "growth substances" has stimulated investigation of their possible relation to the formation of these tumorlike malformations. The Wisconsin station has recently reported on a study of the production of one of these growth substances (beta-indoleacetic acid, known to be capable of stimulating cell multiplication) by virulent crown gall bacteria in comparison with that by attenuated crown gall and nonpathogenic bacteria. In repeated tests, no significant differences were found among these three organisms with respect to their ability to

produce the growth substance, notwithstanding the fact that they differed widely in their ability to induce tumorlike growths when inoculated into plants susceptible to crown gall. Furthermore, in undertaking to identify the growth substances obtained from tomato gall tissue, from tomato foliage, and from crown gall bacterial cultures, it was found that the same growth substance or one very similar to it occurs under all three conditions. Although the basis of parasitism in this widespread and often destructive disease has not yet been fully solved, these are important steps on the way and they also illustrate the long and painstaking effort often necessary to the solution of the general problems of disease causation and control. Furthermore, the same station has recently published a paper enumerating the advantages of plants over animals as objects for fundamental research in cellular pathology, based particularly on these studies and directed toward determining the processes by which bacteria stimulate the infected plant to pathological enlargements and abnormal cell multiplication.

Bindweed disease.—A fungus attacking field bindweed (*Convolvulus arvensis*) has been found in the experimental plats and adjacent farming area of the Genesee, Idaho, Bindweed Field Station. Among strains of fungi isolated from infected plants, three, identified as belonging to the genus *Rhabdospora*, were shown to be parasitic and capable of inducing typical infection. Another *Rhabdospora* has been described on Canada thistle which further study may prove to be identical with the bindweed strains. Experimental evidence indicates that the fungus is soil-borne.

Downy mildews and rusts.—The downy mildew and rust fungi are generally considered to be especially favored by wet weather under natural conditions, and free water is usually thought essential for spore germination and subsequent attack. Investigating this relation of moisture to infection, the California station found that inoculations with downy mildews of onion, spinach, hops, and cucumber, and with rusts of clover, bean, snapdragon, and sunflower were successful when dry spores were added to dry leaves, provided the plants were kept under conditions of high relative humidity at constant temperatures. More rust infection occurred on detached leaves of snapdragon, bean, and sunflower when the inoculated surface faced downward for a period. Onion leaves, either outdoors at night or in dark, moist chambers, generally registered lower temperatures than those of the surrounding air. This lower leaf temperature is believed primarily responsible for the moisture condensation on the leaves and the consequent favorable conditions for infection by this mildew.

Physiological races of parasites.—Our present means of control of the highly destructive rust diseases attacking cereal crops, by the development of resistant varieties, is contingent on determining their reactions to the various races of rust likely to be met with in the localities where these crops are to be grown. Continuing its studies, the Minnesota station has just announced that physiological races are becoming recognized in the flax rust fungus and in the microorganism (related to both the fungi and the bacteria) which causes the well-known potato scab.

Powdery mildew of hops.—This fungus lives parasitically on the surfaces of the growing leaves, stems, and cones, arresting growth

and often markedly reducing the quality as well as the quantity of the crop. The New York State station has found various sulfur dusts and sprays effective against this disease. Of the dusts, those with very fine sized particles proved most satisfactory—increasingly so when applied with a motor-driven duster—and liquid sulfur sprays gave even better results in preventing infection. Certain cultural operations were also found to assist in control, and stripping the leaves off the lower parts of the vines likewise proved important since these lower leaves act as rungs in a ladder, enabling the fungus to progress up the vine. In the disease-resistance varietal plats, left without control treatments, infection was present last year on 88 to 100 percent of the cones of all native varieties. New varieties reported as free from infection in England were severely diseased in this planting, possibly due to the occurrence of a different physiological race of the parasite in the United States. However, two of the English varieties have proved very resistant here, and it is hoped they may serve as a starting point for eventual control.

Coffee root disease.—A root rot formerly believed to be due to the fungus *Rosellinia bunodes*, and for some time under study by the Puerto Rico University station, has recently been shown to be caused by a species of *Fusarium*. Since the principal cause of this important root disease in Puerto Rico is now established, it is believed that the way is finally open for development of economic control measures.

Chlorosis in New Mexico.—Among the chief factors reported by the New Mexico station as causing chlorotic conditions in various ornamental plants and fruit and forest trees in that State, mineral deficiency is believed to be the most important, and it has been proved to be temporarily controllable by injecting or spraying affected plants, or treating the soil, with iron salts. The most effective permanent cure consisted in applying barnyard manure with added iron and aluminum sulfates. An acid solution of iron and aluminum sulfates is described which proved effective against chlorosis of American grape varieties and other plants.

Seed-borne organisms.—It is concluded from a study by the Iowa station that the effects of seed disinfectants on germination in laboratory soil or sand and to some extent in blotters are reasonably indicative of what would occur under field conditions. Seedling blights of corn, sorghum, and small grains, and seed rots of peas and lima beans were partly or completely controlled by proper seed treatment. In both field and laboratory tests, ethyl mercury preparations of proper strength proved satisfactory disinfectants for barley, corn, lima beans, oats, sorghum, and wheat, controlling parasitic micro-organisms and effectively checking molds and other saprophytes which might interfere with laboratory tests. Heat-sterilized sand, or soil plus sand, provided a laboratory medium said to be superior to blotters for germination tests of barley, lima beans, oats, peas, sorghum, and wheat, and for measuring the effects of seed disinfectants on germination. From the results obtained, dry treatments were deemed preferable to liquids for both field and laboratory use. The detection of seed-borne fungi was facilitated by placing seeds on moist blotters with spaces between the seeds to prevent their rapid spread. It was concluded that such laboratory tests are valuable aids to the establishment of seed treatments in agricultural practice.

Host index of plant diseases.—The Oklahoma station has brought together, in the form of a concise annotated check list, all available information on the occurrence, distribution, and importance of diseases attacking both crop and wild plants in the State due to bacteria, fungi, seed plants, viruses, and unfavorable conditions. It is believed that this preliminary outline will serve as a framework for further studies of plant disease occurrence in Oklahoma.

Plant diseases in the Antilles.—The Puerto Rico University station has recently published a 530-page monograph on the diseases of economic plants on the islands of the Caribbean region. The account includes discussions of the history of plant disease work in the area covered and of the more general phases of plant pathology and disease control, as well as detailed consideration of specific diseases.

FUNGICIDES

The results of experimental work with chemicals used to protect plants against either infectious or deficiency diseases have already been presented in large part under the diseases of the various crops. Additional achievements in the field of fungicide research, however, are reported below.

Mustard-oil vapor.—The possibility of controlling certain plant diseases by using volatile fungicides has been given more attention recently than in the past. The results have been encouraging. Vapors of mustard oil were found capable of killing four different plant disease-producing fungi in tests at the Wisconsin station. Little or no effect occurred until a certain vapor concentration was reached and maintained, then death followed promptly. The practical uses remain largely to be explored.

Toluene compounds.—New possibilities in plant chemotherapy are foreseen in the great reduction of stem rust infection in seedling wheat plants by adding small quantities of ortho- or para-toluenesulfonylamide to the soil in experiments at the Minnesota station. Although considered impracticable for field use, the chemicals were felt to have possibilities that should be explored for use with valuable greenhouse plants.

Actinomycin.—From certain soil organisms the New Jersey station has extracted a substance of almost startling potency which has been named actinomycin. Minute quantities of the material killed soil bacteria and bacterial contaminants of milk, as well as laboratory animals. Studies were being continued to learn more about its chemical nature and practical possibilities.

Soybean flour.—That soybean flour is unexcelled as a wetting, spreading, and sticking agent for bordeaux mixture and liquid lime-sulfur is the conclusion arrived at by the Virginia station from recent tests. This material also reduced the caustic properties of these fungicides and, in combination with manganese sulfate, prevented the usual undesired chemical reaction between lead arsenate and lime-sulfur. Soybean flour also proved effective as an emulsifying agent in preparing all types of oil emulsions, and when used with powdered sulfur and lime made them wettable.

Water spray.—Plain water at 70 pounds pressure was applied at the California station to both sides of the foliage of euonymus, rose, bean, cucumber, and barley repeatedly in the late afternoon in order

to wash off loose spores of powdery mildew before they were able to cause infection. This treatment resulted in marked reduction in mildew attack and may prove practical for small-scale use at least in greenhouses.

The limitations of methyl bromide.—Attempts were made by the New Jersey station to find out whether methyl bromide, as used for the fumigation of plant materials for insect destruction, would penetrate root galls formed by the root knot nematode and kill these microscopic eelworms. In preliminary tests the gas failed to destroy them.

Polysulfide content of lime-sulfur.—The Pennsylvania station tested 30 samples of concentrated lime-sulfur from 13 different sources as to their content of polysulfides upon which the major fungicidal value is believed to depend. It was found that the specific gravity of the solution closely indicated the polysulfide strength. Thus the value of the hydrometer for testing the activity of this widely used orchard spray is confirmed.

Carbon bisulfide soil-treating machine.—Although carbon bisulfide is known to be effective against plant nematodes and certain other pests, lack of suitable apparatus for applying it conveniently in accurate dosages has been one factor impeding its use. The California station has devised a special power pump delivering exact small amounts of this material. When attached to a heavy-duty field-chisel cultivator this pump accurately discharged the disinfectant into the soil at a rate sufficient to treat about half an acre per hour. This method may prove applicable to soil treatment with other chemicals as well.

INSECTICIDES

Thanite.—The Delaware station has announced that Thanite, a synthetic terpene derivative, will become available commercially in 1941. This material is said to be a satisfactory substitute for pyrethrum in fly sprays and can be sold at a price which will enable manufacturers to produce an AA-grade spray at less cost than a B-grade straight pyrethrum spray. Since it can be developed from natural resources found in abundance in this country it will also make feasible the replacing of an imported product.

Basic copper arsenate.—A new insecticide-fungicide material, basic copper arsenate, has proved, according to the Ohio station, fully as effective as acid lead arsenate or calcium arsenate on several leaf-feeding insects. Since this material has a slower initial effect and a more rapid final effect on the insects tested than does lead arsenate, the chance that leaf-feeding insects will ingest a toxic dose before the poison causes feeding to cease is increased. As it has a low soluble arsenic pentoxide value, basic copper arsenate is safer on most types of plant foliage than are other commercial arsenicals. The factor of lead is eliminated and the copper gives the material fungicidal promise.

Nicotines.—The New York (Cornell) station in searching for new nonresidue sprays has found that a few of the more insoluble compounds of nicotine may be more effective than the soluble forms. For instance, insoluble nicotine has the advantage over the present free or partially fixed nicotine of staying on the tree longer and thus lengthening the period of effective protection.

According to studies by the New York State station, nicotine is nearly equally distributed between petroleum oils and water at low concentrations. The distribution in favor of the water increases with intermediate concentrations, reaches a maximum, and decreases at high concentration.

Spray removal.—In studies on the effect of insect residues and other factors on removal of spray residues from apples, the New Jersey station has found variations in the difficulty of removing residues from different kinds of apples. The factors thought responsible for these variations are insect residues such as honeydew, differences in conditions of the foliage on the trees, and the sticker and spreader used in spray material. For a given spray treatment, apples from trees with a heavy, luxuriant foliage were much easier to wash than those from trees with light foliage. Of several materials compared, Orthex had the desirable qualities of producing a heavy coating and of being removed without difficulty in washing.

Spray deposits.—An apparatus designed for taking pictures, with very short exposure, of drops of a liquid at any desired time before, during, or after contact with a solid has been described and figured by research workers at the California station. From the photographs, accurate measurements can be made of the advancing and receding angles. Continued spraying effects may be studied by allowing any desired number of drops to strike and move down the surface, and since the method is relatively cheap, many tests may be made so that small differences in behavior may be evaluated with precision.

Preventing decomposition of lead arsenate.—The New Jersey station concluded than an excess of calcium hydroxide is required to prevent the decomposition of lead arsenate by hydrogen sulfide.

Spray activators.—In studies on activators for nicotine sprays, the Louisiana station found agar-agar trebled the effectiveness of nicotine sprays for the pea aphid.

Calcium cyanamide.—The Washington station reported that in studies conducted in prune orchards of Clark County, Wash., during the spring of 1939, commercially pulverized and oiled calcium cyanamide applied to the soil and cover at the rate of 300 pounds per acre prevented the development of apothecia of *Sclerotinia fructicola* and reduced the number of prune thrips that emerged from the soil.

Methyl bromide.—As an insect fumigant this compound was studied by the Minnesota station. It was demonstrated that of the insects tested larvae of the black carpet beetle were most resistant. Baking tests with flour fumigated with methyl bromide at 2 pounds per 1,000 cubic feet showed no detectable injury.

Experiments by the New Jersey station indicated that methyl bromide emulsions made by adding 50 cubic centimeters of methyl bromide to 250 cubic centimeters of wood alcohol and 3 gallons of water, applied by sprinkling to 50 square feet of soil, will kill grubs of the Asiatic beetle in azalea beds in the greenhouse and outdoors without injury to the plants.

Semirefined oils.—Investigations by the New Jersey station have resulted in the recommendation of semirefined oil which costs 11 to 14 cents a gallon in tank-car lots rather than highly refined oils at a cost of 30 cents per gallon for summer sprays to control the codling moth and European red mite. The semirefined oil is heated in such

a way as to remove most of the unsaturated and aromatic hydrocarbons which are mainly responsible for the damage done to plants by petroleum products.

Fumigants.—From toxicity tests of hydrogen cyanide, chloropicrin, and ethylene oxide on eggs, nymphs, and adults of the bedbug, the Montana station concluded that hydrocyanic acid is 2 to 48 times as toxic as the other gases. Eggs of the bedbug are less resistant to hydrocyanic acid and ethylene oxide than are nymphs and adults, but are apparently much more resistant to chloropicrin than are nymphs and adults, which are very similar in their reaction to the fumigants used in the experiments.

ANIMAL PRODUCTION, PRODUCTS, DISEASES, AND DISORDERS

CONTENTS

The problems confronting the livestock producer are many and varied. In order to meet his demands for assistance, research has been called upon to furnish information in the fields of breeding, nutrition, management, and the protection of animals from diseases and parasites. Contributing to these broad fields of investigation are studies in the basic sciences on specific segments, the solutions of which are essential to the maintenance and progress of a livestock industry.

Research agencies concerned with problems in animal production are learning that the pooling of their resources has many advantages. While this procedure is not new, it received a marked stimulus from the establishment of the Bankhead-Jones regional laboratories. Experimental work with farm animals is costly, and in addition the concentration of large numbers of animals presents many difficulties from the standpoint of disease control. By combining facilities, following a procedure agreed to by all interested parties, it has been possible to use a sufficiently large sample to give weight to the results, but not to burden the individual agency with an unwieldy overhead. These cooperative and coordinated programs are extending to many phases of research with animals and animal products.

Among the oldest of these joint undertakings are the cooperative meat investigations. The regional laboratories are serving as focal centers for studies in the improvement of sheep and swine by breeding, the improvement of viability in poultry, improvement of pastures, and methods of combating animal diseases. Other such studies include jack-stock and mule production, input as related to output in dairy farming, relation of conformation and internal anatomy to productive ability in dairy cows, proving dairy sires for ability to transmit increased milk and butterfat production, and cheese-quality

improvement. In all of the above work the Department of Agriculture is cooperating with the State experiment stations.

An example of a coordinated research undertaking is found in the field of physiology of reproduction in farm animals. Mutual problems and technique are discussed and plans for further research are made at an annual meeting of workers in this field. A number of State experiment stations are working on different phases of a national problem to find a satisfactory means of feeding high-roughage-low-concentrate rations to dairy cattle.

The following examples briefly review some of the research accomplishments in the many fields related to animal production.

NUTRITION, MANAGEMENT, AND PRODUCTS

The changes from year to year in the trends of animal-production research at the State experiment stations are not sharply marked, but there is a constant and growing tendency to develop sound fundamental research programs which establish basic facts and principles underlying the observed responses of animals and animal products to varying conditions. Examples of information gained through recent research are set forth in the following pages:

GENERAL

The evaluation of feeds.—It has long been recognized that different food substances contained in animal feeds exert different influences on the animal body and that many specific substances are required to supply the needs of the animals at various stages of development, production, and reproduction. There is also a growing recognition that the long-used method of evaluating feeds on the basis of total digestible nutrients is grossly inadequate. Numerous attempts have been made to establish more reliable criteria for measuring the true nutritive value of feeds.

Findings of the Oklahoma and Michigan stations indicate that the common practice of expressing the carbohydrate components of a feedstuff in terms of crude fiber and nitrogen-free extract is not a reliable index of nutritive value, and that the partitioning of the carbohydrate fraction into lignin, cellulose, hemicellulose, and other carbohydrates is of greater biological significance than the former method. Enzymatic methods of carbohydrate digestion also gave much sharper distinction between the highly digestible and poorly digestible fractions than the commonly accepted method for crude-fiber analysis. The Michigan station further determined that values for true fat in feeds are of greater biological significance than ether-extract values now generally used. The Minnesota station, comparing chemical and biochemical methods for determining the biological value of proteins, showed that a protein-quality index based on chemical determinations bore little relation to true biological values in the case of isolated proteins but was fairly reliable for natural feedstuffs.

The Texas station found, through determinations of the stored energy in the body of animals, that the relative quantities of feed required per unit of gain in live weight differed materially from that required per unit of gain in energy. The conclusion was reached that the feed required per unit of gain in live weight is not a safe

standard for comparing the feeding value of rations and that, when measured by gains of energy, neither total nutrients, digestible nutrients, nor metabolizable energy are correct measures of the productive-energy values of feedstuffs. The productive-energy values for various feedstuffs have been determined by the above method.

A method of comparing the nutritive values of feeds, developed by the California station, involves the use of casein and glucose as reference substances. Feeds are judged in terms of the pounds of casein and glucose in a basic ration that can be replaced by 100 pounds of a given feed. The procedure promises to be of real use in determining the comparative value of different animal feeds. Similarly, the Washington station has perfected a method for determining the gross value of protein concentrates, using casein as a reference substance with an assigned value of 100 and employing protein-depleted chicks as test animals. Typical protein values determined by this method were: Herring fish meal, 105; hydraulic soybean meal, 58.5; skim milk, 88; and alfalfa hay, 14.

The digestion and utilization of feeds.—Determinations made by the Pennsylvania station of the digestibility and of the metabolizable energy of alfalfa, soybean, and mixed clover-timothy silages showed that silage preserved with molasses ranked higher in total digestible nutrients and metabolizable energy than silage made from the same plant preserved with phosphoric acid. Only in digestibility of crude protein did the silages containing phosphoric acid consistently rank higher than those containing molasses. Hydraulic-, solvent-, and expeller-process soybean meals were found similar in digestibility, the solvent-process meal having slightly higher digestible crude protein but lower total digestible nutrient and metabolizable energy values than the other two.

Digestion trials with mature range grasses by the Washington station indicated that bluebunch fescue was more palatable and had higher coefficients of digestibility for all constitutents than bluebunch wheatgrass. The addition of small amounts of linseed cake or ground barley to the range plants increased the palatability and digestibility of the mixed ration.

Experiments at the West Virginia station gave evidence that silage made from the entire corn plant was more digestible than silage made from corn from which the ears had been removed, while silage prepared from normal corn plus the ears removed from the stover silage excelled the normal silage in digestibility. These findings emphasize the undesirability of snapping the ears from corn before ensiling it.

Partial hydrolysis of casein by enzyme digestion markedly reduced the nutritive value of the product for chickens, according to findings of the California station. Furthermore, the presence of the digested casein in diets containing adequate amounts of whole casein resulted in depressed growth rates. The cause of this phenomenon is obscure, but evidently it is not attributable to partial amino acid deficiency.

Experiments with laboratory animals by the Pennsylvania station gave evidence that the metabolizability of diets and also the heat production of the animals diminished at a nearly regular rate as the protein content increased from 10 to 45 percent of the diet. Body

309632—41——9

gains diminished materially on a low plane of food intake, but increased slightly on a high plane of intake as the protein level increased. A study of the dynamic effect and the net-energy values, of protein, carbohydrate, and fat revealed that the dynamic effect of protein (beef muscle) was highest, that of carbohydrate (dextrin) intermediate, and that of fat (lard) lowest, while that of a mixture of the three was even lower than lard alone, indicating that the effects of individual nutrients are not significant with respect to combined nutrients. They ranked in order of ascending net-energy values as follows: Beef muscle, dextrin, the mixture of all three, and lard.

The Illinois station found, through studies with laboratory animals, that while 30 to 50 percent of the nitrogen lost in endogenous metabolism could be replaced by a variety of incomplete dietary combinations of amino acids, the remainder of the requirement must include at least seven essential amino acids; and further, that the utilization of the required amino acids is dependent upon the simultaneous presence in the diet of certain combinations of the essential amino acids. Threonine or isoleucine, or possibly both, was essential for the utilization of the other essential ones, suggesting that they may occupy a key position in this respect.

Metabolism of farm animals.—Measurements by the New Hampshire station of the energy expended by the horse during work indicated that an individual weighing 650 kilograms, when standing, walking, or trotting at 5 and 10 miles per hour expended about 750, 2,400, 3,800, and 5,000 calories of energy per hour, respectively.

The Iowa station found that a basic ration of 3 pounds of oats and 20 pounds of timothy hay provided sufficient protein to maintain draft geldings in positive nitrogen balance during periods of heavy, moderate, or light work, as well as when at rest.

The basal metabolism of growing dairy animals was found by the New Hampshire station to vary with age. It was very high in heifers 8 months of age, averaging about 2,660 calories per 100 kilograms live weight. At 12 months of age the rate had dropped about 25 percent and remained fairly constant up to the fourth or fifth month of pregnancy. From 5½ to 8½ months of pregnancy the metabolic rate gradually increased to about 30 percent higher than for nonpregnant animals. A summary of four trials conducted at the North Dakota station indicates that cows running loose in open sheds (mean temperature, 29.4° F.) produced slightly more 4-percent milk, consumed less total feed, and gained more in live weight than cows confined (in stanchions) in warm barns (mean temperature, 50.6°). Feed consumption per 100 pounds of 4-percent milk produced was slightly less for the open-shed group than for cows in the warm barn.

The preservation and use of roughages.—Factors affecting the composition and nutritive value of forage crops and methods for effectively preserving them, and utilizing them to best advantage in livestock production, continued to occupy a prominent place in the research program of many stations.

The Delaware station found that frequently clipping immature grasses and artificially drying them increased the annual acreage yields to some extent, the protein yields by 40 to 60 percent, and the carotene content by 80 percent over the usual sun-cured hay. Such

dried grass could be used to replace a considerable portion of the concentrates in a dairy ration without reducing the milk production, and when used to replace all the concentrates reduced the cost of milk production about 0.4 cent per quart.

The Vermont station, comparing natural drying, artificial drying, and ensiling as methods of conserving common grasses and legumes, found that the nutrients in hays and silage were about equally digestible except for the ether extract in sun-cured hay, which was relatively very low. There was no significant difference in the recovery of digestible nutrients per 100 pounds of dry matter ensiled or made into sun-cured hay under ideal weather conditions. Unfavorable weather conditions materially increased the losses during haying.

The Puerto Rico Federal station found that the biological value of the proteins of native grasses generally excelled that of common legumes. The grasses varied in this respect, Guinea grass having the highest and Yaragua grass the lowest net protein value among the several species studied. The biological value of the protein in cowpeas progressively increased as the plant passed from the blooming to the full-pod stage.

The Texas station, through systematic analyses of the forage grasses in the east Texas timber country, found a direct relation to exist between the total nitrogen, active phosphoric acid, and active lime in the soil, and the level of these constituents in the forage. Protein and phosphoric acid decreased materially with advancing maturity of the plants, and as plants approached maturity there was a marked increase in the proportion of forages that were deficient or very deficient in protein and phosphorus. Johnson, Dallis, and Bermuda grasses were generally higher in these constituents than the principal native species collected. Napier grass proved to be a valuable grazing crop under rotational grazing as practiced by the Florida station. It sustained average daily gains of 1.7 pounds per head in beef steers and supplied 54 percent of the total nutrients required by heavy-milking dairy cows. The Hawaii station, comparing Napier and Sudan grasses as soiling crops for dairy cows, found the latter to be more palatable and to sustain higher milk production. Sugarcane proved to be a valuable feed crop, in trials at the Florida station, containing 62 percent total digestible nutrients in the dry matter of the fresh crops. Shocked fodder and silage contained 84 and 62 percent as much nutrients (dry-matter basis), respectively, as the fresh soiling crop.

A study by the Michigan station of the carotene content of several common forage plants during the growing season indicated a much higher concentration of this constituent during the early growth stages than at the stage of maturity at which the plants are generally harvested. In general, according to the Oklahoma station, carotene content of feed plants increased up to the time of blooming, and then decreased. It was influenced by the season in accordance with the favorableness of conditions for growth. Properly cured hay contained about one-half as much carotene as that in the green forage. It dropped to about one-third that of the green plant after 6 months' storage under good conditions. Carotene in silage was quite stable over long storage periods, averaging at least one-half of the initial value after 6 months. The Mississippi station found that the leaves of freshly cut alfalfa made up less than 50 percent of

the weight of the plant yet contained over 90 percent of the total carotene. One-half to three-fourths of the initial amount of carotene was lost during 24- to 30-hour curing in the shade, while drying in resulted in a 25-percent reduction in riboflavin content.

The Ohio station has shown immature grasses and legumes to be relatively potent sources of riboflavin, a member of the vitamin B complex. Both timothy and alfalfa declined about one-third in riboflavin content as they progressed from the prebloom to early-bloom stage. Exposure of cut alfalfa to sunlight for 48 hours resulted in a 25-percent reduction in riboflavin content.

Studies by the New York (Cornell) station with alfalfa hays subjected to natural exposure to smelter fumes or intermittently exposed to sulfur dioxide gave evidence that none of the treatments caused chemical alterations of nutritional significance, although they did increase the sulfur content of the hays in all cases.

Interest in conserving grasses and legumes as silage is becoming increasingly widespread, with a consequent increase in the research of the stations on this subject. Numerous trials, as previously reported, have shown that molasses is an effective preservative agent for such material. Phosphoric acid has also been used to some extent as a preservative, and findings of the New York (Cornell) station indicate that it is of definite value but that for best results its action must be supplemented by a strong lactic acid fermentation. With low-sugar crops the further addition of molasses may thus prove to be desirable. The Tennessee station has successfully ensiled both alfalfa and *Lespedeza sericea*, using 60 pounds of molasses and 10 pounds of phosphoric acid per ton. Feeding tests with dairy cows indicated that *L. sericea* silage was slightly inferior to alfalfa silage or good corn silage when fed as a supplement to grain and hay. A mixture of grasses and legumes ensiled with additions of phosphoric acid proved about equal to corn silage for milk production, but, according to reports of the Massachusetts station, was somewhat inferior to corn silage for supporting growth in dairy heifers.

The Pennsylvania station found that, despite the presence of phosphoric acid, when the reducing sugar of silage plants decreased to 1 percent, by dry weight, abnormal fermentations occurred, lowering the lactic acid content and increasing the pH value and the volatile acid content with a resulting reduction in silage quality. The loss of protein was very slight, but the loss of soluble carbohydrates as determined by the Michigan station was considerable in grass-legume silages preserved with molasses. A sharp loss in carotene occurred during storage, but the silage was still several times higher in carotene content than hay.

The New Jersey station found that the carotene contained in various kinds of silage, including grass-molasses silages, was equal to International Standard carotene in vitamin A potency. The Wisconsin station has shown that a nutritive principle designated as the "grass-juice factor" is effectively preserved in grass-legume silages. Milk from cows fed phosphoric acid-alfalfa silage was about as rich in the grass-juice factor as milk produced by cows on summer pasture. This station also found that the vitamin A potency of milk increased markedly when pea-vine silage preserved with phosphoric acid replaced alfalfa hay in the dairy ration. A high-quality silage was prepared from Russian-thistles when 1 percent of phosphoric

acid or 3 percent of sucrose was added to the green crop in a trial at the Montana station.

Nutritive value of unusual feeds.—Analyses of dehydrated sweetpotatoes by the South Carolina station showed this product to be relatively rich in carotene. In feeding experiments with milking cows, dairy calves, and chickens it proved to be a palatable and nutritious feed and materially enhanced the vitamin A potency of milk and of eggs.

Distillery byproducts proved to be good sources of riboflavin for chickens in trials at the Minnesota station. The addition of 4 percent of distillers' dried solubles or 9 to 10 percent of either corn or special distillers' dried grains to the ration of growing chicks gave results comparable to those obtained with 100 to 130 micrograms of pure riboflavin per 100 grams of ration. The dried solubles proved as effective as dried skim milk in flavin-deficient rations.

The Maryland station found that replacing one-half of the dry matter in the concentrate ration of milking cows with rye stillage (distillers' slop) did not significantly influence milk production and had no ill effect on milk flavor when fed immediately after milking. With grain at $30 per ton, the stillage was worth $1.52 per ton.

Deleterious effects of soybeans and soybean products.—The Colorado station found that raw soybeans or soybean meal, when added to the ration of young chicks, exerted a marked goiterogenic effect, producing thyroid glands about six times as large per unit of body weight as when casein was fed. Supplementary iodine in the ration tended to counteract this effect. The feeding of soybeans or soybean meal as a protein supplement in simplified diets for chickens had a depressing effect on production and reproduction entirely distinct from the goiterogenic action. In further studies of a vitamin A-suppressing factor previously found to be present in soybean oil, the Indiana station has demonstrated the possibility of removing the active principle by adsorption on a special preparation, Nuchar. The principle was not inactivated by this process but was held tightly by the adsorbent.

Nonprotein compounds as sources of nitrogen in livestock feeding.—Since protein concentrates are generally the most expensive constituents in livestock rations, the possibility of utilizing less costly sources of nitrogen has been investigated. The Wisconsin and Hawaii stations, working with growing dairy animals, and the Illinois station, working with lambs, have demonstrated that urea can be effectively utilized by both classes of animals to cover a considerable portion of their protein requirement. As much as 3½ percent of urea in the ration of lambs was neither toxic nor deleterious. Tissues of calves fed 43 percent of their total nitrogen requirement as urea were normal in composition.

The Wisconsin station also found that ammonium bicarbonate could be used to partially replace protein in the ration of calves, although nitrogen from this source was used less effectively than that in urea. It is probable that these simple nitrogenous compounds are used in the production of protein by bacterial action in the rumen. Experiments with rats by the Pennsylvania station and with growing chicks by the Nebraska station indicated that neither can utilize urea to any significant extent.

Mineral requirements of animals.—Studies on the optimum levels of various minerals in livestock rations and the physiological effects of mineral deficiencies continue to occupy a prominent place in animal-nutrition investigations.

The results at the Pennsylvania station of a long-time feeding experiment with timothy hay, corn silage, and concentrates as the basic ration for milking cows indicated that no significant deficiency of minerals existed under this regime, and that the feeding of bonemeal as a mineral supplement was not justified. The New Mexico station confirmed previous findings on the suboptimal phosphorus supply in range grasses for range cattle, especially during the winter months or in periods of drought. The average weight of calves at weaning age was increased 87 pounds, or 26 percent, simply by correcting the phosphorus deficiency in the ration of the cows through the use of dicalcium phosphate as a supplement. Trials at the Idaho station indicated that fattening beef cattle, when maintained on a phosphorus-deficient ration for more than 60 days, developed typical symptoms of aphosphorosis. The requirement of steer calves proved to be about 2 grams of phosphorus daily per 100 pounds live weight. Rations made up largely of sugar beet byproducts, native hay, straws, and molasses were generally deficient in phosphorus, but the inclusion of reasonable amounts of alfalfa hay, grain, and protein concentrates in the ration adequately met the requirement.

The inclusion of excessive amounts of minerals in the rations of pigs allowed to run out in direct sunlight retarded the rate and increased the cost of growth, according to findings of the Wisconsin station. Mineral supplements other than salt were seldom necessary when the ration contained skim milk, tankage, or other animal-protein supplements, and when the ration was entirely of vegetable origin from 0.5 to 0.75 percent of high-calcium limestone or 1 percent of bonemeal proved to be adequate sources of the necessary calcium.

In trials at the Florida station pigs fed largely on peanuts developed very thin bones, and posterior paralysis of such animals frequently occurred. The addition of a small amount of calcium carbonate to the peanut ration corrected this deficiency and promoted more rapid gains.

Calves subjected to suboptimal levels of potassium intake at the Michigan station showed a marked decline in blood potassium values. This condition was accompanied by striking changes in heart action as revealed by electrocardiographic observations.

Blood magnesium values in cattle are subject to marked fluctuations not attributable to age or food intake. The Michigan station found that relatively low values generally occurred during periods of maximum sunshine and relatively high average temperature. On the other hand, the Iowa station found that cattle subjected to extreme drought conditions exhibited relatively very high blood magnesium values. The clinical significance of these fluctuations has not been established.

Experiments at the Wisconsin station indicated that the addition of boron to the ration of dairy cows and laying hens promptly resulted in increased boron content of the milk and eggs. Feeding trials with rats indicated that this species requires very little, if any, boron in its diet.

Further studies by the South Dakota station gave evidence that 10

parts per million of arsenic, in the form of sodium arsenite or sodium arsenate, in the drinking water of rats gave complete protection against selenium toxicity when their diet contained up to 18 parts per million of selenium. Arsenic in the form of sulfides was ineffective. Of a number of other elements tested for protective properties against selenium, only tungsten gave any beneficial action.

Interest continues to center on the role of manganese in poultry nutrition. The Michigan station found a marked difference in the availability of manganese in the natural ore rhodochrosite and in precipitated manganese carbonate. In chick-feeding tests 30 parts per million of manganese as carbonate in the ration gave complete protection against perosis, while levels up to 125 parts per million in the form of finely ground ore proved unsatisfactory. The ore when roasted or dissolved in acid became an effective source of manganese. This station also obtained evidence of a marked difference in the manganese requirement of various breeds, Barred Rock chickens requiring more of the element to insure good hatchability of eggs and to prevent chondrodystrophy of chicks than did White Leghorns. The Wisconsin station found that the level of manganese in the diet of hens necessary to insure good hatchability of eggs varied seasonally, more manganese being required in winter than in spring or early summer. Evidently, the amount of sunshine exerted a marked effect in this regard, but vitamin D was not a contributing factor.

When chicks were subjected to a relatively high dietary intake of calcium and phosphorus, intraperitoneally injected manganese was much more effective than orally ingested manganese in protecting the birds against perosis, according to findings of the New York (Cornell) station. The station further found that manganese deficiency in the diet of breeding hens resulted in embryonic deformity characterized by a shortening of the leg and wing bones. Chicks which were micromelic at time of hatching failed to show any recovery from this condition at maturity.

Findings of the Missouri station indicate that, in addition to an adequate amount of manganese, some organic dietary factor present in dried liver is required to prevent perosis in fowls. The manganese required to prevent perosis was shown by the Oklahoma station to vary markedly with the breed of chicks and with the amount of other minerals in the diet. Many supplementary food materials, when added to a perosis-producing basal diet, exerted some protective action against this disorder which was not always clearly associated with their manganese content, suggesting that factors other than manganese content of the ration may be involved in perosis control.

Sulfur in the diet is commonly recommended for the prevention of coccidiosis in chicks. Trials at the Louisiana station indicated that the addition of small amounts of sulfur to the diet of chicks interfered with normal bone calcification and growth, even in the presence of supplementary vitamin D. Further, increasing the vitamin D intake improved the rate of growth and generally prevented leg weakness, although bone ash values remained below normal. The addition of molasses or charcoal to rations containing sulfur generally reduced the rate of growth, suggesting that the various sulfurs may not be compatible with these ingredients.

The role of vitamins in animal nutrition.—The highly important place of vitamins in the nutrition of livestock has been further elu-

cidated through extensive studies during the past year. Investigations by the Kansas station have shown that lack of vitamin A is definitely one of the limiting factors in the well-being of cattle under drought conditions. Abnormalities such as reproductive failure and weak, sick, or dead calves are common even when feed is ample and complete except for vitamin A potency. It was found by the Michigan station that when calves were maintained on a low-carotene diet blood carotene declined to relatively low levels and when these values fell below 0.13 microgram per cubic centimeter night blindness and papillary edema followed. An intake of 9 micrograms of carotene per pound of body weight daily was inadequate, while 16 micrograms proved adequate to maintain the plasma carotene above 0.2 microgram per cubic centimeter and prevent these disorders. It was concluded by the Pennsylvania station that the minimum carotene requirement of growing calves is 11 micrograms per day per pound of body weight. Increasing the intake above that level did not result in any marked improvement in growth rate. An adequate supply of vitamin A is essential for satisfactory milk production, according to the Texas station, where it was found that cows limited to 1,500 micrograms of carotene daily per hundred pounds of live weight produced 10 percent less milk on the average than cows receiving 10 times this level of carotene in their ration.

Results obtained at the Oklahoma station indicate that when prairie hay is the only source of carotene for Jersey cows and heifers, a daily intake of 40 micrograms of carotene per pound of live weight is adequate for normal reproduction and calving. The requirement for lactation following normal calving was similar to that for growth and maintenance and considerably lower than that required for normal reproduction. That the vitamin A potency of milk is directly dependent of the vitamin A intake of cows has been confirmed by the New Mexico, Kansas, and Indiana stations. The last-named station also found that the source of vitamin A is an important consideration, about five times as much of the vitamin ingested in the form of carotene in alfalfa hay being required to impart a maximum vitamin A potency to milk as when the vitamin was supplied directly in the form of cod-liver oil. In addition to commonly recognized symptoms of vitamin A deficiency, the Michigan station has shown a marked increase in the pressure of the cerebrospinal fluid to exist in cattle during avitaminosis A. Recovery from this condition was very slow when adequate feeding was resumed. Other conditions developing in male cattle as a result of vitamin A deficiency, as determined by the Ohio station, include degeneration of the kidneys and the germinal epithelium of the testes, absence of spermatozoa in the epididymis, and increased gonadotropic activity of the pituitary gland.

The Wisconsin station determined that avitaminosis A resulted in a lowered vitamin C concentration in the blood of cattle, and that certain symptoms of vitamin A deficiency were alleviated by the injection of ascorbic acid. This station also found that the subcutaneous injection of ascorbic acid effectively restored the fertilizing capacity of certain impotent bulls, and that the ascorbic acid content of fresh semen offers a promising method of predicting its potency.

Additional evidence has accrued to indicate that ruminants are self-sufficient in meeting certain of their vitamin requirements. The

growth of calves reared on purified diets by the New York (Cornell) station was not improved by additions of vitamin B, riboflavin, ascorbic acid, or the "grass-juice factor" to the diet.

The Ohio and California stations agree in showing that important members of the vitamin B complex are synthesized in the bovine rumen. The Texas station has found that nicotinic acid is synthesized in the body of sheep, and the South Dakota station reports that vitamin C is synthesized by the dairy cow and that cattle are not dependent on food sources for this factor. On the other hand, the California station has confirmed the requirement of the pig for all important members of the vitamin B complex, while obtaining evidence that this species cannot synthesize its own riboflavin and thiamin (B_1).

The dog also has been found to have a specific requirement for most of the known dietary factors. In trials at the New Jersey station young dogs developed pronounced symptoms of vitamin A deficiency in about 45 days when fed a diet low in this factor. The symptoms were alleviated when carotene was added to the diet. The Wisconsin station has demonstrated that for normal bone development, the dog requires about 20 International Units of vitamin D per 100 grams of diet in the presence of a favorable calcium-phosphorus ratio, and that thiamin, riboflavin, nicotinic acid, vitamin B_6, and factor W, all members of the B complex, are essentials in the dog ration. In addition, the California station found that dogs require the chick antidermatitis factor (pantothenic acid) for normal development.

Nutritionally induced paralysis due to muscular dystrophy has frequently been observed in laboratory animals. Experiments at the California station with rats and at the Wisconsin station with dogs gave evidence that the administration of a vitamin E concentrate or synthetic alpha-tocopherol gave complete protection against the onset of this disorder.

Vitamin requirements and sources for poultry.—Continued investigations in this field have increased our knowledge of the requirements for and functions of known essential dietary factors and have demonstrated the requirements of fowls for previously unrecognized factors.

In an attempt to define narrowly the requirement of chickens for vitamin A when fed as carotene, the Texas station found that young chicks, growing pullets, and laying hens require 125 to 150, 150 to 175, and not less than 450 micrograms of carotene per 100 grams of ration, respectively.

Growing turkey poults were found by the Colorado station to require about four times as much vitamin A as young chicks or about 600 units per 100 grams of ration. A new vitamin A-deficiency symptom has been described by the Connecticut (Storrs) station, which found that the degree of deficiency is accurately reflected in the histological condition of the nasal mucous membrane. The specific lesions recede caudally as the severity of deficiency decreases.

The Indiana and Ohio stations agree in their finding that ultraviolet irradiation is an effective source of vitamin D for growing chicks. The former station found this procedure to be highly practical for the production of poultry meat during seasons of the year when birds must be confined. The latter station, continuing the pullets as layers, found that the group subjected to ultraviolet light yielded more eggs than

groups receiving vitamin D as cod-liver oil. The vitamin D requirements of turkey poults is about 250 chick units per 100 grams of ration, which is considerably higher than that of chicks, as determined by the Pennsylvania station.

The essential nature of riboflavin in the ration of breeding hens to permit normal embryonic development in their eggs has been confirmed by the California and Wisconsin stations. Distillers' byproducts proved useful as sources of riboflavin in chick and hen rations in trials at the Massachusetts station. The Maryland station, comparing crystalline riboflavin, dried whey, and dried skim milk as sources of riboflavin for chicks, found dried skim milk to excel the other two when fed on a riboflavin-equivalent basis. The requirements of chicks for this factor under the conditions of these trials proved to be higher than is generally recognized.

Trials at the California, Alabama, Wisconsin, and Missouri stations definitely indicated vitamin B_6 to be an essential component in chick rations. The requirement for normal growth seems to range from 300 to 400 micrograms per 100 grams of ration. It appeared that practical rations may, at times, be deficient in this factor.

Further investigations by the Wisconsin station on the role of pantothenic acid (chick antidermatitis factor) in fowl nutrition indicated that a deficiency sufficient to produce dermatitis in chicks also resulted in a definite neuropathology of the spinal cord, involution of the thymus gland, liver damage including fatty livers, and keratitis. Yeast is a potent source of this factor, and certain animal tissues, particularly liver and kidneys, proved to be relatively rich sources. The requirement of the chick for this factor has been set by the California station at about 1.4 milligrams of pantothenic acid per 100 grams of diet.

Further studies by the California station on sources of the antihemorrhagic vitamin revealed pure synthetic phthiocol to possess marked activity. Vitamin K or synthetic compounds possessing antihemorrhagic activity are now widely used in medical clinics, largely as an outgrowth of work at this station.

Evidence of the essential nature of other heretofore unrecognized dietary factors has been gained through recent studies. The New York (Cornell) and California stations have confirmed the requirements of chicks for a new growth factor obtained from dried brewers' yeast. Late work by the former station has indicated that this in turn may be of a complex nature, probably containing two distinct factors.

Efforts of the California station to identify the principle in polished rice not present in dried yeast which has a growth-promoting effect on chicks revealed that the rice factor can be identified with, or at least replaced by, a mixture of glycine and chondroitin. Each proved to be a distinct growth factor for chicks.

The Missouri station has demonstrated that a characteristic type of anemia will develop in chicks deprived of a nutritive factor contained in dried pork liver. This unidentified factor has been tentatively designated as vitamin B_c.

The Maryland station has described a type of generalized edema which develops in chicks maintained on a certain type of simplified ration. The administration of alpha-tocopherol prevented the onset of this disorder.

Choline proved to be a valuable supplement to low-fat basal diets for chickens, resulting in increased egg production, decreased mortal-

ity, and inhibition of abortion of egg yolks, according to results obtained at the Florida station. The California station reports that the addition of choline to a perosis-producing basal ration effectively prevented the occurrence of perosis in young turkeys. In the absence of choline the disorder occurred in a high percentage of the cases even in the presence of a manganese supplement.

BEEF CATTLE

Efficiency of feed utilization.—Trials at the Mississippi station have evidenced that high-grade beef calves sired by Devon, Hereford, Shorthorn, or Angus bulls and from unimproved native cows made more rapid and more efficient gains than calves sired by native bulls. The Devon grade calves slightly excelled the other crossbred lots, while the average gain of all crossbred calves exceeded that of the native calves by about 0.2 pound per head daily. Furthermore, the crossbreds yielded higher grading carcasses than the native calves. Preliminary record-of-performance tests at the Montana station in cooperation with the Department (B.A.I.) for the appraisal of female stock as to efficiency of feed utilization, both as calves and as yearlings, have revealed rather wide differences in their individual abilities to utilize a roughage ration fed at a uniform level according to body weight. Also evidence of the practical importance of variations in efficiency of steers from different sires, both within and between groups, has been revealed. These findings indicate the significance of such tests for the evaluation of beef cattle breeding stock. Trials at the Ohio station showed no significant difference in the rate or economy of gains of calves produced by mature cows and those produced by heifers.

Grazing and forage in beef-cattle rations.—Much attention is being devoted to determining ways of utilizing a maximum amount of pasture and roughage in the production of market beef. The Missouri station has demonstrated the feasibility of carrying animals to a fairly mature age before marketing, using legume hay and silage as the winter ration for calves and yearlings and taking advantage of two seasons of grazing on bluegrass and lespedeza pasture. Good market cattle were produced with relatively little grain as compared with the dry-lot fattening of calves and yearlings.

Effective use of pasture in the fattening of yearling heifers was attained at the Kansas station by well wintering the calves, carrying them on grass for 90 days, and then full-feeding in dry lot for 90 to 100 days. Heifers handled in this manner gave a high dressing percentage and returned a good profit over feed costs. The West Virginia station, in cooperation with the Department (B.A.I.), in comparing methods of feeding supplement to steers on grass in the Appalachian region concluded that the practice of limiting grain feeding to the latter part of the grazing season is more profitable than supplementary feeding throughout the period on grass. It was found by the Louisiana station that the feeding of about 3 pounds of concentrates per head daily to steers on riceland pasture materially increased the rate of gain over those receiving no grain and resulted in greater profits than when no grain or a larger amount of grain was fed.

The addition of a small amount of cottonseed to corn for beef

calves on pasture proved to be a profitable practice in trials at the Ohio station. The value of crested wheatgrass hay as a roughage for wintering beef cattle was substantiated in trials at the Montana station. Furthermore, it was possible to utilize this grass as a winter range for beef cattle by feeding relatively small amounts of protein supplement in addition to the range.

Alfalfa silage made with the addition of 60 pounds of molasses per ton proved to be a more valuable roughage for fattening yearling steers than alfalfa hay from the same crop and fed on an equivalent dry-matter basis, in trial at the Kentucky station. Shocked sugarcane was found by the Florida station to be an economical and practical roughage for wintering beef cattle. The North Carolina station found soybean hay to be an excellent supplement to cottonseed meal and hulls in the ration of young growing cattle, excelling alfalfa hay for this purpose. When fed at a rate to provide 20 percent of the dry-matter intake, the soybean hay provided an adequate amount of vitamin A for normal growth and well-being of the animals. Yellow corn when fed as a supplement to cottonseed meal and hulls failed to supply an adequate amount of this vitamin.

At the Hawaii station, grazing cattle on native herbage, including koahaole, pigeonpea, and improved grass pastures supplemented with cane molasses, seemed to be a more economical system of beef production than dry-lot feeding, using native feeds. Cattle in dry lot, fed fresh-cut green cane tops and allowed free access to a mixture of cane molasses and soybean meal (4–1), made excellent gains with no gross evidence of damage to kidney or liver tissue due to the heavy consumption of molasses, which averaged 12.7 pounds per head daily.

A series of trials at the Kansas station showed that sorghum silage supplemented with either 3 pounds of wheat bran or 4 pounds of ground alfalfa hay per head daily was an excellent ration for wintering stocker cattle. Either of these supplements proved superior to the feeding of 1 pound of a protein-rich concentrate per head daily with the silage. No. 2 alfalfa proved to be practically equal in value to No. 1 and only slightly more valuable than No. 3 hay in the ration of fattening cattle in feeding tests at the Arizona station. No advantage of grinding alfalfa was apparent. When fed in combination with alfalfa hay, barley, and cottonseed meal, hegari (sorghum) silage was worth approximately 50 percent as much per ton as alfalfa hay. When only roughage and cottonseed meal were fed, the hegari silage was worth 36 and 61 percent as much as hegari fodder and cottonseed hulls, respectively.

A comparison of ground versus unground peanut hay for fattening beef cattle at the Georgia station indicated grinding to be profitable.

Concentrate feeds for beef cattle.—Recent experiments have demonstrated the feasibility of utilizing relatively large amounts of cottonseed meal in cattle-fattening rations. In trials at the New Mexico station, using corn silage and alfalfa hay as the roughage ration, more economical gains were secured by feeding cottonseed meal as the sole concentrate than with mixtures of ground kafir and cottonseed meal. Steers full-fed cottonseed meal throughout the fattening period consumed an average of 9.5 pounds daily and developed into choice fat cattle with no evidence of nutritive deficiency under this feeding plan. Cottonseed meal proved equal to meat meal or fish

meal when fed at the same protein level as a supplement to hay, silage, and barley, as determined by the Arizona station. Peanut meal and cottonseed meal were of practically equal value when fed with either peanut hay or silage in cattle-fattening experiments at the Georgia station. Soybean meal proved as palatable as cottonseed meal, according to findings of the Colorado station, but did not show as great feed replacement value in cattle rations. Tankage alone proved to be an unpalatable supplement and resulted in more expensive gains than when cottonseed meal was fed. The addition of an iodine supplement to standard rations exerted a depressing effect on rate of gain, with a resulting increase in cost per unit of gain. Treating cottonseed meal with iron sulfate, which has proved to be of value in swine feeding, did not improve the value of this product for cattle, according to reports of the Ohio station. This station also found open-pollinated corn and hybrid corn to have essentially the same value in cattle-fattening rations. The Illinois station found that cattle made as rapid and somewhat more economical gains on year-old corn than on the same variety of corn of the current crop.

Experiments at the Louisiana station indicated that a mixture of rice bran and rice polish (1–1) was worth approximately 82 percent as much as ground corn when fed with cottonseed meal and rice straw as a steer-fattening ration. Combinations of rice byproducts and molasses had from 80 to 90 percent the value of corn.

Sorghum grains failed to equal corn for fattening steers at the South Dakota station. Sooner milo produced only slightly slower gains than corn and resulted in equally good carcasses. Amber cane was inferior to either in rate of gain and quality of carcass.

Distillers' rye dried grains when used at the Maryland station to partially replace corn in steer-fattening rations had a value of about three-fourths that of corn. Substitution of distillers' rye slop for part of the corn materially decreased the degree of finish of steers in all cases.

Tests by the South Carolina station in the Coastal Plain area indicated creep feeding of beef calves running with their dams on pasture to be a profitable practice. The calves receiving supplementary feed made 100 pounds more gain per head, or about 50 percent greater gains to 7 months of age, than non-creep-fed calves. This was reflected in materially higher values for creep-fed animals when sold for slaughtering purposes.

DAIRY CATTLE AND DAIRY PRODUCTS

Roughage in dairy-cattle rations.—Studying the value of irrigated pastures for dairy cattle, the Oregon station showed that milking cows could secure a high percentage of their total nutrient requirement from such pastures. Unfertilized pastures yielded feed equivalent to 3.7 tons of alfalfa hay per acre, while the feed from improved Ladino clover and grass pastures equaled 4.8 tons and that from well-fertilized pastures equaled 6.4 tons of alfalfa hay per acre. Comparing the milk and butterfat production of cows on different planes of roughage feeding, the Utah station, in cooperation with the Department (B.D.I.), found that cows receiving alfalfa hay only or hay and corn silage with pasture in season produced about 70

percent as much milk as cows receiving a full grain feeding, while those receiving a limited amount of barley in addition to roughage produced 86 percent as much as the full-fed group. The average butterfat content of the milk on roughage rations was lower than that from the grain-fed group.

The Wyoming station, as a result of extensive tests with Holstein cows on sweetclover pasture and alfalfa hay, concluded that animals having the inherent ability to produce only 30 to 40 pounds of milk daily at the peak of production will benefit little by supplementary grain feeding. At prevailing prices for feed and dairy products in that region, only those cows which could produce 50 to 60 pounds of milk at the peak of production justified grain feeding.

The high value in the dairy-cattle ration of silage produced from various farm crops has been further affirmed through recent experiments. The Michigan station, comparing the efficacy of alfalfa hay, with half hay and half grass silage or grass silage alone as roughages for dairy cows and heifers, found little difference in the live-weight trends of cows under the three systems, while heifers made strikingly greater gains on the all-silage ration than on hay. Trials at the Alaska station indicated that cows could be maintained in good production and body weight on a ration of oat-pea silage and grain for a period of 6 months. Slightly better results were obtained when some dry hay was fed in addition to the silage and grain. The Oklahoma station determined that silage prepared from mung beans, a drought-resistant legume well adapted to that region, could successfully replace one-half of the alfalfa hay in a ration for milking cows. The dry matter in the silage and hay were of equal value pound for pound. This station also showed that prairie hay had a relatively high value for dairy cows, amounting to approximately 90 percent that of alfalfa hay when fed with an adequate concentrate mixture. The Ohio station found that apples could be satisfactorily fed to dairy cows either in the form of silage or in the raw state. Satisfactory silage was produced by chopping the apples in combination with some dry corn stover or cured alfalfa hay. Chopped raw apples fed at the rate of 30 to 36 pounds per cow daily gave as good results as an equivalent amount of dry matter intake from corn silage, and it appeared that an apple surplus could be easily disposed of via the dairy herd.

A dairy ration composed of sorghum stover, sorghum silage, and sorghum grain has proven, in trials at the Kansas station, to be grossly inadequate for maintenance and satisfactory milk production. Additions of cottonseed meal and bonemeal to the sorghum diet only slightly relieved the deficiency condition, but additions of chopped alfalfa hay and wheat bran to the ration rendered it entirely adequate. The trials are being continued in an effort to determine the exact nature of the deficiency in the all-sorghum ration.

Nutrient sources and requirements for dairy cattle.—Trials at the Oklahoma station, in which cottonseed meal was added to the concentrate mixture at various rates above that necessary to provide the required amount of protein, indicated that 100 pounds of this product was equivalent to 113 pounds of a mixture of corn, oats, and wheat bran as a source of nutrients in dairy rations. Any desired amount of cottonseed meal could be fed safely so long as an adequate amount of vitamin A was supplied in the roughage portion of the

ration. Cows maintained on a ration of corn-soybean silage and cottonseed meal through the fall and winter months at the South Carolina station developed an unusual disorder when spring pasture grazing replaced silage in the ration. The ailment, which was gradually alleviated, was characterized by loss of appetite, declining milk production and body weight and ruminal stasis. This finding indicates that the limitations of cottonseed meal when fed in various combinations are not fully established. The Hawaii station found that the use of dried yeast or wet yeast sludge to replace ordinary protein supplements in the ration of dairy heifers resulted in a satisfactory growth rate, suggesting that yeast produced from native products may be considered an important source of protein feed. The Iowa station demonstrated that irradiated molds were about as effective as irradiated yeast in increasing the vitamin D potency of milk, while irradiated ergosterol was only one-half as efficient as the yeast when all were fed at equivalent levels. A dual deficiency of protein and phosphorus in the ration of dairy heifers resulted in retarded growth and sexual development, according to findings of the Minnesota station. While such animals frequently conceived later, normal parturition was less common and milk production was relatively very low.

By use of a special ration well fortified with essential dietary factors, the Missouri station was able to produce dairy heifers 30 percent larger than normal at the usual freshening age. These heifers were of breeding size when 7 to 9 months younger than normal.

The Illinois station showed that soluble carbohydrates, such as molasses, when added to the ration of dairy heifers were very inefficiently utilized. Apparently bacteria in the rumen made use of these sources of carbohydrates when available rather than the more resistant celluloses and hemicelluloses, the utilization of which would set free other available carbohydrate materials. Two trials at the Ohio station showed no advantage for 4.5 percent over 2.7 percent of fat in the grain mixture for dairy cows when fed with alfalfa hay and corn silage, the fat in the mixture being regulated by the fat content of soybean meals used. This indicates that dairymen are not justified in paying a higher price for high-fat soybean meal for feeding with alfalfa hay and corn silage.

Quality and flavor of milk.—Factors involved in the development of oxidized flavor in milk have continued to command attention. The New York (Cornell) station has reaffirmed its finding that oxidized-flavor development can be largely prevented by the removal of the dissolved oxygen from milk. The oxygen content of milk, which is relatively low when the milk is drawn from the udder of the cow, is altered in the process of milking and during various plant operations. It tends to decrease during pasteurization by the holding method but increases sharply when milk is passed over a surface cooler. This station has developed an improved rapid method for the quantitative determination of oxygen in milk. The Vermont station showed that development of bacteria, constituting the normal microflora in milk, resulted in a decreased oxygen content which in turn tended to inhibit or prevent the development of oxidized flavor. Milk stored under reduced pressure exhibited a greatly reduced tendency for oxidized flavor development, and under this condition bacterial growth was not an important factor in the prevention of this flavor. The Michigan

station, studying further the effect of various heat treatments of milk upon the stability of ascorbic acid and the development of oxidized flavor, established a critical temperature range around 170° F. which, when applied to milk momentarily, gave the greatest stabilizing effect to ascorbic acid in milk. Samples heated below this temperature generally developed an oxidized flavor but no cooked flavor, while a "pure" cooked flavor occurred in those heated to a higher temperature. Apparently, reducing substances formed at the higher temperatures play an important role in protecting ascorbic acid and inhibiting oxidized flavor. This station was unable to establish any relationship between the susceptibility of milk to copper-induced oxidized flavor and the lecithin content of the milk, although the theory has been advanced frequently that this constituent of milk is involved in the development of this flavor defect. Despite the fact that oxidized-flavor development is induced by certain catalysts, notably copper, which are known to affect the oxidation-reduction potential of the milk, the Wisconsin station was unable to show that the Eh of the medium either accelerated or inhibited the development of this flavor defect. Findings of the Pennsylvania station indicated that when milk is heated to a sufficiently high temperature sulfhydryl compounds are formed that impart a cooked flavor to the milk and which are active antioxidants that protect the ascorbic acid in milk and prevent oxidized-flavor development. On holding, the sulfhydryls may become oxidized and lose their flavor characteristic, after which tallowy or oxidized flavor may develop.

The New Jersey station found that the intensity of yellow color in milk bore a direct relationship to the desirable flavor of fresh milk and an inverse relationship to the loss of flavor during storage. The feeding of grass silage intensified the yellow color, and such milk proved highly resistant to copper-induced oxidized-flavor development. This station also obtained evidence that the addition to milk of certain metals, particularly manganese, was an effective way of counteracting the catalytic effect of copper which leads to oxidized flavor. These findings suggest the possible effective use of manganese in alloys for dairy equipment and also other uses, such as the addition of small amounts of this metal to butter salt. The Pennsylvania, New Jersey, and Massachusetts stations confirmed the value of oat flour as an antioxidative agent when added in small quantities to milk or its products. The last-named station found corn flour to be similar to oat flour in this regard, while wheat, barley, and rye flours possessed but little antioxidative value. The Pennsylvania station further found the addition to milk of pure ascorbic acid, or tomato and orange juices which contain ascorbic acid, to be highly effective in preventing oxidized-flavor development, the ascorbic acid practically disappearing before this off-flavor appeared. Citric acid did not possess such antioxidative properties. Certain pancreatic enzymes also effectively inhibited the development of this off-flavor. Both trypsin and steapsin, particularly the latter, were active in this respect while pepsin was not, suggesting that the beneficial effect of such enzymes is due to their action on the fatty material rather than on the protein fraction of the milk. Both the Pennsylvania and Wisconsin stations found little difference in the iodine number of the butterfat in normal and oxidized milks. However, the latter found that development of oxidized flavor was accompanied by a marked

decrease in the iodine number of the phospholipid fraction, suggesting that this flavor defect is primarily due to oxidation of the phospholipids. Condensing milk under vacuum to a concentration of about 2:1 rendered the condensed product or reconstituted milk entirely immune to the development of oxidized flavor even in the presence of copper, according to results obtained at the Illinois station. Both high-temperature pasteurization and homogenization of cream were found by the Ohio station to effectively prevent the development of this defect in frozen cream, and the beneficial effect of such heat treatment was confirmed by the Pennsylvania station.

Lipolytic activity in milk, which leads to the development of rancid flavors, was, according to the California station, largely inhibited by holding milk for 30 minutes at a temperature of 130° F. or above. The Michigan station found that the acceleration of lipolysis in milk due to homogenization was relatively small when samples were homogenized at temperatures of 135° to 145° F., whereas maximum fat-splitting occurred in samples homogenized at temperatures of 105° to 125°.

The development of relatively high acidity in cream through the action of lactic starters did not effectively retard lipolysis due to the action of fat-splitting micro-organisms, since such bacteria are capable of developing in cream having a titratable acidity of 1 percent, as shown by the Oklahoma station.

The Pennsylvania station, studying methods of cooling milk on the farm, found that the pumping of 60° water directly over cans of milk did not afford efficient cooling. Cans of milk submerged in water at 35° to 37° cooled slowly when the water was not agitated, resulting in a marked increase in bacterial content during 12 hours of holding. When the water was agitated, cooling was rapid and a static bacterial content resulted. A high percentage of the total bacteria in a can of milk held for 12 hours was found to be present in the top or cream layer, which cools at the slowest rate.

The Kansas and Minnesota stations agreed in their findings that the addition of about 10 percent of common salt to cream permitted the holding of cream at relatively warm temperatures for several days with little deterioration in quality. Since this method is both cheap and simple it is considered well adapted to preserving farm cream.

The Washington station demonstrated that either clotted cream or soft cheeses when sealed in cans could be successfully held for several weeks in frozen storage. Prompt freezing immediately after packaging gave best results.

At the Illinois station the addition to milk of small amounts of sodium salts, resulted in a permanent reduction in the acid tension of the product. Additions of these salts had little influence on the acidity or creaming quality of the milk, but did affect the flavor to some extent.

Paper milk containers.—The rapidly increasing popularity of the single-service paper containers for milk has stimulated further research regarding their desirability from the standpoint of milk quality. Studies at the New York State station on the sanitary properties of containers prepared from various types of paper stock and under varying conditions led to the conclusion that paper containers made

from essentially sterile stock and properly water-proofed and sterilized should be able to meet a standard of freedom from pathogenic organisms more rigid than those enforceable for the containers in common use. Studies at the Ohio station indicated that while none of the commonly used types of paper containers were entirely impervious to moisture absorption when filled with liquid for 72 hours, the cone-shaped containers were more nearly impervious than square ones. Additional dipping in paraffin reduced the absorption, while higher storage temperatures tended to cause greater absorption by the containers. Both the Pennsylvania and New Jersey stations found that the sizing of paper stock in a bath containing oat flour prior to fabrication imparted antioxidative properties to the container, resulting in an inhibition of oxidized-flavor development in milk held in such bottles. The California station, comparing the protective properties of various milk containers against the deleterious effect of exposure to sunlight, showed that containers made from relatively thick paper stock of light brown color were highly effective in inhibiting oxidized-flavor development and ascorbic acid destruction in milk during 2 hours' exposure to direct sunlight. Even paper bottles made from thin bleached stock were superior to glass bottles in their protective action.

Butter production.—Factors affecting churning losses in buttermaking, initial composition, flavor, and quality of butter, and its keeping quality have been further investigated.

Findings of the Minnesota station indicated that the use of high-temperature (260° F.) pasteurization of cream by direct injection of steam resulted in much greater losses of butterfat in the buttermilk than when cream was pasteurized by the conventional holding method at 160°. Neither salted nor unsalted butter from the high-temperature cream kept better in storage than that from the low-temperature cream. Studies on the moisture content of butter direct from the churn by the Illinois station indicated that not only did this factor vary markedly with different types of churns but from one part of the churn to another, indicating the importance of a buttermaker's knowing the characteristics of his churn in order to produce a standardized product. Finding a marked seasonal variation in the physical properties of butter, the Wisconsin station has demonstrated the usefulness of two simple tests, i. e., resistance to slicing and the sagging-beam test which indicates rate of softening, that can readily be applied by creamerymen to measure the physical behavior of their product. Trials at the Michigan station with six different cream neutralizers indicated that these products were not equally effective in lowering the acidity of butterfat and butter, the limes being less effective than the sodas. While the average acidity of the butterfat was lower than that of the corresponding butter, this relationship varied with the amount and type of neutralizer used. The curd content of butter was not materially affected by the kind of neutralizer used or by the degree of acid reduction except when lime was used to reduce acidity to 0.15 percent or lower, in which case pronounced increases occurred. Studies at the Washington station indicated that high increases in the acid values of butter after storage showed a rather high degree of correlation with reduced keeping quality, particularly with sweet-cream butter. Also increases in the

ratio of fat acidity to butter acidity during storage were closely related to poor keeping quality.

The Oklahoma station showed that lipolytic organisms in cream and butter generally caused an increase in the acid number of the butterfat, although rancid flavor did not always follow. Acid-producing organisms, on the other hand, increased the titratable acidity without affecting the acid number of the fat. Micro-organisms were found to be of greater significance than the enzyme lipase in causing fat hydrolysis in raw cream and in butter. A simple test which consists in determining the flavor, acidity, and total and proteolytic bacterial counts of butters after 7 to 14 days' incubation at 60° F. proved to be a rather reliable way of predicting the keeping quality of the butter in storage, according to findings of the New York (Cornell) station. It appeared that proteolytic, Gram-negative, rod types of bacteria were largely responsible for deterioration of unsalted butter.

Efforts of the Indiana station to apply the phosphatase test as a means of detecting butter made from improperly pasteurized cream, gave evidence that in about 10 percent of the cases butter changed from negative to positive reaction during storage at temperatures as low as 35° F. It is concluded that the application of this test to butter does not result in the detection of improperly pasteurized cream with the high degree of accuracy that is obtained by applying it directly to cream or milk. Flash-pasteurized cream more frequently gave positive reactions to the phosphatase test than vat-pasteurized cream, with further evidence that under average plant conditions operators are more liable to pasteurize inefficiently by the flash system than with the vat system. This station has also shown that a close relationship exists between the copper content and rate of deterioration of butter in storage, emphasizing the importance of guarding against exposed copper surfaces in butter-manufacturing equipment.

Cheese production.—Studies at the New York State station gave evidence of considerable variation in the flavor development of winter- and summer-made Cheddar cheeses, the former developing a less desirable flavor, particularly when held at relatively low curing temperatures. Curing at generally low temperatures with short intervening periods at higher temperatures appeared to be the best solution of developing cheese with desirable flavor and free from defects. In any event, control of curing-room temperature is considered of great importance. The Iowa station demonstrated that certain types of micro-organisms not commonly used in cheese-starter cultures might be used to good advantage in improving the flavor of Cheddar and Swiss cheese. Propionic acid bacteria were particularly beneficial and certain selected types of micrococci were definitely useful in this respect. The development of bitter flavor in Cheddar cheese was found by the Illinois station to be closely associated with low salt content. Cheeses containing 1.3 percent of salt developed a characteristic bitter flavor, while those containing 1.6 to 1.7 percent were protected against this flavor defect. As determined by the Iowa station, the inclusion of about 2 percent of salt in the curd for blue cheese encouraged proper mold development, improved the color, and tended to control certain flavor defects. Pasteurizing the cheese milk, controlling the flora of the cheese starter, and proper washing of the

curd proved to be important steps in preventing the development of "early gas" in brick cheese, in trials at the Wisconsin station.

Ice-cream production.—The relative effects of various components in the ice-cream mix on the texture of ice cream was investigated by the California station. Increases in total milk solids, regardless of source, improved the smoothness of ice cream and decreased the size of the ice crystals. The solids-not-fat proved to be more important than the milk fat in governing the formation of small ice crystals. Increasing the proportion of fat in the mix had a greater effect on ice-cream texture as judged by taste than it did in reducing the size or retarding the growth of ice crystals. The Missouri, Illinois, and New York State stations agreed in showing that up to one-third of the cane sugar ordinarily used in ice-cream mixes can be replaced by corn sugar and corn sirup without undesirable effect. Even higher percentages of corn sweeteners could be used to advantage in water ices since they tended to prevent surface crustation. Tests by the Massachusetts station on the value of various powdered egg-yolk and egg-powder blends in ice-cream manufacture showed that their value in improving ice-cream texture was directly proportional to their yolk-solid content. Old or stale egg products detracted from the flavor of ice cream even when used in very small amounts. The Illinois station has developed a method of preparing a low-lactose milk product from skim milk. Ways are prescribed for utilizing this product in diets where a low sugar content is desired, including its use in the preparation of ice cream of low carbohydrate content.

The Kansas station applied numerous tests to ice creams in an attempt to find suitable criteria for accurately measuring quality. The standard plate count for bacteria, the minimum amount of sample containing *Escherichia-Aerobacter* organisms, the butterfat test, weight per gallon, and quality score all proved of worth, but no single test was adequate for this purpose. The Nebraska station examined representative samples of commercial ice cream for weight, overrun chemical composition, bacterial content, and quality score. Reasons for differences in price level of the ice creams were not apparent on the basis of these criteria. The need for establishing a sound basis for differences in price per unit quantity of retail ice cream is stressed.

Miscellaneous dairy products.—Studies at the Illinois station showed that up to 50 percent of the cane sugar used in the preparation of sweetened condensed milk could be successfully replaced by corn sugar or high-conversion corn sirup. The New York (Cornell) station found that moisture is a very important factor in controlling the rate of browning of dried milk and dried whey, but that other modifying factors, such as physical state of the lactose and reactions between lactose and casein, exert an influence.

The Montana station demonstrated the value of adding a small amount of citric acid to the pasteurized skim milk to improve the flavor of cultured buttermilk prepared from it.

Evidence was obtained by the Wisconsin station that the addition of cocoa to milk used in the preparation of chocolate milk drinks resulted in a greatly reduced curd tension of the product as compared with the untreated whole milk. The Minnesota station reports that

of 15 commercial chocolate-milk preparations studied, all but 2 produced a stable chocolate milk. Slow cooling and a low fat content were conducive to relatively low stability of the finished product.

A process developed by the Minnesota station permits the concentration of rennet to approximately four times the strength of the ordinary commercial product while removing practically all of the proteolytic activity of the extract.

Studies by the New York (Cornell) station indicated that normal amounts of rennin in whey could be entirely inactivated by holding at 50° C. for 14 minutes, provided the pH was adjusted to 6.8 to 7.0.

Bacteriology and sanitary control.—Contributions in this field dealt with the application of various tests to milk and its products for determining their sanitary properties and the significant role of various types of micro-organisms in dairy products. Tests at the Kansas station, comparing the bacterial counts of milk, cream, and ice cream on the new standard milk agar (officially adopted by the American Public Health Association) and the old standard medium, confirmed the superiority of the new over the old for the development of certain bacteria commonly found in milk. Experiments at the Pennsylvania station have defined within narrow limits the optimum amount of dyes to use in culture media employed for the analysis of *Escherichia-Aerobacter* organisms in milk. Media used in water analysis were found ineffective in milk analysis, due to the fact that a considerable portion of the dye present was absorbed by the milk and thus rendered inactive. Studies at the New York (Cornell) station showed that various functions of bacteria do not always occur at the same optimal temperature. For example, a strain of *Streptococcus lactis* was found to give the largest amount of acid formation at 30° C., to grow most rapidly at 34°, and to exhibit the most rapid rate of fermentation at 40°. The Vermont station showed that a close and intricate relationship exists between the reduction of methylene blue or resazurin dyes in milk and the dissolved gases. Reduction of either dye occurred only when the oxygen concentration was low, usually below 0.045 volume percent. It is significant that this level was generally reached sometime before reduction of the dyes occurred. A marked increase in carbon dioxide and a lesser increase in nitrogen content of the milk occurred during this period. The effect of bacterial growth, exposure to sunlight, and other factors on rate of dye reduction has been further elucidated.

The Iowa station has established the fact that a typical form of *Achromobacter putrefaciens* is a common cause of putrid deterioration in commercial butter. Contaminated water supply was shown to be a possible source of introduction of this organism into butter. This station also demonstrated that the Burri smear-culture technique could be successfully adapted to the examination of butter and ice cream, although certain difficulties were encountered, particularly in securing uniform weight samples for inoculation.

An extensive survey of the sanitary quality of commercial ice creams by the Kansas station indicated that about 15 percent of the total gallonage sampled exceeded the legal limit of 100,000 bacteria per cubic centimeter. Improper pasteurization and gross contamination during manufacture were prevalent causes of poor sanitary quality.

SWINE

Protein requirements and sources for swine.—The Illinois station, studying the optimum protein requirements of pigs of different weight levels, concluded that 18 to 20 percent, 15, 14, and 11 to 12 percent of protein in the ration is desirable for pigs under 50 pounds, 75 to 100, 100 to 150, and 150 to 200 pounds, respectively. The Pennsylvania station showed that young pigs under 70 pounds in weight developed normally in dry lot when the ration contained 17 to 27 percent of protein and on rape pasture when 9 to 18 percent protein rations were fed. However, maximum and most economical gains were made by those on the highest protein level in each instance.

Findings of the Hawaii station indicated that lactating sows produced significantly lighter pigs at weaning time when fed a ration containing only 10 percent total protein than when fed rations known to be adequate in protein for good milk production. The savings on protein supplement at the low rate of feeding were not economical. Purchased protein supplements in rations for fattening pigs were economically replaced by clover, green oats, or other forage crops in trials at the Alabama station, demonstrating the feasibility of the farmer producing his own supplements in this manner.

The Ohio station found that the precooking of cottonseed meal prior to the extraction of oil failed to reduce the toxicity of the resulting meal for pigs regardless of the process used for oil extraction. Confirming earlier findings, the addition of 2 pounds of ferrous sulfate in solution to each 100 pounds of cottonseed meal rendered it entirely safe for pigs.

Grains for swine.—Trials at the Illinois and Ohio stations agreed in showing that any difference in feeding value for hogs which may exist between hybrid and open-pollinated corn is due probably to the particular hybrid or the strain of open-pollinated corn used rather than to the fact that the corn belongs to one or the other of these groups. In seven separate trials at the latter station hybrid corns had relative values ranging from 90 to 108 percent that of open-pollinated corn. Results of free-choice feeding tests did not particularly favor either type of corn, but rather indicated that corn of the lowest moisture content was most palatable and that of highest moisture content least palatable.

Trials at the Nebraska station in cooperation with the Department (B.A.I.) showed that various sorghum grains compared favorably with corn in palatability when self-fed to pigs and that the rate of gain and degree of finish and firmness were similar for corn-fed and sorghum-fed groups. On the basis of feed required per unit of gain kafir, milo, and kalo were each approximately 90 percent as valuable as shelled corn, with little difference in the value of the whole and ground sorghum grain. Sooner milo and corn proved to be of practically equal feeding value for fattening pigs in a trial at the South Dakota station. However, the grain of Amber cane and of a low prussic acid strain of sorghum was considerably lower in value than corn for hogs.

Trials at the Hawaii station gave evidence that rations containing 40 to 50 percent of cane-molasses or pineapple-sirup concentrate could be successfully fed to swine weighing over 100 pounds. While growth on such rations was slower than that on a regular grain

ration, it proved economical because of the low cost of these native products. The addition of beet molasses to a basal ration of barley, tankage, and alfalfa for pigs weighing about 50 pounds resulted in slower and more costly gains than were obtained with the control ration in experiments at the Utah station. Similar trials with pigs over 100 pounds showed that the larger pigs could utilize molasses to much better advantage than the smaller ones.

The full feeding of grain to pigs on oat-pea pasture proved a very economical method of pork production under conditions at the Alaska station. The use of such pasture resulted in significant savings of grain as compared with dry-lot fattening of pigs.

Trials at the Montana station in cooperation with the Department (B.A.I.) gave evidence that desirable pigs could be developed into hogs suitable for Wiltshire sides through the feeding of simple rations, consisting generally of alfalfa pasture, minerals, a small amount of tankage, and sufficient grain to maintain animals in the desired physical condition. Crossbred pigs resulting from mating Yorkshire males with Chester White sows excelled other crossbred or purebred pigs compared in these trials. Similarly, crossbred pigs (Duroc-Jersey male × Poland China female) excelled purebred pigs of either parent strain in rate and economy of gain in trials at the Nevada station in cooperation with the Department (B.A.I.).

SHEEP

Feeding the breeding flock.—Work of the Indiana station indicated that sheep are more limited than beef cattle in the type of feed they can utilize during the winter and the types of pasture they can use during the summer months. Records obtained during the past year indicated that ewes fed alfalfa hay during the winter months made $3.39 more net profit per head than ewes fed oat straw and corn silage. General surveys in this State indicated that a great number of flocks are maintained on a relatively low plane of nutrition during the winter months, and that the addition of a sufficient amount of leguminous roughage to the ration would result in large financial gains to their owners. Similarly, investigations at the Oregon station showed that the cost of wintering sheep, which is the largest single item of expense to the operator, could be greatly reduced through the more extensive use of inexpensive home-grown forage as a substitute for expensive purchased feeds. Such practice could be followed without significantly reducing the succeeding lamb crop.

Trials at the Utah station indicated that relatively inexpensive gains could be obtained with ewe lambs through the feeding of alfalfa hay and corn silage, although this ration was not as satisfactory for the production of clean wool as alfalfa alone or alfalfa supplemented with barley. Of the sheep farm-fed as lambs, 64.7 percent lambed as 2-year-olds, whereas only 45.5 percent of those carried on the range as lambs produced young at this age. Also the farm-fed group averaged 1.3 pounds more clean wool per head at 1 year of age than those carried on the range.

Crude soybean lecithin, when added at various rates up to 12 percent of the ration, was consumed by sheep without unfavorable re-

sults, suggesting its value in sheep rations if comparable in price with other feeding stuffs.

Rations for fattening lambs.—Studies at the Pennsylvania station to determine the optimum amount of soybean meal as a supplement to corn and clover or clover and timothy hay for growing lambs gave evidence that a concentrate mixture composed of about one-third soybean meal and two-thirds corn and fed at a concentrate-to-hay ratio of 3:2 promoted more economical gains than any other combination tested. Increasing the proportion of hay in the ration materially increased the feed requirement per unit of gain.

Studies were conducted at the New Mexico station to determine methods of utilizing hegari fodder in lamb-fattening rations, since under dry-land farming this type of roughage is generally available. It is shown that the addition of 0.35 pound of cottonseed meal per head daily as a supplement to the hegari fodder and hegari grain resulted in gains closely approaching those on an alfalfa-hay and hegari-grain ration. Such gains were more economical than when more or less cottonseed meal was fed. It appeared, however, that good alfalfa hay without a protein supplement is a better roughage for fattening lambs than hegari fodder supplemented with any amount of cottonseed meal.

Experiments at the Oregon station indicated that while alfalfa hay is much superior to wild hay, cereal-grain hay, or alsike clover straw for fattening lambs, these other roughages could be used to good advantage as a part of the ration. Pea-vine silage also was used to good advantage when fed in combination with 1 pound of chopped alfalfa per head daily. Wheat proved somewhat better than barley as a grain supplement in the lamb ration, and barley, in turn, was superior to oats. Grinding grain for the lambs was not a profitable practice, but grinding or chopping the alfalfa hay did prove profitable. About 200 pounds of alfalfa hay and 100 pounds of grain were required to convert a thin feeder lamb into a good market lamb in about 90 days.

Self-feeding and hand-feeding of fattening lambs resulted in practically the same rate of gain when the hand-fed lambs received a full feed of grain to supplement alfalfa hay, in trials at the Michigan station. The ratio of concentrate to hay was narrower under the self-feeding plan, suggesting that with relatively high-priced grain hand-feeding would prove more economical. Chopping or grinding the hay increased the cost of gains under the conditions of this trial. The addition of linseed meal as a supplement to corn and alfalfa, while increasing the rate of gain, was not a profitable practice.

Ground milo with the heads attached was found to be equal in feeding value to ground corn fodder with the ear on the stalk when each was fed in combination with barley, cottonseed cake, and alfalfa hay to fattening lambs at the Colorado station. There was no apparent difference in the carcass grade of lambs produced on these two rations. Other trials at this station gave evidence that the addition of an iodine supplement to a lamb-fattening ration retarded the rate of gain and increased the cost of gain approximately 20 percent. The deleterious effect of the iodine supplement was greatly reduced when yellow corn replaced ground oats in the ration.

Testing the value of rice and rice products in lamb-fattening rations, the Louisiana station obtained evidence that chicken-feed rice

was fully equal to corn, while ground rough rice, rice polish, and rice bran were about 76, 73, and 32 percent as valuable as corn, respectively.

At the Oklahoma station the addition of blackstrap molasses to a corn and alfalfa-hay ration and an oat and alfalfa-hay ration reduced the digestibility of the crude fat of the rations very materially and the protein of the rations to a lesser degree. Digestion of the carbohydrate in the ration was not consistently altered by the presence of molasses. This station also showed that extremely fine grinding did not increase the digestibility or utilization of feeds by sheep, indicating that the extra cost of fine grinding is not justified.

MEATS

Effect of the ration on the quality of meat.—Additional trials at the South Carolina station, in cooperation with the Department (B.A.I.), confirm earlier findings that steers fattened on a ration of cottonseed meal and cottonseed hulls produced meat of as good quality as those fed shelled corn and lespedeza or alfalfa hay. No significant differences in quality, color, or palatability of the meat from the two groups of animals have been found. The Virginia station found comparatively little difference in the dressing percentage or carcass grade of grass-fed and grain-fed fat cattle. The carcasses of the grass-fed lot had more yellow color, which was penalized to some extent, although it is pointed out that such carcasses are probably actually higher in nutritive value because of the higher carotene content of the fat.

A comparison by the California station of the carcasses of grain-fed hogs and hogs fed largely or entirely on garbage indicated that the grain-fed group yielded a firmer carcass and the water content of the muscle of cured smoked meat was lower than that of the garbage-fed hogs.

Pork curing and storage.—A summary of extensive studies at the Maryland station, in cooperation with the Department (B.A.I.), indicated that salted hams aged for 10 or 12 weeks at a controlled temperature of 108° F. compared favorably in chemical composition and in palatability with hams aged 1 year or longer at ordinary room temperature. Hams aged longer than 10 weeks at the higher temperature rapidly increased in saltiness and in intensity of aged flavor. Allowing salted hams to air-cure for 2 weeks prior to smoking proved desirable when a minimum salt concentration was used. Hams smoked immediately after curing lost their smoky aroma and uniform color with aging, while smoking after aging was of value only for removing excess moisture.

The Indiana station showed that pork from hogs fed either a high or a low fat ration which produced firm and soft carcasses, respectively, could be frozen by the quick-freezing method and storing for 6 months or slightly longer without practical change in quality. After 9 months to 1 year in storage, however, some chemical and histological deterioration accompanied by lowered palatability had occurred. Tests at the Michigan station with pork cuts and at the Washington station with cuts of beef agreed in showing that the moisture loss of meat held in freezer lockers was relatively very low when the products were wrapped in cellophane, but increased in

order with waxed or oiled paper and in kraft or butcher paper. The latter station showed that losses were materially higher in freezers having a forced draft than in those with overhead bunkers without forced draft.

At the Illinois station the addition of 1 percent of dextrose or one-eighth of 1 percent of dextrose plus one-eighth of 1 percent of lecithin to pork fat during rendering increased the stability of the resulting lard several hundred percent as compared with lard rendered from similar materials without the addition of these antioxidants. The improved stability was retained even in the bleached lard.

POULTRY

Artificial illumination for laying flocks.—A summary of 10 years' investigations at the Oklahoma station indicated that the use of all-night lights did not increase or decrease the annual egg production of either pullets or hens and did not have a deleterious effect on hatchability or adult viability. The illuminated birds laid more eggs in November and December and fewer eggs in March, April, and May than the unlighted controls. Year-old hens showed a greater response in this regard than did pullets. Results obtained at the Delaware station indicated that artificial light on White Leghorn pullets during the first winter of egg production aided in maintaining larger egg size during May, June, and July when egg size usually decreases. With the exception of late-hatched (May) birds, those under light laid larger eggs and more eggs during the period of higher egg prices than did the unlighted controls.

Protein requirements and sources for poultry.—According to a summary of extensive investigations at the Delaware station, involving many levels of protein feeding for growing and laying pullets, chicks receiving an 18-percent-protein ration to 12 weeks of age and a 16-percent-protein ration from 13 to 20 weeks excelled all other groups both in rate of gain and efficiency of feed utilization. Lowering the protein content below 18 percent prior to 8 weeks of age resulted in lower weight birds at 20 weeks of age. Allowing pullets access to range from 8 to 20 weeks did not result in heavier birds at 20 weeks than similarly fed confined birds. The protein level during growth had no apparent influence on the rate of egg production during the pullet laying year, but reducing the protein content below 18 percent prior to 8 weeks appeared to increase subsequent mortality during their laying year.

Similarly, trials at the Washington station showed that the ration of growing chicks should contain not less than 17 percent of high-quality protein for from 1 to 6 weeks of age, 15 percent from 7 to 12 weeks, and 13 percent from 13 weeks to maturity. All groups showed highest efficiency of feed utilization during the first 6 weeks, with a progressive decline thereafter. Differences in size at maturity were largely attributed to differences in growth rate during the first 6 weeks, since after that age the growth curves of all groups were nearly parallel.

At the Nebraska station artificially dried Sudan grass meal when fed on an equivalent protein basis successfully replaced 10 percent of alfalfa meal in the ration of growing chicks. Neither the growth rate to 6 weeks of age nor the retention of nitrogen, calcium, and phosphorus was significantly altered by the substitution.

Soybean meal proved to be a valuable protein supplement in the ration of growing chicks when properly supplemented, according to the findings of the Wisconsin station. Linseed meal and corn-gluten meal failed to enhance the growth-promoting value of rations containing the soybean meal as the main source of protein, but fish meals proved to be very effective supplements and other animal proteins including casein, dried skim milk, meat scrap, and liver meal were also effective. Other trials at this station demonstrated that eggs produced by pullets receiving soybean meal as a principal source of protein had a low average percentage hatchability. The addition of casein to the ration failed to improve hatchability significantly, but the addition of flavin-bearing compounds, such as yeast, dried whey, or dried skim milk, or synthetic riboflavin consistently resulted in improvement.

Results of experiments at the North Carolina station in which peanut meal was used to replace a considerable portion of the animal protein in a typical laying mash indicated that this vegetable protein in the ration did not significantly reduce the rate of egg production. Fertility and hatchability were not adversely affected by the high level of peanut-meal feeding.

The South Carolina station showed that corn-gluten meal could be used to good advantage in the ration of either growing chicks or laying hens provided a limited quantity of some material rich in lysine, such as milk or meat-scrap protein, was added to the ration. A ration in which approximately 44 percent of the total protein was from corn, but which included 20 percent animal protein, supported excellent growth in the chicks. With laying hens as good egg production was obtained on a ration containing both corn-gluten meal and meat-scrap protein as on one containing only the meat scrap.

Grains for poultry.—The Mississippi station found no difference in the value of white and yellow corn meal for growing chicks when adequate amounts of alfalfa-leaf meal and cod-liver oil were included in the ration as the source of vitamin A. Other experiments at this station indicated that grass clippings or good grazing are satisfactory sources of carotene (vitamin A) for chickens.

At the South Dakota station both proso millet and oats were used to good advantage in poultry rations. In starting rations millet and oats each fed singly proved to be about 93 percent as efficient as yellow corn, with no apparent difference in the value of white and red proso millet. When used in growing rations red proso was fully equal to yellow corn, while oats had about 80 percent of the value of corn. In rations for laying hens either the red or white proso was approximately equal to either yellow corn or oats for egg production and maintenance of body weight. Grinding the millet slightly reduced the feed requirement per dozen eggs produced as compared with unground millet.

Employing a method for determining the productive-energy value of feeds previously described (p. 128), the Texas station found corn meal to have a value of 225 calories per 100 grams, while other common feeds were rated as follows: Patent flour 188, wheat shorts 86, wheat bran 61, rice polish 216, rice bran 181, rye flour 133, and corn bran from 63 to 132 calories per 100 grams.

The Nebraska station showed that the proteins of the whole-wheat kernel, wheat bran, and wheat shorts when fed as supplements to a

complex basal diet were utilized with about equal efficiency by growing chicks. It was noted, however, that chicks receiving bran showed markedly superior feather development, while those receiving shorts were intermediate in this respect and those receiving whole wheat were poorly feathered.

A previous report of the Western Washington station indicated cannibalism-preventing properties of oat hulls in chick-growing rations. Subsequent experiments have shown that the fiber obtained by dilute acid digestion of oat hulls was highly effective in controlling cannibalism, but that the oat-hull ash and the dilute acid extract were of little value in this regard.

A mixture of 80 percent of finely ground pineapple bran and 20 percent of soybean meal was successfully used to replace ground oats in a standard poultry ration in trials at the Hawaii station. Pineapple sirup replaced corn meal pound for pound up to 15 percent of a standard poultry ration. It appeared that pineapple sirup could be fed successfully to poultry in larger amounts than could cane molasses.

The Florida station obtained evidence that while citrus meal could be utilized in limited quantities in rations for poultry, the value of this product was considerably less than yellow corn meal, growth and egg production being significantly lower on the citrus meal at comparable rates of feed intake.

Fat requirements of chickens.—A comparison, by the New Jersey station, of the growth rate of chickens maintained on an ether-extracted ration containing only 0.1 percent of fat and those on a normal ration containing 4.1 percent of fat indicated that birds on a low-fat diet supplemented with all known essential dietary factors grew nearly as rapidly as the control group. The only significant difference noted was the higher degree of saturation of the body fat of birds fed on the low-fat diet. Trials at the Indiana station indicated that the addition of soybean oil to the diet of young chicks significantly influenced their rate of growth as compared with birds fed similar diets of ordinary fat content. Balance trials indicated that over 90 percent of the fat in rations containing as much as 20 percent of fat was utilized by the chick.

Feeding and management practices.—The importance of green herbage in the ration of laying hens was confirmed at the Michigan station, where it was shown that hens receiving cereal grasses either in the fresh state or as silage, or a commercial mixture of condensed buttermilk and dehydrated grass produced significantly more eggs during the year than the birds receiving dehydrated alfalfa-leaf meal. Birds receiving the green feed did not have as severe a winter pause and were able to overcome it in less time than those receiving the dried alfalfa.

A comparison of coarse grit and very fine grit in poultry rations by the New Hampshire station indicated that the latter (granite waste) was not detrimental to chick growth during an initial 16-week period. However, this material had a cumulative detrimental effect due to damage of the inner lining of the intestinal tract which was reflected in lower egg production and higher feed requirement per dozen eggs when the birds reached laying age as compared with birds receiving the coarse grit.

Laying hens are not particularly affected by sudden changes in

type of ration fed, according to evidence obtained at the Mississippi station. Hens subjected to abrupt change in type of diet four times during a laying year showed a higher average production than comparable birds fed throughout on one type of ration. A comparison of five methods of feeding laying hens by the Washington station showed that egg production was highest and feed cost per unit of production lowest when hens had free access to grains and the concentrate mixture, whereas egg production was lowest and feed cost highest under an all-mash system of feeding. Trials at the Ohio station, in which laying pullets had access to whole grains and concentrate mixtures of varying protein content, indicated that hens have a remarkable ability to properly balance their diet with respect to protein. Returns from eggs over feed cost were higher where birds were allowed free choice of feeds than when fed a grain-mash mixture of relatively high protein content.

The New Jersey station has found that pullets hatched in November and January produced a higher percentage of small eggs than birds hatched in April, June, or September. The June- and September-hatched lots produced more medium-sized eggs, while the April- and January-hatched lots produced the highest proportion of large eggs. Apparently egg weight at any particular time is influenced by the interaction of age, temperature, and body size. A continuous record over a 10-year period by the West Virginia station for a group of White Leghorn hens maintained under constantly uniform conditions gave evidence that the decline in egg production was about 19 percent each year as compared with the preceding year. First-year production was not related to length of life, nor was the percentage change in production from the first to the second year. Egg size was greatest during the second and third laying years, and then gradually decreased to the tenth year.

Studies at the New York (Cornell) station on the incidence of leg deformity of chicks commonly called crooked toes indicated that the type of floor on which chicks were confined had a marked effect on the development of this disorder, smooth paper-covered floors resulting in a much larger incidence than wire-covered floors. It appeared, however, that both inherent defects and nutritional deficiency were probably related to the development of this defect.

Turkey production.—A comparison of vegetable-protein concentrates for young turkeys at the Missouri station gave evidence that soybean meal in combination with meat scrap and dried skim milk was a more valuable supplement than either cottonseed meal or corn-gluten meal similarly used. In addition to supporting more rapid growth, the soybean meal possessed definite antiperosis properties not contained in corn-gluten meal. Feather pigmentation was normal on the soybean ration, while rations containing either the cottonseed meal or corn-gluten meal produced feathers containing an abnormal amount of white.

Studies at the Utah station indicated that after poults are 8 weeks old a mash ration containing 17 to 18 percent of protein is as good as and cheaper than higher protein mashes. Soaked or wet feeds had no apparent advantage over dry feed and increased the labor cost of feeding. Grain mixtures of barley and wheat or barley, wheat, and oats proved equal to a mixture of corn and wheat and resulted in a significant saving in cost under existing feed prices.

Turkeys receiving proso millet, Sooner milo, or feterita either in hoppers or as pasture crops at the South Dakota station made as good growth as those receiving corn. However, Amber cane proved inferior to corn in growth-promoting quality. Other trials at this station indicated that wheat, barley, and oats have values of about 99, 98, and 89 percent, respectively, that of corn in rations for growing turkeys.

Grasshopper meal prepared by pressure cooking or by quick-freezing (also frozen whole grasshoppers) proved satisfactory sources of protein for growing turkeys in trials at the Oklahoma station. No off-flavors or odors in the carcass resulted from the grasshopper feeding.

At the California station differences in protein level of the turkey-growing ration were found to have an important influence on growth of the body as a whole and on the muscles, bones, and gonads. A marked difference between sexes, not only with reference to gross body weight but also in the growth of parts and in the relative rate of growth of bones and muscles, was found to exist. Muscle growth was more closely correlated with body weight than was bone growth. Also there was a greater association of the pectoralis major with the underlying keel than with the leg bones.

The Pennsylvania station obtained evidence that artificial lights stimulated sexual maturity in turkey hens more rapidly than in the toms. It is suggested that in order to facilitate early mating the toms should be placed under lights about 4 weeks earlier than the hens to which they are to be mated. A summary of 4 years' experiments at the Oklahoma station showed that all-night lights were of no value in increasing the rate of growth of turkey poults.

Hatchability of eggs.—Tests at the South Carolina station showed that the factor in cottonseed meal which adversely affects the hatchability of eggs when this feed is employed in laying rations is contained in the oil fraction. Additions of cottonseed oil to a satisfactory ration reduced hatchability to about one-third of that on the control ration. Neither soybean nor peanut oils exhibited this deleterious effect, and neither high oil content of the ration nor rancidity of the oil were direct causes of low hatchability. The specific factor involved is as yet unidentified.

In an attempt to relate certain physical measurements of eggs to hatchability, the Pennsylvania station found that egg weight bears a low though significant correlation. None of the measurements of internal egg quality, including yolk weight and albumen score, were significantly correlated with hatchability. Studies at the Kansas station failed to establish any correlation between the porosity of the eggshell and hatchability.

Recent studies at the New York (Cornell) station have indicated the possibility of the detection of infertile eggs prior to incubation through differences in the electric conductivity of fertile and infertile eggs.

Egg quality.—Comprehensive studies of factors affecting egg quality have been continued at the Washington station. Cloudiness of egg albumen as observed in fresh eggs seems to be an indication of excellent interior egg quality, this condition being associated with a low pH of the albumen and a high albumen index. A comparison of several packaging methods showed that while the ordinary carton

package was entirely satisfactory for short-time holding at low temperature, the sealing of eggs in airtight containers either in normal atmosphere or in a carbon dioxide atmosphere was preferable when eggs were held at higher temperatures. Sealing eggs in the carbon dioxide atmosphere proved very effective in preventing loss in interior egg quality and in preventing mold development, even at high temperatures. Vacuum packaging had little advantage over sealing in airtight containers. The inclusion of relatively large amounts of salmon fish meal up to 28 percent of the ration did not adversely affect the flavor or odor of eggs, either in the fresh state or after 60 days' storage at 34° F. Records over a complete laying year indicated that the rate of egg production bears little relation to the thickness of the eggshell, and there was little difference in shell thickness between the first and last egg laid in clutches of two to four eggs. A definite seasonal variation in shell thickness was observed which seemed closely related to atmospheric temperature, maximum thickness occurring in winter and minimum thickness in midsummer.

Studies at the Kansas station have confirmed the pronounced effect of air temperature on eggshell thickness, a very marked reduction in shell thickness at a temperature of 90° F. having been observed. This change in shell thickness was in the same order as the reduction in blood calcium content of fowls at high temperature. High humidity tended to accentuate the depressing effect of high temperature on shell thickness.

The chemical composition of eggs is not significantly affected by wide variations in the starch and protein content of the hen's ration, according to findings at the Kentucky station. However, more body fat was deposited with rations having a relatively high carbohydrate content.

The inclusion of molasses-grass silage in the ration of laying hens resulted in a high percentage of olive yolks or "grass eggs" at the Kansas station, the silage exerting a more pronounced effect in this regard than fresh cereal grasses in the ration. This condition may prove to be a rather serious limitation in the use of grass silage for laying hens.

Extensive studies at the Maryland station to establish the relationship of egg grade, as determined under the candle and the actually observed interior egg quality, indicated a significant but negative correlation between candling grade and albumen condition. Eggs having good-score albumen tended to have a low candling grade. In general, quality based on appearance of eggs under the candle declined very rapidly during April and then less rapidly until December, while the percentage of thick white of the egg decreased very rapidly in May, reached its lowest level in June, and then gradually increased until December.

A study of different types of disinfecting agents which may be used to control mold development on cold-storage eggs by the Michigan station showed that those materials which act through direct contact are of doubtful value, whereas very promising results were obtained with certain materials which continuously give off a vapor inhibitory to the germination of mold spores or the development of mold mycelia. Certain phenol derivatives have proved very useful in this regard,

levels which are effective in preventing mold development exerting no bad effect on the odor or taste of stored eggs.

FISH AND WILDLIFE

Experiments at the Alabama station on the stocking and management of farm fishponds gave evidence that through proper fertilization of the water it was possible to produce from 500 to 600 pounds of fish per acre of water. Thus a properly managed farm fishpond may be considered a dependable source of food for the farm family at moderate cost.

Continued studies at the New York (Cornell) station in cooperation with the Federal Bureau of Biological Survey have shed further light on the nutritional requirements of trout. A number of new practical feeds for the producing hatcheries have been developed, due to the discovery that spleen treated with salt develops physical properties that bind the ingredients together and prevent the pollution of water by suspended organic nutrients, such as powdered dried skim milk that is in a condition too fine to be eaten by trout.

Field studies by the Indiana station have shown that legumes such as the tick trefoils and the native woody lespedezas will grow and produce crops of seeds on sites no longer productive for agricultural grains, ragweeds, foxtails, and smartweeds, the latter being the preferred and staple foods for bobwhite quail and pheasants. Both the trefoils and lespedezas may be artificially propagated, but to date only the lespedezas have been successfully transplanted. Likewise, the habitability of the farm game range is increased by the interplanting of mixed coniferous windbreaks with corn or kafirs and buckwheat. The windbreaks studied thus far have been in the seedling or thicket growth stage. They provide the winter loafing and, in some cases, the escape cover essential for bobwhite quail and pheasants during the winter.

The Pennsylvania station has developed an improved starting ration for young ring-necked pheasants which includes a mixture of meat scrap, whitefish meal, and soybean meal as a source of protein in addition to the other common basic ingredients in the ration. Death losses and the incidence of perosis were much lower on this ration than when high levels of animal protein and little or no soybean meal were fed.

Studies at the Alaska station gave evidence that salmon as the sole animal protein in the ration of mink reduced the reproductive efficiency of the breeding stock as compared with those on certain other types of fish. These studies are being continued to determine the effect of salmon feeding on the quality of the fur.

APICULTURE

The California station presented detailed records of colonies of package bees held under observation during 3 years. Their conclusions indicate that variation in the relative productivity of the queens and their colonies is far more important than the actual supersedure of queens. The problem of the queen breeder is to improve methods of queen rearing and to eliminate undesirable characteristics that will hinder high uniform production. Honey producers can assist by returning to the breeder queens that have the most desirable charac-

teristics. Feeding warm sirup to package bees at the time of installation will aid them in warming the cold hives and will reduce the ill effects of exposure on queens and worker bees. The presence of drone brood in worker cells is the most important symptom preceding the supersedure of queens, and this may occur soon after installation or several weeks later.

A significant finding of the Wisconsin station is that soybean flour when mixed with pollen in the ratio of 3:1 is a very satisfactory substitute for pollen in productive beekeeping. Feeding bees in this manner enables them to begin rearing a brood in January in that northern area and allows the young bees to mature satisfactorily regardless of weather conditions. A simple trap consisting of two screens of hardware cloth in front of the hive proved an effective way of collecting pollen from the bees. The pollen could then be air-dried and stored for such emergency feeding.

GENETICS

Increased interest in studies of inheritance in animals was directed toward characters of economic importance related to reproduction, viability, and lactation. The development of the principles of genetics was advanced by investigations concerned directly with the tangible and repeatable measures for such qualities and characteristics. The success in transmitting qualities for excellence from parents to offspring served as a criterion of the superiority of the germ plasm. Frequently the results from studies of more practical problems may be equally applicable to the study of more theoretical phases of the problem.

Color inheritance in horses and cattle.—A study of the physical and chemical nature of the pigment concerned in coat color in horses, at the Texas station, showed that there were nine basic colors modified into color patterns by three major modifying genes. The triple dominant was black, the dominant for one factor gave sorrels, for the second bays, and the palominolike colors resulted from dominance of the third factor. Other combinations of these genes produced liver chestnuts and blood and mahogany bays. The patterns gray, roan, dun, and light points were produced by dominant qualitative genes acting independently on the different colors. Histological studies of the pigments showed the presence of but one type of granule which was amber in color and shades. The tips of the hairs were more intensely colored than the bodies of the hairs.

Brown Swiss and Holstein-Friesian cattle were found by the Connecticut (Storrs) station to differ in that Brown Swiss cattle were heterozygous or homozygous for the dominant blackish gene and the dilution factor. A genetic factor for whitening present in the Holstein was expressed in the absence of black. Although some Holstein-Friesian cattle carried a white star gene, brindling was not present.

Inheritance of milk production.—A statistical study of the records of the Ayrshire Breeders' Association furnished a basis for the West Virginia station to develop formulas for predicting the transmitting ability of butterfat percentage by young untried bulls. When averaged with the fat percentage of the cow to which the bull was bred the average fat percentage of the daughters could be indicated. Attention was called to the fact that such predictions were based on

the average results rather than what may be expected from individual females. A new system of culling based on the average production of the dams to which the bull was mated was adopted by certain breeders rather than basing selection on tests of individual dams.

Further studies of the records of the Ayrshire Breeders' Association by the West Virginia station indicated that old bulls were not as efficient for breeding heifers as young bulls. Such differences in production largely disappeared for heifers with more than one calf, but they were very significant in case of first calves. The Iowa station found better indications for predicting future production and breeding value from the average records of dairy cows having 6 or more tests in herd improvement associations than from the highest record of the individuals. These results were based on the production of 115 Holstein cows in cow-testing associations. The high correlation between the cows' highest record and the average of the other records from which it was selected was considered to result from the statistical effects of correlations of data with a group of which it made a part.

An analysis of variance in milk-production and fat-percentage records of the daughters of 13 bulls grouped according to maternal grandsires was found by the Iowa station to show no favorable indications of nicking. On the other hand, analyses of the fat-production records of the daughters of 17 Jersey bulls grouped according to maternal grandsires by the New Jersey station indicated that the sires nicked better with the progeny of certain bulls than with others, although no very positive conclusion regarding the operation of nicking could be derived with the small number of individuals furnishing the basic data in these studies and the possible effects of environment.

Double mating in cattle.—The production of progeny in the same litter but sired by different males affords an unusually favorable opportunity for eliminating the influence of all factors except the contribution from the male. This method is followed out very successfully with swine where several individuals are born in each litter, but is much rarer in the case of other large domestic animals. The Iowa station described a set of twins born of a cow which had been mated with an Aberdeen Angus and a Hereford bull at the same breeding period. One of the calves was polled and showed Aberdeen Angus characteristics, and the other was white-faced and resembled the Hereford.

Improvement in wool production and conformation in sheep.—The New Mexico station found it possible to increase the length of wool of range sheep approximately 0.5 inch by proper selection of breeding animals. A reduction in shrinkage of the wool and improvement in the grade and weight of the fleeces increased wool prices an estimated average of 40 cents per ewe. Smooth-skinned Rambouillet ewes produced 4 pounds more of feeder lamb per head than heavily wrinkled, tight-fleeced ewes.

Black fibers in the wool of Hampshire sheep were found by the Arkansas station to be hereditary. Significant dam-progeny correlations between the black fibers in Hampshire fleeces when a sire with no black fibers was used suggested the partial dominance of color. Little or no correlation was found between the appearance of black

fibers in dams and their daughters when the sires had black fibers in their fleeces.

Consideration was given by the Texas station to the use of wild sheep for crossing with domestic breeds. Since crosses of the mouflon with domestic sheep produced fertile offspring, the transference of the desirable genes from wild to domestic sheep seemed practicable and under certain conditions desirable.

Progress was made at the South Dakota station in the development of a strain of sheep with tails sufficiently short that docking was not required. In the origin of this flock there were employed in 1913 fat-rumped rams from Siberia which were mated with purebred and grade Shropshire, Cheviot, and Hampshire ewes. Later Rambouillet ewes were introduced to improve the quality of the fleece. Most of the progeny in 1939 had tails less than 1.5 inches in length, or no tails at all, making docking unnecessary. When rams of this type were crossed with the domestic breeds none eliminated the tails from the progeny in the first cross, but on successive backcrosses only small proportions of the lambs needed docking.

Inbreeding and crossbreeding swine.—Comparison of crossbred and purebred Poland China and Duroc-Jersey pigs produced in double matings at the Illinois station showed crossbred pigs to be significantly superior to purebreds, especially when mixed litters containing both purebreds and crossbreds were produced. There was an average of 7.78 pigs in purebred litters from one boar as compared with 9.8 pigs in mixed litters where sires of two different breeds were involved. The birth weights of purebred pigs were significantly smaller than the weights of crossbred pigs, and the strength of live pigs at birth was slightly in favor of crossbreds. Crossbreds likewise gave more favorable results as regards the daily rate of gain, feed per unit of gain, and weight at market age than purebreds, although differences were not statistically significant. Slightly larger percentages of crossbreds than purebreds were dead at farrowing. Similar results were obtained in studies at the South Carolina station from crossing purebred Berkshire sows with Duroc-Jersey boars. The crossbred pigs were 20 percent heavier at birth and 34 percent heavier at weaning than purebred Berkshires, and crossbreds gained 25 percent faster than purebreds with an equivalent feed requirement per unit of gain.

Inbreeding ranging from 19 to 30 percent in several lines of pigs at the Minnesota station was generally deleterious, but at least four lines showed no harmful effects. A crossbred Landrace-Tamworth line was considered nearly ready for distribution to a selected group of collaborators. These lines were produced in cooperative studies with the regional swine breeding laboratory at Ames, Iowa.

Further substantiating conclusions drawn from the effects of inbreeding, the Minnesota station found that the variability in terms of efficiency of feed utilization in rat litter mates decreased as inbreeding was continued through successive generations.

Transmission of economy of production and morphological traits in swine.—After three generations of selection based on efficiency of gain, the Alabama station developed a strain of pigs which was heavier at birth and weaning and fattened on less feed than another line descended from the same ancestors but selected for uneconomical

gains. Rapid and cheap gains were associated with heavy feed consumption, and feed requirements per unit of gain were low.

The South Carolina station found a correlation between the weights of the heart, liver, thyroid, and adrenal glands and the economy of gains made by 22 Berkshire barrows individually fed from an average weight of 33 to 200 pounds. Such findings give justification for consideration of conformation, vigor, vitality, etc., of animals and the relation to economy of production.

Legless abnormalities in pigs.—The Iowa station described the occurrence of 15 legless pigs among 112 progeny in 7 Poland China litters produced by a boar mated with daughters of a related sire. The legless condition was evidently the result of a recessive gene transmitted in the related animals by both the sire and the dam. The same sows produced 7 legless among 60 pigs on subsequent matings with the same boars.

A linkage map in fowls.—Of the large number of chromosomes in fowls, gene markers have been observed with 6 and possibly 7 in studies at the New York (Cornell), Kansas, and other stations. The loci of 21 mutant genes have been ascertained as the result of new investigations and compilations from various authors. Many genes have been located on the chromosomes in the fruitfly, and comparable information, although less extensive, is being accumulated for the fowl. Several of the more important deficiencies in the knowledge regarding linkage relationships and crossing over between genes located on the same chromosome were pointed out for the guidance of others working along these lines.

A mutation in the fowl designated as naked, which caused an almost complete lack of down and juvenile feathers and deficient feathering in the adult, was found by the New York (Cornell) station. The gene causing naked was recessive and sex-linked. All birds of the F_2 population showing the deficiency were females. The mortality of the affected chicks was 55 percent during the first 6 weeks after hatching and 13 percent in normal chicks. Skin transplantations between nakeds and normals showed that feather growth continued as in the donor.

The Kansas station studied brachydactyly in the fowl involving shortening of toes. This condition was found related to the degree of leg feathering, but evidence was not sufficient to indicate whether these two characters were expressions of the same gene or due to separate factors that were closely linked. Birds with normal toes seldom showed tarsal feathering, and only a small percentage of the birds with shortened toes were free of leg and foot feathering.

A recessive gene causing pink eye in the fowl was described by the same station. The effects of this gene on eye color were similar to those exhibited by albinism, but there was a dilution of the melanic pigment in the plumage in pattern of birds homozygous for the gene. F_1 progeny from matings of normal and pink-eyed parents produced only normals. In the F_2 and backcrosses the usual 3:1 and 1:1 ratios were obtained, but somewhat more daughters than sons were produced.

Another morphological condition described as spike-blade involving a comb variation extending back to the attachment in Single-Comb Rhode Island Reds was found by the Kansas station to be controlled by a recessive non-sex-linked gene. A condition difficult

to explain was also noted in breeding such birds, in that many normals were produced from matings of spike-blade parents.

Breeding poultry for growth rate and longevity.—Two strains of Barred Plymouth Rocks showing highly significant differences in average body weight at 12 weeks of age were produced by the Indiana station. In the sixth generation the fast-growing strain averaged 6.3 pounds in weight and laid eggs weighing 23 ounces per dozen, while the breeding hens from the slow-growing strain weighed 3.6 pounds and the eggs 20 ounces per dozen. Possibilities for increasing the efficiency of poultry for meat and egg production by improvement along this line were suggested, as well as the probability that lessening the time required for attaining given weight would make the production operations more profitable.

By the selection of Rhode Island Red sires showing complete back feathering at 8 weeks of age and sires for another line that lacked back feathering at that age, the Massachusetts station produced a line which in the sixth generation gave 70 percent early-feathered sons as contrasted with 100 percent late-feathering in the other line. The data seemed to indicate that early dorsal feathering of males was due to several recessive autosomal genes. The presence of a sex-linked recessive gene was not essential.

Early feathering or lack of it may be of much significance in broiler production. Strains were produced at the Oklahoma station that will not produce the "bareback" condition. Feathering of the chicks at hatching or at 10 days of age served as the only criterion that could be used to eliminate permanently the "bareback" condition from the flocks.

Production records of hens carried for as long as 6 years in the Vineland hen test revealed a number of hens that had laid more than 1,000 eggs each in 5 years. Study of the data by the New Jersey station suggested that longevity of egg yield is an inherited character that could be built up in the flock through careful selection.

Improvement in egg production and freedom from broodiness in poultry.—An index based on the dams' sisters' production was found useful in indicating the daughters' egg production in studies at the California station with Single-Comb White Leghorns. In breeding procedures where the number of eggs laid is the only measure of breeding worth, trap-nesting for the winter months is as efficient a guide to family selection as trap-nesting for the year, but neither system was adequate when the records of the dams alone were considered. In further studies the date of first egg of the daughters of 26 sires proved as efficient a measure of sexual maturity of the family as the mean age at first egg. Significant correlations between early maturity and annual production were observed.

Selective breeding at the Massachusetts station for the absence of broodiness in Rhode Island Reds showed that sires may be discovered that produce no daughters exhibiting the broody instinct in the first laying year.

Inheritance of viability.—Inheritance was found to play an important part in the mortality rate of Rhode Island Reds in studies at the Massachusetts station. In the sixth generation the mortality was 6.6 percent to 6 months of age in the low-mortality line and 10.46 percent in the high-mortality line.

Marked differences in mortality from excessive heat were noted by the New York (Cornell) station between White Leghorns, Barred Plymouth Rocks, and Rhode Island Reds. It was suggested that perhaps the color and morphological characteristics of White Leghorns aided the thermoregulatory processes more than did the characteristics of the heavy breeds. Analyses within breeds indicated that differences in heat resistance were independent of body size and egg production. Resistance tended to decrease with age.

The fact that White Wyandottes hatched fewer chicks per hundred eggs than White Leghorns or Rhode Island Reds was found by the New York (Cornell) station to be due presumably to a specific gene causing greater mortality in the breed or linkage of a deleterious gene with genes for other breed characters.

The laying-house mortality was decreased from 89 percent in 1935 to 34 percent in 1938 in a flock selected by the Alabama station for resistance to fowl paralysis. The average age of survival after the first egg was laid increased rather steadily from 149 days in 1935 to 177 days in 1938. This represented an estimated saving of 87 eggs per bird and a difference in gross income of $1.50 per hen.

Progeny of birds selected by family because of good viability at the Delaware station exhibited 21 percent less mortality than the progeny of birds for which this characteristic was not considered.

After two generations of breeding for reduced adult mortality to tumors in Single-Comb White Leghorns at the New York (Cornell) station, only 19 percent of the birds in the resistant line, as contrasted with 36 percent in the susceptible line, succumbed to neoplasms.

Comparative development of normal and heterozygous lethal fowls.—Comparative development of normal and heterozygous lethal fowls in creeper stocks at the Connecticut (Storrs) station showed that the variability in somite counts of embryos up to 4 days of incubation did not serve as a satisfactory basis for differentiation of the genotypes. However, homozygous creepers (lethal) were on the average slightly less advanced in early development than heterozygous sibs which were viable. The first signs of the pathological condition in lethals appeared at from 40 to 50 hours' incubation. In a further study of creeper fowls, body weights, long-bone measurements, and weights of the eyes, liver, and gizzard were found to be drastically reduced in homozygous lethal embryos, but heterozygous creepers approached the normal with some slight variations. There was some tendency for a compensatory hypertrophy of the heart and spleen in homozygous creepers, presumably as a result of the anemic symptoms occurring after the second week of incubation.

In another study at the same station heterozygous creepers and their normal sibs were fed rations containing selenium. The early development of creeper and normal progeny of parents which were fed selenium is in general similar, but heavier mortality was noted in the heterozygous creepers up to the eighteenth day of incubation. As a result, mortality was higher among normals in the later stages. The creeper mutation exaggerated the defects produced by selenium. In the embryos from creeper and normal matings deformities of the eyes and wings tended to be more common and more extreme on the left side of the body than on the right, while the reverse was true for malformations of the legs.

In another approach to the study of lethal fowls the California station made a comparison of the association of glutathione and ascorbic acid concentration in embryos from stocks carrying the Cornish lethal and creeper lethal genes. After 14 to 19 days of incubation normal and heterozygous embryos of the Cornish lethal stock showed similar growth records and glutathione concentrations, but lethals were consistently below normal in body weight and glutathione. On the other hand, heterozygotes and normals from creeper stock showed no significant differences in these respects.

Identification of sex in fowls at hatching.—Poultrymen are interested in determining the sex of baby chicks at an early age so that they may discard the cockerels from laying flocks. At the New York (Cornell) station strains were developed that were easily and rapidly sexed at hatching by taking account of the inheritance of sex-linked color and markings from different crosses. Genetic characters from two breeds were employed by the use of Barred Plymouth Rocks and mottled Anconas in this way. Chicks of the new breed, called "Ancobars", were sexed at hatching with an accuracy of more than 90 percent. It was also noted that in some strains of Barred Plymouth Rocks male chicks could be distinguished from females by the lighter color of the down and shanks and less regular head spots. The Oklahoma station crossed white Plymouth Rocks and Rhode Island Reds to produce the Oklabar, an autosexed breed at hatching, and showed the possibilities of developing a silver-barred autosexing large variety from crossing this breed with Silver-Laced Wyandottes.

Inheritance studies with turkeys.—Autosomal as well as sex-linked genes were found to operate in determining sexual maturity in turkeys in studies conducted by the California station. The operation of sex-linked factors was made evident by the fact that the progeny of late-maturing males and early-maturing females laid earlier than birds in a late-maturing line, but later than the progeny from the reciprocal cross.

In studies at the same station the progeny of black-winged Bronze turkeys mated with Bourbon Reds resembled Bronze in the distribution of pigment in the down. These results showed the black-winged Bronze turkeys to be homozygous for the bronze color factor, causing black and nonbarring of the wings. The barring gene and its allel had little or no influence on the distribution of brown pigment. A pattern similar to that of the Narragansett except for nonbarred flight feathers was produced in the F_2 generation after crossing with Narragansetts. Slate color occurring in turkeys was shown to be controlled by an autosomal gene recessive to nonslate. The bronze color gene in slates caused barring of the flight feathers and penciling in the tail feathers. Nearly white, nonbarred flight feathers and nonpenciled tail feathers in genotypic slates were produced by the homozygous Bourbon Red gene. By selection for body weight, a large strain of Bronze turkeys of which the hens averaged 11.7 pounds at 24 weeks of age was produced at the Indiana station. The weight of the hens from the strain selected for small body size was 9.0 pounds, and the corresponding weights of toms from these strains were 17.3 and 13.1 pounds, respectively. Dressing losses and percentage of edible flesh from the two strains were essentially the same.

PHYSIOLOGY

Rapid advances were made in the study of endocrines and their role in reproduction and lactation. The functions of the pituitaries in stimulating and controlling the physiological activity of vital organs and the activities of the nervous system and glands received much consideration. In ascertaining the hormone production of various of these glands and the concentration in body fluids, it was necessary to develop standard tests with rats, guinea pigs, rabbits, pigeons, and other small animals for carrying out the biological assays. Much use was made of laboratory animals in such studies.

Increased attention was given to improved methods of semen collection, dilution, storage, and transportation for the greater use of superior germ plasm in artificial insemination of domestic livestock.

The relation of endocrine products to energy and protein metabolism and growth.—Extracts of the anterior pituitary glands of beef animals were found by the Pennsylvania station generally to stimulate the appetite of rats during 4 to 8 weeks, but a depressing effect on food consumption followed. The fasting heat production of the injected rats was considerably greater than that of the controls during the early part of the experimental period, but later the differences disappeared and finally were reversed.

The plasma fat of healthy female guinea pigs was depressed in proportion to the amount of anterior pituitary fat-metabolism hormone injected, in studies at the Missouri station. The maximum depression occurred at about 6 hours after injection. Intraperitoneal injections with anterior pituitary extracts lowered the fat content of the blood plasma of rabbits within 6 to 8 hours, but it returned to normal within 24 hours. The effects of fractions of this extract and hormones from the adrenal, thyroid, and other glands indicated that the fat-metabolism hormone was responsible.

Since injections of the female sex hormones from pregnant mare serum and human pregnancy urine into immature female fowls were found by the California station to produce a rise of blood lipides and increases in oviduct growth similar to that in normal laying birds, additional studies were made of the effects of synthetic oestrogenic substances such as oestrone, oestradiol, oestradiol benzoate, ethinyl oestradiol, and stilboestrol. All of these caused increased concentration in the total fatty acids, phospholipides, and cholesterol in the blood of chicks. The most striking response followed stilboestrol injections. Testosterone, progesterone, and desoxycorticosterone acetate did not affect blood lipides even when administered in excessive amounts.

During the period of rapid growth in rats, the Missouri station found in chick assays a higher concentration of thyrotropic hormone in the pituitary glands than at other times. Males always showed more thyrotropic hormone per gland than females, and definite increases were observed during the latter part of gestation and during the initiation of lactation.

The Ohio station found the pituitary glands of rats on vitamin A-deficient diets to have a greater-than-normal stimulating effect on ovarian development of immature animals. Analyses of the glutathione content of both liver and muscle from rabbits of different breeds, ages, and sizes at the California station showed that the gluta-

thione concentration may be taken as an index of anabolic activity. The glutathione content of both liver and muscle of rabbits was significantly lowered by the injection of potent sources of the growth hormone, indicating the effect of this hormone on the more rapid utilization of glutathione.

The discharge of an excessive number of ova in young female rats ranging from 30 to 33 days of age was induced at the California station by the administration of 8 units of mare gonadotropic hormone. There were produced in the ovaries of 3 females 30, 32, and 33 corpora lutea, respectively. More than 20 live embroyos were found in some litters on the twenty-first day of gestation. It was possible to increase markedly the number of viable young carried to term.

The California station increased ovarian weights of hypophysectomized immature rats by the implantation of pellets of oestrogens and androgens following hypophysectomy and injection of a pregnancy-urine extract. The most striking increases in ovarian weights were obtained from the injection of diethylstilboestrol and an extract of human pregnancy urine.

Chemical studies of hormones.—The California station conducted extensive chemical investigations on the gonadotropic hormones present in the blood serum of nonpregnant mares. Samples of blood were drawn every 4 to 7 days throughout recurring oestrous cycles. Marked variations were noted between samples from the same mares, but only in rare cases were positive responses obtained when extracts of less than 100 cubic centimeters of blood were employed. The highest concentrations of gonadotropic hormones were observed in blood samples collected in metoestrum. Augmentation, luteinization, and antagonistic effects were noted from simultaneous administration of follicle-stimulating and interstitial-cell-stimulating fractions of sheep pituitary extracts.

The potency of gonadotropic hormones from the pituitary and chorion was decreased or destroyed by the addition of cysteine, in studies at the California station, but no loss of potency of the gonadotropic hormones followed the addition of cysteine to pregnant mare serum.

In the separation of extracts of hormones from sheep and cattle anterior pituitary glands, the Missouri station obtained fractions in which only traces of the thyrotropic, gonadotropic, carbohydrate-metabolism, and fat-metabolism hormones were present. Slightly less than 50 percent of the lactogenic hormone was recovered.

Endocrines in relation to milk secretion.—Hormones of the pituitary gland were found by the Missouri station to regulate growth of the udder through direct control of growth of the duct and lobule-alveolar structures in the mammary gland. Further studies showed that the pituitaries of cattle in different stages of gestation vary in the content of these hormones. Mammogen in the pituitary was low in early pregnancy, rising to a peak at about 150 days of gestation, and dropping off in late pregnancy. The largest amounts of the hormone were found in the pituitaries of lactating dairy cows. Beef cows produced less than dairy cows in comparable stages of oestrus and gestation. Pregnant beef heifers showed from 40 to 60 percent more mammogen than pregnant beef cows, but the mammogen content of pituitaries of nonpregnant beef heifers was low.

Injections of the lactogenic hormone which stimulates the secretion of milk may cause considerable augmentation in the rate of milk flow. The inheritance of variations in the yield of milk and fat may in part be dependent on the rate of secretion of these hormones of the pituitaries and the glands and organs affected. Thyroxine, a hormone produced by the thyroid gland, is known to influence the rate of milk secretion. The activity of this gland is in turn stimulated by the thyrotropic hormone of the pituitaries. Injections of thyroxine at intervals throughout the lactation period, at the Missouri and Mississippi stations, caused increases in both milk yield and fat percentage. Continued feeding of thyroid maintained the lactation at a high rate for periods of several months. Differences in the inheritance of the rate of secretion of the various endocrine glands concerned in milk production were sufficiently promising to suggest the possibilities of quantitatively assaying endocrine production for different breeds and strains, which may adequately differentiate their productive capacity and serve as a sensitive measure for appraising the merits of individuals and strains.

The sensitivity of different methods for assaying lactogen was compared by the Missouri station. Evidence was found that the factors which initiate lactation in mammals were identical with the pigeon crop-gland-stimulating factor. The test based on the local proliferation following the intradermal administration of the extract over the pigeon crop gland was several times more sensitive than the rabbit test based on mammary-gland proliferation.

In a comparison of the lactogen content of the pituitaries of rabbits and guinea pigs at different stages of pregnancy and lactation the Missouri station showed that the lactogen content increased little until the last portion of gestation when parturition approached. A peak in production was reached in both animals shortly after parturition, but the rise in the rabbit production was more pronounced. Absence of nursing resulted in an increased lactogen content of the pituitaries. In a chemical experiment separation of mammogen from other pituitary hormones was effected, and it was found that mammogen differed from oestrogen in being heat labile and subject to oxidation.

The "letting down" of milk during the milking process was found by the Minnesota and Kentucky stations to be due to a conditioned reflex involving nerves, posterior pituitary gland, blood, and the mammary gland. A stimulus to the udder, usually resulting from the first milking operations, caused the secretion of oxytocin from the posterior lobe of the pituitary, which was carried to the mammary glands by the blood. There resulted a contraction of the smooth muscle to force the milk out of the alveoli. Anger, fright, and anxiety are emotional states acting on the adrenals, causing secretion of adrenalin and completely preventing the normal response.

Lactation was initiated in pseudopregnant rats at the New Jersey station by injection following ovariectomy of suitable doses of lactogen with adrenal cortical hormones with and without glucose solution. These studies gave evidence that another hormone besides lactogen limits milk secretion before the effects of lactogen can be expressed, pointing toward the operation of the duct-development factor. The crop-gland-stimulating activity of the lactogenic hor-

mone was found by the California station to be completely destroyed by nitrous acid as a result of a 30-minute treatment.

In cooperative studies of the Nebraska and New Jersey stations, daily injections of an extract of human pregnancy urine did not prevent lactation in female rats during the first 5 days after parturition. The rate of growth of the suckling young was reduced as much as 22 to 33 percent by large doses, but it also made the dams ill.

At the New Jersey station the daily administration of a synthetic male hormone augmented the lactogen content of the pituitaries of spayed female rats about 40 percent, without changing the pituitary weight. There was also an extensive development of the lobule-alveolar system of the mammary gland. The action of a pituitary factor inducing growth of the mammary gland was demonstrated. Removal of the hypophysis and the ovaries of sexually immature female rats caused involution of the mammary gland. However, histological examination showed that pituitary implants from adult males and females in such animals produced numerous enlarged end buds 12 days later. There was no difference in the effectiveness of pituitary implants from adult males and females with and without previous oestrogen treatment.

Artificial insemination.—Progress in artificial breeding methods and their adoption in several States through the aid of the experiment stations was noteworthy. For example, the New Jersey station not only aided in working out a cooperative plan but made available for use in this work sires of proven ability to transmit desirable milk-production qualities. More satisfactory methods of preserving sperm that will permit transportation of viable sperm for long distances constituted a part of the research program of several stations.

Considerable variation was observed in the physical and chemical characteristics of semen collected from different bulls as well as separate samples from the same bull. Fertility was maintained in diluted and undiluted samples stored for 24 to 196 hours, in studies at the Missouri, South Carolina, and Texas stations. The ability of spermatozoa to retain motility under storage conditions was one of the best indexes noted for evaluating fertility in sires.

A yolk-buffer pabulum was perfected by the Wisconsin station for the preservation of bull spermatozoa so that they could be stored for periods of 150 to 180 hours and successfully used for breeding dairy cows. Motility of the sperm was maintained for 300 hours by this method. The optimum storage temperature was 5° to 10° C., with a pH of the pabulum of 6.75. The New York (Cornell) station found this egg yolk-buffer nutrient mixture to increase markedly the livability of spermatozoa. The importance of keeping bacterial growth at a minimum with a storage temperature of 41° F. was emphasized, and changes in the temperature had to be made gradually. There was little, if any, advantage of covering samples with mineral oil for storage periods up to 6 days. In connection with their investigations, the same station perfected an artificial vagina for controlling temperature in the collection of semen. This consisted essentially of a test tube inserted in a rubber hose surrounded by warm water.

The technique for storing semen from boars, rams, stallions, and bulls was improved by the Missouri station, in cooperation with the

Department (B.A.I.), to the point where boar semen may be stored in a viable condition over a 2-day period. Mares were artificially inseminated in Montana 20 hours after semen collections were made at Beltsville, Md., 2,000 miles away. Artificial-insemination methods have been satisfactorily and profitably employed with beef cattle on the range with the single objection that it is necessary to treat each cow individually. Maximum utilization of outstanding sires has been possible, with an actual saving in cost of maintenance and service.

As a measure of the viability and quality of sperm from rams, the Minnesota station investigated a test based on the metabolic activity of ram sperm at different intervals after storage. This test was suggested as having possibilities for comparing the breeding potentialities of different rams.

Employing an avian semen collector for artificial-insemination purposes, the Missouri station found that cockerels were more active sexually in the late afternoon than in the morning and that too frequent collections resulted in a reduced volume and number of sperm. However, the Kansas station found no direct relation between the sperm counts and successful fertility from artificial insemination. In natural matings a decline in density was observed in males of the lowest fertility. Successive semen collections from the same individuals showed as marked variation as samples from different sires.

The Pennsylvania station found that the reproductive organs of female turkeys responded to artificial illumination in the winter, eggs being produced after 21 days, but that males did not become fertile before 30 to 35 days' exposure to lights. Excellent fertility was obtained when toms were illuminated 5 weeks before placing the hens under lights. Hens must be mated within the 3-week period before they start to lay.

DISEASES AND DISORDERS

HORSES

Periodic ophthalmia.—The Kentucky station studied this disease and found it to be present in a total of 14.7 percent of 2,258 horses examined. Because it had been suggested that the cause was infection with a member of the genus *Brucella*, 148 horses were tested for *Brucella* infection by means of agglutination and other tests. Of 53 horses affected with periodic ophthalmia, 26.6 percent reacted positively to one or more of the tests as compared with 28.4 percent of 95 horses that showed no clinical evidence of the disease. Horses injected intravenously with *Brucella* cultures developed none of the characteristic ocular lesions over a period of several months, and even when introduced into the conjunctival sac these cultures produced no permanent lesions. Attempts to cultivate an etiologic agent from the eyes of infected horses gave negative results.

Parasites of horses.—The parasite *Trichostrongylus axei* was found present in the stomachs of 72 percent of 50 horses examined by the California station. The heaviest infections were observed in the farm horses of central California, while infections of the majority of the wild range horses were conspicuously light. Heavy infections of the parasite produced a chronic catarrhal gastritis in horses and mules. The repeated egg count-larval method appeared

to be the most accurate way to diagnose trichostrongylosis. Transmission of an equine strain of the parasite to a 17-month-old Jersey steer was demonstrated.

A series of observations by the Kansas station showed that of 174 horses killed at a meat-packing plant, 84 percent were infested with *Strongylus vulgaris* in the cecum. Twenty percent of the horses had infestations that were probably extremely harmful to the host.

Equine encephalomyelitis.—A statistical study was made by the Montana station in cooperation with the Department (B.A.I.) on the difference in resistance to encephalomyelitis of equally exposed groups of horses at the United States Range Livestock Experiment Station. Among all yearlings 50 percent of those of Nonius breeding were affected, whereas only 11.1 percent of the yearlings of other breeding were affected. In the foals the corresponding percentages were 72.7 and 10.5. No differences in resistance were observed between males and females.

The Kansas station developed and used successfully an extremely sensitive chick-embryo technique for detecting minute amounts of the virus in the blood of experimental animals. The Massachusetts station isolated the eastern type of virus in two ring-necked pheasants and showed by experimental inoculation that the English sparrow was highly susceptible to the virus. This finding added the latter to the list of hosts that may contract the disease.

The California station, in comparing various strains of viruses, found that the eastern and western American and a form from the Union of Soviet Socialist Republics showed distinct differences in their incubation periods, temperature curves, and clinical behavior in guinea pigs. All three forms infected the horse and the same species of experimental animals. The eastern American variety easily infected animals intracutaneously in high dilutions, while the others are less invasive by this route. The Russian form was most infective when given through the central nervous system and did not readily invade by other routes unless in comparatively large doses. Because of many other differences in response to laboratory tests, the Russian form may be considered a distinct variety of the group of viruses causing equine encephalomyelitis.

CATTLE

Mad itch.—The filtrable virus of Aujeszky's disease or "mad itch," a highly fatal brain disease in cattle, was isolated and identified by the Illinois station. Losses among a large herd of cattle on feed were promptly stopped by separating hogs from the cattle. Apparently the virus was carried by swine.

Parasites of cattle.—The Hawaii station found a very significant correlation between the number of eggs per gram of feces and the number of adult liver flukes in infested cattle. Each adult fluke was represented by 1.01 eggs. This finding not only makes it possible to determine the extent of fluke infestation, but to determine the efficacy of a drug treatment. A new drug developed at the station, consisting of a mixture of hexachloroethane and kamala extract, was found to be highly effective in the treatment of cattle for liver flukes.

Experiments at the Louisiana station suggest cutaneous infection by the hookworm *Bunostomum phlebotomum*, although licking of

larvae from the hair may have occurred. Instances of cutaneous infection with nodular worm larvae were recorded. On the basis of these results, it would seem important that the places where cattle, especially calves, lie down, such as in the shade, the barn, and the barn lot, should be taken into consideration in the program of parasite control of the hookworm and nodular worm.

Forage poisoning.—The heavy losses of cattle that sometimes occur after access to stacks of oat hay or straw are caused, according to the Wyoming station, by high percentages of potassium nitrate (saltpeter) which have accumulated in the oats during the growing season. Other plants often eaten by livestock, such as pigweed (*Amaranthus retroflexus*), may also contain toxic amounts of potassium nitrate, and horses and sheep are subject to poisoning from the same source. Forage containing less than 1.5 percent of potassium nitrate is not deemed likely to be dangerous to livestock, and the toxic substance is not cumulative. The determination of the safe margin of concentration should enable farmers and stockmen in dangerous areas to avoid risk by securing forage analyses. In cases of forage poisoning, it has been found that 2 grams of methylene blue is sufficient as an antidote to protect an animal weighing up to 550 pounds against the ingestion of 14 pounds of plant material containing about 5 percent of potassium nitrate.

Toxicity of spoiled hays.—In the course of experimental testing of the toxicity of various spoiled sweetclover hays, the Wisconsin station in cooperation with the Department (B.P.I.) noted marked differences in the susceptibility of rabbits of similar age to sweetclover disease. Susceptible animals became somewhat less susceptible with advancing age, while resistant animals maintained their resistance. This finding suggested that the variation in a group of rabbits is an expression of the inherent constitution of the animal and not the result of previous diet. Small amounts of alfalfa fed as a supplement to a toxic hay have not protected rabbits against the disease.

Calf pneumonia.—In studying the pathological changes of calf pneumonia, the Michigan station noted three variations: (1) An acute pneumonia, which progresses very rapidly, the animal dying within several days without evidence of any productive tissue changes but usually with a serofibrinous exudate filling the alveoli; (2) an acute pneumonia superimposed on a chronic bronchiolitis or chronic broncho-pneumonia in which a large part of both lungs is consolidated, accompanied by a marked fibrinous pleurisy; and (3) cases in which large numbers of abscesses and necrotic areas are present in the lung. It was also found that the pneumonia usually begins in the apical lobes and that it is consistently of longer duration in the left lung than in the right. Streptococci of the Beta type and *Escherichia communior* were considered probable causative agents in the disease.

Bloat in dairy cattle.—Rumen gases collected from both live and dead cows that had bloated on sweetclover or alfalfa were analyzed by the South Dakota station, as well as gases generated under laboratory conditions from a number of legumes and nonlegumes. No significant difference was noted in the composition of the rumen gases nor in those generated in the laboratory except for a relatively low percentage of carbon dioxide in the gases from corn plants, marsh grass, and bromegrass. The rumen gases differed from those gener-

ated in the laboratory mainly in their higher methane content. No single factor was found which would seem to explain the cause of bloat or the cause of death from bloat.

Studies at the Oregon station showed that gas absorption from the rumen during bloat was quite rapid. Carbon dioxide absorbed from the rumen produced marked symptoms in the respiratory organs, relatively high pressures causing extreme difficulty in breathing. Carbon monoxide was found in appreciable amount in two experimental cows fed freshly cut Ladino clover.

Diarrhea in calves.—The Puerto Rico station established the fact that the nodular worm *Oesophagostomum radiatum* is one cause of diarrhea in calves. Doses of 20,000 to 50,000 infective larvae of the nodular worm administered in water by mouth to young calves caused a rise in body temperature which coincided with the entrance of the larvae into the intestinal wall, and also with their return to the lumen, caused loss of appetite, anemia, and severe diarrhea, the feces containing some mucus and blood. The most severe symptoms continued for 2 or 3 weeks after their onset, which was coincident with the exit of the larvae from the intestinal wall. Calves suffering from an infection of nodular worms never equaled in weight calves that had been protected from infection.

Bang's disease (infectious abortion).—The Montana station in cooperation with the Department (B.A.I.) concluded that a fundamental factor in controlling Bang's disease in a beef herd is the restriction of the breeding season to 2 months. An annual fall blood test, with the shipping of all reactors at 1–50, when the breeding season is limited will eliminate the infection from the herd even in the face of an acute outbreak of the disease.

Results obtained at the Ohio station tended to show that it is not the method of administration nor the channel of entrance of *Brucella abortus* organisms but rather the "status of the animal" at the time of exposure that determines what will happen insofar as the act of abortion is concerned. Age, puberty, the presence or absence of pregnancy, and the duration of gestations were variables affecting this status. Reinfection exposures with virulent *Br. abortus* organisms did not appear to cause definite and consistent alterations in the agglutinin content of the blood of previously exposed animals, nor did they significantly interfere with the capacity to carry calves to maturity.

Studies by the Minnesota station of samples of saliva from reacting and nonreacting cattle indicated that saliva is not an important source of elimination of *Br. abortus* from the animal body. On the other hand, evidence was accumulated to the effect that the common barnyard rat is a host of *Brucella*, that infection may pass from rat to rat living in close contact, and that *Br. abortus* may be found in the urine and feces of rats. The station has also isolated *Br. abortus* from the feces of infected horses, indicating that these animals may be responsible for distributing Bang's disease.

The Kansas station found that cattle injected subcutaneously with hemorrhagic septicemia bacterin gave rise to agglutinins for *Pasteurella* organisms but not to agglutinins for *Brucella* organisms. When Bang-reacting cows were given hemorrhagic septicemia bacterin subcutaneously, the Bang titer of these cows was not lowered

from a positive to a negative level during the 6-month period of observation.

Results of comparative tests at the Missouri station showed that neither the tube nor the plate test was greatly superior in reducing the number of suspected animals, but a slightly smaller number of suspicious reactions were obtained by the plate method. The study emphasized the importance of uniform methods of testing and reporting results in order to eliminate apparent variations in the agglutination test when reported by various laboratories.

The Wyoming station concluded that the vaccination of first-calf heifers during their calfhood with United States Bureau of Animal Industry *Brucella* strain 19, living culture vaccine, prevented permanent infection of the udder to the extent that *Br. abortus* could not be recovered after 11 days post partum. In only one of 28 cows vaccinated at 4 to 6 months of age could *Brucella* agglutinin be demonstrated in the milk 3 to 26 days following parturition.

Mastitis of dairy cattle.—In the treatment of cows affected with chronic mastitis with doses of sulfanilamide ranging from 0.5 to 16 ounces over a period of from 12 hours to 22 days, the Nebraska station found that the drug exerted a transient effect on the streptococci. As long as the drug could be detected in the milk the streptococcal count remained low or in some instances disappeared. However, as soon as the udder was cleared of the drug the streptococci reappeared in numbers as great as before the treatment was begun. When animals were infected with staphylococci the drug showed no effect on the organisms. At the Idaho station cows tolerated doses of sulfanilamide of 5 grams per 100 pounds body weight per day. The counts of bacteria in the milk were much reduced during medication in all cases, and in most cases the milk was temporarily rendered nearly or completely sterile by the drug. However, there was no permanent improvement in the udder. The station also tried the use of X-ray treatments at daily intervals for acute and chronic mastitis. Exposures at a distance of 20 inches for 15 minutes daily over a 15-day period did not eliminate *Streptococcus mastitis* from any affected quarter. In a chronic case the milk returned to normal macroscopic consistency and the affected udder became soft, but on autopsy the quarter showed considerable fibrosis, many buckshot-sized abscesses, and a decrease in the soft cellular tissue of the udder. In an acute case the secretion became scant and remained flaky in all affected quarters. The West Virginia station noted no difference in the incidence of mastitis, after 2 years of study, between two groups of dairy cows, one of which was fed a ration very high in corn meal and the other a normal ration.

The Hotis reaction, according to results obtained at the Washington station, appeared to be an agglutination reaction, and the alteration of the surface which causes the organisms to clump would also cause them to tend to migrate to the surface of the test tube and adhere. It appeared that the yellow flakes or balls which form on the side of a tube of bromocresol-purple milk after incubation, and which in the Hotis test have been considered diagnostic of *Streptococcus agalactiae*, may be produced by any organism which (1) stimulates the production of agglutinins, (2) grows in the presence of 0.025 percent bromocresol purple in a milk medium when incubated in a test tube under aerobic conditions at 37.5° C, (3) forms clumps on

the side of the tube when grown in the presence of its agglutinins, and (4) produces sufficient acid from lactose to increase the hydrogen-ion concentation to about pH 5.4. The New Jersey station found that the Hotis test could not be relied upon to indicate the presence of mastitis streptococci in 95 percent of cases unless the streptococci were of Minett's group I. If infection with streptococci of other groups greatly predominated in a herd, the efficiency of the test might be reduced to as low as 10 percent. In herds where the type of infection was not diagnosed bacteriologically the exact value of the test would be unknown. On the other hand, results at the Kansas station showed that despite certain errors the Hotis test appeared to be the most satisfactory that has been developed to date for the field diagnosis of streptococcic mastitis.

In studying methods for the diagnosis and control of bovine mastitis, the New Hampshire station concluded that the strip-cup, bromothymol blue, and Hotis tests could not be relied upon for an accurate diagnosis of infection. The Burri agar slant method was approximately as efficient as the blood-agar plate test, but it did not permit any observations on the hemolysis of the organisms nor was it satisfactory for the isolation of pure cultures. The microscopic test was valuable for the detection of streptococcic mastitis, but was of little assistance in the diagnosis of staphylococcic mastitis. A combination of tests was necessary for a complete and accurate diagnosis of mastitis.

The Wisconsin station has developed two standard solutions of potassium permanganate for making reduction tests for mastitis in the field and in the laboratory. In the reactions of this test the depth of color is indicative of the degree of abnormality of the milk. The test is simple, inexpensive, informative, and can be made in the field at the time of the physical examination, when the information it reveals is most useful.

Other experiments at the Wisconsin station have shown that nonspecific mastitis apparently lowers the resistance of the mammary gland to infection with *Streptococcus agalactiae*. Quarters affected with nonspecific mastitis are readily susceptible to internal infection with small numbers of *S. agalactiae*. The physical changes produced in the milk as a result of the superimposed bacterial infection are proportional to the degree of involvement of the quarter with nonspecific mastitis. The pathological changes produced in mammary tissue by nonspecific inflammation are identical to the changes observed to be associated with chronic streptococcic mammary infection. The results suggest that nonspecific mastitis is the primary or predisposing condition and *S. agalactiae* a secondary invader in chronic bovine mastitis.

SWINE

Necrotic enteritis in swine.—Results obtained at the Michigan station indicated that necrotic enteritis develops primarily as a result of nutritional deficiency. More pigs were affected with this disorder when fed a basal ration of yellow corn than when fed barley, while intermediate numbers were affected when fed wheat or oat groats. Additions of liver, yeast, and particularly nicotinic acid to the rations of pigs severely affected with this disorder exerted remarkable curative effects. Rations supplemented with nicotinic acid prevented the de-

velopment of necrotic enteritis in the same environment where pigs fed the same ration without supplement developed the disease. The Hawaii station found that necrotic enteritis decreased and even disappeared while the growth rate increased when yeast was fed.

Coal-tar-pitch poisoning.—In investigating an uncommon disease of young pigs characterized by gross lesions of degeneration of the liver, the Illinois station found that naturally affected pigs had access to pasture on which remnants of clay targets or expended clay pigeons were found. Remnants of the clay pigeons when mixed with wholesome rations and fed to healthy pigs produced gross and microscopic hepatic changes indistinguishable from those observed in the affected animals. Since one of the chief ingredients of clay-pigeon targets is coal-tar pitch, commercial coal-tar pitch was fed to healthy hogs, whereupon symptoms, mortality, and gross and microscopic degenerative liver lesions resembling the spontaneous disease were induced.

Death losses in newborn pigs.—Post mortem examination of a large number of pigs from field cases and from experiments by the Indiana station revealed that the most nearly constant pathological changes were enlarged and very friable livers showing degenerative fatty infiltration and also degenerative changes of the kidneys. Feeding experiments with pregnant sows indicated that the feeding of a good quality protein during the entire gestation period materially reduced mortality in young pigs as compared with sows receiving only grain and minerals.

Hog cholera.—A new tissue vaccine for hog cholera developed at the California station has been released on a Nation-wide scale. The vaccine is made by grinding the glandular tissues of pigs infected with hog cholera and treating the ground tissue with eucalyptol. The vaccine cannot produce cholera in hogs, but does have the ability to give them a lasting immunity to the disease. It has a particularly important advantage over the present serum-virus system of combating cholera in that it eliminates the necessity for taking active cholera virus into the field. The new vaccine, known as BTV (Boynton's tissue vaccine), has been tested successfully on more than 100,000 hogs both on the Pacific coast and in the Corn Belt. It is believed that if universally used it would eventually eliminate the cholera virus. At present, it is estimated, hog cholera costs the farmers of the United States some $500,000 annually for every million hogs produced.

SHEEP

"Sore mouth" complications in sheep.—According to the Colorado station, sore mouth or contagious ecthyma, a disease of lambs which appears shortly after the lambs are received in the feed lot, is caused by a filtrable virus and is in itself not very serious from the viewpoint of death loss. *Actinomyces necrophorus*, a secondary invader in this affection, however, often causes serious complications climaxed by death. When the lesions of the disease are confined to the mouth few losses occur, but in other parts of the body the malady may become serious. Necrotic lesions may appear on the tongue, hard palate, and the larynx, and necrotic ulcers may be present in the paunch, in the other three stomachs, and in the small and large intestines. Small grayish areas may be observed in the liver. If

the necrophorus bacterium is aspirated into the lungs a pneumonia develops. A protective vaccine prepared from scabs removed from typical cases of sore mouth and applied during the first 2 weeks of the lives of the lambs has been found to be effective in preventing the disease.

"Lunger" disease of sheep.—An analysis by the Montana station of the lungs of normal and affected sheep revealed that there was an increase in minerals in the diseased group varying from 17 to 90 percent. However, it was concluded that there was no justification for assuming that this difference indicated any causal relation between the minerals and the pathological condition, but that more likely the increase in mineral content was the result rather than the cause of the disease.

Internal parasites.—At the Illinois station 4 successive treatments with 1-percent copper sulfate in 4 separate 4-ounce doses on alternate days, followed by 14 consecutive weekly treatments of the same order, failed to effect complete elimination of the stomach worm (*Haemonchus contortus*) from sheep. Two successive weekly treatments with 5 cubic centimeters of tetrachloroethylene following repeated preliminary treatment with copper sulfate proved slightly more effective as judged by fecal and post mortem examination. Carbon disulfide and nicotine sulfate in repeated doses, like copper sulfate, suppressed but did not completely expel all *H. contortus* from naturally infected sheep.

The California station found that 1-week-old lambs were susceptible to trichostrongyle infestation. Resistance and susceptibility based on the fecal egg count were present not only at this age but at more advanced ages as well. There was a fluctuation in the fecal egg count from day to day in untreated animals. In anthelmintic investigations where efficiency is based on egg counts, it is necessary to make such counts daily over a prolonged period.

POULTRY

Fowl leukosis.—The Iowa station concluded that the term fowl leukosis should be used to include the group of transmissible leukemic, aleukemic, and leukemiclike diseases of fowls. The disease in all expressions may be transmitted to healthy chicks by injection of tissue suspensions of affected organs, by injection of cell-free filtrates, by pen-contact exposure, or by contact with contaminated soil or litter. Evidence indicates that fowl leukosis is an infectious disease caused by a filtrable virus. There seems to be a definite inherent difference of susceptibility and resistance in different birds and in birds of different strains. The most important methods of control are careful culling, sanitation, and the use of breeding stock from resistant sources.

Observations by the Louisiana station of 227 chicks hatched and grown in isolation from the parent stock revealed approximately 20-percent incidence of iritis, strongly suggesting transmission of the disease through the egg. High incidence of fowl paralysis in the control group of birds indicated that the disease was spread by contact. The incidence of iritis in the progeny of parents with iritis was found to be greater than in those from parents with normal eyes. Slight cases of iritis did not greatly decrease the mean body

weight of individuals so affected. Coccidiosis and parasitic infection apparently played no part in the incidence of iritis.

The Iowa station has shown that fowl leukosis in all its forms may be transmitted to healthy chicks by injections of cell-free filtrates. Such an injection from one type apparently produces all of the various types considered as expressions of this disease. The behavior of the causative agent of fowl leukosis, when subjected to electrophoresis, was so like that of a virus that there seemed little doubt that the disease was due to a filtrable virus.

Results of an experiment at the California station failed to show that intravenous inoculation of young chickens with lymphomatous nerve tissue or the repeated oral administration of cultures of *Salmonella aertrycke*, either alone or in combination, caused the development of lymphomatosis or produced changes in the blood picture of the chickens. Several types of abnormalities of blood pictures were found in chickens with lymphomatosis. These, however, did not conform to any particular trend as to their nature nor with respect to the type of lymphomatosis with which the chickens were affected. Their appearance was nearly coincident with the development of paralytic symptoms in the case of neurolymphomatosis and shortly before death in the case of visceral lymphomatosis. They were regarded as a doubtful or valueless diagnostic aid. At the same station the addition of 0.25 part of wheat-germ oil in the mash had no appreciable effect on the incidence, type, or age of onset of lymphomatosis in chicks.

Ruptured ova.—The West Virginia station has shown that the ether-extract content was the most satisfactory method of making a differential diagnosis between exudate resulting from chronic peritonitis and ruptured ova in the body cavity. The ether extracts of inflammatory products are low compared with yolk, which normally contains 66 percent.

Parasites of poultry.—Small doses of phenothiazine were found by the Washington station to be 95- to 100-percent effective in killing and expelling *Heterakis gallinae*, a common parasite of chickens that serves as a vector for *Histomonas meleagridis*, the causative organism of blackhead. Five one-hundredths to five-tenths of a gram of phenothiazine per bird removed the cecal worm most effectively, and massive doses were no more effective than lighter doses. This anthelmintic did not disturb the digestion of the birds, had no effect on the flavor of the meat, and did not appreciably reduce egg production. The cost of treatment was estimated to be but a fraction of a cent per bird.

Studies on the large roundworm (*Ascaridia galli*) showed that the parasite may be very detrimental to young chicks but that those 3 to 4 months of age develop a marked natural resistance to its growth unless their diet lacks vitamin A or the vitamin B complex. The resistance of the birds was more potent when they were fed a cereal basal diet supplemented by animal tissue and milk. Older birds had markedly more duodenal goblet cells than did younger birds, and the mucin secreted by these goblet cells contained a substance that was inimical to the worms.

Fowl pox.—Fowl pox virus was not affected when exposed at the Illinois station to dosages up to 888 r-units of hard X-rays. The virus was inactivated by ultraviolet light from a mercury vapor lamp in 2 hours at 20 centimeters and alternated by irradiations of 15 to 90

minutes. A concentration of 1–50,000 methylene blue added to the virus suspension reduced the irradiation time necessary for inactivation to 5 minutes, while a 2.5-minute irradiation markedly attenuated the virus.

The Hawaii station has obtained promising results in preventing fowl pox by vaccination of chicks at hatching time. Vaccination in the web of the wing with a needle was more satisfactory than on the leg by the "follicle" method.

Infectious bronchitis in chickens.—The Rhode Island station found that the mortality from infectious bronchitis in semimature and adult birds was negligible, but the loss of egg production was of economic importance. The disease was readily transmissible by inoculation of the larynx, trachea, air sacs, air spaces of bones, and peritoneum with the virus. Recovery from the disease resulted in the development of a complete immunity. Attempts to immunize birds by inoculation of the mucous membrane of the cloaca and the bursa of Fabricius showed "takes", but immunity did not develop sufficiently soon to prevent infection of the respiratory tract. Birds which had recovered from the disease except for a mild nasal discharge were carriers of the infection.

Blackhead of turkeys.—Experimental blackhead disease of turkeys resulted at the Virginia station in a marked disturbance in the blood picture which is characterized by: (1) A marked heterophilia of from 8 to 21 percent within 24 hours of receiving the infective material; (2) a persistence of the heterophilia until death; (3) an irregular monocytosis in some cases, especially in those receiving subcutaneous implantations of infective material; and (4) myelocytosis and anemia usually preceding the fatal termination. Natural cases of the disease were found to have leucocyte disturbances very similar to those present in the experimentally infected birds.

Fowl typhoid in poults.—The Virginia station found *Shigella gallinarum* in the ovaries of adult turkeys from a flock that produced affected poults, and regarded this finding as presumptive evidence that the poults came from infected eggs. The outbreak of fowl typhoid in the adult birds was of a chronic nature, and the organism involved seemed to be of very low virulence. In the poults the course was acute and had all the characteristics of an acute septicemia. Testing at frequent intervals with pullorum antigen gave results that made it seem doubtful whether all infection could be eliminated by this method.

Enteritis of poults.—An investigation was made by the California station of the relationship of a flagellate of the genus *Hexamita* to a catarrhal enteritis of turkey poults. This enteritis is principally confined to the duodenum and upper jejunum and is characterized by marked lack of tone, watery contents, distended bulbous areas, and a heavy infection by *Hexamita*. No other protozoa are present at the principal site of the pathology and they can be experimentally produced only when *Hexamita* is present in the inoculum. The station recommends the following means of prevention: (1) Selling all breeding birds at least 2 weeks before any poults are hatched; (2) complete isolation of the breeding unit from the brooding quarters; (3) separate attendants for the breeding flock and young poults; (4) use of cement yards and wire pens; and (5) arrangement of feeding and watering equipment so that the attendant does not need to enter the pens.

Parasites of turkeys.—The Florida station found that the characteristic symptoms of turkeys infested with *Capillaria contorta* were indisposition, weakness, droopiness, emaciation, frequent swallowing, and a penguinlike position of the body. Macroscopic lesions consisted of catarrhal and hemorrhagic inflammation, thickening, necrosis, and sloughing of the mucosa of the esophagus and crop. Microscopic lesions consisted of areas of hyperplasia, hypertrophy, necrosis, and hemorrhage in the layers of epithelium. This parasite did not penetrate deeper than the basement membrane. A satisfactory treatment consisted of feeding the flocks 5 percent of sulfur in the regular mash for a period of 3 weeks.

GENERAL

Salmon poisoning in dogs.—The Oregon station produced immunity to salmon poisoning in dogs by feeding parasitized salmon and treating with sulfanilamide when symptoms appeared. In the experimental treatment of this condition a drop in temperature and return of the appetite followed within 24 to 48 hours after the first administration of sulfanilamide.

Nonparasitic skin diseases.—The use of sulfoleum, a mixture of a light petroleum-oil fraction wtih a vegetable-oil admixture and a pentasulfide was found of value by the Florida station in the treatment of canker of the ears of mules, rabbits, and dogs.

New prophylaxis.—The California station found that a mixture composed of 25 percent acid-free dehydrated Stockholm pine-tar oil with a specific gravity of 1.075, 12.5 percent amorphous paraffin wax with a U. S. P. melting point of 160°–170° F., and 62.5 percent viscous oil with the following specifications: Flash point Cleveland 540° maximum, viscosity at 100° Saybolt universal 144,200, viscosity at 210° Saybolt universal 2,900–3,200, pour point +50° maximum, color A. S. T. M. 2.0 maximum, carbon Conradson 0.5 percent maximum, sulfur bomb 0.5 percent maximum, and Sligh test 1.0 maximum, applied to wounds over an oakum substratum when a sinus is present, and where a sinus is not present after the wound has been dried by the application of motor ether or tannic acid, afforded efficient protection against myiasis and also stimulated tissue repair in the wounds,

Phenol-contaminated water.—Extensive tests by the Oklahoma station of waters contaminated by phenolic wastes from refineries, factories, and mines led to the conclusion that phenol even in appreciable concentrations apparently was not toxic to animals. A large amount of phenol was rapidly conjugated and eliminated in the urine as fast as absorbed, and considerable seemed to be metabolized or lost. The presence of concentrations less than 1 percent seems not to interfere with normal digestion, absorption, or other metabolic functions.

Poisonous plants.—Feeding tests conducted by the Texas station in connection with investigations of outbreaks of stiffness among range sheep in west Texas showed conclusively that the common sneezeweed (*Helenium microcephalum*) is rapidly fatal to both sheep and cattle. The severity of symptoms and sickness induced seemed to depend on the amount of sneezeweed eaten. Doses of from ¼ to ½ pound of the mature plant caused sickness and death within 1 or 2 hours in from 75- to 100-pound sheep, while smaller amounts in-

duced a severe, protracted illness that was not always fatal. Tests with smaller doses demonstrated that the poisoning was cumulative, the animal showing symptoms several days or weeks after the test was started.

Sodium chlorate poisoning.—The Washington station found the lethal oral dose of sodium chlorate for young chickens to be slightly greater than 5 milligrams per gram of body weight and for sheep between 2.06 and 2.5 milligrams. Marked darkening of the blood, muscles, and viscera caused by the presence of methemoglobin, together with deep, black erosions in the lining of the abomasum and upper part of the duodenum were the characteristic pathological changes found in acute fatal cases. Neither the administration of reducing agents nor the alkalization of the digestive tract with copious amounts of sodium carbonate solution, 2 hours after the sodium chlorate, prolonged the life of sheep fed sodium chlorate, and no successful antidote for sodium chlorate poisoning in sheep has been found. Bindweed sprayed with 5 pounds of sodium chlorate per square rod did not prove toxic to a sheep fed no other food over a period of 11 days.

AGRICULTURAL ENGINEERING

CONTENTS

Research on agricultural engineering has been carried on by the experiment stations for more than a generation, and has become an essential technique in the development of the modern concept of farming as a method of living as well as an industry. The following discussion presents examples of how the stations are depending more and more upon contribution in this field in their efforts to build up a permanently sound agriculture.

MACHINERY AND POWER

The development and adaptation of mechanical farm equipment, especially that which can be used with profit on family-size farming units, and greater efficiency in the use of farm power are objectives of many of the efforts of the stations to bring about the best use of farm land.

Better use of tractors and power equipment.—During 1939, according to a preliminary report of the Bureau of the Census, the value of tractors sold by manufacturers for use in the United States was $158,367,475. This represents an increase of about 4.6 percent in this value over the previous year. The same report indicates that the total production of farm tractors of all types for 1939 was 215,409, which was also a substantial increase over 1938, reflected in both wheel and track types, although there was a small decrease in the number of garden or motor-cultivator types under the previous year. This would indicate that the popularity of the all-purpose types of

tractors continued to increase, particularly those equipped with rubber tires.

The stations continued efforts to increase the efficiency of tractor operations and of the power equipment used with tractors. In connection with general efforts to reduce costs of producing crops, studies of the cost of tractor power on Nebraska farms by the Nebraska station showed that large economies in tractor-power use are possible. A method of hitching two horse-drawn grain binders behind the farm tractor has been worked out by the South Dakota station with the idea of using machines already owned by farmers when a tractor is purchased. It was found possible to redevelop old horse-drawn grain binders into windrowers for small grain, and a satisfactory four-row corn cultivator and hitch was developed for the tractor from old two-row horse-drawn cultivators. In view of the difficulty encountered in the cultivation of listed corn with single pneumatic tires on tractor drive wheels, the Nebraska station has cooperated with manufacturers of pneumatic tractor tires in the development of dual tractor tires for this purpose. It has been found that dual tires of any size spaced 3.5 to 4.5 inches apart on the tractor-wheel rim ride lister ridges satisfactorily, obviating the necessity of throttling the tractor down. Dual tires also slip less in wet stubble and give better traction, but do increase the cost of tractor operation through higher fuel consumption. They permit carrying more weight than single tires, and the traction increases in proportion to added weight until limited by engine horsepower. However, the Michigan station found traction to be greater for the single than for the dual pneumatic tires for the same slippage in the range of soil conditions represented by sand, disked ground, freshly plowed ground, plowed and rolled muck, sod, and muck stubble. Inflation pressure is one of the most important factors affecting rolling resistance of pneumatic implement tires, according to the Iowa station. Reducing the inflation pressure increases the work of flexing the tire but decreases the energy expended in displacing the soil. On a smooth, hard surface where there is no soil displacement, reducing the inflation pressure, therefore, increases the rolling resistance. On intermediate surfaces, such as bluegrass sod, changing the inflation pressure has relatively little effect, whereas on loose sand reducing the pressure greatly decreases the rolling resistance. Thus, if a tractor or other machine is to be operated intensively on soft, loose surfaces, the resulting power economy may justify the use of larger capacity tires which permit lower inflation pressures. The advantages of rubber tires over steel wheels for farm machines other than tractors were also pointed out by the Iowa station in experiments in which at 2.5 miles per hour a steel-wheeled manure spreader received approximately six times as many shocks in passing over 5 miles of graveled road as did a rubber-tired machine of the same model. The shocks ranged from 1,050 to 3,425 pounds force for each machine. In connection with the development of home-made rubber-tired carts and trailers from used car wheels, axles, frames, and tires and tubes, the South Dakota station ascertained that the pneumatic tires on such equipment roll more easily than steel wheels on all but very smooth, hard surfaces, and that large-diameter wheels are superior in this respect to smaller-diameter wheels for both steel wheels and pneumatic-tired wheels. Tires with larger cross

sections have proven more adaptable to farm-cart use than those with small cross sections.

More efficient tillage methods and equipment.—Since the power load for tillage continues to be the largest for any of the power-consuming farm operations, special efforts by the stations were directed toward the further development of tillage methods and equipment to reduce the power-requirement factor to a minimum commensurate with good crop production. For example, in tests of different plow shapes and materials under adverse plowing conditions it was found that changes in shape alone do not eliminate scouring difficulties in clay soils but must be supplemented by suitable changes in the plow materials, according to the Alabama station. Owing to economy requirements of practical manufacturing it has been found that the substitution of a sufficiently strong material possessing low surface-wetting properties and which can be manufactured at a reasonably low cost is the only logical solution to the problem. In this connection certain commercial resinous plastics were found to show promise. Plowing tests showed that plow bottoms made of wood slats, impregnated with paraffin or linseed oil, produced considerably better scouring than did steel-slat bottoms, especially in the higher soil-moisture ranges. The advantage of using left-handed disk jointers in plowing where insufficient resistance is developed to landside pressure and where furrow width is nonuniform because of increased soil resistance, has been demonstrated by the Iowa station and the Department (B.A.C. and E.). Trials with left-handed disk jointers over a two-bottom, 16-inch plow showed that landside pressure was reduced and the width and depth of furrow were more uniform.

During the past year the use of plows in the one- and two-bottom sizes mounted on tractors has become quite popular among power farmers. According to the Pennsylvania station mounted plows have some advantages over the conventional separate plows, including greater flexibility in close quarters, convenience of control, and usually, first cost. Studies by the station on this equipment showed that horizontal hitching is less favorable for a mounted plow than for a separate plow when the tractor is much wider than the plow, particularly for one-bottom plow models. When all of the plow weight and the downward soil force is carried the tractor traction is assisted. However, much of this benefit is lost when the soil force on the plow is upward. It was found also that when soil penetration is difficult and rolling coulters are used, any light mounted plow is at a disadvantage. This can be corrected by removing the rolling coulters or by adding weight to the plow. A variable-width plow provides a means of adjusting the width of furrow to the resistance of the soil, according to the Iowa station. Experiments made in cooperation with the Department (B.A.C. and E.) resulted in the development of a 16-inch plow bottom to which has been added a left-hand, 7-inch bottom so mounted that the shins of the two bottoms coincide and the 7-inch bottom cuts 1.5 inches shallower than the 16-inch bottom. The furrow slice of the small bottom is thrown onto the unplowed land, the effect being to fold a 23-inch furrow slice into a 16-inch width which is turned by the 16-inch bottom on the next trip through. Landside pressure is reduced by this attachment, but it shows no consistent advantage

in draft. The station feels that this equipment is especially advantageous for mounted plows on small tractors.

Better mechanical planting and fertilization of field crops.—Cost of seed and fertilizer, labor cost of seed and fertilizer placement, and proper placement of seed and fertilizer are primary considerations in continued investigations by the stations aimed at the development of more efficient methods and equipment for these farm operations. The best experimental alfalfa-timothy seedings in 1939 by the Wisconsin station were obtained with a seeder mounted on an experimental cultipacker or corrugated roller having narrow disks and shallow corrugations to insure fairly shallow planting. This was the second year in succession that cultipacker seeding showed up favorably in comparison with other methods. The experiments indicated that all known mechanical seeding methods waste considerable seed, and efforts were continued to bring this waste to a minimum consistent with establishment of good seedings. The results indicate a potential saving in seed of 20 to 30 percent by improved seeding technique. A machine was developed by the New York Cornell station for seeding peas and beans in a grain drill in which single-disk furrow openers permit the placing of fertilizer in a band at the side of the seed dropped, after the fertilizer is placed, through hoe openers so spaced that trash does not collect between them. The advantages of this design of drill have been established and demonstrated to the extent that commercial machines of this type are soon to be available on the general market.

The growing popularity of sorghums as drought-resisting grain crops has prompted the stations in the Great Plains region to study methods for their most efficient production by mechanical means. For example, the adjustment of corn planters and listers for the planting of sorghums has been successfully accomplished by the Nebraska station. The broadly cooperative studies by some 15 of the State stations and the Department (B.A.C. and E.) on the mechanical placement of fertilizers for some 12 or 15 crops were continued. These studies, which have been under way for several years, are now pointing to the best manner of placement of fertilizers for some of the more important row crops such as corn, cotton, potatoes, and several truck and vegetable crops, and are resulting in the development of the principles of mechanical equipment to accomplish this objective. The rapidity with which hybrid seed corn has become established has made it desirable to assist manufacturers of grading equipment to adapt their units for use with seed corn in the shortest possible time. Many improvements in existing machines and a number of new machines have been secured through experiments of the Illinois station in which particular attention has been given to the development of small units for economical use by small farmers.

Mechanical harvesting.—During 1939 farmers purchased over $38,000,000 worth of harvesting machinery of various kinds, according to preliminary reports from the Bureau of the Census and the Bureau of Foreign and Domestic Commerce. New problems in the harvesting of various crops continued to confront the stations, not only in connection with the economical adaptation of available machinery but in the necessity to develop new harvesting principles to meet special problems and conditions. There was a

marked increase in the use of small combines on small farms. According to the Missouri station the necessary investment in these smaller machines is much less than in former years, thus making available to smaller farms the advantage of lower harvesting costs. A survey by the station including some 182 machines indicated that they are being used successfully to harvest most small-grain and seed crops grown in the State, and that for areas of more than 60 to 80 acres per year the small combine offers the most economical harvesting and threshing method. Performance costs for fifty-three 5-foot combines averaged $1.24 per acre when harvesting an average of 238 acres per year. Increases in the acreage of forage crops such as lespedeza have confronted the stations with new harvesting problems. The use of lespedeza seed-harvesting attachments to mowers is profitable where seed is not harvested by the direct combine method, according to the Tennessee station. All such harvesters of the pan type were found to be comparatively low in first cost and harvest only fully ripened seed. Unlike threshers and combines, they leave dodder seed unhulled so that it can be more easily cleaned out of lespedeza seed, especially the Korean variety. Seed harvesting attachment units on mowers greatly reduced the considerable windrow losses experienced when threshing or combining lespedeza from the windrow. Cutting short lespedeza or lespedeza on rough land with a mower resulted under ordinary conditions in comparatively low stubble losses even when direct combining was practiced.

Efforts by several of the stations in cotton-producing States to develop efficient mechanical equipment for the harvesting of cotton have been influenced by varietal characteristics of this crop. These were found by the Texas station to include, especially, shape and height of plant; length and number of branches; density of foliage; type, number, and arrangement of bolls; storm resistance; degree of boll spread; fluffiness of the cotton; brittleness of branches and boll peduncles; and height of first branches above ground. The best plant type for both the mechanical stripper and the picker is one having relatively short but numerous fruiting branches with short nodes, no vegetative branches, and open-type growth, light foliage, storm resistance, and a large, strong boll on a single peduncle which will snap easily under tension but will withstand considerable plant agitation. Factors found to influence the efficiency of an extractor were rate of feeding and flow of material through the machine, speed of extractor saws, compactness, uniformity of distribution, agitation, amount of burs, size and shape of boll, degree of boll spread, fluffiness, fiber drag, and length of staple. Trash was more easily removed from coarse-bodied than from fine, silky cotton.

Hay curing both by natural methods in the field, and by artificial methods under conditions where economically appropriate, continued to confront the stations with numerous problems, especially in view of the increasing practice of processing grass at immature stages, either as hay or silage. For example, according to experiments at the Delaware station, frequent clipping of immature grasses increased the acreage yield of protein from 40 to 60 percent over that recovered by the usual haymaking procedure, and artificial dehydration preserved more than five times as much carotene as did field curing. Only insignificant losses of carotene occurred during the artificial dry-

ing and baling of immature grasses. The loss of carotene during storage of this material also was less than that from stored hay. High-protein, low-fiber, high-carotene feed could be produced from grass and clover dried artificially in a two-tray batch drier, heated by an oil burner with inlet temperature at 250° to 300° F. According to the New Jersey station, the principal mechanical difficulties in the manufacture of grass silage have resulted from attempts to use the regular haying equipment to harvest the green grass, which weighs three to four times as much as hay. Existing machinery has been improved and strengthened to meet the new demands so that field break-downs are now the exception rather than the rule. Silo fillers generally have been adapted to handle the green material without difficulty, and pumps have been attached so that the necessary preservative material may be added conveniently.

Tests of conveyor- and drum-type hay driers by the Pennsylvania station showed thermal efficiencies of 63 to 65 percent for the former as against 67 percent for the latter. It appears that the large initial investment in machinery and the necessary haulage of green forage render the cost of artificial drying too high to permit dehydrated hay to compete with sun-cured hay in dairy feeding. However, dehydrated alfalfa, even at a cost much higher than sun-cured alfalfa, is much in demand for poultry feeding. The station has developed an experimental hay crusher that passes cut forage between rollers, thereby cracking the stems lengthwise with minimum injury to the leaves, after which the crushed hay is dropped to the ground for natural drying. Hay so treated dries enough so that it may be stored a day earlier than with usual curing procedure. The principal advantage of crushing is when partial field drying precedes artificial dehydration. Crushing soybean hay reduced the field-drying time from 17 to 5 days and resulted in a better product. Alfalfa hay harvested by the crushing process dried in less than half the time required by uncrushed hay, according to the Illinois station. The station has developed a satisfactory tractor-drawn crusher.

A low-cost system of barn-drying hay has been developed by the Tennessee station in cooperation with the Tennessee Valley Authority which involves the use of wooden ducts constructed on the floor of the hay mow over which partially field-dried hay is stored. This duct system is connected to an electrically driven blower and a solar heat absorber placed on the barn roof. The temperature of atmospheric air drawn under this absorber prior to forcing it through the hay can be increased by 10° to 22° F., with a resultant decrease in relative humidity of about 1.5 percent for each degree rise in temperature. Whereas with favorable weather conditions 31 hours are required to dry alfalfa hay completely in the field, only 4 hours of field drying are needed for drying to a point where it may be stored on the barn drier where drying is completed in from 4 days to 2 weeks. After the first cutting of hay has been dried a second cutting is stored upon the first. The maximum height to which hay may be stored on the barn drier is about 10 feet after settling. The barn-dried hay averages 2.3 percent more leaves, 19 percent more green color, and a higher quality than field-dried hay cut from the same field at the same time.

An air-circulating prune drier has been developed by the Oregon station which has reduced the cost of drying prunes and improved the quality of the dried product. The same station has also developed

a shelled-corn drier, making it possible to dry corn economically and overcoming the limiting factor in field corn production in western Oregon. The use of this drier on Oregon farms may lower the cost of producing livestock through utilization of a larger land acreage for local production of field corn.

Corn dehydration has been studied by the Illinois station, particularly the development of equipment designed to provide an environment as to temperature and humidity which will control such storage insect pests of corn as angoumois grain moth, rice and granary weevil, and lesser grain borer.

Improved sugar-beet machinery.—Efforts to develop efficient machinery for the planting and harvesting of sugar beets have been under way at several of the western experiment stations, usually in cooperation with the Department (B.A.C. and E.). During the year a newly developed beet topper was demonstrated by the Colorado station which gives results comparable to those obtained when topping is done by hand. In trial runs, 98.7 percent of the beets were topped acceptably at a travel speed through the field of about 3 miles per hour. Special plates also were devised by the California station which, when attached to the ordinary sugar-beet seed planters, will convert them into single-seed planters. These plates can now be obtained from commercial companies and allow growers to obtain the advantages of single-seed planting without the expense of buying entirely new machines. Promising progress also was made in the development of a machine to lift topped beets from the soil and free them of clods.

Mechanical spraying and dusting.—Typical of work during the year was the development by the Oklahoma station of a machine for the hot-water treatment of seed wheat and barley for the prevention of loose smut. The machine treats 500 bushels of seed a day, equivalent to 10,000 acres of smut-free wheat. Hot-water treatment of seed has heretofore been difficult under farm conditions, but the new equipment permits rapid treatment and gives semiautomatic control of temperature and automatic control of time, thereby insuring effectiveness. A home-made barrel power sprayer for truck or wagon transport was developed by the Mississippi station at a cost of from $60 to $65. Mechanized dusting equipment for control of the pea weevil was developed by the Idaho station in cooperation with the Department (B.A.C. and E.).

Erosion and run-off control methods and equipment.—The fact that within the last 3.5 years 38 States have adopted soil conservation district laws and that 375 districts have been established under these laws, including in their boundaries over 232,000,000 acres of farm land, has given considerable impetus to investigations by the stations to develop methods and equipment for the conservation of land and water resources for agricultural purposes. Much of this work is cooperative with the Department (S.C.S.) and, in fact, almost the entire research program of the Department in this field is either directly or indirectly cooperative with the experiment stations. Much of this research is organized on the basis of the conservation needs of soils by type areas and climatic conditions as regards Federal-State cooperative relationships. For example, it has been found at the Alabama station that very little increase in vegetation can be expected from contour furrowing on sandy loam and stony sandy loam soils ranging in slope from 4 to 6 percent. Run-off studies on contour furrow plats,

having furrows 6 to 12 feet apart, have shown that the total run-off is very small in comparison with the total rainfall. Soil-moisture determinations have shown that while the moisture content in furrows is slightly higher than on check plats the moisture on the ridge is smaller. The station has incorporated into the technique of measuring run-off velocity material improvements which introduce greater accuracy in the work and save time. The interplanting of *Crotolaria* species with corn reduced soil erosion losses resulting from rainfall of as great intensity as 2.74 inches in 2.5 hours considerably under the losses from soil planted to corn alone on slopes as high as 12.5 percent, according to the Mississippi station.

Progress was reported by the Minnesota station in the development of the essential design factors for the aprons at the foot of dams used in gully control. This work is being carried on in cooperation with the Department (S.C.S.) under controlled laboratory conditions that simulate the action of water from heavy run-off around dam aprons. It has been found, for example, that gully-floor gradients must be reduced to a stable condition, apron gradients should be steeper than those of the gully floor with a 3-foot cut-off wall at the apron toe, and submergence of the apron toe below the gully floor is desirable. A table of suitable lengths of aprons for differing conditions has been released for practical use in field construction.

The broad regional study of soil and water conservation in the limestone valleys and upland regions of Virginia, which is centered at the Virginia station and participated in by the Department (S.C.S.) and the Tennessee Valley Authority, has yielded widely significant information regarding the factors affecting erosion of these residual soils. Progress is being made in the development of run-off and erosion-control measures for pasture watersheds and in row-crop land where contour furrowing can be practiced. Better plant growth with an accompanying increase in organic-matter content and improved soil structure resistant to erosion in the topsoil of permanent bluegrass pasture was secured from annual applications of superphosphate. Lespedeza also manifested a beneficial effect on soil structure, having superior resistance to erosion.

Contour farming lessens power consumption, according to the Iowa station, and this power saving is generally considered to offset any increase in the time required for contouring. Except where terracing is essential to erosion control, contour cropping is preferred to terracing because of the greater cost and the inconvenience of tillage operations on terraced lands. Simple equipment for contour lay-out work has been developed by the station.

The use of rotation tends to increase the ability of soil to take up water, according to the Arkansas station. Within a 3-year rotation clover was the most effective crop in preventing run-off losses and row corn the least effective. Plowing in winter decreased run-off losses, and the plowing under of crop residues further decreased the losses.

USE OF IRRIGATION WATER

The development of methods and equipment for the efficient application of irrigation water to crops is a continuing problem of economic importance in both arid and humid regions, where recurring droughts have indicated that adequate soil moisture is a primary

limiting factor in crop production. For example, low water-application efficiencies and resulting deep-percolation losses on valley highland soils of Utah may not deplete the fertility of these soils, but according to the Utah station they do lower the productivity of low-lying valley bottom soils in the same valleys by contributing to rise of the ground water and alkali concentration. Copious irrigations were found by the Washington station to lower the salt concentrations in well-drained soils. The Utah station has reported progress in determining the proper spacing depth and size of tile drains necessary to prevent waterlogging of irrigated soils. Where large tracts of land are waterlogged because of artesian pressure, as in the Cache Valley, the station has found that in order to be effective tile drains would have to be buried 10 feet deep and spaced not less than 40 feet apart, which is considered to be prohibitively expensive. The use of vertical pump wells for the drainage of such lands is being developed.

Light, frequent irrigations of onions during the growing season make the best bulb growth and result in the most economical use of irrigation water on this crop, according to the New Mexico station. Cotton is one of the most important cash crops of the southern irrigated valleys of New Mexico. With this in mind the station has secured valuable information regarding water requirements of the crop and the effect of different amounts of water on square shedding and yields. Indications are that from 24 to 28 inches of water properly distributed through the seasons will result in as good yields as larger amounts. Frequent applications of water during the blooming period increase the number of blooms and consequently the number of bolls. Indications are that maturity can be delayed by an excessive supply of moisture in the soil late in the growing season.

ELECTRIFICATION

During the year ended June 30, 1940, there was again a steady increase in the number of farms receiving electric service for the first time. According to the Rural Electrification Administration, 1,871,994 farms were receiving central station service on that date. This is 27 percent of all the farms in the United States and represents an increase for the year of 358,766 farms receiving such service. The stations and the Department (B.A.C. and E.) continued investigations to increase the efficient use of electricity in farming operations.

Electricity in poultry production.—Positive control of air circulation is incorporated in a home-made electric brooder for chicks recently developed by the Wisconsin station. When used in conjunction with an auxiliary brooding chamber, previously devised by the station, the new brooder makes it feasible to brood chicks in almost any suitable building, even though it is not a warm one, without undue expense for electricity. An insulated electric brooder was developed by the Nebraska station which is not only inexpensive but very efficient on farms where electric service is available. This brooder can be made on the farm with ordinary tools and fits readily into the common 10- by 12-foot brooder house. Uniform heat distribution throughout the brooding space is provided, and no auxiliary heat is required in the brooder house except in the severest weather.

Soil sterilization by electricity.—Studies by the New York Cornell

station of the thermal death points of more than 120 plant-pathogenic micro-organisms involved in practical soil tests indicated that a final soil temperature of 150° F. provides pasteurization sufficient to kill all important plant pathogens and most weed seeds. A portable, electrically operated inverted steam pan, with which pasteurizing temporatures in bench and ground-bed soil were obtained to a depth of from 7 to 10 inches in 2 hours at an expenditure of approximately 1.5 kilowatt-hours per square foot of soil, gave promising results as a means of treating coldframe, hotbed, cutting bench, seedbed, and slat-house soils while in place. Successful use was made of a new electric dairy-utensil steamer for pasteurization of soil in flats or trays at an expenditure of approximately 1.37 kilowatt-hours per cubic foot of soil treated.

Electric feed grinding.—The efficacy of the small feed grinder powered by electricity for grinding and mixing feeds and for grinding certain grains for cereals and whole flours was demonstrated by the Kansas station. In a State where the farmers spend over $4,000,000 annually for prepared feeds for livestock and poultry it was found that the small burr mill and the small hammer mill when powered by a 1- or 1.5-horsepower motor have sufficient capacity for the average farmer, dairyman, or livestock feeder. Little difference was found between the capacities and costs of grinding by the burr and hammer mills.

Use of electricity in handling milk.—To meet the problem of pasteurizing milk in small quantities on individual farms, the Maryland station has successfully developed a small pasteurizer that will handle 10 gallons of milk with approximately 2.3 kilowatt-hours of power. At prevailing prices for electricity, the cost of operation of this small unit is considerably lower than that of steam or hot-water units. From studies of electric-steam dairy sterilizers the California station has found that in selecting a boiler on the basis of two sterilizing periods per day, consideration of factors such as convenience, electric rates, and initial cost is more important than energy consumption. Where selection is based on one sterilizing period per day the instantaneous type has a definite advantage in energy consumption. It was found that the efficiency of accumulator-type boilers can be increased only by insulation, whereas that of the instantaneous type can be improved by increasing the insulation and by reducing the amount of heat left in the boiler after the sterilizing operations are finished.

Corn borer control by electricity.—Material reduction in corn borer infestations and populations by use of electric light traps has been demonstrated by the Indiana station. It appears that color is a much less important factor in attractiveness of light traps than is light intensity, and that intensity and size of the luminous area are the important factors to consider in selecting the lamps to be used in the traps.

STRUCTURES

Continued efforts by the stations to develop more efficient production structures, as well as better farm homes, have considered the

needs of both the large farming enterprises and the small family-size farming unit.

Better farm homes.—Convenience and comfort in farm homes and economy arising from maximum use of local materials and labor have been primary objectives in efforts of the stations in this important field. With these objectives in mind, the Kentucky station, for example, has developed and published a series of plans for farm dwellings for use in a State where it is estimated that an annual expenditure of approximately $17,000,000 is required to provide adequate housing on farms. The comfort aspect of farm homes has received special attention by the stations, efforts being made to develop construction procedure that will reduce heat losses and moisture penetrations to a minimum. With reference to the latter aspect, heavy, asphalt-saturated felt insulating materials and sisal kraft papers were found by the Iowa station to be of low moisture permeability, and aluminum paint applied in 2 coats to serve as a good vapor seal. Tests on wall sections showed that to prevent moisture accumulation the permeability of the cold side of the wall must be many times that of the warm side. The Arkansas station, in a study of about 200 farm homes, showed that such structures can be improved in quality under Arkansas farm conditions only by the substitution of other values for cash. The average cash expenditure per house in 190 cases was $700 and the principal noncash contributions were home labor valued at $344 and native materials valued at $531 per house. This is in line with efforts by the station to develop maximum use of native building materials.

Rammed-earth construction.—Continued progress in the development of rammed earth as an economical building material for certain farm structures is reflected in the satisfactory use of cement stucco for application to rammed-earth walls by the South Dakota station. It was found that the wall should season for several months before stucco is applied, and bonding wire or mesh should be used on walls more than 8 feet in height. Two inexpensive plasters that proved satisfactory on rammed-earth walls were dagga-cement plaster and dagga-plaster with an admixture of asphalt emulsion. The most valuable and most practical admixture for rammed-earth walls yet found by the station is ordinary sand.

Corn storages.—Investigations by several of the stations and the Department (B.A.C. and E., B.A.E., W.B., B.P.I., and A.A.A.) have resulted in distinct progress in determining the types of cribs and the storage practices most successful in conditioning and maintaining quality of corn stored on the farm. Emphasis is placed, for example, on the importance of maximum ventilation of ear corn at every opportunity when the weather is favorable as an essential to drying. It appears that the width of a corn crib is the most important dimension in promoting ventilation. Corn in a crib 6 feet wide will dry more rapidly than in a crib 8 feet wide, which makes storage of high-moisture corn in a driveway between cribs particularly objectionable from the standpoint of drying. Slatting of crib walls full height above the floor is desirable for promoting rapid ventilation, but snow must be prevented from driving in on top of the

209632—41——13

corn. Exposure of cribs to prevailing dry winds is important. The storage of dry shelled corn differs radically from that of ear corn, and shelled-corn bins must be designed to carry horizontal loads about three times those imposed by ear corn.

Poultry-production buildings.—Inexpensive single-walled laying houses have been found by the Indiana station to be as satisfactory during winter months as more expensive structures involving double walls and special ventilating devices. It appears that much of the expense often believed necessary in laying-house construction can be saved and that egg production can be maintained by other and less expensive means. What is termed an improved "foolproof" poultry house has been developed by the Missouri station. It appears that the square floor plan provides a given floor space at the least cost for materials and with the least exposed wall surface. The Iowa station has demonstrated that a curved or gothic roof with 6-foot clearance at the center makes a desirable shape for a brooder house. A plywood roof covered with dark-colored roll roofing absorbs heat from the sun and glued plywood construction reduces air infiltration to a minimum. Brooder houses of plywood over laminated, bent, glued rafters can be made light in weight and strong and rigid.

The Nebraska Station has developed and is recommending for use an insulated electric brooder which is not only inexpensive but very efficient on farms where electric service is available. Several types of brooders were built, varying in insulation and in other structural features. These were tried out and the results compared under actual brooding conditions. The Wisconsin station has improved an electric brooder previously developed.

A summer home-made egg cooler that uses the evaporation of water to reduce the temperature in summer has been developed by the Oklahoma station.

Silos and other dairy structures.—A concrete silo stave of durable aggregates, testing in transverse strength 140 pounds per inch of width and having a 10-minute absorption not in excess of 2.5 percent and a 48-hour absorption not in excess of 5.5 percent, should give long satisfactory service, according to the Minnesota station. Staves of this high quality are now being sold by many manufacturers. The New Jersey station, in cooperation with the Department (B.A.C. and E.) has found that corn silage of moisture content ranging from 68 to 72 percent exerts lateral pressures of 8 pounds and vertical pressures of 5 pounds per square foot for each foot of depth in silos 14 feet in diameter. In an 18-foot silo, the lateral pressures run as high as 14 pounds and vertical pressures as high as 8 pounds per square foot per foot of depth. Grass silage put up with molasses exerts lateral pressures of 19 pounds or more and vertical pressures of 6 to 9 pounds in an 18-foot silo. The Wisconsin station has developed a satisfactory one-story dairy barn of flat-roof construction which stores hay and forage in the silo. The North Dakota station has found that dairy cows provided with an adequate ration, shelter from storms, and a dry bed, withstood exposure to temperatures averaging 30° F. and produced practically as much milk as in a stable where the temperature averaged 50° F.

HOME RESOURCES FOR DEFENSE

CONTENTS

INTRODUCTION

For several years an attempt has been made in this section of the report on the work of the agricultural experiment stations to cover the current progress in research of special value to the home. With the attention of the country now focused on preparedness and defense, it seems fitting to emphasize the value for defense of the year's research contributions that have a bearing on the various aspects of home life.

Proper nutrition, which is being emphasized on all sides as the first bulwark of defense for the Nation, depends upon many factors, some of which have been the subject of research at the experiment stations from their establishment more than half a century ago. Notable contributions to present knowledge of the vitamins and their functions have come from the stations, largely in connection with research for the improvement of domestic animals. Increased emphasis is now being given in station research to human nutrition in its various aspects.

Food production to meet consumption needs as a defense measure should involve quality as well as quantity. With fruits and vegetables mineral and vitamin values are quality factors of prime importance. Recent experiment station research has shown a wide range in available iron in different types of vegetables and marked varietal differences in the vitamin content of fruits and vegetables. Knowledge of these differences should be of value particularly in home-garden planning.

For large-scale food-production planning as well as for educational programs additional knowledge is needed concerning food requirements of different age groups and food-consumption habits in sections of the country not reached by the extensive consumer-purchase studies of the Departments of Agriculture (Bureau of Home Economics) and Labor (Bureau of Labor Statistics). Information is very meager concerning the actual nutritional status of various population groups. Better methods of determining nutritional status are urgently needed.

The health and welfare of the people depend not only on proper food but also on adequate housing and suitable clothing. To the material aspects included in the familiar trio of food, clothing, and shelter should be added the management of the family's material and spiritual resources, or family economics and family relationships, respectively. Each of these fields of research discussed in the annual reviews takes on special significance in planning for total defense.

NUTRITION

Food supplies the body with energy-yielding materials for its internal and external activities and with material essential for the building and repair of tissues. The metabolism processes involved in the utilization of food components for these purposes, the requirements and utilization of the various factors, and methods of judging nutritional status with respect to many of them continue to receive attention in experiment station research and have acquired new significance in total defense preparations.

METABOLISM

Energy metabolism.—In the processes of metabolism the protein, fat, and carbohydrate may be burned within the tissues, thereby liberating heat to warm the body, or there may be retention or storage of these factors. In a study by the Pennsylvania station the effects of the level of protein intake on the utilization of the food protein and energy of equicaloric diets containing 10, 25, and 45 percent of protein were investigated, using rats as experimental animals. The findings, interpreted to relate to human beings, indicate that it would be ineffective to decrease the proportion of protein to nonprotein in the diet as a means of lowering heat production in excessively warm weather and that the logical procedures would be to avoid unnecessary activity, to decrease the total quantity of food eaten, and to keep the caloric value of the food relatively low by increasing the proportion in the diet of watery foods such as fruits and vegetables.

Studies at the Michigan station with a group of preschool children indicated that with this age group, as well as with older people previously studied, the sugars, starches, and fats of high-calorie diets are used for body energy in preference to protein which is stored. This means for the child growth in muscle rather than in adipose tissue (fat). The study suggests, therefore, that the growing child needs not only an adequate protein intake, but also an ample supply of foods furnishing fat and particularly carbohydrate in order that these latter may meet the energy needs, thus sparing the protein for the building of muscle tissue.

Carbohydrate-metabolism and nutritional-cataract work at the Wisconsin station has confirmed the Massachusetts findings noted in an earlier report that the sugar galactose at high levels in the diet produces nutritional cataract in the rat. In a further study at the Massachusetts station of factors that may hasten or delay the development of this type of cataract, which in many respects resembles the cataracts often developing in old people, no protective action was obtained with massive doses of several of the vitamins. A calcium salt gave some protection when lactose instead of galactose was used to produce the cataract, but this protection was attributed to some interference by the calcium salt with the digestion of the lactose. In view of earlier success in delaying cataract production by increasing the protein of the diet, various protein derivatives were tested with the discovery that one of the amino acid fractions from the break-down of the protein was even more effective than the protein from which it was obtained. Although this investigation has not been completed, the findings to date are of significance in illustrating the interrelationships among food constituents in their metabolism and suggesting

that senile cataract may well be due to some metabolic upset, either through faulty dietary practices or digestive difficulties.

MINERAL REQUIREMENTS AND UTILIZATION

The importance of minerals in man's diet is well recognized and must be kept in mind by those concerned with the nutritional welfare of the people. Housewives planning family meals, and nutritionists school lunches to supplement home diets, economists and nutritionists surveying nutritional lacks or needs of population groups, institutional dietitians, and the military commissary—all should give thought to supplying adequate quantities of minerals, particularly calcium, phosphorus, and iron, in the foods for the day. It thus becomes important to know what are the daily requirements of these minerals, what foods contain them in largest amounts and in most available form, and what factors may interfere with their proper absorption and utilization.

Calcium and phosphorus.—The relative availability of calcium from different sources continued to receive attention in feeding tests on rats and balance tests with human subjects. For rats turnip greens were found by the Georgia station to be nearly as effective as milk, followed by tendergreens, collards, and kale, and last by New Zealand spinach, which was very poorly utilized. The low availability of the calcium in spinach and New Zealand spinach was also demonstrated by work at Oregon State College and at the Illinois station. It was shown that the calcium in these greens was in the form of calcium oxalate, an insoluble compound which, according to the Georgia station, was utilized only about half as completely as other calcium salts, such as the carbonate, citrate, chloride, lactate, phosphate, sulfate, tartrate, and acetate, when fed to experimental animals. The effects of various proportions of soluble oxalate in the diet were also investigated. From the results to date it seems that only part of the harmful effect of New Zealand spinach is due to its oxalate; an attempt is being made to determine the other interfering factor or factors.

At the Illinois station the utilization of calcium from various foods was estimated by determining the calcium content of the carcasses of young rats which had been given different foods in amounts to furnish equal quantities of calcium until they had all made 100-gram gains in weight. Under the conditions of the experiment, the calcium of fresh carrots, lettuce, and green string beans was only 85, 80, and 74 percent as available as the calcium of milk. Liquid skim milk and commercial dried skim milk, fed in quantities to furnish equal amounts of calcium, gave comparable results. It appears, therefore, that the commercial drying of milk does not appreciably impair the value of its calcium in the nutrition of the growing animal.

These findings were corroborated in another study planned to test the utilization of the calcium in carrots and milk by human subjects. Seven adults were first given a constant low-calcium basal diet on which they lost more calcium from their bodies than they ate. When 700 grams (about 25 ounces) of carrots were added as a source of calcium the subjects still lost calcium, it being calculated from the losses that the percentage utilization of this form of calcium by the different subjects varied from 0 to 34 percent, with an average of 15 percent. Since the amount of carrots fed in this experiment was very

large, it is obvious that the usual-sized serving would contribute but very little to man's requirement for calcium. With milk the utilization values ranged from 20 to 34 percent, thus indicating better utilization of milk than of carrot calcium. Although further observations are considered necessary, it was tentatively concluded by the Illinois investigators that the adult's need for calcium is determined by his weight. The tallest, broadest, and heaviest (165 pounds) person in the experiment needed approximately 0.9 gram of calcium for equilibrium, whereas the smallest subject, weighing approximately 120 pounds, would have been in equilibrium on an intake of approximately 0.5 gram daily.

The availability of phosphorus in cereals has been studied from time to time with rather conflicting findings. Recent evidence obtained by workers at the Wisconsin station is of significance, therefore, for the support it lends to the view that the phosphorus in grain is usually available to animals. About 70 percent of the phosphorus in cereal grains is in the form of phytic acid. On rations with optimum calcium content the phytic acid (or calcium phytate) phosphorus was almost as available as that of inorganic phosphates. In the presence of an excess of calcium the availability of phytic acid was much reduced; the reduction was slight, however, with diets low in calcium. Although these results were obtained with rats, the findings may have significance in the case of human diets which, for economic or other reasons, of necessity contain relatively large amounts of cereals. Such diets would conceivably furnish adequate amounts of phosphorus but would necessitate consideration of the calcium supply.

The possible relationship of kidney-stone formation to faulty balance of calcium and phosphorus in the diet is indicated in observations made by Wisconsin workers in experiments with white rats on a low-phosphorus diet. They found that kidney stones consistently developed in animals fed rations extremely low in phosphorus, and that the stones were composed of calcium citrate. Whether the stones are formed simply because there is an excess of calcium, or whether a low-phosphorus diet also causes excessive amounts of citric acid to be produced, is not yet known.

It is well known that normal bone development requires the presence of vitamin D in addition to calcium and phosphorus (and other elements), and that without this vitamin rickets may develop in children. Studies on the microscopic changes occurring in bone growth in vitamin D-deficient animals were conducted by the West Virginia station in cooperation with the medical school of the university. These studies have yielded important information regarding the changes taking place in the cartilage and bone tissues during the healing of rickets. A correct understanding of the nature of these changes has been of much practical value in the interpretation of X-ray studies in clinical work on human rickets.

Iron.—This mineral element is used by the body for the formation of hemoglobin, the iron-containing pigment in the red blood cells. The results of a long-time study by the Mississippi station of the effectiveness of some common southern foods as sources of iron for the regeneration of hemoglobin in rats made anemic on a milk diet have been brought together in a station technical bulletin. When fed at the same level of iron content, legumes (cowpeas, soybeans, lima beans, and pinto beans) were much more effective than leafy vege-

tables (turnip greens, mustard, collards, lettuce, spinach, and tendergreen) in raising the hemoglobin level of anemic rats. That this superiority of the legumes was due to greater availability of the iron rather than to differences in the amount of copper present (for a certain amount of copper is necessary as well as iron for hemoglobin regeneration) was proved in another series in which adequate amounts of copper were fed along with the different vegetables. Sorghum and sugarcane sirups and blackstrap molasses were also used in a similar manner and found to be very effective. As final tests of the availability of iron in the different foods examined, both biological and chemical methods were used. In the feeding experiments sufficient copper was always given, and the foods were compared in effectiveness with a pure iron salt. In the chemical tests both total and available iron were determined. The combined tests showed that from 90 to 93 percent of the iron in legumes, from 84 to 85 percent in sugarcane sirups and blackstrap molasses, and from 60 to 65 percent in leafy vegetables are available for hemoglobin building and the prevention of nutritional anemia.

Workers at the Arizona station found that low-iron diets continued from generation to generation did not produce any decided decrease in the hemoglobin iron of mother or young, but that the total body stores of iron did suffer progressive decrease. In studying the effect of iron-containing supplements on anemic rats, it was considered more reliable, therefore, to pay attention to the total iron content of the animal (milligrams of iron per gram of rat) rather than to the hemoglobin iron alone. Using this procedure, it was determined that the iron of whole-grain cereals was 100-percent available to the rat. It was also observed that there is a sex variation in the utilization of iron by anemic rats, the female showing greater hemoglobin gains and iron retentions than the male.

The human nutritional-anemia studies of the Florida station noted in the 1939 report continue to attract much comment for the demonstration they afford of the relationship between the iron content of the diet, particularly with reference to home-grown foods on soils of widely varying iron content, and the hemoglobin levels of people subsisting on these foods. Hemoglobin values obtained for an additional number of children and women, and also from 55 college students from different parts of the State, varied widely according to locality. Analyses for iron of food samples obtained as duplicates of all food eaten in 6 consecutive meals by selected children in 80 farm families showed that the diets were furnishing the children iron in amounts ranging from 1.2 to 8.6 milligrams per day.

In studies at the West Virginia station on the nutritional status of students native to West Virginia, one-half of the girls tested showed low initial hemoglobin values which improved with the more adequate diet obtained after entering the university.

At the Nebraska station the intake and output of iron were determined for four college women, who were maintained for long periods on a diet supplying only from 3.5 to 4.0 milligrams of iron daily. The "balance" picture showed that these amounts of iron were not quite sufficient to meet the needs of the women. In particular, the iron level of the blood serum fell markedly, thus indicating a depletion of bodily stores of iron. When meat was substituted for milk in the basal diet in amounts to increase the daily iron intake

to 7 milligrams, the serum iron levels returned to high normal values. The results indicate a probable minimum daily requirement for these subjects of somewhere between 4 and 7 milligrams of iron. The findings suggest further that the trend of serum iron level may furnish a convenient means of studying the iron requirement of humans and of comparing the efficacy of different foods in maintaining normal serum levels.

Fluorine.—This element assumed importance in human-nutrition studies when proof was established a few years ago by investigators at the Arizona station that mottled enamel, a disease of human teeth, is caused by small amounts of fluorine in the drinking water. More recently the Arizona investigators developed a bone filter that can be economically employed on either a family scale or for larger operations and that is capable of reducing high-fluorine waters to a fluorine content of less than 0.8 part per million (below the toxic limit) simply by filtration through the prepared bone. The discovery was also made that cows drinking water with as much as 11 parts per million of fluorine excrete this in the urine. The milk is practically free from fluorine, and there is thus no possibility of children developing mottled enamel from drinking milk from cows which have only high-fluorine waters to drink.

The Arizona station has also recently reported the results of a dental survey of the mottled teeth of the inhabitants of a region where the water supply contains from 1.6 to 4.0 parts per million of fluorine and where mottled enamel is endemic. A third of the children in the age group from 12 to 14 showed mottled teeth that were decayed. Beyond this age the occurrence of cavities in mottled teeth increased greatly, and 85 to 100 percent of the people of all age groups of 18 years and above showed decay in these teeth. Cavities in mottled teeth cannot be successfully repaired in many cases, so that a large percentage (70 to 100 percent) of people in the age groups at 24 to 26 years and beyond had had extractions because of failure of fillings to anchor. In these groups fully 50 percent of the people had had all teeth extracted and replaced by false teeth. These findings offer ample evidence that mottled teeth, though they may be somewhat more resistant to the onset of decay, are structurally weak, so that when decay does set in the result is often disastrous.

VITAMIN FUNCTIONS AND METABOLISM

Continued research on the differentiation of the various components of the vitamin B complex and on methods of determining nutritional status of individuals with respect to vitamins A, B, and C has extended information of value in diet planning and in the selection of subjects in need of special attention.

Vitamin A.—Night-blindness or dark-adaptation tests continue to receive attention in a number of the stations, with efforts in some cases to improve apparatus and techniques.

A further comparison at the Georgia station of the biophotometer and differential leucocyte count test for vitamin A deficiency, using about 400 children, Negroes and whites, and with and without cod-liver oil supplements, gave rather conflicting results, leading the investigators to conclude that "this test of dark adaptation (bio-

photometer) as a measure of vitamin A deficiency may be qualitative but assuredly is not quantitative."

The Feldman adaptometer was used at the Massachusetts station to test the dark adaptation of 248 subjects from 5 to 65 years of age. Among 163 college students 3 percent and among 75 adults 18 percent gave readings indicating poor adaptation. Seventeen subjects showing prolonged dark-adaptation time were given 3 halibut-liver oil capsules daily for 15 days, at the end of which time 5 failed to improve in their night-blindness tests, 6 showed less than 1 minute improvement (normal values 1 to 5 minutes), and 6 improved from 1 to 3 minutes.

A new dark-adaptation instrument, the rhodometer, developed at the Rhode Island station, was subjected by the station to further tests in which it was established that the time for completing the test could be cut down from 30 to 35 minutes to 12 to 15 minutes, thus making the test more practical for the routine examination of large numbers. A tentative normal range was set up as the result of testing a considerable number of healthy, presumably normal, subjects. Repeated tests on the same subjects showed apparent day-to-day fluctuations. In one subject tested at regular intervals for over 3 months, a tendency to a lessened dark adaptation during premenstrual and menstrual periods was observed. One definite case of night blindness was found and cured by vitamin A therapy, with the dark-adaptation values improving to well within the normal range. Large amounts of vitamin A increased the dark adaptation of different subjects only to a maximum characteristic of each individual. For some this maximum was higher in the normal range than for others.

Among a group of 28 home economics students given biophotometer tests at the West Virginia station 17 showed normal reserves, 5 borderline, and 6 sufficiently low reserves to indicate night blindness and a possible hazard in night driving. One of these 6 brought her reading up to normal simply by changing her boarding house to one where more green and yellow vegetables and more milk were served, 2 improved their readings by increasing their milk consumption to 1 quart daily, and the other 3 showed rapid improvement following 6 weeks' use of cod-liver oil or halibut-liver oil. Of a group of 14 students in the physical education department, 64 percent gave borderline or low readings as compared with 39 percent in the home economics group which had had more nutrition teaching.

It is well-known that under certain conditions vitamin deficiencies may develop on what would presumably be adequate provision for the vitamin in the diet. Mineral oils are used in large quantities in America as a laxative, but using white rats and dogs as laboratory subjects, it was found by the Arizona station that vitamin A reserves in the livers, if present at all, were much lower in oil-fed animals than in litter mates given no mineral oil. Females showed a shortened period of fertility and produced only one-third as many litters as non-oil-fed litter-mate sisters, and were less successful in raising their young. Mineral-oil ingestion also interfered definitely with the utilization of vitamin D to such an extent that three times as much cod-liver oil was necessary to induce healing of rachitic lesions when the basal ration contained 5 percent of mineral oil. These findings lead to the conclusion that mineral-oil ingestion by humans in ordinary

therapeutic doses probably seriously interferes with the utilization of vitamins A and D.

The B vitamins.—Special attention has been given during the past year to vitamin B_1 requirements, the method by which nicotinic acid exerts a protective and curative effect for human pellagra, and the antigraying factor and its possible relation to one of the vitamin B concentrates known as the filtrate factor. The practical application of the findings of this fundamental type of research is illustrated by the success which has followed the use of pure nicotinic acid in the treatment of pellagra, riboflavin in the treatment of sores about the mouth formerly thought to be one of the symptoms of pellagra, and vitamin B_6 in the treatment of certain skin conditions.

Further work at the Wisconsin station has confirmed the earlier conclusions of workers at this and the Alabama station that the requirement for vitamin B_1 is directly related to the carbohydrate content of the diet, for it has been shown with dogs as well as with rats and chicks that when some of the carbohydrate (starch and sugar) in the diet is replaced by fat the vitamin B_1 requirement is reduced. From this it may be inferred that any increase in the carbohydrate portion of the diet results in increased vitamin B_1 requirement. Old people are inclined to eat more carbohydrate and less protein and fat than when younger, and presumably have a higher vitamin B_1 requirement. To test this hypothesis the Massachusetts station is studying the vitamin B_1 metabolism of a group of elderly people.

In an extension of a long-time investigation by the Arkansas station of the vitamin B requirement for fertility and lactation, all of the B complex factors now available in pure form or in very active concentrates were studied separately. In general, the requirements of the different B vitamins were greater for rearing the young than for growth and pure thiamin (B_1), riboflavin, and nicotinic acid were incompletely transferred to the milk, but in the case of vitamin B_1 a small dose of manganous chloride overcame this difficulty. The practical application of these findings is the need of supplying additional B vitamins in the diet of women during pregnancy and lactation.

Considerable interest has been shown in the antigraying factor, the existence of which was first demonstrated by investigators of the California station working with rats. The work has been extended to guinea pigs, dogs, and silver foxes, with equally striking results in the production of graying of the hair or fur on diets containing all of the B vitamins except for the filtrate factor. The authors note again that the graying of the hair or fur is accompanied by other changes typical of old age, and suggest that perhaps the aging process results from an increasing need for this sparsely distributed factor. Attempts to isolate the factor are being made in a number of station laboratories in order to determine its chemical nature and test its effectiveness in treating humans. Other investigators at the California station have shown that the filtrate factor from various rich sources of the B vitamins, after removal of the known factors, is made up of at least two factors, one essential for growth and the other the antigraying factor. Cane molasses, a water extract of rice bran, and a liver preparation appear to be good sources of both factors; brewers' yeast, a rich source of the growth factor but low in the antigraying factor; and whole-milk powder low in both factors.

If the antigraying factor should prove essential for slowing up aging processes in man, vitamin B concentrates from rice bran would appear to be preferable to yeast preparations for older people.

Vitamin C (ascorbic acid).—Studies on the relative effectiveness of pure ascorbic acid and different natural sources of the vitamin and of the vitamin C requirements for complete saturation of the tissues, noted in the 1939 report, have been continued. In work at the Washington station the vitamin C in frozen red raspberries was utilized as well as the same quantity of pure ascorbic acid by five of the seven women tested and better than pure ascorbic acid by the other two, as judged by blood values. When the same quantity of ascorbic acid was taken in the form of either the pure vitamin, orange juice, or strawberries, the vitamin C content of the blood rose to the same level, but with the strawberries this was not reached until half an hour later than with ascorbic acid or orange juice, indicating a somewhat slower absorption. At the same station and the four other stations in the Northwest participating in the cooperative project on the ascorbic acid metabolism of college students, it has been concluded that determinations of the ascorbic acid content of the blood under certain conditions give a reliable indication of the relative amounts of vitamin C in the diet, and are probably a more accurate measure of dietary habits in regard to this vitamin than would be calculations from food-composition tables of the content of the vitamin in the foods eaten. That this is true can readily be seen from the wide range in vitamin C content of different varieties of some of the more important natural sources of the vitamin.

Potatoes, although relatively low in vitamin C, have long been considered a practical source of this vitamin because of the quantities eaten, particularly in low-cost diets. Investigators at the Maine station have shown, with college students as subjects, that the vitamin C in potatoes is well utilized, and that in the season of the year (November) when the tests were made "three medium-sized baked potatoes of the Green Mountain variety can supply two-thirds of the optimum daily requirement for vitamin C of a normal adult." The "optimum daily requirement" is used in the sense of requirement for complete saturation as noted in work reported earlier from the New York (Cornell) station.

Further study by the New York (Cornell) station of the vitamin C requirements for saturation have confirmed the earlier findings that the requirements may range from 75 to considerably over 100 milligrams a day for adults. In three adult subjects tested in a similar manner at the Washington station, saturation values of 60, 70, and more than 70 milligrams a day were obtained, representing 1.6, 1.7, and more than 1.6 milligrams per kilogram of body weight. The New York (Cornell) workers have tested a few preschool children in the same way, with results indicating that for children of this age from 30 to 35 milligrams of ascorbic acid daily is required for saturation—about one-third of the requirement for adults.

FOODS

MINERAL CONTENT

Since the body's needs for mineral elements should be met by the foods consumed it is important to know which foods are good sources

of the nutritionally important minerals. Such information assumes particular importance at times when the most must be made of local food resources and of foods which may be preserved and transported upon demand. Within the year experiment station work has yielded mineral data on a number of foods heretofore but little studied. Other studies of foods better evaluated as to mineral content have dealt with possible cooking losses, with variations due to the region where grown or the part of the plant analyzed, and with the content of available (rather than total) mineral elements present.

Less familiar foods.—With an interest in local foodstuffs, the Hawaii station has analyzed macadamia nuts and made a study of the opihi or Hawaiian limpet, a mollusk common to Hawaiian waters. Macadamia nuts were found to contain 0.055 percent of calcium and 0.00188 percent of iron, being comparable to peanuts with 0.067 percent of calcium and 0.0020 percent of iron. At this composition the nuts would rate as a poor to fair source of calcium and iron. The total edible portion of opihi was found to contain 0.230 percent of calcium, 0.146 percent of phosphorus, 0.01395 percent of iron, and 0.00010 percent of copper. These values indicate that the opihi is a good dietary source of phosphorus, calcium, and iron, but is low in copper. The results as to iron and copper were borne out by experiments with anemic rats, in which the feeding of opihi did not result in any marked regeneration of hemoglobin until copper was also fed.

Another sea food was analyzed by the Massachusetts station. This was crab meat (the American blue crab, *Callinectes sapidus*) canned by a new method employing a brine dip containing very small quantities of harmless aluminum salts which protect the meat against turning blue to black in color and developing a strong ammonia flavor after canning. Crab meat canned by this process was found to contain 0.1880 percent of potassium, and 0.1880, 0.0120, 0.0380, 0.0020, and 0.0013 percent of calcium, magnesium, phosphorus, iron, and copper, respectively. The iodine content amounted to 400 to 500 parts per billion. At this composition the product appears to be a fair source of phosphorus and a good to excellent source of calcium, iron, copper, and iodine.

Mineral value of cooked vegetables.—The loss of minerals from vegetables upon cooking in large amounts of water has been recognized for some time. That such losses do not occur upon sautéing vegetables quickly (6 to 9 minutes) in a small amount of fat (a common Chinese practice) was indicated by a study at Oregon State College. Raw asparagus averaged 0.026 percent of calcium and 0.074 percent of phosphorus; cooked by this method, the average was 0.026 for calcium and 0.073 for phosphorus. Raw and cooked peas each averaged 0.022 percent of calcium and 0.115 and 0.119 percent of phosphorus, respectively, while for celery cabbage values of 0.032 and 0.034 percent were obtained for calcium in the raw and cooked vegetable, respectively.

At Purdue University a study was made of the effect of the addition of salt to the cooking water upon the loss of calcium from the vegetables. The results indicated that under approved household methods of cooking such vegetables as asparagus, green beans, cabbage, carrots, peas, potatoes, and turnips, the amount of calcium lost was little affected by the presence of salt in the cooking water.

The Illinois station found that steam cooking of carrots and commercial canning of string beans had little effect on their value as

dietary sources of calcium. Analytical determinations incidental to the study showed calcium percentages of 0.0325, 0.0140, and 1.200 for fresh carrots, lettuce, and milk, respectively. Phosphorus, determined in carrots and milk, is reported at levels of 0.0398 and 1.022 percent, respectively.

Variations in mineral content.—That all parts of a plant are not equally rich in mineral content was demonstrated by analyses of leafy vegetables at the Mississippi station. The iron content (and moisture) of the leaf blades and of stems (petioles) plus midribs was determined for turnip and mustard greens, collards, pokeweed, and lambsquarters. When interpreted, the results indicated that on the basis of dry weight the leaf blades contained from 1½ to 5 times as much iron as stems and midribs, while the leaves with midribs left in contained from 1⅓ to 2 times as much iron as the stem. In further studies of turnip greens the leaf blades were found higher (on a dry-weight basis) in iron than the midribs plus petioles; this relationship was also found in the case of calcium and phosphorus, the leaf blade containing as much or more calcium and from 20 to 50 percent more phosphorus than the petiole plus midrib. These results are interpreted as justifying the common practice of discarding the stems or stems and midribs in the preparation of leafy vegetables for cooking.

The turnip greens utilized in this study were grown in different areas by the Mississippi station, and several other stations have grown turnip greens from a uniform seed source. Preliminary results point to differences in mineral content in greens produced in different regions. In the nutritional-anemia study of the Florida station, previously discussed, samples of water, vegetables, and soil from homes of selected children under observation were collected and analyzed. The results showed variation with locality; leafy vegetables grown along the coast, for example, were relatively higher in calcium and iron than those grown inland. That there is a seasonal variation in the copper, iron, and manganese content of muscle tissue of common haddock was indicated in analytical results obtained by the Massachusetts station. The lowest content of these minerals occurred after the spawning migration in February or early March.

Iodine determined in Texas waters (103 samples from cities in 10 different areas) was found by the Texas station to vary greatly. The average was 56 parts per billion. The iodine content of waters was highest in those geographical areas covered with relatively heavy soils and located in the subhumid section of the State. Some 18 or 20 vegetables, each grown on various soil types in 5 different areas, gave values ranging from 62 to 3,502 parts per billion, and the variations were due not only to the kind of vegetable but also to the location and soil.

VITAMIN CONTENT

There is a tendency to think of one or two foods only as sources of specific vitamins, such as orange and tomato juice for vitamin C, whereas a sufficient variety of foods each furnishing a fraction of the day's requirement of the vitamin in question will serve the same purpose as one food of particularly high vitamin content. Moreover, a food may be a very practical source of vitamins in one locality where it is produced in abundance and an impractical source else-

where, or certain varieties may prove much richer than others in a given vitamin. Consequently the experiment stations continue to study the vitamin content of foods particularly important to their own section of the country, and are gradually accumulating information which is not only of general value but may prove of special local value in the event of any disruption in transportation facilities and in more intensive live-at-home programs. Information on the vitamin content of foods obtained during the past year is summarized below by vitamins rather than by foods.

Vitamin A.—Values for vitamin A reported in the various studies are expressed in terms of micrograms (a microgram is a millionth of a gram) of carotene, or International Units of vitamin A. One International Unit of vitamin A is equal in activity to that of 0.6 microgram (μg.) of beta-carotene.

The chili pepper, "chile," is such an important item in the diet of the people of New Mexico that the station in that State is investigating its value as a source of vitamins, starting with carotene. Three varieties were tested in the green state at the same stage of maturity. A variety known as No. 9 was found to contain 810 micrograms, the Anaheim variety 520, and a small, mild paprika pepper which is being grown experimentally at the station 350 micrograms of carotene per 100 grams of fresh material. When dried, corresponding values were 5,400, 5,200, and 3,500 micrograms per 100 grams, respectively. Fresh red (ripe) chili contained more carotene than the green of the same variety; two samples of No. 9 contained 7,900 and 22,000 micrograms per 100 grams, the difference in values probably denoting different degrees of ripeness. A sample of ripe Anaheim contained 10,700 micrograms. Green chili canned by methods recommended by the station contained practically the same amount of carotene as the raw sample. A locally purchased sample of powdered dried chili contained 20,700 micrograms of carotene per 100 grams, a value calculated to be equivalent to about 34,000 International Units of vitamin A per 100 grams, or 10,000 per ounce. The tests thus far made are sufficient to show that chili, whether fresh, dried, or canned, is an excellent source of vitamin A. For many people in the State it is probably the chief source of this vitamin.

In a comparison of soybeans and cowpeas the Alabama station reported carotene values for soybeans in the young green-bean stage ranging from 212 micrograms per 100 grams for the Higan to 705 micrograms per 100 grams for the Tanloxi variety. Fresh cowpeas had a very much lower but more uniform content of carotene, ranging from 140 micrograms per 100 grams for Dixie Queen to 231 micrograms per 100 grams for the Lady and Virginia Blackeye varieties. The ranges in values for seeds tested at early maturity were 17.5 to 23.5 micrograms per 100 grams for soybeans and 20.8 to 41.7 micrograms per 100 grams for cowpeas. While the values even for the soybeans appear very low in comparison with those for chili peppers, it should be remembered that the quantities ordinarily consumed would be much higher.

The investigation conducted by the Washington station on the effect of various factors on the vitamin content of frozen peas, as noted in the 1939 report, has been extended to vitamin A. Fresh peas of the Telephone variety (the same as used in the earlier tests

on vitamin C) were consistently lower in vitamin A values as determined biologically than the Tall Alderman and these in turn than the Dwarf Alderman, with values of 600 to 900, 1,000, and 1,300 to 1,600 International Units, respectively, per 100 grams. None of the processes involved in the freezing of the peas appeared to alter their content of vitamin A, and this was also true of holding the peas for 7 to 8 hours before freezing and of cooking the frozen peas. The New York State station has also reported no appreciable losses in the vitamin A (determined as carotene) content of peas of the Thomas Laxton variety during freezing and subsequent storage for 11 months at very low temperature, −40° F., but losses of from 7 to 26 percent in the frozen product when held at a somewhat higher storage temperature (0°), although still below freezing. This variety in the fresh state contained about 620 International Units of vitamin A per 100 grams.

Green peas of the Laxtonian variety frozen for use in studies of the effect of cooking and canning on vitamin content were reported by the Montana station to have an average vitamin A content (determined biologically) of 400 International Units per 100 grams, with values of 860 International Units after boiling for 30 minutes, and 960 International Units after canning by the pressure-cooker method, storing for 6 months, and reheating for 10 minutes. A sample of commercially canned peas stored for 6 months and reheated for 10 minutes gave a value of 810 International Units of vitamin A per 100 grams. While it is difficult to explain the lower content of vitamin A in the raw than in the cooked or canned peas except through increased availability of the vitamin on cooking, the results at least demonstrate the stability of vitamin A in food materials on cooking .

The practical importance of the sweetpotato as a source of vitamin A in sections of the country where it can readily be grown on the farm for home use has been noted in earlier reports. That the type of fertilizer used in the soil does not affect significantly the carotene content of sweetpotatoes was demonstrated in studies by the Iowa station with the Prolific variety when receiving muriate of potash, manure, nitrate of soda, or no fertilization. The samples tested, which were cured for 2 weeks at 80° F. and then wrapped in paper and stored at 53° in ventilated baskets until needed for the biological tests, had an estimated range in vitamin A value of 1,960 to 2,610 and an average of 2,340 International Units per 100 grams.

The successful dehydration of sweetpotatoes of the Porto Rico variety to give a satisfactory flour that does not cake or spoil is reported by the South Carolina station. The flour contained about 5 percent of moisture and averaged about 12,000 micrograms of carotene per 100 grams. Baked goods such as cookies, biscuits, muffins, pastry, and cake in which this sweetpotato flour had been incorporated to the extent of from 12.3 to 22.6 percent contained from 1,480 to 3,370 micrograms of carotene per 100 grams when freshly baked and practically as much after 3 weeks' storage. The dehydration process thus has promise as a practical means of preserving surplus sweetpotatoes for later use as a readily available food source of vitamin A, particularly for reinforcing products ordinarily deficient in this vitamin.

Both butter and egg yolk are excellent sources of vitamin A. It might be assumed that rich cakes and cookies containing considerable

butter or eggs or both would also contribute to the vitamin A content of the diet, but the Iowa station found that in the presence of certain other oils and fats the vitamin A may be destroyed during the baking, and concluded that—

> the effects of the addition of fat to baked products on the vitamin A of the products will depend on the nature of the substance used as a source of vitamin A in the baked products, possibly upon the nature of the fats added, and upon certain unknown factors involved in the baking process.

Thiamin (vitamin B_1).—Values for this vitamin, determined by chemical analysis or by rat or chick assay procedures, are reported either in International Units or in micrograms, 1 International Unit being equivalent to 3 micrograms of vitamin B_1.

The effect of freezing and of canning on the vitamin B_1 content of snap beans received attention at the Massachusetts station, which reported that when the beans were properly blanched before freezing they showed no loss in vitamin B_1 on freezing, but if the blanching was omitted the loss amounted to 20 percent. Canning was even more destructive, with losses as high as 40 percent. The vitamin B_1 value reported for the fresh raw beans (350 International Units, or 1,050 micrograms per 100 grams) was on the moisture-free basis and consequently much higher than for the beans in their natural state.

Dried beans (*Phaseolus vulgaris*) form one of the chief agricultural crops of Michigan and are an important item in low-cost diets. Among eight kinds of field beans grown in two localities of the State and studied by the Michigan station, the Blue Pod and Robust varieties were found to rank highest and the Red Kidney, Yellow Eye, and Dark Cranberry types lowest in their vitamin B_1 content, with the Great Northern, Michelite, and a variety designated as 1200–1 of medium value. The extreme range in values was from 290 International Units per 100 grams for Blue Pod to 100 International Units per 100 grams for the more common Yellow Eye beans. It is noted, however, that even the types with the lowest values compare favorably with whole wheat, certain nuts, and egg yolk in their vitamin B_1 content. The station was also interested in finding out if differences in soil type affect the vitamin B_1 content of the beans, but although a number of varieties were slightly higher in the Fowlerville area (light to medium sandy loam) than in the Romeo district (heavy sandy loam), the differences were not significant.

Cabbage and onions were tested by the Montana station, the former before and after, and the latter only after, 6 months' winter storage. The fresh raw cabbage tested contained 28 International Units (or 84 micrograms) of vitamin B_1 per 100 grams and the same cabbage after storage 21 International Units. Coarsely shredded fresh cabbage cooked for 10 minutes in a generous amount of water also had a value of 21 International Units per 100 grams. Winter-stored onions gave values of 11 International Units per 100 grams when tested raw and when cooked 13 International Units. This difference is probably significant only in showing no loss of the vitamin on cooking.

Green peas were also tested by the Montana investigators. In the raw frozen state the peas contained 102 International Units per 100 grams, after boiling for 30 minutes 85 International Units, and after canning in the pressure cooker, storing for several weeks, and reheat-

ing 82 International Units per 100 grams. Commercially canned and reheated peas also contained 82 International Units per 100 grams.

Ten varieties of green peas were tested at the Oregon station, by a rat-growth method, after blanching at 88° and 93° C. for 1 minute and freezing as is done for frozen-pack peas. The Asgrow, World Record, Alderman, and Rogers varieties gave values ranging from 740 to 650 micrograms per 100 grams; Stratagem, Early Extra Grading, and Confidence 520 to 430; and Glacier Park, Telephone, and Laxton Progress 360 to 200 micrograms per 100 grams. Duplicate lots of the Telephone peas used by the Washington station in the vitamin A studies noted on page 206 were also tested by the Oregon station for the effect upon the vitamin B_1 content of the various processes used in the commercial freezing of peas. The highest value, 400 micrograms per 100 grams, was obtained for the sample blanched at 71° for 2 minutes and the lowest, 260 micrograms per 100 grams, for those blanched for 2 and 3 minutes at 99°. As either the temperature or the time of blanching increased, the vitamin B_1 content tended to decrease but not significantly except with an increase in both temperature and time. There was no significant difference between the effect of steam and hot-water blanching and little effect from holding at room temperature before freezing.

Nuts are probably rather good sources of vitamin B_1, although very little work has been done on them. Macadamia nuts grown in Hawaii and now available in the States have been tested by the Hawaii station, which reported very low values for vitamin A but relatively high values for vitamin B_1. In the raw state the vitamin B_1 content of the samples tested averaged 480 micrograms per 100 grams, but the customary roasting process caused a loss of about 40 percent, as market-roasted nuts contain only 280 micrograms (93 International Units) per 100 grams. This value is said to be somewhat higher than for roasted peanuts and to place Macadamia nuts in the class of excellent sources of vitamin B_1.

With the numerous canned meats on the market, it is important to know how well vitamin B_1, present in abundance in fresh meat, particularly pork, is preserved in processing. Unfortunately, as shown by recent studies of the Wisconsin station, processing is very destructive of this vitamin in meat, with increases in the temperature somewhat more destructive than increases in time of processing. As an illustration, a prepared meat product containing a small amount of cereal grains and vacuum dried for testing gave a value of 500 micrograms per 100 grams unprocessed, 200 micrograms after processing for an hour at 240° F., 170 micrograms after processing for 1½ hours at 240°, and less than 100 micrograms after processing for 1 hour and 50 minutes at 250°.

Lamb frozen and stored for 3 months was found by the South Dakota station to have suffered no loss in vitamin B_1. It would thus seem preferable, where possible, to preserve meat by freezing rather than by canning if advantage is to be taken of its value as a source of vitamin B_1.

Milk, both cow's and human, is rather low in vitamin B_1 content, and attempts to raise the value of cow's milk by special feeding have proved unsuccessful. The possibility of increasing the vitamin B_1 content of human milk by increasing the mother's intake of the vitamin was tested in two healthy young women by investigators at the Uni-

309632—41——14

versity of California. The women had been on diets differing appreciably in vitamin B_1 content and this was reflected in the vitamin B_1 content of the first milk samples tested, one containing 32 micrograms and the other only 11 micrograms per 100 grams. After their diets had been adjusted to furnish about the same quantity of vitamin B_1 (1,150 and 1,140 micrograms daily) and each subject had taken 5 micrograms of thiamin chloride(the pure vitamin) daily for about a month, the milk of the higher original B_1 content remained unchanged, but the other gave a value of 20 micrograms per 100 grams. After a further adjustment in vitamin B_1 intake, the vitamin B_1 values of the milk from the two subjects became equalized at 25 micrograms per 100 grams. Three market samples of cow's milk had values of 27, 30, and 32 micrograms per 100 grams. As a result of this study the California investigators expressed the opinion that—

> the level of vitamin B_1 in human milk is controlled in the lower brackets by the vitamin B_1 content of the diet, but that, as in cow's milk, a maximum level exists above which the vitamin content cannot be raised even by massive doses of thiamin chloride. This maximum level appears to be the same in human and cow's milk, 25 to 32 micrograms per 100 grams of milk.

Yeasts, although varying widely in their vitamin B_1 content depending upon their source and the media on which they are grown, are among the richest sources of this vitamin. Yeast with a vitamin B_1 value of 5,280 micrograms (1,760 International Units) per 100 grams has been produced on molasses by the Hawaii station. This is comparable to some dried brewers' yeasts and greatly superior to any bakers' yeasts.

Riboflavin.—Comparisons of the riboflavin content of different foods are complicated by the fact that the various methods now in use do not give identical results with the same material. However, the values are sufficiently comparable to indicate the relative richness of different types of foods in this vitamin, recently shown to be essential in human nutrition.

The Wisconsin station used a bacterial growth method of assay in a continuation of studies on the distribution of riboflavin in meat and meat products. Of the organs examined, liver and kidney were the richest in riboflavin. Amounts varying roughly from 2,500 to 3,900 micrograms per 100 grams of fresh liver were found for various samples of liver (beef, veal, lamb, and pork), while kidney (beef, pork) contained amounts in the neighborhood of 1,800 to 2,300 micrograms per 100 grams of fresh kidney. Values reported for heart were in the range of from 750 to 1,150 micrograms, and for other organs (brain, lung, pancreas, and spleen) in the range of 250 to 600 micrograms per 100 grams of fresh tissue. All muscle tissue examined contained lower amounts of riboflavin than did the organs. Beef round, leg of lamb, pork ham (fresh, boiled, canned, and smoked), pork loin, veal hindquarter, and dark meat of poultry ranged from about 200 to 350 micrograms per 100 grams of the lean meat; white meat of poultry was notably low, containing only 70 to 80 micrograms per 100 grams. From analyses of a few cooked samples it appeared that the cooking method having the least destructive effect was stewing. Frying resulted in losses ranging from 33 to 50 percent, and roasting from 30 to 60 percent.

The Kansas station, using a method involving rate of growth in rats, found the riboflavin content of various kinds of liver to range

between 2,700 to 5,400 micrograms per 100 grams of fresh liver. The livers were purchased in the early fall and again in the winter at local retail markets supplied by Kansas City packing plants, and each sample represented from two to six animals. Lamb liver gave values of 4,950 and 5,400 micrograms per 100 grams in the fall and winter, respectively; sheep liver (winter sample only), 4,350; calf, 3,450 and 4,350; beef, 2,850 and 3,450; and pork liver, 2,700 and 2,700 micrograms per 100 grams in the fall and winter, respectively.

The riboflavin content of yeasts was determined by workers at the New York (Cornell) station, using the photometric method and chick and hen bio-assays. Results by the two methods were in good agreement, but differed somewhat from values determined by the rat-growth method and supplied by the company furnishing the yeast. The data indicated that different samples of yeasts vary widely in their riboflavin content; various yeasts, for example, contained from 34.2 to 78.2 milligrams per gram.

The pinto bean, one of the chief commercial crops of New Mexico and an important part of the food supply of many people of the Southwest, was studied at the New Mexico station as a source of riboflavin by comparing the gains in weight of rats fed the beans with those of similar rats fed graduated doses of pure riboflavin. The rats were not able to utilize the riboflavin contained in the raw beans, but gains made on the cooked beans showed the latter to have a content of about 800 micrograms of riboflavin per 100 grams. The method of cooking had only a slight influence on the availability of the riboflavin, and the amount of the vitamin lost in the discarded soaking water was negligible. The difference between the raw and the cooked beans suggested that other grains and seeds that assay low in the raw state might show higher values if assayed after cooking. The riboflavin content of raw and cooked wheat, corn, soybeans, and hegari was therefore measured by rat-feeding tests. In each case the cooked food proved superior to the raw as a source of riboflavin, although the differences were not so pronounced as those between raw and cooked pinto beans. The results, which emphasize the importance of testing foods in the form in which they are to be used, point to grains and seeds as better sources of riboflavin than have been recognized.

Vitamin B_6.—Pinto beans were also subjected to tests by the New Mexico station to determine their value as a source of vitamin B_6. The content of this vitamin was measured by comparing the number of cases of dermatitis in rats fed pinto beans as a source of vitamin B_6 with the number of cases among similar groups of rats fed graded doses of an autoclaved rice-polish concentrate rich in vitamin B_6. Although the raw beans gave some evidence of protection against dermatitis, their vitamin B_6 was apparently not very well utilized by the rats. Cooked beans, however, proved to be an excellent source of the vitamin, for 750 milligrams of the beans, cooked in distilled water without soaking, contained as much vitamin B_6 as 50 milligrams of the autoclaved rice-polish concentrate. When the beans were soaked before cooking, a considerable fraction of the vitamin was lost in the discarded soaking water. Pressure cooking or the use of baking soda to soften the seed coats also resulted in loss of much of the vitamin.

Nicotinic acid.—Dogs on a basal diet deficient in nicotinic acid but satisfactory in ather respects lose weight. Graded doses of nicotinic acid then administered permit graded gains in weight. By comparing

these gains with those obtained in other tests with measured quantities of some food, the content of nicotinic acid per gram of food can be calculated. This procedure was used by Wisconsin station workers in tests on a large number of foods. As thus determined, the highest content of nicotinic acid was found in liver, the values ranging from 27.5 to 46.0 milligrams per 100 grams of fresh liver. One sample of fresh beef kidney contained 17.8 milligrams of nicotinic acid and the other tissues (spleen, lung, brain, and pancreas) from 2.7 to 12.3 milligrams per 100 grams. Muscle tissue, represented by samples of beef tongue, roast beef, pork loin, and pork ham, contained from 5.2 to 13.0 milligrams of nicotinic acid per 100 grams of sample.

A series of foodstuffs other than meat was tested by the same method. Among the values reported are skim milk powder from 4.3 to 6.2 milligrams per 100 grams, bakers' yeast 50, brewers' yeast (6 samples) from 34 to 93, hard-boiled egg yolk less than 4 and white less than 2.5, and wheat germ less than 4 milligrams per 100 grams.

Ascorbic acid (vitamin C).—Numerous experiment station studies on the effect of various factors on the vitamin C contents of fruits and vegetables have been reported during the year. The data were usually obtained by chemical tests and reported as milligrams of ascorbic acid per 100 grams of food.

Variety seems to influence the vitamin C content of cantaloups as shown by independent tests at the New York (State) station and the University of North Carolina, 6 varieties being tested in each place. The range in the New York varieties was from 23 milligrams of ascorbic acid per 100 grams for Bender Surprise to 48 milligrams for Honey Rose, with intermediate values of New Wonderful 24, Cooper Sweetheart 25, Aristocrat 37, and Golden Marvel 38 milligrams per 100 grams. The range was less wide in the North Carolina varieties tested, from 20.91 milligrams per 100 grams for the Banana variety to 31.23 milligrams for the Rocky Ford, with intermediate values of Hale Best 25.47, Baltimore 28.14, Wood Perfection 28.92, and Perfection 30.56 milligrams per 100 grams. The North Carolina study showed that for all varieties tested the vitamin C content was somewhat higher for ripe than very ripe (presumably overripe) samples, the averages being 29.7 and 20.7 milligrams per 100 grams, respectively. No relationship was evident between the sizes of the cantaloup, which ranged in weight from 750 to 1,343 milligrams, and their vitamin C content. Cantaloups, in view of the generous size of the portions usually served and their relatively high ascorbic acid content, thus appear to be a valuable source of vitamin C.

Raspberries (preserved by the frozen-pack method) were analyzed at the Washington station, where it was found that the Antwerp was approximately twice as rich (35 milligrams per 100 grams) as other varieties tested. Marlboro, Tahoma, Latham, Lloyd George, and Cuthbert varieties ranged from 14 to 18 milligrams per 100 grams.

Seven varieties of strawberries, grown at the North Carolina station under identical conditions of soil, fertilizer, and climate, and harvested and analyzed at the firm-ripe stage, showed variations from sample to sample within a variety. Average values based on 8 or 10 samples for each variety indicated, however, that there were distinct varietal differences in ascorbic acid value. The 2 varieties with lowest ascorbic acid, Klondike (38.8 milligrams per 100 grams) and

Missionary (36.2 milligrams per 100 grams), are standard commercial varieties widely planted, while the Fairmore, which averaged highest (64.8 milligrams per 100 grams), is a new berry, originating as a cross. It is a vigorous grower noted for its firmness and shipping quality, uniformity of shape, deep color, and high dessert quality.

Marked varietal differences have also been reported during the year for a number of vegetables. Among 20 varieties and strains of cabbage grown under similar conditions in the gardens of Ohio State University and tested soon after harvesting, the ascorbic acid content ranged from 48 milligrams per 100 grams for Allhead Select to 181 milligrams per 100 grams for Midseason Market. The average for all varieties was 100 milligrams per 100 grams.

Varietal differences were found by the New York (State) station to be slight for four varieties each of broccoli, cauliflower, and endive, The average ascorbic acid values reported for these vegetables were 130, 90, and 14 milligrams per 100 grams, respectively. Of the five varieties of lettuce tested, four gave rather similar values, California Iceberg, Mignonette, White Boston, and Salamander testing 10, 11, 13, and 14 milligrams per 100 grams, respectively. Black Seeded Simpson, however, gave 21 milligrams per 100 grams.

The location where fruits and vegetables are grown, season, and maturity at harvesting are other factors found to influence the vitamin C content.

In a study at the Florida station, oranges from individual trees of three varieties, Parson Brown (early ripening), Pineapple (midseason), and Valencia (late ripening), were picked at intervals of 2 weeks from the green to the mature stage. With the advance of maturity there was a decrease of acidity, but the content of vitamin C remained surprisingly constant. The juice of samples of green very young Valencia oranges weighing less than 10 grams apiece gave an average vitamin C content of 347 milligrams per 100 grams for the outer rind and 335 milligrams per 100 grams for the inner portion. These very high values indicate that the vitamin C develops early in the fruit.

In the New York (State) station studies already referred to, broccoli had a higher ascorbic acid content in September than in July, with averages of 164 and 119 milligrams per 100 grams in samples harvested in these 2 months, respectively. At any given season the blossoms were higher in ascorbic acid content than were the stems. In July, for example, an average of 146 milligrams per 100 grams was obtained for blossoms as compared with an average of 109 for the stems. Cauliflower blossoms were likewise richer in ascorbic acid than the stems, with values of 103 and 90, respectively, for the July samples.

Fresh peas of 21 varieties analyzed by the Utah station ranged in ascorbic acid content from 7 to 33 milligrams per 100 grams, with samples harvested in the latter part of the season showing a tendency to higher ascorbic acid values than those harvested in the first week. Raw frozen peas of the Laxtonian variety analyzed by the Washington station had an average ascorbic acid value of 27 milligrams per 100 grams.

Tomatoes were examined by the Georgia station for their vitamin C content as affected by location as well as by variety in 1939, when 17 varieties were grown at the main station and 8 at the Mountain

station. At each location the values obtained differed from variety to variety and for the 6 like varieties there were differences when grown at the 2 locations. The entire range in values at the main station was from 18 to 30 milligrams and at the Mountain station from 18 to 21 milligrams per 100 grams. The Utah station found that tomatoes from vines supported on poles were consistently higher in ascorbic acid content than tomatoes from unsupported vines on the same plat. It is considered that this variation was probably due to the amount of sunlight received.

One factor sometimes forgotten in comparing different foods for their value as a source of vitamins is the amount ordinarily eaten. Parsley, included among the foods analyzed at the New York (State) station, was found to be exceptionally high in ascorbic acid content (200 milligrams per 100 grams). Yet in spite of this high value parsley is not an important source of vitamin C in the diet, since it is served either as a seasoning, in amounts furnishing not more than 5 or 10 grams per person at any one serving, or as a garnish.

Thus far, the vitamin C values reported have been for the freshly harvested fruits or vegetables. Attention has also been given to the retention of vitamin C during the period of storage and preparation before the food is finally eaten.

As for storage losses, the Wyoming station found that potatoes kept in a storage cellar lost about one-half of their vitamin C in 6 months. The Utah station studied the problem in tomatoes, but observed no definite or consistent decrease in their ascorbic acid value when held 2 weeks or more either at the laboratory temperature or in the refrigerator (40° to 50° F.), even though the former lot became soft and developed molds and the latter developed spots that appeared to be black rot. In the New York State station study already referred to, it was found that broccoli, cauliflower, endive, kale, lettuce, and New Zealand spinach lost ascorbic acid rapidly when held at room temperature in the summer. Refrigeration effectively retarded the losses for broccoli, cauliflower, and endive, but not so effectively for lettuce and kale.

Parsnips are considered to improve in flavor if not dug until after the ground has frozen. The Montana station analyzed parsnips of the Hollow Crown variety purchased at the local market in the fall and others of the same variety in the early spring after being in the frozen ground over winter. The three lots analyzed in the fall gave average ascorbic acid values of 22, 23, and 32 milligrams, respectively, with a range of 12.8 to 40 milligrams per 100 grams for all lots, while the spring-harvested samples averaged only 9 milligrams per 100 grams with a range of 5.5 to 12.7 milligrams. This decrease upon storage was borne out by the results obtained at the New York State station, the parsnips grown there averaging 40 milligrams of ascorbic acid per 100 grams at the time of the fall harvest and only 15 milligrams per 100 grams after winter storage in a pit slightly above freezing. These several results support the view, based upon earlier studies, that vegetables (except those acid in reaction, such as tomatoes) tend to decrease in ascorbic acid value upon storage. This loss is retarded somewhat in certain of the perishable vegetables if these are held in the refrigerator rather than in a warm room.

Changes in the vitamin C content of vegetables upon cooking received attention in a number of studies. In the Montana station

studies noted on page 214, losses amounting to about 13 percent of the original ascorbic acid content occurred in unpeeled parsnips boiled whole and to about 36 percent in those peeled and sliced before boiling. When the sliced boiled parsnips were fried in butter the ascorbic acid content appeared to increase. The reasons for this are not clear at present. Peas which averaged 27 milligrams of ascorbic acid per 100 grams when tested in the raw (frozen) state, averaged only 18 milligrams per 100 grams after boiling for 30 minutes and 19 milligrams after being canned in the pressure cooker at a temperature of 240° F. for 45 minutes. The figure for canned peas was for juice and peas heated together, and showed no appreciable loss after storage for 8 and 12 months.

Rutabagas, which are high in vitamin C, were cooked at the Maine station by five methods, namely, steaming, cooking in a small amount of water and boiling off any excess liquid, panning in a small amount of fat with no water, cooking in a large amount of water until just soft, and cooking for 90 minutes in a large amount of water. The smallest losses, amounting to about 30 percent, occurred by the first two methods, and the largest loss, about 70 percent, occurred upon cooking the vegetable in the large amount of water for the 90-minute period.

The canning of sauerkraut in pint jars is recommended by the Wisconsin station, which has shown that vitamin C is well preserved in this "kitchenette" sauerkraut except when discolored. The cause of this brown discoloration is not known, although trials with individual cabbage heads and various lots of cabbage have suggested that the conditions under which cabbage is grown may have something to do with it. The cooking of kitchenette sauerkraut for a normal period of 10 to15 minutes was found to cause a loss of not more than 10 percent of the vitamin C, which is much less than the loss in cooking fresh cabbage. Even when the sauerkraut was overcooked for 2 hours the loss of vitamin C was only 25 percent.

Losses of vitamin C in turnip greens cooked in various ways in different utensils were determined at the Texas station. In order to compare the content of the cooked greens with the raw the leaves only were used, the samples for analyses in the raw state being taken from one side of the leaves and for cooking from the other. The ascorbic acid content of 141 samples of the raw greens ranged from 67 to 422 milligrams per 100 grams. Under conditions considered similar to practical cooking an average of 88 milligrams of ascorbic acid per 100 grams of greens was found in the cooking water and 53 milligrams per 100 grams in the cooked greens.

Losses of total vitamin C under conditions similar to practical cooking ranged from 15.5 to 26.7 percent on rapid cooking and from 23.8 to 36.5 percent on slow cooking. There were lower losses in uncovered enamel, pyrex, or stainless steel vessels when the greens were cooked rapidly than when they were cooked slowly. The losses were the same (25.3 to 26.9 percent) when aluminum was used, covered or uncovered.

PROXIMATE CONSTITUENTS

During the year a number of foods have received attention with regard to the general aspects of their nutritive value and also their dietary contributions in protein, fat, and carbohydate—the group known as proximate constituents.

Milk.—Experiments on rats conducted by the Wisconsin station have indicated that whole milk has greater nutritive value than filled milk even when the vegetable oil used to replace the butterfat is supplemented with vitamins A, D, and E. The animals receiving mineralized skim milk in which 4 percent of butterfat had been homogenized grew better, had a better general appearance and finer coat of hair, and apparently got along on less food than similar groups of animals receiving the mineralized skim milk into which 4 percent of corn oil, cottonseed oil, or soybean oil had been incorporated by homogenization. On the basis of these results it is believed that the fat found in natural milk has special, if little understood properties which make it more valuable, particularly for the young, than any known substitute.

Sea foods.—Common haddock, opihi, or Hawaiian limpet (a mollusk), and American blue crab (canned), discussed on page 204 with regard to mineral content, were also analyzed for proximate constituents. Analyses of the haddock, caught over a period of 1 year and frozen whole or as fillets, revealed no significant differences in the composition of the samples frozen by different methods. Although very low (usually less than 1 percent) in fat at all times, a slight rise during the late fall was noted, followed by a sharp decline during December that continued until late summer. On the whole haddock is to be considered as a very lean fish of value primarily as a good source of protein (about 17 percent).

The opihi, a local food quite generally used in Hawaii, was found to average for the total edible portion, 17.3 percent of protein, 1.7 of fat, 2.21 of ash, and about 1 percent of glycogen (animal starch). The opihi is thus a good source of protein. The canned meat of the blue crab was also found to contain about 18 percent of high-quality protein and to be low in fat (about 0.4 percent).

Soybeans.—Soybeans, rich in fat and protein (and also of value for their vitamins and minerals), have long been used in the Orient, but only within recent years have they begun to find favor on the American table.

Earlier work has demonstrated that the protein of soybeans is superior in nutritional quality to that of the more familiar kinds of beans but is efficiently utilized only after heating. In a study conducted at the Wisconsin station soybeans roasted by oven baking were found to be improved over the whole raw soybeans in the nutritive quality of the protein to an extent about the same as that effected by boiling but less than by autoclaving for short periods. If the soybeans were ground before baking there was but little improvement, presumably because of rapid loss of water. When fried in deep fat without previous treatment they were very little improved in regard to protein, but if soaked or autoclaved before frying, not only was the palatability improved but the nutritive quality of the protein approached that of the oven-roasted soybeans.

In animal-nutrition investigations at the Alabama station the protein of soybeans was found to be markedly superior to that of cowpeas. It is suggested, therefore, that at least part of the cowpeas used in Southern diets be replaced with edible types of soybeans.

Piñon nut.—From the New Mexico station comes information on the composition and food value of piñons (*Pinus edulis*), and of pecans grown under irrigation. Analyses of piñon samples from the 1937 and 1938 crops indicate a protein content of about 14.0

to 15.6 percent, fat 59.6 to 62.0, carbohydrate (by difference) 17.9 to 18.3, crude fiber 0.86 to 0.91, and ash, 2.76 percent. The pecans analyzed contained 9.2 to 11.8 percent of protein, 70 to 76 percent of fat, and 8.6 to 12.8 percent of carbohydrate.

Rice.—Although uncooked rice contains about 7.5 percent of protein, this is of unsatisfactory quality to meet the needs of the body. Studies at the Arkansas station, involving paired-feeding experiments with rats, showed that some of the inferiority of rice protein was due to lack of certain amino acids (cystine, methionine, and lysine).

Grapes.—Aside from water, sugar is the chief constituent of grapes. Analyses of a number of varieties at the Arkansas station showed the expected variations in the amount of this constituent. A number of varieties had a low sugar content (12 to 13 percent), while others were high in sugar (18 to 20 percent). For the most part the sugar content and acidity fell within the range reported for the same varieties grown in other sections of the United States, and apparently Arkansas grapes would be as satisfactory for juice purposes as grapes from other regions.

PRESERVATION

The preservation of foods, of importance at any time as a means of conserving seasonal surpluses, of providing against seasons of nonproduction, and of facilitating storage and transport of products perishable in the fresh state, becomes especially important in the marshaling of food resources for defense. Recent experiment station research has dealt particularly with frozen storage, although canning and other methods have received some attention.

Frozen storage.—Increased use of the freezer locker for holding over surpluses of home-produced foods and of frozen storage for certain market crops has given rise to various questions as to kinds and varieties suitable for frozen storage, as well as questions concerning preparation of foods for freezing, their storage life, and their handling upon removal from the locker.

The Georgia and Tennessee stations (both in cooperation with the Tennessee Valley Authority) have been particularly interested in the method of freezing fruits and vegetables individually before packaging rather than in mass. They have concluded that superior products are obtained in this method by freezing in direct contact with a cold solution, such as invert sugar sirup, for practically all acid fruits, and brine for vegetables.

To the rapidly growing frozen-pack industries on the west coast, a number of stations in the Northwest are contributing valuable information as to factors making for the best quality in the frozen product. The troublesome effect of enzyme action in changing texture and flavor, as well as vitamin content, of vegetables before and during frozen storage was studied with string beans by the California station. On the basis of this study it was reported that a satisfactory product coud be obtained with string beans of the Kentucky Wonder variety by blanching the cut string beans at 185° to 189.5° F. for 2 minutes, or at 180° for 5 minutes. The less mature the beans the greater their enzyme activity in the cut state, but by leaving them uncut and blanching for 2 minutes at 212° (the boiling temperature) satisfactory re-

sults were also obtained. These findings are of course equally applicable in the small-scale preparation of string beans for frozen-locker storage. Other studies of the Washington station were concerned with factors affecting the texture of the frozen product after cooking. It was found that the skins of green peas that had been vined were tougher than the skins of hand-picked peas, and both vined and hand-picked peas were tougher after delay between harvesting and freezing, the longer the delay the tougher the product. Covering the peas with cracked ice delayed the toughening. The inside of the peas was affected less than the skins.

Freezing preservation is considered to offer such a promising market for Utah fruits and vegetables that several departments of the station are actively engaged in research in this field in cooperation with the California frozen pack laboratories of the United States Department of Agriculture. Over 200 varieties of Utah tree fruits and berries were tested during the past year for their suitability for preservation by freezing. Many of these appear to be promising for use in ice cream and sherbets; among the most promising are Chinese apricot, Carmen, South Haven, and Rosebud peach, Montmorency and Morello cherry, Cuthbert and Taylor red raspberry, Marshall strawberry, Santa Rosa plum, and boysenberry. Among 21 varieties of Utah-grown peas preference was given to Morse Market, dark-podded Thomas Laxton, Gradus, and Hundredfold when the frozen peas were cooked in slightly salted water for 8 minutes (actual boiling time).

Information on the location of community freezer lockers within the State, the selection of varieties of locally produced fruits and vegetables best suited for freezer-locker storage, and the most satisfactory methods of preparing and packaging the various food products has been published during the year by a number of the stations. Data of general interest on the development of refrigerated locker plants in the United States and the lay-out of a typical plant, with the services rendered, were published by the Michigan station, together with information of local interest on the location, sizes, and rental charges for lockers in the State. Similar information on the location of freezer storage plants in Illinois, classified by county and by cities within the county, with estimated number of lockers in each, is to be found in an Illinois extension circular.[2] A bulletin[3] of the New York State station is of general value in the construction and management of freezer-locker plants and also on farm frozen-storage cabinets. The cabinet, designed for large farm households or homes located at some distance from community lockers, is a heavily insulated top-opening box of 14 to 40 cubic feet capacity, containing two compartments—a small one for freezing at about −10° F. and a larger one in which the products are stored at about 0° after freezing.

The New York State and Illinios publications noted also contain information based upon research on the selection of kinds and varieties of fruits and vegetables, choice of containers, methods of packing and freezing different foods, and methods of using the frozen products. According to the New York report most fruits if properly selected, prepared, packaged, frozen, and stored yield products of high quality,

[2] KLAAS, H., and WOODRUFF, S. HOW TO PREPARE FRUITS AND VEGETABLES FOR FREEZER STORAGE AND HOW TO USE THEM. Ill. Agr. Col. Ext. Cir. 510, 20 pp., illus. 1940.

[3] TRESSLER, D. K., and DUBOIS, C. W. FREEZING AND STORAGE OF FOODS IN FREEZING CABINETS AND LOCKER PLANTS. N. Y. State Agr. Expt. Sta. Bul. 690, 60 pp., illus. 1940.

although plums and prunes are given only a fair rating, and blackberries, grapes, and pears are considered unsatisfactory for freezing. The report states that as a general rule those vegetables which are ordinarily eaten raw and should be crisp and firm are not commonly frozen, but that those which are ordinarily cooked before being eaten usually give excellent products. A similar service is rendered to Illinois farm people through the Illinois circular, which rates the locally grown varieties of different fruits and vegetables with regard to suitability for freezing. In this circular emphasis is given to general rules for success, with the reasons for the various processes involved; to the choice of paper containers on the market with respect to size, shape, and linings; and to the proportions of vegetables and water for the blanching process.

A report of the first year's work on an investigation of the adaptability to freezer-locker storage of varieties of North Dakota fruits and vegetables, together with recommendations as to types of pack and containers and methods of freezing, has been issued by the North Dakota station. Corn proved better when frozen off rather than on the cob, and lima beans and corn when frozen in 2-percent salt solution than in dry pack, while wax beans, green beans, and peas were better when frozen in dry pack. Raspberries were best when frozen in a 50- or 60-percent sirup. Glass jars are recommended for all except the corn on the cob.

General directions for the preservation of fruits and vegetables in refrigerated food lockers have been issued by the Michigan station in the form of a chart [4] for convenient reference. Varieties that give desirable products are listed and specific directions are tabulated as to harvesting, handling, preparation, blanching (in the case of vegetables), packing, and containers. Certain rules—and these are applicable in any State—that must be adhered to for satisfactory products are given as follows: Use fruits and vegetables of the best quality available, harvest at the proper stage of maturity for immediate table use, process within a few hours after harvest, and handle throughout with the utmost precautions as to cleanliness. It is pointed out that berries, sour cherries, and rhubarb are especially adapted to preservation by freezing, that peaches and light-colored cherries make excellent frozen products but turn brown if not properly prepared, and that it is doubtful economy to freeze apples and pears, since these may be readily stored at home. As for vegetables, peas, lima beans, corn cut from the cob, asparagus, broccoli, green beans, peppers, spinach, and other greens are suitable for freezing, but are more exacting in their preparation than are the small fruits. Corn on the cob requires special blanching treatment and takes up much valuable locker space, while vegetables high in water content or high in starch are not adapted to freezing.

According to a survey of cold-storage locker plants in Wisconsin by the Wisconsin station, meat made up about 90 to 95 percent of the products stored in the 177 cold-storage locker plants of the State in the summer of 1939. Although this proportion might not hold in other States, meat is an important item in freezer-locker storage and one offering many problems, among them the tendency of the fat

[4] Seaton, H. L., and Griswold, R. preparation of fruits and vegetables for storage in refrigerated food lockers. Mich. State Col. Ext. Bul. 208, Chart. 1940.

of pork to become rancid. The effect of different wrappings, temperatures, and length of storage on the keeping qualities of frozen pork chops was studied by the Michigan station. The results indicated that wrapping had little effect on the palatability of the chops but did have a pronounced effect on moisture loss. Kraft wrapping paper permitted the greatest moisture loss; brown waxed whalehide was next; Thermo M (a heat-sealing paper), lard (as a coating applied by dipping), and lard and tallow mixture were about the same; and cellophane permitted the smallest moisture losses. The palatability of the chops decreased and shrinkage increased as the storage period lengthened. Most of the chops were still edible after 180 days of storage, although the fat of some was rancid. Little difference was found between chops stored at 5° and 15°. At the Minnesota station pork-loin roasts were frozen at 0° and stored at 0°, 10°, and 15°, but after 12 weeks of storage the fat had deteriorated in flavor. This was not due to the freezing alone, since frozen roasts tested immediately after freezing compared favorably with fresh unfrozen roasts in flavor and aroma. Directions for the preparation and freezing of meat, poultry, fish, shellfish, and game are included in the New York (State) station bulletin referred to previously.

The increased use of quick-frozen foods, whether these be commercial packs obtained from city markets, or home-produced packs taken from the freezer locker, makes it desirable to know how well such foods "keep" after they are taken out of cold storage. The Wisconsin station studied quick-frozen corn. Allowed to thaw and stand at room temperature (68° to 77° F.) the first signs of spoilage appeared after 17 hours; at ice-box temperature of 44° to 57°, spoilage set in after 70 hours, while at temperatures of 32° to 41°, such as would be maintained in an electric refrigerator, spoilage began after 119 hours. The first sign of spoilage was a slight sour odor associated with the development of an acid reaction (a shift from pH 7.4 to 5.0). A number of organisms were found present in the corn, but the one chiefly responsible for the souring was a yellow one called *Micrococcus flavus*. With continued standing the number of organisms became greater, the corn became more sour (pH 4.5), and finally began to spoil (the reaction shifting back in the alkaline direction) under the action of bacteria and molds.

This study suggests the need for adequate storage conditions if the frozen product is not to be used soon after removal from the freezer locker. Frozen-food studies started by the Indiana station have pointed to the need for adequate household refrigeration to care for such products. The two-zone refrigerator or one with a large freezing compartment seems desirable.

At the Washington station samples of frozen vegetables were cooked by boiling and steaming for different lengths of time and scored by a panel of judges. The methods given the highest scores for the different products were boiling for 5 minutes in the case of cauliflower, broccoli, spinach, and asparagus; cooking for 6 minutes for peas, although the scores did not agree as to the best method; boiling for 20 to 25 minutes for lima beans; cooking 12 to 15 minutes, with no preference for boiling or steaming in the case of green beans; steaming for corn, since it gave the sweeter product, with a 5-minute period for corn on the cob, but no preference as between 3-, 5-, 8-, and 12-minute cooking periods for cut corn. The results

of these tests give an idea of the cooking times and methods generally recommended for frozen vegetables.

Canning.—The freezing of foods has by no means supplanted home canning, nor have frozen foods made particular inroads on the consumption of commercially canned goods. In a survey by the Wisconsin station it was found that the purchase of frozen peas introduced in Madison grocery stores in 1939 was at the expense of about an 80-percent decrease (with regard to 1938 sales) in the purchase of fresh peas and only an 8-percent decrease in the purchase of canned peas. With canning still the most important of home and commercial methods of food preservation, it is natural that attention should continue to be given to canning problems in experiment station research.

The home canning of vegetables was included in the food-research program of the Illinois station, where more than 3,000 containers of corn, string beans, asparagus, and tomatoes in the garden-fresh state were canned by three methods commonly used in the home. Certain packs were inoculated with spoilage organisms before processing and examined after several months of storage. Corn was the most difficult to keep successfully, whether processed by pressure, boiling water bath, or oven methods. Corn, string beans, and asparagus, the nonacid vegetables, showed some survival of the flat-sour organisms with which they were inoculated, and survival was most common with the boiling water bath. Processing in the oven gave a lower degree of spoilage than had been expected, but appearance, color, and flavor were less acceptable because of the caramelization. This study gives definite evidence, therefore, that acid vegetables, such as tomatoes, may be processed in a boiling water bath, but that safe and successful canning of nonacid vegetables requires processing in a pressure cooker.

The canning of green vegetable varieties of soybeans was investigated at the Iowa station. It was found that the addition of small quantities of acid (either lemon juice or vinegar) to the brine gave a more palatable product than that obtained with the use of the plain salt solution.

In peaches canning quality is an important character in making varietal selections. At the Colorado station freestone varieties of peaches (1939 crop) which were considered promising from the production standpoint were investigated for their canning qualities. Of the varieties tested the college strain of the Canadian Queen showed the smallest shrink during processing. This variety and also Vivid Globe and J. H. Hale gave smooth-pack peaches, whereas packs from standard Elberta, July Elberta, and Jewel were distinctly ragged. The Jewel and Z-peach, possessing distinctly undesirable characteristics, scored low in consumer preference.

The utilization of fruit in the making of fruit juices on a home scale was investigated at the Colorado station for cherries and at the New York (State) station for apples. The Colorado workers found that the cold pressing of cherries yields a juice that retains the fresh cherry flavor better than hot pressing, but that hot pressing yields a more highly colored juice; that English Morello cherries when cold pressed give a more highly colored juice than do the Early Richmond or Montmorency varieties; and that because of the astringency of pure cherry juice the best flavor can be brought out by diluting

and sweetening the juice. Based upon these findings several formulas have been developed for attractive and palatable juice blends of hot- and cold-pressed English Morello and Montmorency juices with appropriate amounts of 18 or 15 percent sugar sirup. Juice from cannery pitters was too dilute to make a palatable beverage, although it could be used in blends with cold-pressed juice, or after clarification, in jelly making. Clarified cold-pressed Montmorency juice and blends of clarified cold-pressed and hot-pressed Montmorency juices made excellent jellies.

The New York (State) station has designed a simple, inexpensive flash pasteurizer which may be constructed for about $15 on the farm and used for canning apple juice. It is absolutely necessary to use sound fruit of proper maturity and variety. Overmature, undermature, and soft-ripe fruit does not give good-quality juice, it was found, nor can apples be used that have been in storage or on the ground for even a few days. The method therefore gives an outlet for surplus crops but not for cull apples. Tart apples give a better quality of juice than some of the better grades of earlier apples. McIntosh juice, in particular, must be blended with juice from tart apples.

Deterioration and consequent undesirable changes in bottled and canned fruit juices were traced, in studies at the Massachusetts station, to oxygen (air) in the head space and dissolved in the bottled juice. This oxygen disappeared in 15 to 40 days, depending upon storage temperature, as a result of combining with vitamin C present in the juice. Not only was there a loss in nutritive value due to the destruction of the vitamin, but, in addition, undesirable color and flavor changes in the beverage developed which were hastened by heat and light. These findings would suggest the storage of fruit juices in a cool dark place. Since deaeration of fruit juices previous to bottling or canning resulted in marked improvement in quality and ascorbic acid content, this procedure is to be recommended where possible.

Jelly making and preserving.—Results obtained at the Massachusetts station confirmed earlier findings indicating that corn sugar can be used successfully to replace sucrose (cane and beet sugar) to the extent of 20 to 40 percent in most cooked fruits, jellies, jams, preserves, fruit butters, fruit sirups, and sweet pickles. The dextrose, or corn sugar, it appears, is more effective in juices and sirups than is sucrose in inhibiting the growth of bacteria, yeasts, and molds, and this action is effective even in mixtures of dextrose and sucrose. It has been determined in these studies that fruit preserves and jellies containing 50 percent of dextrose should be "finished" at a temperature approximately 2° F. higher than when sucrose is used as the only sugar.

Sweetose, a high-conversion corn sirup, which has been used alone or in combination with sucrose in the making of many fruit jellies, jams, and butters at the New York (State) station, has been found to be as satisfactory as sucrose in effecting jellying. No crystallization of dextrose occurred during storage of the products prepared experimentally, and these products were found to have very smooth texture, excellent spreading qualities, and a pronounced fruity flavor. Jams and preserves made with straight Sweetose or blends of Sweetose and sucrose possessed a very high gloss.

Drying.—Certain dried fruits have a well-established place in our food supply, since they are well adapted to storage and ready transportation and serve as products to which fresh fruit surpluses may be readily converted. Drying or dehydration of vegetables has not been extensively practiced because of difficulties in preparing satisfactory products adaptable to practical use.

To extend the use of prunes, the Oregon station has developed a simple machine which produces dried prune halves. These are dried at lower temperatures and in about one-third the time needed for drying whole prunes, with the result that there is practically no caramelization of sugars and the natural reddish color is retained. The station has also developed a practical process for making prune pulp from both fresh and dried prunes. This pulp has many possibilities in the baking field and is suitable for use in other foods.

A successful process for dehydrating the Porto Rico sweetpotato without its turning dark was developed by the South Carolina station. This dehydrating process results in a sweetpotato flour of yellow-orange color that is palatable, high in provitamin A, adaptable in recipes as a substitute for raw sweetpotatoes, and is capable of indefinite storage without molding or similar spoilage, and does not cake upon exposure to humid atmospheres.

PREPARATION

Problems in meat cookery, bread making, and high-altitude cake baking continued to receive attention at several experiment stations.

Meat.—From tests conducted on the rate of heat penetration in cured hams cooked by methods recommended on the labels, Illinois station investigators concluded that the hams reached a temperature high enough to remove danger of trichina poisoning. Although the methods recommended differed somewhat, all permitted the temperature in whole or half hams to go safely beyond 137° F., a temperature which will kill the organism. Danger from the parasite might exist, however, if the housewife failed to give the ham the necessary amount of cooking, as the meat would test tender long before it reached the recommended degree of temperature. A warning on this point is considered timely in the case of hams smoked in cold-storage locker plants where the inside temperature reached by the ham during smoking might be even lower than in the large meat-packing concerns. In further work on the heat penetration of meats, it was found that the temperature of lean muscle tissue rose faster than that of the connective or fatty tissues. After the fat had melted, however, its rise in temperature corresponded with that of the lean. These differences in rate of heat penetration of different types of tissue may serve to explain irregularities in the degree of doneness of large roasts.

The effect of an extremely low oven temperature on the tenderness of meat was observed in comparative tests made at the Texas station. Bottom-round roasts containing a large amount of coarse connective tissue were cooked in ventilated ovens regulated at 176° and 257° F., without adding water or covering the cooking utensil. The roasts cooked at the lower temperature required about 30 hours to become well done, an average of about 23 hours longer than their pair mates, but gave higher scores for tenderness. While it would be impractical to extend the cooking time of any meat to 30 hours, the results of this

study confirm the belief expressed in earlier contributions from the station that the time of cooking is the most important factor in making tough cuts of meat tender.

Experiments carried out by the Wyoming station have been concerned with the development of good formulas for home-made bread with white and whole-wheat flour. Wyoming hard-wheat flour was found to have excellent gluten properties and to yield bread of good quality when fermented and baked under standard conditions. Of the leavenings used, more consistent results were secured with quick-acting yeasts than with the dry cakes in which preliminary sponges or ferments were used. Both dry and compressed yeasts stored in air-tight containers kept their leavening power over a long period when stored in the low-temperature compartment of a mechanical refrigerator. This was in contrast to the quick loss of leavening power at room temperature or even at ordinary ice-box temperatures, and indicates that with the increased use of mechanical refrigeration rural homes can store and make use of compressed yeast, which formerly had been available only to the city woman who could have it delivered fresh daily.

Cake.—The altitude laboratory of the Colorado station has continued with the studies of controlled cake making, and formulas and directions for mixing and baking yellow egg sponge cakes at different altitudes have been developed. It has been possible to maintain the sugar requirement of these sponge cake formulas constant over an altitude range from 0 to 12,000 feet. The balanced formulas for each altitude given are adapted for use with hand equipment, small mechanical mixing equipment, and larger equipment of the commercial type. The reason for the difficulty often experienced in the use of sponge cake recipes adjusted for altitude is that the leavening, air, is added almost by chance as it is whipped into the meringue. In the technique developed, the amount of air is controlled by improved methods of mixing, with alterations only in the quantity of flour and liquid.

Work has also been continued on foundation butter-type cakes, and formulas and directions for mixing have been presented for different altitudes for whole-egg cakes of normal and high sugar ratio. A suitable modification of the single-stage method of mixing served to overcome difficulties arising from the use of ordinary hydrogenated shortening in the preparation of whole-egg butter-type cakes high in sugar. A basic whole-egg cake formula lean in sugar, eggs, liquid, and shortening was rebalanced stepwise with small additions of sugar, egg solids, shortening, and liquid. Based on these findings, a scheme has been prepared which permits the formulation of an indefinite number of whole-egg butter-type cake formulas for any altitude up to 10,000 feet. These guides to successful cake baking point also to economical production and should prove most useful to the housewife or the commercial bakery operating at any altitude.

TEXTILES

Durability and satisfactory performance during wear are two factors which, among others, are of particular importance to one charged with the responsibility of selecting household textiles or fabrics for wearing apparel whether these be in the piece or in ready-made articles. In view of this, several reaserch projects have been

directed toward studying fabric qualities in relation to performance in actual wear.

Flannel fabrics manufactured from different grades of wool fiber are being studied at the South Dakota station. Four fabrics of known history and composed of different percentages of virgin and reworked wool are being used. Rambouillet wool from the station was used as the source of virgin wool, and clippings from pastel wool sweaters were used as a source of reworked wool. As the first step in the study the physical characteristics of the virgin and reworked wool fibers were determined. Then the physical characters of the fabrics themselves were studied, using the fabrics as woven and after dry-cleaning and pressing for 15, 30, and 45 times. These steps are preliminary to the actual wearing tests of the fabrics, which have been made up into skirts and are being worn by college girls for a definite period of time under controlled conditions.

Although the relationship between quality and properties is recognized in certain types of fabrics, accurate information is often not available as a buying guide at the time of purchase. In a study at the Oklahoma Agricultural and Mechanical College 36 percales at various price levels ranging from 8 to 25 cents a yard were purchased from 7 stores and 2 mail-order houses. Little information about the various samples could be obtained at the time of purchase except as to number of yarns per inch and fastness of color to washing. Laboratory tests showed that percales with the greater number of yarns per inch had the greater weight per square yard, a higher breaking strength in both directions, and a greater elongation in the filling direction. Correct statements as to yarn count would thus be helpful in the selection, but the sales information available sometimes overestimated and sometimes underestimated the count found in actual tests. Guaranties as to fastness of color to washing were not specific, and it was found in actual tests that although all percales withstood the test for ordinary laundering, only 24 were fast to washing with a bleach. In fastness to light the percales were much less satisfactory than in fastness to washing. The amount of sizing varied from 1 to 18 percent. On the whole the lower-priced percales had a much greater amount of sizing, although wide differences were found within a price group. Shrinkage in the warp varied from 1 to 2 inches per yard and in the filling from about 0 to 2 inches per yard. From this study it is concluded that the consumer may expect to find a wide range in grade of percale at the same price and to receive little sales information that will help her to make a wise selection.

Various viscose, cuprammonium, and cellulose acetate rayons were tested at the Kansas station to determine the effect of light and heat on their service qualities. Light, it was found, did not change the color nor greatly decrease the breaking strength of any of the rayons, but heat decreased considerably their breaking strength and changed the color of all of them, although the change in color was less for the cellulose acetate rayons. Greater changes found in breaking strength and in certain chemical tests indicated that the viscose and cuprammonium rayon fabrics were deteriorated more by heat than were the cellulose acetate rayons.

309632—41——15

In answer to some of the home-laundering problems in Montana, the experiment station of that State made a study of the comparative qualities of soap and nonsoap detergents for the laundering of wool in hard and soft water. For all-wool fabrics the nonsoap detergents in either hard or soft water proved to be more efficient than soap as cleansing agents. For part-wool fabrics soap seemed to be the better.

THE HOUSE AND ITS EQUIPMENT

House-planning ideas of rural women.—To get a picture of the preferences of rural homemakers concerning items that must be considered in house plans, the Oregon station submitted to a large number of women throughout the State a check list of about 15 items covering various features of a dwelling with an introductory question, "If you were planning to build what kind of a house would you want?" Replies were received from 450 women, 60 percent of whom lived on farms and 40 percent in villages, in suburban districts, and on acreages.

One-story and two-story houses were about equally favored in the State as a whole, but regardless of the number of floors specified 4 out of 5 women desired a basement, the checked uses of which included laundry, canning, a feeding place for crews of farm workers, and storage. Relatively large living rooms and bedrooms were desired, with greatest preference in dimensions for 15 by 20 feet for the living room and 12 by 14 feet for the bedroom. The kitchen should be large enough to serve family meals comfortably, for 5 out of 6 women specified provision for meal service in the kitchen even when other dining areas were checked for frequent or occasional use. For the four-room house opinion was about equally divided as to whether the dining area should be in the kitchen or living room, and for the five-room house as many favored the dining area in the living room as those favoring a separate dining room. At least one bedroom on the first floor was preferred by 99 percent of the homemakers, and a second by a number with young children. Facilities for outdoor living, such as living, dining, and sleeping porches, were considered as either necessary or highly desirable by about 3 out of 4, and a fireplace in the living room, even when it is not the main source of heat, by more than 3 out of 4 of the women.

The high value placed on this feature of the home emphasizes the desirability of a study to determine possibilities for cutting construction costs. It also suggests the desirability of teaching rural men and boys how to build fireplaces for their own homes, as a means of bringing the costs of this feature down to a sum which permits its inclusion in low-cost houses as well as in more expensive ones.

The bulletin [5] in which the results of this study are reported in full contains a copy of the questionnaire, which in itself would be of help in house planning through calling attention to items not always remembered until too late, and 16 descriptive house plans varying in probable cost of construction from plan 1 of a one-story house without basement to plan 16 of a two-story house with basement and porch.

The cost of rural housing.—Arkansas rural families have received valuable house-planning assistance from the station, not only

[5] WILSON, M., and WELLS, L. HOUSE PLANNING IDEAS OF OREGON RURAL WOMEN. Oreg. Agr. Expt. Sta. Bul. 369, 28 pp. 1940.

in workable house plans available without cost, but also in advice and encouragement in making use of home labor and native or local materials. In new houses built from plans supplied by the college 30 typical records showed that an average cash value of $1,630 involved average cash and noncash expenditures of $790 and $840, respectively. These houses had an average area of 1,062 square feet, representing a unit cost value of $1.53 a square foot.

Floor finishes.—A study of inexpensive floor finishes that can be applied by home labor constituted a part of the Arkansas cost-reduction studies noted above. A new pine floor was given various finishing treatments and subjected to use for 3 years with regular observations on durability, appearance, and ease of cleaning of the various finishes applied. As a result of these observations it was concluded that various low-cost and home-made finishes are of little value unless protected by a surface coating of floor wax, and that home-mixed stains applied to obtain the desired color, if followed by waxing, afford the lowest-cost desirable finish. If a varnish finish is desired, a stain, two coats of standard transparent varnish, and wax should be used.

Tests of the serviceability of various commercial floor finishes, particularly water-emulsion waxes, are being continued by the Rhode Island station. The accelerated wear test machine devised at the station has been further improved and a technique developed for measuring the wearability of a finish by the number of impact blows from the test machine it can withstand before a certain degree of wear is reached. The project has aroused the interest of the State purchasing department, which has been given information on water-emulsion types of wax, and of various manufacturers who have submitted samples for testing and are making an effort to produce a product meeting the Rhode Island standard.

Floor waxes are also receiving attention in a study by the New York (Cornell) station of the most satisfactory methods of maintaining felt-base floor coverings in home kitchens. This study includes objective tests by a sand-abrasion device constructed at the station and records kept by homemakers of the performance of different finishes in actual use in the home. In the early returns the water-emulsion-type wax ranked first in ease of application, appearance, and care; the paste wax in cost and (in general) in wear. The liquid spirit-solvent wax took less time to apply than the paste wax but was more expensive.

Utensils for the farm kitchen.—The contributions of the Oregon station to kitchen planning reviewed in the report for 1939 have been extended to a circular [6] giving information on utensils considered adequate for the preparation, serving, and clearing away of meals in farm kitchens in western Oregon where there is a sink with running water, a wood range is used, bread is usually made, and cooking is regularly done for 4 to 6, and occasionally for as many as 12, persons. The circular is of general usefulness not only in fitting out a new kitchen but also in replacing old utensils and discarding useless ones in an old kitchen.

Wood ranges heated by oil burners.—The most recent type of kitchen range to receive attention in station research is the wood range

[6] WILSON, M., and MCCULLOUGH, H. E. A SET OF UTENSILS FOR THE FARM KITCHEN. Oreg. Agr. Expt. Sta. Cir. 134, 31 pp. 1940.

in which oil burners have been installed. In efficiency tests on one of these ranges at the Maine station it required an hour or longer to heat the oven from room temperature to 450° F., and 520° was the highest temperature it was possible to get with the flames from both burners at the highest position and with oven damper closed and check and ashpit dampers half closed. With only one flame operated at the lowest recommended position 237° was the lowest temperature that could be obtained. The heating of 5 pounds of water from 68° to 194° in covered cast-aluminum saucepans took 30 minutes when the heating was begun with the lighting of the burners and 15 minutes when the stove was at a steady temperature with both burner valves at the highest operating position. No time was saved when the pan containing the large quantity of water was placed directly over the flame (stove lid removed) as soon as it was lighted, and it actually took more time to heat the water over the free flame than on the lid with the stove already hot.

With an oil-burner range, regulation of the dampers is of importance. Oven temperatures were increased 20° to 50° in the Maine study by partially closing the check, ashpit, or pipe dampers when the oven damper was already closed. When either the ashpit or check damper was partly closed the back stove lid became hotter than the front lid. Higher top-of-the-stove temperatures, as well as oven temperatures, were obtained by keeping the oven door closed.

Electric roasters.—A bulletin [7] of the Virginia station gives the results of a study of electric roasters noted in the 1939 report as in progress and lists a number of ways in which this piece of electric equipment can be of great service to the farm housewife.

There were no marked differences in performance among the six makes of roasters tested, of which one was a 1939 model and the others 1938. Shape and size seem to be the more important items to consider in selection. The small oval roasters tested were found to use somewhat less electricity to operate, but the larger size rectangular models were better suited to the use of standard baking pans and cooking vessels and of course would be more satisfactory for a large family. All of the roasters had the disadvantage of requiring quite a long time to preheat. Particular attention was given in bread, cake, and pastry tests to the best location in the roaster. In the larger roasters provided with two racks, products baked on the bottom rack usually scored higher than those on the upper rack, where the heat was less and more uneven. The cooking of vegetables and the roasting of meat appeared to be slightly more successful than the baking of cakes and pastries when the products were compared with similar ones cooked in the regular way. Broiling was quite successful in all the roasters provided with the necessary broiling equipment.

The Virginia workers concluded that in the farm home the electric roaster is useful in supplementing the regular range when the latter is taxed to capacity, and in serving as a temporary substitute for it in preparing lighter meals in hot weather. Moreover, because of its low wattage and wiring requirements (it can be plugged into the ordinary circuit) the roaster offers a convenient and relatively inexpensive means of getting started in electric cooking at a much lower investment for some who cannot yet afford the electric range.

[7] POTTER, P. B., and NEALE, E. C. A STUDY OF ELECTRIC ROASTERS. Va. Agr. Expt. Sta. Bul. 325, 30 pp. 1940.

FAMILY INCOME AND CONSUMPTION PATTERNS

Information on the size of family incomes, who earns them, the size and composition of the families dependent on the earnings, the kind of services and commodities for which families spend their money, the variation of income and expenditures with the location of families and the occupations of contributors, economies in buying practices, relative economy of home-produced and commercially produced goods, satisfaction for money expended, and adequacy of goods purchased can be of interest and of use to those who plan, those who educate, and those who carry out the plans for meeting existing inadequacies in family living or toward adjusting to changing conditions. All of these points have been touched upon in the assembled work as reported by the various experiment stations within the past year.

Income and expenditure patterns.—Analyses by the respective stations of farm-family incomes and expenditures of representative families in Iowa, Mississippi, and Arkansas gave a picture of rather similar spending patterns. The total value of living of the 160 Iowa families averaged $1,605 ($669 to $2,789), about one-third of this being provided by fuel and food and house rent from the farm, the balance, averaging $1,093, representing cash expenditure. Food expenditure was the largest single cash item in the family living, even though one-half of the total food was farm-furnished. The automobile was next in importance, except for large families and those in the highest income group; for these clothing ranked second.

For the 65 white farm families included in the Mississippi study, total incomes averaged $1,063, of which $485 was nonmoney income. The average cash expenditures for family living amounted to $370, three-fourths of the families spending less than $500. Food produced on the farm and used by the family averaged $362, yet purchased food was the largest item of expense for families of five or more members. Families with smaller incomes spent relatively more for food and clothing, while those with higher incomes spent more for home furnishings and equipment, recreation, and automobile.

Analysis of home account books of 132 Arkansas farm families indicated an average expense for living (for 1937) of $468, with food and clothing as the most important items in the lower-income groups. In the higher-income group, however, relatively more was spent on the automobile and housing.

Urban studies reported in the past year were concerned with incomes and expenditures of 299 Vermont village families, and with the economic status of 436 families of Missouri clerical workers and wage earners. Among the Vermont families annual net cash incomes ranged from $123 to $4,829, averaging $1,493, with an additional average of $124 worth of goods. The cash living expenditures ranged from an average of $455 for families with incomes under $500 to $2,728 for those with incomes ranging from $2,500 to $5,000, with an average for all families of $1,461. The percentage expenditures for food decreased from 48 for those with cash incomes under $500 to 25 for those receiving $2,500 to $5,000, and averaged 30 percent of the total expenditure. The average values for the other items constituting family living were household operations 14, housing 13, automobile 11, clothing 8, medical care and recreation each 4, furniture and gifts each 3, personal care

and tobacco each 2, reading matter, education, taxes, and miscellany each 1 percent.

In the Missouri group total net incomes ranged from $330 to $4,769, averaging $1,600. Twenty-eight percent of the families had incomes less than $1,000 and 52 percent had less than $1,500. About 95 percent of the total income for family living was money income and included occupational earnings of all family members, money from boarders and roomers, and from miscellaneous sources. Rather definite spending patterns were apparent, although spending practices varied somewhat from family to family, depending on such factors as location of the family, the occupation of the main breadwinner, size and composition of the family, and, most of all, the size of the money income. The total expenditure averaged $1,338, almost one-third of this being spent for food, slightly less than one-third for shelter, and one-tenth each for clothing and automobile expenses.

These studies suggest certain practical measures for future planning of family welfare. The implications are discussed at length in the report of the Missouri study, where it is pointed out that plans for the future welfare of families must be made within the limits of their particular incomes. Supplementing small incomes with nonmoney income through the wise use of home skills and energy and through generous and well-planned home-production programs that will safeguard diets thus becomes important. A study of levels of living in the industrial, farm, and part-time families in rural Mississippi points also to the desirability of supplementing farm income in poor areas by part-time industrial employment where this is possible. The part-time group in this Mississippi study was found to be better off, since it had a larger cash income than the farm group and an advantage over the industrial group in a generous supply of home-produced food. Future plans, it is further indicated by the Missouri station, must give special attention to the larger families where increase in income is seldom commensurate with increase in size, must recognize that expense for food is the most important item at all low-income levels, that household operation is not a minor item and should be studied for effective expenditures, and that goods received should give the maximum of satisfaction for the money expended, this being a particular problem in the matter of clothing. The necessity for evaluating expenditures for different groups of commodities and services and the necessity of budgeting effectively and purchasing wisely and with a knowledge of qualities in goods that make them suit their purpose become very important when incomes are low. Surveys and studies bearing particularly on one or another of these special problems have been conducted at a number of the stations.

Relative economy of home and commercially produced goods.—A survey was made by the Nebraska station of the baking habits of 1,300 women, of whom 68 percent lived on farms, with detailed records from 76 of these women (in areas representing different agricultural practices) on amounts and costs of ingredients and fuels, production time, and kinds, amounts, and costs of bread purchased over a 2-week period. Information as to ingredients was also obtained from commercial bakers. Finally, as a check on the information secured in the home, breads were prepared and baked in the laboratory by a standardized procedure adaptable to home use and

with a number of fuels. The savings possible to the Nebraska homemaker in baking bread rather than buying it were calculated in various ways. For white-loaf bread the savings ranged from 2.56 to 5.9 cents per pound; for whole-wheat bread the savings were similar but somewhat lower. The cost of rolls, both home-made and purchased, varied widely, depending on the ingredients. Information from commercial bakers showed that the ingredients they used were not inferior and frequently superior in nutritive quality to those in home-produced bread. It is concluded that household production of bread is a sound economic practice, and that economic necessity, market value of the time of the homemaker, family preference, and availability of commercial products are factors in considering home-produced versus commercial bread.

The relative economy of household production and purchase of canned tomatoes, green snap beans, peas, and greens was estimated from data obtained in a study at the Vermont station. Detailed canning records as to cost and spoilage were obtained from about 60 homemakers, and a total of 115 cans of vegetables were graded. The home-canned products were compared as to cost and quality with the corresponding commercially canned vegetables representative of the brands sold locally, at the low, medium, and high price range. The commercial brands on the whole scored higher than the home-canned goods in flavor, tenderness, and stage of maturity. Low flavor scores in the home-canned products were largely due to the use of overripe and underripe vegetables. Estimates for No. 2 cans, calculated to cost per pound, showed average costs for home-canned (quart jars) and commercially canned products of 22.24 and 16.33 cents, respectively, for peas, 6.21 and 19.54 cents for snap beans, 14.82 and 13.49 cents for greens (spinach), and 2.83 and 7.98 cents for tomatoes. The general conclusion drawn is that the home canning of tomatoes and beans was a profitable operation for the Vermont homemaker, while the canning of greens and peas was unprofitable.

Price in relation to quality of canned goods.—At the Ohio station, in cooperation with the Ohio Canners' Association, No. 2 cans of Ohio-packed corn and tomatoes, representing numerous brands and packs, were purchased on the open market, coded, and graded for quality score. Wide variations in price were found, with corn varying from 5.5 to 15 cents, and averaging 6.52 cents a can in corporate chain stores and 9.87 cents in independent stores. Tomatoes varied from 5.5 to 14 cents, averaging 6.36 and 9.77 cents in chain and independent stores, respectively. The quality scores also varied widely, with considerable differences between poorest and best samples packed by certain packers even under the same label, and with no appreciable difference between the average scores of samples bought in chain and independent stores. Price alone was wholly unreliable as an index for both corn and tomatoes. With tomatoes, for example, it was found that the five samples scoring highest as to quality sold at an average price of 7.75 cents, while the five poorest sold at an average price of 8.25 cents.

This lack of relationship between quality and price was borne out by findings at the Indiana station on canned tomatoes sold in Indiana. While 10 percent of the samples purchased in chain and independent stores were sold as Fancy, only 2 percent were so graded and while none was sold as substandard, 4 percent were of that grade.

Of the 5,500 cans of tomatoes purchased in 5 years only 2 percent were graded as Fancy (and 4 percent substandard), so that regardless of the price paid by the consumer the chance of getting a can of Fancy tomatoes was very small. From these studies it appears that fully informative labeling is needed for economy and satisfaction in buying canned goods.

Consumer demand for fresh and evaporated milk.—Preliminary results of a survey of the total use of evaporated and fresh milk by about 1,000 families in Johnstown, Pa., have been published by the Pennsylvania station. The survey indicates that for drinking purposes, without the addition of flavors, evaporated milk seems to offer little competition with fresh milk, but that low-income families substitute evaporated milk for fresh milk in cocoa, half-and-half coffee, and similar beverages. As estimated for all the Johnstown families interviewed, about one-tenth of the milk used on dessert and cereals, and slightly more than half of that used for cooking and baking purposes, was evaporated milk; in the families with low incomes these ratios were about one-fifth and two-thirds, respectively.

Food-consumption surveys.—Surveys to determine the amounts of food products produced, purchased, and consumed have been conducted by a number of stations. The findings interpreted in the light of nutritional adequacy of the diets of families in the areas studied illustrate the relationship that often exists between nutritional status and economic condition, and point to the need for education in sound use of the food dollar and supplementation where possible by home production.

In Alabama, for example, an analysis of farm records of production, purchase, sale, and use of specified foods indicated that the value per person of foods produced and consumed by white farmers (other than croppers) in selected counties was about $64 for Baldwin, $82 for Jefferson, and $89 for Pickens. Areas having more satisfactory markets tended to produce less for home consumption. The diets of these farm people were more than adequate in foods high in carbohydrates and less than adequate in foods rich in protein. Vegetables for supplying vitamins and minerals were usually produced in sufficient quantities, but the seasonal distribution was not satisfactory. In South Carolina, information obtained in the Piedmont and in the Coastal Plains areas on the weekly per capita consumption of foods in diets having various money values indicated that diets of farm families in all sections of the State could be greatly improved in nutritive value by increased use of fruits and vegetables, and that Coastal Plains families should place more emphasis on milk and less on lean meats.

A food-consumption study of urban and rural sections of Puerto Rico showed variations in consumption patterns with various agricultural areas (coffee, tobacco, sugarcane districts) and with the availability of imports. One-third of the rural families studied did not raise any food crops. The survey indicated further that under normal conditions the island does not produce more than one-half of the food consumed by its population, and that the great fault of Puerto Rican diets is the lack of protein. The survey points to the need for growing more vegetables and food crops and the production of more livestock to permit of greater consumption of milk and meat.

In Hawaii the diets of 104 independent farmer families were found

on the average to be adequate in calories, protein, phosphorus, iron, and vitamin G, but to be deficient (sometimes seriously so) in calcium and vitamins A and B. The diets of relief families in Honolulu indicated a real need for education in budgeting the family food dollar.

Biophotometer measurements as an index of vitamin A status were made by workers at the Pennsylvania station as part of a study on the nutritional status of 100 families of widely varying cash incomes and educational ratings. Cash incomes, money spent for food, and the education of the adult members of the family were shown to be related to the vitamin A consumption of the family. The study showed that many families, particularly in the lower economic groups, were not selecting foods with a satisfactorily high vitamin A content.

Clothing consumption.—Analysis of clothing expenditures was made for 299 village and 551 farm families in Vermont, interviewed in 1935 and 1936. Clothing inventories of farm families in 36 counties in Arkansas were also obtained. These studies show rather similar spending patterns in the proportion of total outlay spent for certain items of clothing, with footwear, underwear, coats and wraps, and outer garments accounting for about 85 percent of the total in each case. The results of the Vermont study showed that the village and farm families spent, on clothing, 8 and 11 percent, respectively, of their total monetary outlays for family living. Clothing costs increased with rising levels of cash income and with increasing numbers in the family, and the women spent but little more than did the men. In the Arkansas families the outlay for men's clothing was slightly more than for women's. The greatest percentage of the total clothing expenditure was for outergarments, being 33 and 37 percent in the Vermont and Arkansas surveys, respectively; respective percentages for other items were approximately 20 and 15.3 for shoes, 16.6 and 12.5 for underwear, and 16.6 and 20.5 for coats and wraps. In both studies it was found that relatively little was spent for headwear, accessories, and other small items, and that expenditures per person for clothing of all sorts tended to increase with the age of the consumer up to adult years.

FAMILY RELATIONSHIPS

No less important than the tangible resources of the family to meet the difficult situations which may be confronted in the near future are the intangible ones such as the character and morale of the family members, particularly the younger ones who may be drafted to serve the country in one way or another in the defense program. This makes of particular significance the Nebraska study of personality development in farm, small-town, and city children (noted in the 1939 report) in which high-school students served as subjects. The data obtained in this study have yielded further information of value to those concerned with family-life problems. Certain characteristic family-life patterns were found to be common to family, town, and city settings—some favorable and others unfavorable to the best development of the children in the homes represented by the different patterns. At one extreme was a pattern characterized by confidence, affection, and companionability, and at the other a family-discord pattern. The

children of homes of the first pattern were among those who had been characterized in the earlier report as having a favorable attitude toward home life and adequate adjustment to life in general, while the opposite was true of children from the family-discord setting.

As a supplement to the information obtained from the high-school students, an attempt was made to obtain data concerning the attitudes of their parents toward certain items concerned with the family development of the children, specifically their attitude toward self-reliance in children and toward the question of adolescent freedom versus parental control. Analyses of replies received in response to questionnaires sent to the parents showed certain significant tendencies concerning attitude toward self-reliance on the part of the child. The results as a whole furnished no evidence of differences between fathers in general and mothers in general, or between parents on farms, in small towns, or in the city. The attitude of parents toward the question of parental control was not to any significant degree related to sex but appeared to be somewhat related to age, with the older parents showing a greater tendency toward attitudes favoring control. Farm parents were inclined to favor the greatest degree of parental control, while city parents favored granting the most freedom to their adolescent children.

A comparison of the parents' attitude with the personality scores of the children showed a very slight tendency for attitude toward self-reliance in mothers to be associated with the development in their children of two types of self-reliance—independence of judgment in personal problems and resourcefulness in the group situation. A relationship was also indicated between this parental attitude of mothers and adequacy of personal adjustment, and between this attitude in fathers and appreciation of home life in children. A home situation in which both parents agreed that high-school children should be granted considerable freedom from parental domination appears to be favorable to the development of self-reliance as shown by independence of judgment in regard to personal problems and difficulties. For the development of this particular trait the city-home situation was the most favorable and the farm-home situation the least favorable of the three studied.

RURAL SOCIAL SCIENCE

CONTENTS

Planning for better land use and the enrichment of rural home and community life is the common objective of all agricultural research, both natural science and social. The emphasis placed upon the tech-

nical phases of soil conservation, crop adjustment, and other improvements in land use is reflected in the research currently reported in agricultural economics and rural sociology at the State experiment stations. The concept of planning, broadened to include the economic and sociological as well as the technical phases, calls for the results of previous research in such fields as farm management, marketing, costs, taxation, tenure, and credit and for new types of research concerning, for example, the alternative uses of land, the diet and health of the rural family, and a diversity of short-term, or service, research helpful in planning for better rural conditions. Other phases of economic and social study now demanding attention are population problems including its migration and distribution, rural education, transportation facilities, and the rural family and its consumption requirements in terms of food, clothing and shelter, and a satisfactory home and community life.

Much of the research of the stations during the year, as in the past, was done in cooperation with the Bureau of Agricultural Economics, the Soil Conservation Service, the Bureau of Plant Industry, the Forest Service, and other bureaus and agencies of this and other departments of the Government. The following items have been selected to illustrate the lines of investigation undertaken by the stations in agricultural economics and rural sociology and some of the findings.

AGRICULTURAL ECONOMICS

SOIL CONSERVATION AND GOVERNMENT PROGRAMS

Soil conservation.—From a study made in cooperation with the Department (B.A.E., S.C.S., and A.A.A.) in seven areas representative of the wheat-growing region of Washington to determine the status of the soil, seriousness of erosion, present land use patterns and farming systems and practices and to provide data for suggestions as to desirable changes to promote soil conservation and provide a maximum long-time income, the Washington station predicted that—

> Once a new equilibrium is established, there will be among other things, less land in tilled crops, less wheat, more forage crops, an increase in livestock, a shift of low-yielding wheat land to range land, new ranch units, an increase in the size of the small wheat farms in the dry sections, and a possible decrease in the size of the extremely large farms in the humid sections. All of these changes should operate to conserve the soil and to improve the welfare of the farmers of the wheat region.

Of 696 farms in different sections of Ohio, 15 percent were found by the Ohio station, cooperating with the Department (B.A.E. and S.C.S.), to have a zero or plus soil-productivity balance. On the farms in balance the percentage of rotated cropland in soil-depleting crops was less than the average, the relative amounts of alfalfa and clover, compared with timothy, and the amount of manure used were higher, crop yields were higher, numbers of livestock greater, and the amount of hay fed per roughage-consuming animal unit greater. As the productivity balance approached or exceeded zero, labor income per farm and per 100 rotated acres increased. While the farms in balance had less land in corn and sold less corn and other feed crops, they produced nearly the same volume as the out-of-balance farms because of higher yields. The production of high-quality hay was found to be of particular importance in bringing farms into soil-productivity balance. Inadequate buildings, small-size businesses, lack of capital,

tenancy problems, and age of operators were obstacles to desirable shifts in farm organization and practices needed to increase soil productivity. The station in cooperation with the Department (B.A.E.) also studied the effects of conservation practices adopted from 1934 to 1938 on 35 demonstration farms in the Salt Creek Watershed, Zanesville, Ohio, and found that the calculated productivity balance of croplands increased from −1 percent to 0 on the farms where soil-depleting crops were reduced and conserving crops increased and from −0.5 percent to 0 on the farms where both types of crops were increased, but remained at −0.6 where both types of crops were decreased. The study indicated that when the conservation program is in full operation, the net income of the first class of farms should remain fairly constant, that of the second class should increase, and that of the third class probably decrease.

Government programs.—From a survey of 195 farms in the Sandy Creek soil conservation demonstration area in 1933 and 157 of the same farms in 1937, the Georgia station found that there was no greater reduction of the cotton acreage under the crop-reduction program on steeply sloping farms than on gently rolling farms. There was an increase in the acreages of close-growing crops, especially on the least sloping farms. On the farms included in both surveys the percentage of land in winter legumes increased from 0.1 to 10.2, that in cowpeas alone from 9.8 to 17.3, and that in cowpeas interplanted with corn from 0.8 to 15.1. There was a slight decrease in livestock production. In a study in Toombs County the same station found that reductions in 1935 in cotton acreage from the base period were 42, 37, and 40 percent, respectively, on family cotton farms (less than 30 acres in crops) with low, medium, and high yields and the reduction in tobacco 19 percent on tobacco farms. On combination farms with a moderate tobacco-cotton acreage ratio the reductions were 44 percent for cotton and 30 percent for tobacco, while on farms with a high ratio they were 38 and 9 percent. On large farms (30 acres or more cropped) the cotton reductions were 49, 45, and 52 percent, respectively, on the cotton farms with low, medium, and high yields. On tobacco farms the reduction of tobacco was 16 percent. On combination farms the reduction in cotton acreages varied from 42 percent for those with a low cotton-tobacco ratio and high cotton yields to 53 percent where the ratio was high and the cotton yields low.

Studies by the Illinois station in cooperation with the Department (S.C.S. and B.A.E.) showed that 19 cooperators in the soil conservation program in Madison County increased their acreage of soil-building legumes 46 percent, that their crop yields were 14 percent higher, and that their farm incomes, allowing for price changes, increased from $859 to $1,228 per farm. A comparison of 30 cooperating and 30 comparable noncooperating farms in McLean County showed that the cooperators had 18 percent better crop yields and livestock returns and 67 percent higher net incomes. The net income per acre of the cooperating farms exceeded that of noncooperating farms by $1.49 in 1935 and $2.50 in 1938.

The Kansas station found that farmers in Nemaha County who followed agricultural conservation program practices had larger incomes, exclusive of payments, than did noncooperators. The Oklahoma station reported that farmers who have adopted a program designed to conserve soil and water are not operating at an economic disadvantage

as compared with those using soil-depleting systems of farming. A study by the West Virginia station showed that in Upshur County, where an agricultural conservation program was approved in 1938, there were 2,312 units of pasture improvement in 1938 and 5,797 in 1939, as compared with practically none in 1937. A random survey in 1939 of 601 farms in Upshur and 3 adjoining counties showed that some pasture-improvement work was being done on over 25 percent of the farms, 64 using limestone alone, 61 superphosphate alone, and 37 both. The first 3 years of a 5-year study by the New Mexico station of 50 ranches have shown that small ranches and those owning most of their grazing lands are having difficulty in earning anything on their investments and that they need more encouragement to reduce their grazing land and use other conservation methods.

A study in three townships representative of the most productive, intermediate, and least productive areas of the State led to a statement by the Iowa station that—

> In view of our limited inventory data, if the national program continues to have the two objectives—price maintenance through controlled production and conservation of the soil—ways and means must be found to permit the local committees to set up the detailed procedure for accomplishing the conservation goals. Local farmers are the only ones who have sufficient knowledge of their resources and how they are being used to be able to work out a procedure adapted to the variety of conditions encountered. (But they will probably need technical assistance.) Such a plan would increase administrative expenses. To offset this, however, less money would be paid to farmers for adjustments not desired or for legal compliance with the program even though no benefits to either the individual or the Nation resulted.

And further—

> Studies of farm organization and management might be improved in many cases by putting more emphasis on adequate sampling of farms with similar resources rather than the sampling of geographic areas. Adjacent geographic location simply does not assure similarity of productive resources, which is so often assumed in these studies.

In cooperation with the Department (B.A.E.) the Ohio station studied the results in 1939 of the station's experimental agricultural conservation program in Licking County, which was in its third year, as compared with the regular regional program in 6 adjoining counties. The experimental program is based on the method of measuring soil improvement or deterioration developed by the station and the Ohio State University, and the payments to farmers are determined by the productivity balance of each farm for the year independent of the change from the preceding year and on the amount of improvement in the balance from the preceding year. In 1939, 83.7 percent of the 258 farms studied in Licking County and 65.4 percent of the 240 farms in the adjoining counties received payments averaging about $63 and $111, respectively. The productivity balance on the farms receiving payments and planting corn within the 1939 allotments increased from −0.74 in 1937 to −0.45 in Licking County and from −0.75 to −0.49 in the other counties. Those of the farms participating but planting more than the 1939 corn allotment increased from −0.77 to −0.67 in Licking County and from −0.50 to −0.45 in the other counties. On the nonparticipating farms there was a decrease from −1.01 to −1.19 in Licking County and an increase from −0.78 to −0.75 in the adjoining counties. One hundred fifty-two of the 258 farms in Licking County and 130 of the 240 farms in the adjoining counties increased the productivity balance from 1938 to 1939. In both areas

the percentage of farmers receiving payments increased with size of farm, and in general farms with low yields complied to a lesser extent with the 1939 corn allotments. On farms operated by owners and related tenants the percentage of cropland in corn decreased 1.4 from 1938 to 1939 and that in wheat, 5.1. Those for other soil-depleting crops and for soil-conserving crops were increased 3.2 and 3.3, respectively. On farms operated by tenants not related to the owners, corn acreage decreased 0.9 percent, wheat 3.5, and soil-conserving crops 0.2 percent, and depleting crops other than corn and wheat increased 4.6 percent.

In a study of tobacco farms in Pittsylvania County, Va., in 1933 and 1936 the Virginia station found that the reduction in average size of businesses was due to the A. A. A. crop-reduction program rather than to the adjustments resulting from the soil conservation program. The changes in land use by farms cooperating in the soil conservation program helped control erosion and in part offset the lower labor efficiency from reduced size of business. In 1933 yields were the same on cooperating and noncooperating farms, but the tobacco from the cooperating farms brought on an average $1.26 less per 100 pounds. In 1936 the cooperating farms had slightly higher yields, and the average tobacco price was $1.11 higher than that for the noncooperating farms owing to the selection of better soils, more adequate crop rotations, and the better use of fertilizers.

LAND USE

A survey by the Ohio station to determine the forest resources of the State was extended into 36 counties. The survey includes data by counties on quantity and distribution of timber by species and size; location and type of wood-using industries; management, marketing, use of forest products on farms, and economic returns from other than farm use; forest-cover maps showing the location, size, and forest type of existing woodlands; and the location of woodlands having possibilities for experimental and demonstration purposes. The survey is proving valuable in initiating a farm woods research program and should be a valuable contribution to the national defense program. The station also, in cooperation with the Department (B.A.E.), made a study of the economic and social factors related to land use in Ross County.

The Delaware station found that about one-third of the land in Kent County is good agricultural land, about one-third of lower agricultural value but which will remain in agriculture, and about two-fifths submarginal land. The Washington station in cooperation with the Department (B.A.E.) made a study of the economic conditions and problems in the Yakima Valley to assist farmers in formulating plans to increase returns on a permanent basis.

The relationship of productivity to ability to pay rent was studied by the Missouri station. On farms of rather low productivity 160 acres were required to cover the minimum costs for production, tenant's living, and landlord's direct costs. On farms of rather high fertility, 120 acres were required. It was found that when the productivity was doubled, the total costs were increased only 12 percent.

Other studies reported and publications received during the year included one by the Maryland station of the major and subtypes of

farming areas in the State, their adaptability to agricultural production, cropping rotations, and other information such as land use, soils, slope, erosion, climate, transportation facilities, etc.; a new soil map of Kent and Washington Counties by the Rhode Island station; soil surveys of 8 counties of Utah by the Utah station in cooperation with the Department (B.P.I., S.C.S., and B.A.E.), the Bureau of Reclamation of the Department of the Interior, and the Utah State Water Storage Commission; a study by the same station in cooperation with the Department (F.S.) of the range resources of Rich County; studies of land use, soils, numbers of livestock, real-estate values, etc., in Chautauqua and Yates Counties by the New York (Cornell) station; studies of the adjustments in Sheridan, Daniels, Roosevelt, and Valley Counties and of 140 unsatisfactory farms and ranches in Teton County by the Montana station; and a study of agricultural production and types of farming in the State by the Minnesota station.

FARM ORGANIZATION AND MANAGEMENT

Organization and management.—By a study in Cumberland County in Illinois, the Illinois station in cooperation with the Department (B.A.E.) showed that the poorer the land, the smaller the size of the farms, the poorer the quality of farming, the more exploitive the cropping system, the smaller use made of soil-fertility-maintaining practices, and the poorer the quality of livestock and feeding practices. The gross incomes in 1938 were from $2,000 to $4,000 on the largest farms and $300 to $600 on the smallest farms.

An experiment of the Mississippi station with a 14.25-acre farm organized for dairying and the production of cotton and all needed feeds (6 acres in pasture and one-fourth of the cultivated acreage in cotton and the remainder chiefly in alfalfa, corn, and small grains) showed that during the 10 years of the experiment the yield of corn had increased 66 percent and that of cotton 33 percent. The total receipts from dairy products and crops sold averaged $515 a year. The station estimates that with hired help a farm 10 times as large as the experimental farm could have an average annual net profit of over $3,500.

An experiment in forage production and livestock grazing made by the Oregon station on approximately 700 acres of typical logged-off land in Clatsop County demonstrated that a large amount of forage can be grown on such lands and converted economically into wool and meat. As a result of the experiment, the station reports that an adjoining tract of 10,000 acres has been sold to commercial livestock growers.

A study by the South Dakota station in the Beadle County area in the central part of the State indicated that a combined livestock and grain farm with a livestock enterprise so organized that it can be expanded or contracted to conform to the feed supplies is the best type of organization for the area, and a 480-acre farm on a rented basis appeared to be the minimum size capable of providing a very moderate standard of living for an average family. Preliminary findings in Hyde County showed that the minimum acreage should be from 640 to 3,000 acres, depending on the type of farming or ranching practiced.

In cooperation with the Department (B.A.E.), the Rhode Island station found that average yields of hay (1.3 tons) and of corn (40 bushels) have changed but little in the last 25 years, but that the proportion of corn used for silage has increased from one-fifth in 1920 to over two-thirds during the last few years. Good management necessitates a farm sufficiently large to provide full-time productive employment of available labor to use the lands, buildings, and other facilities to as near capacity as possible.

FARM AND LABOR INCOME

Labor income.—The Maine station in cooperation with the Department (B.A.E.) studied 95 dairy and cash-crop farms in Androscoggin and Oxford Counties. For the year ended April 30, 1937, the labor incomes increased with the acreage cropped, size of dairy herd, number of man-work units per farm, milk production per cow, number of animal units per man, crop index, increased use of fertilizers and lime, and the percentage of total receipts from other than dairy products. The New York (Cornell) station found that the chief factors affecting labor income on 544 Tompkins County farms during the year ended March 31, 1938, were size of farm, milk production per cow, crop yields, and labor efficiency.

Differences in prices received for products due chiefly to volume and quality of the products, productive work per man, and production rates of crops and livestock, principally hogs, were found by the Virginia station to have been the principal factors causing variations in the labor income in 1932 on 699 farms in Nansemond County. The station stated that (1) as the proportion of the total income represented by products used by the household increased, all important measures of farm business declined; (2) notwithstanding the unsatisfactory situation in 1932 as to prices and weather, commercial farms with relatively high labor efficiency and economic rates of production of high-quality products were able to provide better living for their families and to weather the depression better than were other farms; and (3) the outstanding effect of the depression was to make improvements in rates of production and labor efficiency cost more than they were worth with prevailing prices for farm products unless the improvements could be achieved with little or no cash outlay by reorganizing the farm lay-out or by the addition of hogs to the farm business. Studies by the same station of tobacco farms in Pittsylvania County brought out that the average price received for tobacco affected the labor income more than did yields per acre. Increased acreages and improved quality of the crop both increased income. Increased acreages were accompanied by higher labor efficiency in addition to the benefits consequent upon greater volume of business. Increased quality resulted in higher prices.

A study by the Louisiana station of 118 farms in 4 parishes of the State for 1935 brought out that the average labor income for the farms with over 70 acres cropped was $190 as compared with −$9 for those with less than 40 acres cropped. The average incomes increased from $1 for farms with less than 200 pounds of lint cotton per acre to $92 when the yield was 200 to 299 pounds and to $97 when it was at least 300 pounds. On farms with less than 15 acres of cotton the income increased from −$35 when there were less than

5 dairy cows to $210 when there were 5 or more cows. When there were 15 or more acres of cotton the increases were from −$70 to $201. The average labor income in 1936–37 on the 50 highest-income farms of 270 tobacco farms studied by the Puerto Rico station was $1,290 greater than that of the 50 lowest-income farms, because of 25 percent better yields, 8 percent higher prices received for tobacco, better diversification of income, especially more livestock, higher production per animal unit, lower operating expenses, and higher labor efficiency.

The Indiana station showed that in growing canning tomatoes the returns per hour for all man labor varied from −27 cents in 1934 to 70 cents in 1937, averaging 23 cents. Yield was the most important item affecting labor returns, as costs did not vary greatly with yields. The type of soil, preceding crops, size of fields, use of manure and fertilizers, variety, and date of maturity were among the factors affecting costs. In another study by the station of the financial returns on farms in the northwestern part of the State, 1929 to 1938, it was found that the average labor income for the 10 farms organized and operated in accordance with the principles of good management was $1,529 per year while that for the 10 farms least in line with such principles was $213. Livestock efficiency, including choice of livestock, was the most important factor influencing labor income, with size of business second in importance. Choice and yield of crops, economy in expenses, and efficiency in the use of labor were also found to be factors. It is estimated that the adding of $132 (one-tenth of the difference paid on the above farms) to the net income of the half of the farms of the State having the lowest incomes by improving the organization and management practices would add $13,000,000 per year to the net buying power of the operators.

The Georgia station found that the average returns in Toombs County on investments (farm income plus value of home-produced products used minus value of labor and management) on farms with less than 30 acres cropped were $260 for tobacco farms, −$47 for cotton farms with low yields and $14 for those with high yields, and from $119 on combination farms with a medium cotton-tobacco ratio to $168 on such farms with a high ratio. On farms with over 30 acres cropped the returns per 100 acres increased from −$47 when a large percentage of the cropland was in cotton with low yields to $531 when there was a high tobacco-cotton ratio and medium yields of cotton. Another study by the same station in the Sandy Creek soil conservation demonstration area in 1933 and 1937 showed that the highest incomes were obtained on the farms with high crop yields and a high percentage of cropland in cotton. Total size of farm, acres cropped, volume of sales, and investment had little relation to income received.

The average cost of producing milk in 1937–38 on 68 farms in the southeastern part of Louisiana was found by the Louisiana station to range from $1.28 to $4.29 per 100 pounds. The average net returns were $117 on the farms with an average of 11 cows and $553 for those with an average of 34 cows. The net return increased from −$28 when the average production per cow was 2,331 pounds to $453 when it was 4,487 pounds, from −$20 when the average price received per 100 pounds of milk was $1.94 to $344 when it was $2.36,

309632—41——16

and from −$77 for the farms receiving 44 percent of the total income from milk to $596 when 80 percent was received from that source. A second study in an upland cotton area of the State, based on a survey of 400 white owners and tenants in 1931 and 50 owners in 1933 to 1935, showed that the average operator's earnings on owner-operated farms were: Cotton, $53; cotton and livestock, $100; cotton and truck crops, $53; and cotton and dairy, $245. For sharecroppers the earnings were −$193, −$97, −$49, and $59, respectively. Index of livestock production was most clearly associated with labor income. Family farms with outside earnings of less than $10 had average labor earnings of $68 and those with $10 or over, $142. For sharecropper farms the averages were −$116 and $40, respectively. In two studies made regarding sugarcane farms, the first of 33 farms in 1937 and 35 farms in 1938 with at least 1,300 acres, there was a tendency for costs per ton of cane sold to be higher and net income per ton to be lower on the larger farms regardless of whether size was measured by acres in cultivation, acres in cane, or number of tons of cane sold. The second study covered the crop year 1938 and included 500 family-sized farms with at least 5 acres in sugarcane and 10 acres in crops and 50 percent or more of the income from sugarcane. It showed that the cost of producing cane decreased as the acreage in crops and the yield per acre of cane increased, and that regardless of size of business and yield per acre the costs were lower where a large proportion of the land was in cane.

The labor earnings of dairy-farm operators in the southeastern part of Minnesota and Meeker County were found by the Minnesota station to average $1,616, varying from $3,462 for the highest 20 percent to $321 for the lowest 20 percent. Size of business, choice and yields of crops, butterfat production per cow, feeding and labor efficiency, and overhead charges were the chief factors affecting the incomes. An analysis of farm reports for the years 1930 to 1939 from farms in the north-central part of the State, made by the South Dakota station, showed that the average annual operator's labor income (farm-labor income plus the value of products used minus value of unpaid family labor) ranged from −$2,240 to $1,700, averaging −$408. The farms with the higher incomes were considerably larger, had larger cropped acreages, more productive animal units and equipment per acre, a smaller percentage of total investments in real estate and a higher percentage in working capital, higher crop yields and livestock efficiency, more crop acres and animal units per man, and carried large reserves of grain, roughage, and cash.

According to a study by the Utah station of different types of farming in Utah County, labor earnings (labor incomes plus value of farm privileges) increased from $122 on farms the productive index of which was less than 50, to $1,035 when it was more than 150. Labor income showed a positive correlation with yields and size of business. Size of business could be increased by farming a greater acreage, keeping more livestock, and by intensifying the crop and livestock enterprises. The New Mexico station obtained records from experienced cattle and lamb feeders for the purpose of assisting inexperienced feeders in combining alfalfa and other local feeds so as to secure a maximum return for the alfalfa fed. The need of such assistance was emphasized by the increase in the acreages of alfalfa and forage crops in the irrigated valleys following the reduction in the

acreage of cotton under the cotton program. A study by the Nevada station showed that the earning-power balance per sheep unit (receipts less cost) for from 11 to 20 range-sheep outfits for the years 1933 to 1938 ranged from −$1.19 to $1.20, averaging 24 cents. Using the 1933 to 1938 production and the 1910 to 1938 prices and costs, the average earning-power balance for the period 1910 to 1938 was 78 cents per sheep unit as compared with 24 cents for the period 1933 to 1938.

COSTS OF PRODUCTION

Field crops.—Analyses made by the Illinois station of farm cost records kept by groups of farmers in cooperation with the station from 1913 to 1937 brought out that while the average size of farms had remained approximately the same (230 acres), the amount of man labor per farm had decreased from 6,400 hours in 1923 to 4,500 hours in 1937. The yearly operation cost for a "composite acre" (one-half corn and one-fourth each oats and wheat) decreased from $18.30 in 1919 to $7.80 in 1933. The costs for different crops were: Wheat 1914–15, $17.16 and 1935–36, $8.70; corn 1913–15, $11.61 and 1935–37, $11.22; oats 1913–15, $7.27 and 1935–37, $8.34; and soybeans 1922–24, $17.08 and 1935–37, $9.11. During the same periods the average yield per acre of wheat increased 4 bushels, that of corn 15, that of oats 13, and that of soybeans 10 bushels. The man-labor requirements for wheat decreased nearly 75 percent, for corn 48, for oats about 40, and for soybeans nearly 70 percent. Owing to the use of tractors, the horsepower-hours per acre decreased from 43.6 to 14 for corn, 34.6 to 5.1 for wheat, and 29.1 to 2.6 for soybeans. The costs per bushel, including land charges, were approximately 52.8 cents in 1913 and 29.7 cents in 1937 for corn, $1.14 in 1914 and 51.5 cents in 1936 for wheat, 45.8 cents in 1913 and 38.6 cents in 1936 for oats, and $1.93 in 1922 and 67.2 cents in 1937 for soybeans.

Of 70 cornfields studied by the Indiana station in 1939, 16 had costs of production less than $12 per acre and 15 costs of over $17 per acre. Yields per acre in excess of 70 bushels were found for 13 fields and less than 45 bushels for 5 fields. Similar differences were found in the yields and costs of wheat, oats, and soybeans. Most of the differences were due to factors partly within control of the farmers.

Broilers in Indiana.—In a study of approximately 70 lots of broilers each in 1936 and 1937, the Indiana station found that the average costs of production were 18.3 cents per pound in 1936 and 20.1 cents in 1937. The average profit per pound was 5.2 cents in 1936 and 2.9 cents in 1937. Costs of production and prices received were of about the same importance in their effects on profits. Size of the enterprise had little effect on cost. The greatest profit was made on birds finished at 2½ to 3 pounds and sold in May.

Miscellaneous.—The average yields and costs per ton of different kinds of silage in 1939 were found by the Ohio station to be 5 tons and $2.69 for alfalfa, 7.5 tons and $3.91 for soybeans, and 9 tons and $3.14 for corn.

Studies of the costs and practices in producing honey and hops were completed and published by the Oregon station.

MARKETING

Hogs.—The Indiana station, in a study of 200 lots (6,809 hogs), found that only 50 percent of the hogs under 220 pounds gave first-grade carcasses. The carcass values of light- and medium-weight hogs frequently varied 50 cents per 100 pounds between good and poor lots. Live values varied 15 to 25 cents. The station estimates that by raising proper types of hogs and the use of optimum rations for maximum daily gains from birth to marketing, the live-weight value of the light- and medium-weight hogs of the State could be increased 15 cents or more per 100 pounds, or a total of $1,000,000 or more.

In a statistical study of the use of carcass weight and grades as the basis of selling hogs, made by the Iowa station, it was brought out that commercial butcher hogs are otherwise bought too nearly on a flat price, the differences in the value of different lots being greater than the differences in the prices paid for them. Under the carcass system, the packers would pay during the year about the same amount as under the present live-weight system, but the payments would be more equitably distributed on the basis of quality, the raising of higher quality hogs would be stimulated and packers could, therefore, pay a higher price, and the incentive to "fill" hogs and the cost of filling would be removed. The shift to the carcass system with Government grading would cause only a minimum disturbance in existing trade practices and would protect farmers and others dealing with experienced buyers, remove the need for bargaining over yields and grades of carcasses, provide a uniform language for price quotations, and raise the plane of competition.

Fruits, potatoes, and vegetables.—On approximately 60 apple farms in the Hudson Valley studied for the years 1935 to 1938 by the New York (Cornell) station, farmers having their own refrigeration storage were found to have marketed their apples to better advantage than those who depended on local or New York City commercial storage facilities. Apples sold at the farm averaged 90 cents per bushel as compared with 79 cents for those sold on consignment. The same station, in an analysis of the financial reports for 1935 of 29 wholesale receivers of fruits and vegetables on the lower west-side Manhattan market, 9 wholesalers of the less perishable commodities, and 15 jobbers on the Bronx Terminal Market and the Wallabout Market, found that the gross margins taken by the several types of firms were 6.5 percent, 9.2, and slightly over 10 percent of the sales, respectively.

The Kansas station, in a study of the factors affecting the marketing quality of potatoes from the lower Kansas River Valley, found only 20 percent of the potatoes graded U. S. No. 1, the chief causes for low grades being adhering dirt, 15 percent; handling and cultural defects, 40; and shipping hazards and unfavorable weather, 45 percent. Pyramid loading in freight cars was superior to the usual summer style of loading. It was recommended by the station that more of the crop be stored for local sales in the fall. A study made by the New Mexico station of the possibilities of truck transports to and sale of New Mexico vegetables on Texas markets is being found of considerable value in aiding in the adjustments made necessary by the recent changes in land use.

Cereals.—A study by the Oklahoma station to determine the extent to which wheat grades are raised in passing through the Enid, Okla., market and the resulting gains to elevators showed for 1939–40 that 26 percent of the wheat received graded No. 1 and 46 percent No. 2, while 71 percent of the wheat shipped out graded No. 1 and 27 percent No. 2.

The Arkansas station, in a study of 80 farms for the crop year 1937–38, found that the average cost for repairs, depreciation, and interest for farm granaries for rough rice was 1.2 cents per bushel of capacity and 4.3 cents per bushel stored. Public storage averaged 1.61 cents per bushel for the first month and 4.59 cents for a 6-month period. From 1920–21 to 1936–37 the price of rough rice advanced 7.5 times after October 15 and decreased 3.2 times, and the average price increased over the October price, being 5 percent greater in November, 6 in December and January, 10 in June, and 11 percent in July.

Poultry and eggs.—The cost of marketing Maryland turkeys averaged 75 cents per bird or 5.6 cents per pound dressed weight, in a study by the Maryland station. Twenty-one percent of the turkeys were sold direct to consumers, 43 percent to local buyers, and 25 percent to commission merchants. Only approximately 15 percent of the turkeys received in Baltimore came from Maryland. Data collected by the same station on the receipts, sources of supply, consumer preferences for different types and grades, relation of prices and quality, costs of marketing, etc., of eggs provided much useful information for use in the enforcement of the State fresh-egg law.

Milk and cream.—The Vermont station found that the average total costs per 100 pounds of shipping milk from country-assembling to city-distributing plants within a distance of 221 to 230 miles from Boston by rail and by truck were: Less than carload lots 57.5 cents and 52.9 cents, respectively; carload lots (100 cans) 59.7 cents and 48.5 cents; carload lots (200 cans) 55.5 cents and 46.1 cents; and by tank cars or tank trucks 41.1 cents and 36 cents, respectively. Studies of marketing in the Worcester and Springfield, Mass., markets were made by the Massachusetts station and of the Kalamazoo, Mich., market by the Michigan station.

Based on observations in Butler County, Iowa, the Iowa station estimated that with fewer and larger creameries, each serving the cream producers in a minimum area, the cost of collecting butterfat could be reduced at least 2 cents per pound, resulting in a saving of at least $50,000 per year. It was found that as many as nine creameries were collecting milk from a single township, and in one case five were collecting from a single square mile.

TAXATION

Valuations and assessments.—The average assessed value per acre of rural real estate in Alabama rose from $4.14 in 1910 to $9.76 in 1929 and was $7.42 in 1934 and 1935, according to a study by the Alabama station. The respective millage rates for these dates were 13.8, 20.6, and 20.4, and the burden of taxes was further increased by the fact that the index purchasing power of farm products declined from 109 in 1910 to 96 in 1929 and 76 and 79, respectively, in 1934 and 1935. Increased demands for governmental services such as better schools,

improved roads, more care for unemployed and other dependents, and more regulatory services were responsible for the upward trend in taxes. For the period 1901–10, 1911–20, and 1921–30, the indexes of total assessed value of different kinds of property were: Rural real estate 79, 151, and 212; urban real estate, 73, 122, and 160; public utility, 76, 107, and 153; and personal property, 79, 118, and 164. Assessed values per $100 of farm real estate value varied from 16 to 87 percent for different counties and the taxes from 67 cents to $1.27. In 5 counties studied the more valuable farms in the same size groups, except the 200-acre and over group, were assessed at 9 to 13 percent less of their value than the less valuable farms.

The Kansas station, in cooperation with the Department (B.A.E.), found that assessed valuations of farm real estate were from 67.1 to 70.3 percent of actual values in the period 1923–30 and from 87.8 to 94.0 percent during the period 1931–33. In the latter period the average percentage was 50.3 in one area and 81.2 in another area. A study of the sales prices for 2,935 transfers during the period 1931–33 showed that the assessed valuations varied from 13 to 856 percent of the sale price. When the sale price was under $1,500 the average assessed value was 166.2 percent as compared with 65.9 percent where the sale price was $15,000 or more. Value per acre was the most significant and fundamental factor affecting assessment ratios, but in determining the value assessors apparently did not make much distinction between grades of land. Higher tax returns were found to be associated with lands of lower productivity and with tax delinquency.

Taxes per $100 value of farm lands were found by the Minnesota station to have risen from 58 cents in 1910 to $1.68 in 1938, although there had been a decrease from 1929 to 1938.

The total taxes levied in 200 townships in distinctly agricultural sections of Michigan were found by the Michigan station to be 67 percent less in 1938 than in 1930 and 26 percent less than in 1913, the decrease from 1930 in individual townships being from 45 to 85 percent. Of the decrease, 48 percent was owing to reduced levies for highway purposes, 18 percent to reduction in school levies, and 23 percent to the elimination of the State levy on general property. County taxes constituted 50 percent of the total taxes in 1938. The average per capita property tax in the 200 townships in 1938 was $12.87 in 1913 and $10.80 in 1938 as compared with $16.48 and $34.46 for the entire State. The assessed valuation of personal property in the townships studied was 43 percent less in 1938 than in 1930 and that of real estate 20 percent less as compared with 21 percent and 30 percent, respectively, for the State. The average tax rates per $1,000 in the townships were $26.10 in 1930 and $10.88 in 1938, while those for the State were $31.53 and $27.49.

Tax delinquency.—Uncollected taxes in the State of Montana were found by the station to amount on June 30, 1939, to nearly $27,000,000, equivalent to 8.2 percent of the total taxable valuation of the State. The amount of delinquencies was twice that in 1930 and 4 times that in 1920. Approximately $18,400,000 of unpaid taxes were outstanding against property carried on the current tax rolls, being equal to a 56-mill levy on the taxable valuation of all property. Approximately 4,500,000 acres were subject to tax deed, having been delinquent for 5 years or more, and about an equal amount, comprising over 18,000 farm and ranch properties, had been taken by the counties from 1890

to 1938. Uncollected taxes on farm and ranch real estate were proportionately 40 percent greater on June 30, 1939, than the delinquencies on all property in the State. On July 1, 1936, the taxes on over one-third of the farm land of the State were unpaid. Of the lands taken by the counties 60 percent were still owned by them. The sales failed to equal the delinquent taxes on the lands by $1,250,000. A study of 12 counties showed that the taxes that would have been assessed on the lands leased by the counties would have equaled 174 percent of the returns from the leases. A number of suggestions were made by the station in regard to the administration of the county-owned lands.

The Alabama station discovered that over one-third of the lands of the State were delinquent in 1932 and that the sales for taxes increased from 570 properties, including approximately 71,500 acres, in 1928, to approximately 6,700 properties with over 1,260,300 acres in 1932. Data obtained by the Kansas station in cooperation with the Department (B.A.E.) showed that 6.5 percent of the total taxes levied in 1928 on farm property of the State became delinquent, and in 1932, 21.7 percent. More detailed information for 31 counties brought out the fact that long-time delinquencies amounted to 57.6 percent of the total properties delinquent, and that 66 percent of the properties delinquent in 1932 had been delinquent in at least one of the previous 4 years.

Homestead exemptions.—In anticipation of agitation for a homestead tax exemption legislation, the South Carolina station investigated the probable economic effects of such legislation. Over 260,400 real-estate tax returns were examined, and 38 percent, with an assessed value equal to 20.5 percent of the total assessed value of all property and 39 percent of that of all real estate, were classed as homesteads. It was found that a $500 homestead exemption would reduce the total tax valuations of the State nearly $34,000,000, and involve from 3.8 to 23.6 percent of the taxable property in different counties, with an average of 9.5 percent for the State. With a $1,000 exemption, 13.3 percent of the total taxable real estate would be tax-free.

Miscellaneous.—The Oklahoma station prepared a large-scale map showing the location of the tax-exempt, corporation-owned, and privately-owned nonurban lands of the State. This map affords a precise basis for the calculation of the probable effects of proposed graduated land-tax legislation and also a basis for studies of absentee ownership, changes in ownership, and the effect of tax-exempt lands. Using data obtained in taxation projects that had been carried on by it, the South Carolina station, in cooperation with the State university, prepared, as requested by the Governor, a report which was published by the State Legislature. This report has resulted in a movement for a constitutional convention to consider the policy for assessment of property.

TENANCY

Over 61 percent of the farm operators in Oklahoma in 1935 were tenants as compared with approximately 44 percent in 1900, according to a study made by the Oklahoma station in cooperation with the Department (B.A.E.). The average value of tenant-operated farms in 1935 was $2,809, while that of owner-operated farms was $3,915. The value of machinery and equipment on tenant farms was only about 50 percent of that on owner-operated farms. Approximately 1 of every

3 of the 50,000 tenants moved each year at an estimated aggregate cost of nearly $1,500,000. The tenants operated more cash-crop farms than did owners. The indications are that tenants have higher incomes than owner-operators on the better lands and lower incomes in the poorer areas. A similar study by the Arkansas station, also in cooperation with the Department (B.A.E.), showed that 26 percent of the farms were operated in 1935 by sharecroppers and 34 percent by renters. Owners operated the largest farms and sharecroppers the smallest farms. From 53 to 62 percent of the tenants in different areas of the State had been on the present farm less than 2 years and only 16 to 23 percent for 5 years or more. Tenants had smaller incomes and participated less in social and recreational activities than did owner-operators.

Acquiring ownership.—The Indiana station reported that the "working agreement on the two-thirds," developed by the station, was by 1939–40 the most popular method for older boys of character, whose capital may not exceed $500, to acquire farms. Under this plan the owner advances all farm expenses and a nominal wage to the boy without interest, has the final decision as to operations, and receives two-thirds of the farm income. The boys can begin farming for themselves at least five years earlier and occupy well-improved farms, and with adequate capital and good management may make as high a labor income as the average tenant or farm owner.

Leases.—Data from approximately 4,000 tenants collected by the Kansas station indicated that nearly 50 percent of the present farm leases are of the share-cash type, approximately 40 percent of the crop-share type, and about 4 percent of the stock-share type. The use of the stock-share type of lease is recommended as it reduces the shifting of tenants from farm to farm and increases the interest of landlords in the well-being of the farm and the community. The Washington station made a study of the more common provisions in leases in use in the State and the investment and operating contributions of landlords and tenants under the four principal types of leases, and the Illinois station studied the legal aspects of farm tenancy in that State.

CREDIT

Real estate mortgages.—According to a study by the Montana station two-fifths of the farms of Montana are mortgaged for a total of nearly $70,000,000. This is approximately 20 percent of the assessed value of all lands and improvements, and averages 87 percent of the productivity value of the lands. Eight of the principal types of loan agencies have made loans in excess of the productivity value. A number of methods of correcting the situation were shown as a result of the study. The New York (Cornell) station studied loans from 2,267 farms from 1917 to 1929 in 11 counties in the southern and western parts of the State, and showed that by November 1936, 18 percent of the loans had been paid and 25 percent foreclosed. The percentages of foreclosures and losses were higher on the poorer lands. Within the same land class the percentage of foreclosures was lowest on the farms on hard roads and having electric service. Lower elevation, good houses, and good barns on land adapted to agriculture were associated with greater loan-paying ability. The Minnesota station found that the Federal land bank, the Federal Farm Mortgage Corpora-

tion, and the State Department of Rural Credits owned 6.8 percent of the farm lands of the State on December 1, 1938.

Production loans.—Approximately 60 percent of 842 farm operators in 5 representative counties studied by the South Carolina station in cooperation with the Department (B.A.E.) used nearly $224,300 credit in 1937 for crop- and livestock-production purposes. Twenty-five percent of the cash borrowers had no cash on hand at the beginning of the crop season. The average cash reserve was $277 for owners, $361 for part owners, and $411 for tenants. Approximately 56 percent of the funds for loans came from production credit associations, 34 percent from banks, and 7 percent from individuals. Merchant credit dropped from 31.6 percent in 1926 to less than 10 percent in 1937. The average rates of interest charged by different agencies were for production credit associations and the Farm Security Administration 5 percent, banks 7, and individuals from 5 to 15 and 20 percent. Slightly over one-third of the production credit association loans were on the budget plan, the advances being made as needed and repaid as funds became available. Livestock and crops were the commonest collateral for loans, but the production credit associations also required all farm equipment. Bank loans secured by crops and livestock increased from 34 percent in 1926 to 78 percent in 1937. Because of the service charges of the production credit associations, loans of $300 or less were usually obtained more cheaply from banks.

COOPERATION

Farmers' elevators.—The average returns of earnings on total assets of 83 farmers' elevators in 1938 and of 106 in 1939 were estimated by the Illinois station to be 8 and 11 percent, respectively. When grain constituted over 90 percent of the business, the earnings per bushel were 1.9 cents for corn, 3 for oats, and 3.8 cents for wheat and soybeans. Cost of handling grains, including 6 percent on net value, averaged 1.7 cents per bushel, and the net return in 1939 was 0.55 cent per bushel. In 1939, 66 companies paid or authorized dividends on stock and 28 paid patronage dividends.

Oil associations.—In 1938 the sales of 92 associations studied by the Minnesota station averaged nearly $69,800. The modal gross margin was 20 to 23 percent and the operating expenses approximately 16.2 percent of the sales. The net income was 7.18 cents per dollar of net sales.

Cotton gins.—The New Mexico station showed that some cooperative gins in the State were saving cotton producers as much as $2 per bale on ginning charges.

Cooperative creameries.—The Minnesota station reported that the average production of milk per acre in farms increased from 12.8 gallons in 1899 to 22.9 gallons in 1934 and the total production increased from 5,925,000,000 pounds in 1920 to 8,175,000,000 in 1938. Over 75 percent of the milk is used in manufacturing dairy products, of which 96 percent during the last decade has been creamery butter. In 1938 cooperative creameries manufactured about 72 percent of the butter as compared with about 62 percent in the period 1915 to 1919.

Cooperative exchange credit.—A study of 87 cooperative exchanges by the Missouri station, covering chiefly the calendar year 1937, re-

vealed that the average amount of bills receivable per exchange was $4,470, equivalent to 23 percent of the average total assets and 34 percent of the average net worth. The average cost of extending credit amounted to 3 percent of the sales on credit, of which approximately 50 percent was losses on bad debts, 33 percent interest, and 17 percent accounting and collection expenses. The station suggested that as a means of making credit patrons pay the cost of credit, a flat charge is more practicable than charging interest or giving discounts on cash sales. The charging of interest, it was found, would necessitate a rate over twice that charged by banks.

MISCELLANEOUS

Shifts of sharecroppers and wage laborers.—The South Carolina station made a study in Laurens and Florence Counties to ascertain the shift from 1933 to 1937 between sharecroppers and wage laborers, the factors associated with and the effects of the shifts, and the prospective shifts. The shifts in the counties studied were found to be insignificant and the economic status of both classes to be more closely related to size of family and its working force than to the employment status of the individuals. A change from sharecropper to wage-laborer status resulted in a decline in income from the use of home-produced goods and perquisites. It is estimated that by producing all home-use products needed, the net income of sharecroppers could have been increased 20 to 30 percent and that of wage laborers 40 to 55 percent. A marked change in wage rates in relation to cotton and tobacco prices will be necessary before the incomes of wage-laborer families will equal that of sharecroppers. The station states that—

> Until the technology of cotton and tobacco production is greatly improved, farmers in these areas will find little encouragement to make complete shifts to the use of wage laborers in lieu of sharecroppers.

Farm power.—Records from 261 farmers in central Indiana obtained by the Indiana station showed an average expenditure for operating trucks of 4.9 cents per mile, that for trucks driven approximately 8,700 miles per year being only about 50 percent of the cost for those driven 2,000 miles or less. On an average the trucks were used about 197 days per year. Approximately 28 percent of the mileage and 55 percent of the hours were used on the farm itself and 26 percent of the mileage for custom hauling. Generally, the owners save money by hauling their products to market, but in the case of 27 percent it would have been cheaper if all hauling had been hired. Small loads were chiefly responsible for the losses. Return loads were hauled on less than 2 percent of the trips. Another study by the same station covering the period 1934 to 1938 showed that labor, power, and machinery costs averaged $1.26 less per crop acre on tractor farms (a tractor and not more than 2 horses) than on nontractor farms. In general, the use of tractors has proved profitable on farms with over 120 tillable acres, and it is estimated that if the farms of the State were equipped with the proper kind of power, a saving of $1,000,000 would result.

Cotton gins.—A study by the Texas station of the operating costs and financial conditions of gins in eastern Texas showed that on an average 861 bales were ginned per gin and the average net return

on investment was aproximately 1 percent. The station estimated that if one-third of the gins were eliminated or if cotton production were increased by a corresponding amount, the volume per gin would be 1,292 bales and the return on investment 12.1 percent.

Prices.—Analyses were made by the California station of the relationships of United States supply, index of nonagricultural income in the United States, and trend of supply to f. o. b. prices of oranges; also of domestic shipments, indexes of nonagricultural income, and prices of competing fruits to the prices of canned clingstone peaches and canned apricots; and of Pacific coast shipments of Bartlett pears, indexes of nonagricultural income, and prices of competing fruits to the prices of Bartlett pears.

Based on a study of the broiler industry in western Indiana, the Indiana station stated that—

> Demand, as measured by factory pay rolls in the United States, trend, and the Indiana farm price of chickens in the previous period explain most of the variation in chicken prices from year to year. It was possible to forecast the spring price of chickens in January each year with the use of January 1 factory pay rolls, trend, and the January farm price of chickens.

Indexes of farm prices were published by the Nevada station covering 1910 to 1939, by the Oklahoma and Mississippi stations covering 1910 to 1938, and by the Missouri station covering 1910 to 1939.

Long-staple cotton.—From a study of American-Egyptian long-staple cotton, made in cooperation with the Department (B.A.E.), the Arizona station found that some domestic cotton is substituted for Egyptian cotton when the price of imported cotton is high, and that if the price of the domestic cotton could be reduced the volume so substituted would be appreciable. The average yield of domestic long-staple cotton is only about 250 pounds of lint per acre as compared with 510 pounds for upland short-staple cotton, and during recent years the prices in Phoenix, Ariz., for Pima (long staple) cotton have averaged only 2.1 times those for short-staple cotton.

Cane-sugar milling.—The Louisiana station made a study of the financial operations of sugar mills in the Mississippi and Teche regions of the State in 1937 and 1938.

Death and crippling losses of livestock.—An examination of the records of the St. Paul, Minn., Union Stock Yards Co. by the Minnesota station showed that the percentages of different kinds of livestock delivered by wagon or truck in 1910, 1927, and 1937 were: Cattle 1.8, 8.1, and 57.1, respectively; calves, 0.8, 17.3, and 80.4; hogs, 1.1, 11.4, and 83.2; and sheep, 0.6, 8.1, and 41.5. From 1928 to 1937 the percentages of death losses up to the time of unloading and during unloading for truck shipments increased from 0.034 to 0.062 for cattle, from 0.072 to 0.169 for calves, 0.071 to 0.103 for hogs, and 0.025 to 0.356 for sheep and lambs. The losses from crippling decreased from 0.230 to 0.139 for cattle while those for calves increased from 0.029 to 0.063, for hogs from 0.094 to 0.274, and for sheep and lambs from 0.011 to 0.082. For rail shipments the death losses decreased from 0.031 to 0.029 for cattle, from 0.356 to 0.254 for calves, from 0.111 to 0.088 for hogs, and from 0.197 to 0.106 for sheep and lambs. The crippling losses decreased from 0.090 to 0.032 for cattle and from 0.073 to 0.048 for sheep and lambs and increased from 0.095 to 0.173 for calves and from 0.251 to 0.379 for hogs. Overloading and underloading, failure to use partitions, and

unloading roughly were factors that stood out as causes contributing to the losses in truck shipments.

RURAL SOCIOLOGY

The following are some of the results of studies in rural sociology reported by experiment stations in 1940.

POPULATION STUDIES

In a study of population trends, 1860–1930, the Colorado station found that the rapid rate of increase which characterized the growth of population in Colorado up to 1910 has been retarded. This change in rate of increase will necessitate various types of institutional and industrial adjustments. Future growth will probably be less rapid. The past growth has been accelerated by the migration of persons from other States and nations into Colorado, but after 1920 there was a great increase in the number of people born in Colorado who went to other States. Colorado's population has always been predominantly native white. The early foreign-born whites were from northern Europe, but since 1900 there has been an increase in the number of immigrants from southern Europe and Mexico and this has created some social problems. There have always been more males than females in Colorado, but the ratio of 95 to 5 in 1860 was reduced to 52 to 48 in 1930.

In a study of migratory movements and population changes among farm people of Oklahoma, the Oklahoma station found that during the past 2 years a declining birth rate had been just about offset by a declining death rate. In spite of a virtually stationary farm population since 1935 because of heavy emigration, the reproductive capacity of the farm families of the State continued to be high and the State's main problem one of finding ways and means of supporting its existing population adequately.

The Kentucky station reported that during the decade 1920 to 1930 the population of the State had high rates of natural growth, the index of natural increase for 1930 being 100 or more in all but 5 of the 120 counties. In contrast with the areas of urban influence stands the rural territory of eastern Kentucky, where 7 counties have indexes above 225. The population is these 7 counties would double by natural increase within 24 to 33 years if no migration were to occur.

The Negro population of Kentucky is barely self-maintaining. A significant fact is that 51.6 percent is urban and only 21.2 percent is rural-farm, whereas only 30.6 percent of Kentucky's white population is urban and 47.2 percent is in the rural-farm group. The index of natural increase for the State's Negro population is only 102 in contrast with 146 for the State's white population. The Negro index is consistently lower than the white in all groups—rural-farm, rural-non-farm, and urban.

BASIC TRENDS OF SOCIAL CHANGE

The basic trends of education were studied by the South Dakota station, which found that in proportion to the total population, those

enumerated in the school census, or persons 6 to 20 years of age, have rapidly declined since the peak period in the early twenties. There has been a consistently increasing emphasis on education during the entire period of the State's history. School costs per pupil have risen because of increased demands for an enriched curriculum and for better school plants and equipment. A beginning has already been made toward centralization which is resulting in fewer but better schools. The qualifications of teaching personnel have been progressively raised since the early years of the State. There is a marked tendency toward more practical curricula in the present-day public-school systems. The study indicates that migration in and out of the State has been definitely slowed up.

Social correlatives of farm tenancy were studied by the Oklahoma station. Children of tenant farmers were found to have more limited educational opportunities than those of owners. Tenants are denied many forms of social participation (membership in religious, recreational, social, economic, and other groups) that are available to owners, because of the tenant's lower economic status and higher rate of mobility. However, tenants who remain on the farm and seek to become owners reach that goal about as early in life now as formerly.

The Pennsylvania station found that rural boys in Pennsylvania who drop out of high school constitute a large and numerically important group of potential farmers. As a group, they are handicapped by educational retardation and by inadequate financial resources with which to begin and carry on farming operations. Employment as farmers frequently is not a true expression of their vocational or occupational preferences; but, because of their background of farm experience, the relatively narrow range of vocations in which men of their training and ability succeed, and numerous other contributing circumstances, they enter farming. A comparatively large number reject farming as an occupation and try other ways of earning their living, but eventually they gravitate back, generally to the rural community where they were reared and in which they had gained their early farm experience.

In a study of farming as an occupation, the New York (Cornell) station found a larger degree of transmission from fathers to sons than in any other occupation, although this transmission is decreasing in succeeding generations. Farming is transmitted from the father to the oldest son in the family to a greater extent than to any of the other sons.

SPECIAL PROBLEMS IN SUGAR BEET GROWING

In Montana, the station found that the number of beet growers in the State increased from 1,451 to 2,717, or 87 percent, during the 10-year period 1929–38. The average beet acreage per grower increased from 24.1 to 28.5. About $1,900,000 was spent for thinning, hoeing, and topping in 1939. Some 11,300 beet workers were employed in Montana in 1939 for thinning and for first hoeing. There were 5,665 resident and migrant family household workers, the remainder being solo workers. The cost of beet labor for thinning,

hoeing, and topping varied from $1.90 to $2.06 per ton of beets, or a total of $23.24 to $25.07 per acre, assuming a 12.2-ton yield, which was the average for the 1939 season. It is pointed out that the sugar beet industry is confronted with numerous problems of adjustment, social and economic, which require cooperation between laborers, growers, processors, and the community if satisfactory solutions are to be worked out.

In a study of housing conditions, working patterns, and related problems of sugar beet laborers, the Colorado station found that such laborers have a very high birth rate (averaging 5.9 persons per family) and a meager yearly income, mostly ranging between $412 and $568, including relief. They live in small houses, averaging 2.8 rooms per house. Leaky roofs, defective walls, and poorly fitted windows and doors offer little protection against rain and snow, dust, dirt, rodents, and insects. Damp, cold cement floors, and the lack of adequate sewage disposal and sanitary protection contribute to a high incidence of disease and ill health among them. Most of the laborers come to Colorado with cultural patterns which differ from those prevailing there, and their rate of assimilation has been low. Limited financial resources have prevented them from improving their standard of living or their education. These conditions have led to a perpetuation of their unfavorable status and have accentuated the difference between them and the remainder of the population.

PART-TIME FARMING

An analysis of social characteristics of part-time farmers by the Washington station points to the conclusion that part-time farming represents a quest for security, is a "rurban" phenomenon, and adds an average value of approximately $150 to the income of the family after operating expenses have been deducted. Transportation costs between part-time farms and other places of employment, however, frequently are large and may nullify any savings in rent.

FARM INCOME AND WELFARE

In a study of the difference between "reliefers" and self-supporting families in rural areas of the comparatively newly-settled cut-over sections in northern Wisconsin, the Wisconsin station found 1 family on relief for every 2 making an independent living. In Sawyer County 220 families were visited in the winter of 1938–39, of whom 111 were on relief and 109 making their own way. Of the 111 on relief, 55 were on relief in 1933; and of the 109 who were independent, 100 were also self-supporting 5 years before.

Native-born Americans had a greater tendency to seek public support than the foreign-born. Of the heads of families on relief in Sawyer County, 71 percent were native Americans and 29 percent foreign-born, while of the self-supporting family heads, 53 percent were born abroad. Family heads on relief averaged nearly 53 years in age, 3 years younger than the nonrelief heads. On the average heads of relief families had completed 7.7 grades in school in compar-

ison with 7.4 grades for those not on relief. The corresponding figures for housewives were 7.8 and 7.7 grades. When the family heads were rated on a scale ranging from 0 to 8 for their ability, judgment, and resourcefulness as indicated by their farm practices, the self-supporting farmers excelled relief farmers by an average score of 3.7 to 1.8.

Both relief and nonrelief families decreased in size during the 5 years from 1933 to 1939, but the relief families decreased in size only half as much as the self-supporting families, principally because of a higher birth rate. The indigent group, doomed to the relief rolls indefinitely, had the largest number of children; 57 percent of its members were not more than 15 years of age in comparison with 33 percent in the emergency relief group and 35 percent in nonrelief families.

During the past 5 years there has been a striking tendency for relief families to give up farming but only a slight tendency for self-supporting families to do so. Of these, 77 percent were full-time farmers in 1933 and 71 percent in 1938.

Relief farmers had an average of 24 acres under cultivation, and nonrelief farmers half an acre more. Total farm acreage averaged 67 and 94, respectively. Self-supporting farmers had an average of 1.6 more milk cows per farm, slightly more other cattle, horses, hogs, and sheep, and about the same number of poultry as relief farmers.

The Minnesota station reported that new lines of social cleavage as a result of the administration of relief could not be detected in farm populations, but in the village studied there were indications that relief and nonrelief residents tend to fall into more distinct classes.

MEDICAL FACILITIES

The proportion of physicians to total population in Minnesota was found by the Minnesota station to have increased by about 9 percent between 1912 and 1936, whereas the proportion has decreased in rural communities. In 1931 there was one physician per 1,814 persons in places smaller than 2,500 and one physician per 534 in urban communities.

The Missouri station reported a survey of the medical and health facilities of a typical Missouri county, including the sickness record and the use made of existing facilities by 317 open-country families. More than three-fourths of these families were engaged in full-time farming. One-fourth of the families had no illness during the year, and 60 percent did not visit a doctor; more than 50 percent had no dental service during the year; 40 percent spent less than $10 for all types of medical service including drugs; and 40 percent lived within 10 miles of a licensed practitioner, but 80 percent did not use the nearest one. In some cases distance was a factor in using medical service. Opinions differed among both laymen and practitioners regarding the availability and adequacy of medical service for the county.

STATISTICS OF THE EXPERIMENT STATIONS

In tables 1 to 8 there have been assembled data of a statistical character concerning the personnel, publications, income, and expenditures of the experiment stations for the fiscal year ended June 30, 1940; also disbursements from the United States Treasury to the States, Alaska, Hawaii, and Puerto Rico for agricultural experiment stations under the Federal-grant acts.

PERSONNEL AND PUBLICATIONS

The number of research workers on the station staffs in 1940 was 4,593, an increase of 139 over 1939. The increase consisted of 14 full-time research workers and 125 whose time was divided between research and resident teaching or extension, or research and both resident teaching and extension work. Of the 4,593 technical workers in 1940, 2,258 gave their full time to research while the time of the other 2,335 was devoted partly to research and partly to resident teaching or extension work or both.

The publications of the experiment stations in 1940 included 732 bulletins and circulars in the regular series, 2,386 articles in scientific journals, and 486 miscellaneous publications. The comparable figures for 1939 were 883, 2,241, and 662, respectively.

INCOME

The total income available to the stations for 1940 was $21,216,748.61 as compared with $20,622,758.61 in 1939. The 1940 income consisted of $6,848,750 from the 4 Federal-grant funds and $14,367,998.61 of non-Federal funds, including State appropriations, special endowments and fellowships, fees, sales, miscellaneous, and the unexpended balances from the preceding year.

Federal grants.—Federal grants to the States, Territories, and Puerto Rico for agricultural research in 1940 amounted to $6,848,750 as compared with $6,541,250 in 1939. The increase of $307,500 consisted of $5,000 to Hawaii and $2,500 to Puerto Rico under the Purnell Act, and $300,000 under the Bankhead-Jones Act, which, in accordance with the act, was allotted to the States, Territories, and Puerto Rico on the basis of rural population.

Non-Federal funds.—The amount of funds made available by the States in 1940 was $14,367,998.61 as compared with $14,081,508.61 in 1939, an increase of $286,490. The income of the stations from sources other than Federal-grant funds was approximately $2.10 for each $1 of income from the Federal grants.

EXPENDITURES

As a result of the adoption of revised and simplified accounting schedules, tables 3 to 7 differ in a number of respects from those appearing in the reports for earlier years. Expenditures for Salaries and Labor, previously reported separately, are consolidated under the heading of Personal services. Items formerly classified as Chemical supplies; Seeds, plants, and sundry supplies; Fertilizers; and Feeds (also Stationery) are tabulated as Supplies and Materials; while Vehicles, tools, etc.; Furniture, fixtures, etc.; Library; Livestock; and Scientific

apparatus are entered as Equipment. Postage, stationery, telegraph, and telephone becomes (aside from Stationery) Communication service, and Freight, express, and parcel post is retitled Transportation of things. The heading Structural and nonstructural improvements has replaced the heading Buildings.

Classified expenditures for each station under the Hatch Act are shown in table 3, the Adams Act in table 4, the Purnell Act in table 5, the Bankhead-Jones Act in table 6, and for non-Federal funds in table 7.

DISBURSEMENTS OF FEDERAL-GRANT FUNDS

Table 8 shows the total disbursements from the United States Treasury to June 30, 1940, to each State, Alaska, Hawaii, and Puerto Rico for agricultural experiment stations under the Hatch, Adams, Purnell, Bankhead-Jones, and supplementary acts.

309632—41——17

TABLE 1.—*Organization, personnel, and publications of the experiment stations for the year ended June 30, 1940*

Station	Date of legislative assent to Hatch Act	Date of organization under Hatch Act	Personnel					Publications					
			Full-time research	Research and teaching	Research and extension	Research, teaching, and extension	Total research workers	Station publications		Articles in scientific journals		Miscellaneous publications	
			Number	*Number*	*Number*	*Number*	*Number*	*Number*	*Pages*	*Number*	*Pages*	*Number*	*Pages*
Alabama	Feb. 27, 1889	Apr. 1, 1888	35	35		1	71	7	204	17	103	12	56
Alaska	May 2, 1929	May 1, 1931	3	1	2		6						
Arizona	Mar. 19, 1889	July 1, 1889	17	37	2		56	13	943	28	234	57	209
Arkansas	Mar. 7, 1889	Apr. 2, 1888	17	49	1	2	69	21	805	39	78		
California	Mar. 12, 1889	Mar. 13, 1888	103	176			279	15	492	451	2,925	155	1,659
Colorado	Mar. 25, 1889	Feb. 20, 1888	28	40			68	8	339	10	32	1	3
Connecticut:													
State	May 18, 1887	May 18, 1887	47				47	15	540	25	98	15	33
Storrs	do	Apr. 1, 1888	18	8	1	14	41	2	107	15	116		
Delaware	Apr. 14, 1887	Feb. 21, 1888	12	8	3	3	26	8	151	10	74		
Florida	June 7, 1887	Mar. 16, 1888	68	13	4	6	91	12	609	51	242	75	152
Georgia	Dec. 24, 1888	Feb. 18, 1888	47				47	8	255	9	63	4	18
Hawaii	Mar. 31, 1911	July 1, 1929	24	16			40	7	282	18	244	1	48
Idaho	Jan. 23, 1891	Feb. 26, 1892	14	34	1	7	56	7	173	13	100	8	100
Illinois	May 11, 1887	Mar. 21, 1888	63	81	4	11	159	22	1,117			12	210
Indiana	Jan. 19, 1889	July 1, 1887	82	33	4	1	120	15	593	118	177	14	90
Iowa	Mar. 1, 1888	Feb. 17, 1888	96	123	17	9	245	33	1,666	90	781	4	256
Kansas	Mar. 3, 1887	Feb. 8, 1888	32	101			133	13	766	230	345	2	270
Kentucky	Feb. 20, 1888	Apr. 29, 1888	68	26		7	101	19	1,143	64	342		
Louisiana	July 12, 1888	Apr. 5, 1887	52	22	1	1	76	14	254				
Maine	Mar. 16, 1887	Feb. 16, 1888	32	7			39	6	468	7	76	3	82
Maryland	Mar. 6, 1888	Mar. 9, 1888	24	29	3	14	70	8	348	18	99	16	93
Massachusetts	Apr. 20, 1887	Mar. 2, 1888	67	18			85	20	360	23	145		
Michigan	Apr. 12, 1889	Feb. 26, 1888	55	87	6	7	155	15	679	68	514		
Minnesota	Feb. 4, 1889	Jan. 26, 1888	54	112	4	3	173	13	533				
Mississippi	Jan. 31, 1888	Spring 1888	41	22		1	64	20	400	14	85		
Missouri	June 11, 1889	Jan. 31, 1888	20	84		2	106	29	984	68	272		
Montana	Feb. 16, 1893	July 1, 1893	27	17	2	8	54	10	317	14	69	5	119
Nebraska	Mar. 31, 1887	June 14, 1887	25	45	1		71	18	461	23	46		
Nevada	Feb. 8, 1889	December 1887	20	2			22	7	188				

New Hampshire	Aug. 4, 1887	Feb. 22, 1888	8	39	2	5	54	14	468				
New Jersey:													
College	Mar. 16, 1887	Mar. 5, 1888	25	28	1		54	27	857	106	212	1	92
State			45				45						
New Mexico	Feb. 28, 1889	Nov. 14, 1889	12	22		1	35	38	576	1	7	3	3
New York:													
Cornell	Mar. 30, 1887	Apr. 30, 1888	45	124	8	14	191	24	1,111	396	2,036		
State	(1)		77				77	15	476	52	104		
North Carolina	Mar. 7, 1887	Dec. 5, 1889	47	21	2	6	76	5	231	8	16		
North Dakota	Mar. 8, 1890	Oct. 15, 1890	29	20		1	50	10	290	12	113	3	47
Ohio	Mar. 16, 1887	Apr. 2, 1888	116				116	20	701	54	108		
Oklahoma	Oct. 27, 1890	Aug. 14, 1891	24	60	1		85	21	738	45	232		
Oregon	Feb. 25, 1889	July 2, 1888	66	58		6	130	36	662	31	62		
Pennsylvania	June 3, 1887	June 30, 1887		163			163	17	562	57	472	10	115
Puerto Rico	Aug. 16, 1933	Nov. 14, 1935	51				51	6	247	6	53	2	80
Rhode Island	Mar. 31, 1887	Nov. 3, 1888	16	5	1	4	26	7	245				
South Carolina	Dec. 22, 1887	January 1888	33	19	1	1	54	7	521	7	41		
South Dakota	Mar. 11, 1887	Nov. 17, 1887	9	32	1	3	45	18	649	23	69		
Tennessee	Mar. 29, 1887	July 24, 1887	64	20		4	88	7	151	6	41		
Texas	Apr. 2, 1887	Jan. 25, 1888	154	1			155	19	1,331	49	225	67	275
Utah	Mar. 8, 1888	Nov. 16, 1889	27	34		4	65	5	166	24	117		
Vermont	November 1888	Feb. 28, 1888	16	13			29	12	428				
Virginia	Feb. 29, 1888	June 13, 1888	44	12	1	5	62	4	202	34	155		
Washington	Mar. 9, 1891	May 1, 1891	65	36			101	16	639	36	276	13	102
West Virginia	Feb. 22, 1889	June 11, 1888	23	36	1	6	66	7	308	14	106	3	82
Wisconsin	Session 1889	July 1, 1887	53	78	8	23	162	5	286				
Wyoming	Jan. 10, 1891	Mar. 27, 1891	18	25			43	7	174	2	4		
Total			2,258	2,072	83	180	4,593	732	27,196	2,386	11,709	486	4,194

[1] First made eligible to receive part of the State allotment of Federal funds by legislative act approved May 12, 1894.

TABLE 2.—*Income of the experiment stations for the year ended June 30, 1940*

Station	Federal grants [2]			Non-Federal							Grand total
	Hatch, Adams, and Purnell [1]	Bankhead-Jones	Total	Balance from previous year	State appropriations	Special endowments, industrial fellowships, etc.	Fees	Sales	Miscellaneous	Total	
Alabama	$90,000	$82,695.12	$172,695.12	$166,055.36	$162,300.00	$10,300.00		$73,085.40	$15,096.50	$426,837.26	$599,532.38
Alaska	23,750	2,236.48	25,986.48	62.19	5,000.00			13,681.11		18,743.30	44,729.78
Arizona	90,000	12,422.56	102,422.56	1,239.70	120,477.55			2,495.26		124,212.51	226,635.07
Arkansas	90,000	63,983.20	153,983.20		99,323.83			26,175.71		125,499.54	279,482.74
California	90,000	65,941.96	155,941.96	70,517.39	1,180,978.30	96,904.47		110,389.55		1,458,789.71	1,614,731.67
Colorado	90,000	22,430.96	112,430.96	14,050.06	87,903.82	5,500.00		61,033.98		168,487.86	280,918.82
Connecticut:											
State	45,000	10,329.04	55,329.04		230,387.30	4,824.38	$29,180.98			264,392.66	319,721.70
Storrs	45,000	10,329.04	55,329.04	339.91	47,710.00	6,175.66	6,581.93			60,807.50	116,136.54
Delaware	90,000	5,010.20	95,010.20	3,029.82	26,733.74			16,809.17		46,572.73	141,582.93
Florida	90,000	30,801.64	120,801.64	18,018.85	539,929.00			50,548.49		608,496.34	729,297.98
Georgia	90,000	87,522.92	177,522.92	2,299.96	93,004.25	22,666.52		20,947.50		138,918.23	316,441.15
Hawaii	60,000	9,186.40	69,186.40		9,186.40	1,200.00		21,238.25	73,497.90	105,122.55	174,308.95
Idaho	90,000	13,718.56	103,718.56	7,528.40	30,897.71	650.00		27,153.49		66,229.60	169,948.16
Illinois	90,000	86,736.52	176,736.52		416,340.88	24,448.35		75,133.07		515,922.30	692,658.82
Indiana	90,000	62,722.60	152,722.60	266,204.95	298,300.00	77,489.72	193,795.36	100,528.65	27,597.00	963,915.68	1,116,638.28
Iowa	90,000	64,854.64	154,854.64	21,733.81	254,377.17	50,800.61		24,930.99	14,581.30	366,423.88	521,278.52
Kansas	90,000	50,050.96	140,050.96	21,908.81	120,550.00		62,283.87		2,460.00	207,202.68	347,253.64
Kentucky	90,000	78,938.04	168,938.04	28,324.78	108,990.76		165,610.99	43,276.90		346,203.43	515,141.47
Louisiana	90,000	55,133.44	145,133.44		109,140.65	8,303.28				117,443.93	262,577.37
Maine	90,000	20,692.16	110,692.16	200.06	45,171.21	2,050.00	19,815.17	11,149.95	18,518.99	96,905.38	207,597.54
Maryland	90,000	28,550.48	118,550.48	36,830.70	69,467.95	10,868.50	2,302.60	32,900.15		152,369.90	270,920.38
Massachusetts	90,000	18,182.20	108,182.20		202,378.00	10,417.95			278.87	213,074.82	321,257.02
Michigan	90,000	66,967.84	156,967.84		215,701.96			32,103.66		247,805.62	404,773.46
Minnesota	90,000	56,797.64	146,797.64		384,123.03	19,091.14	286.23	49,960.53	12,546.49	466,007.42	612,805.06
Mississippi	90,000	72,651.40	162,651.40	26,209.83	111,466.52	1,000.00	8,315.34	67,490.20	257.63	214,739.52	377,390.92
Missouri	90,000	76,967.80	166,967.80	33,808.64	84,524.94	16,012.59	26,111.01	27,478.80		187,935.98	354,903.78
Montana	90,000	15,503.16	105,503.16	13,729.46	73,100.00			48,679.49		135,508.95	241,012.11
Nebraska	90,000	38,776.60	128,776.60		117,797.95			81,463.75		199,261.70	328,038.30
Nevada	90,000	2,460.64	92,460.64	4,046.49	3,368.52			9,067.70		16,482.71	108,943.35

New Hampshire	90,000	8,357.20	98,357.20	22,288.37	8,357.20			3,236.25	35,528.28	69,410.10	167,767.30
New Jersey:											
College	90,000	30,525.84	120,525.84								120,525.84
State					499,554.42					499,554.42	499,554.42
New Mexico	90,000	13,761.00	103,761.00	35,617.46	13,788.00			19,111.51		68,516.97	172,277.97
New York:											
Cornell	81,000	80,848.48	161,848.48		721,305.44		2,715.15	100,000.00	2,432.15	826,452.74	988,301.22
State	9,000	8,983.16	17,983.16	4,156.03	359,888.67			18,478.84		382,523.54	400,506.70
North Carolina	90,000	102,628.00	192,628.00	7,624.22	87,350.00	3,871.27		14,864.75		113,710.24	306,338.24
North Dakota	90,000	24,675.76	114,675.76	2,946.37	62,505.26		2,132.93	38,091.05		105,675.61	220,351.37
Ohio	90,000	93,014.76	183,014.76	386,708.07	426,418.60			92,000.40	12,289.23	917,416.30	1,100,431.06
Oklahoma	90,000	68,450.84	158,450.84	48,798.19	175,324.88	2,715.87	55,302.78	41,910.88		324,052.60	482,503.44
Oregon	90,000	20,175.80	110,175.80		220,089.73	9,646.61	47,666.35	49,953.83		327,356.52	437,532.32
Pennsylvania	90,000	134,689.52	224,689.52	4,562.05	125,542.92			41,413.15	25,149.51	196,667.63	421,357.15
Puerto Rico	45,000	48,552.16	93,552.16		163,002.55			8,271.59		171,274.14	264,826.30
Rhode Island	90,000	2,263.84	92,263.84	1,472.96				5,664.20		7,137.16	99,401.00
South Carolina	90,000	59,464.96	149,464.96	15,458.42	83,236.00			117,673.19		216,367.61	365,832.57
South Dakota	90,000	24,432.44	114,432.44	16,961.39	25,560.00	3,469.07		23,749.00		69,739.46	184,171.90
Tennessee	90,000	74,783.88	164,783.88		57,838.06			41,859.15		99,697.21	264,481.09
Texas	90,000	149,364.76	239,364.76	87,763.43	410,336.00	6,375.00		158,685.18	112,444.27	775,603.88	1,014,968.64
Utah	90,000	10,503.68	100,503.68	4,450.12	52,788.00	4,625.00		13,928.12	720.40	76,511.64	177,015.32
Vermont	90,000	10,471.60	100,471.60	699.00			15,209.52	500.46		16,408.98	116,880.58
Virginia	90,000	71,144.56	161,144.56	3.23	99,210.00			11,202.40	570.00	110,985.63	272,130.19
Washington	90,000	29,515.72	119,515.72		163,111.93	2,633.43		56,995.99		222,741.35	342,257.07
West Virginia	90,000	53,813.44	143,813.44	6,593.75	57,500.00			36,155.47	2,000.00	102,249.22	246,062.66
Wisconsin	90,000	60,224.88	150,224.88		338,584.00	107,037.00		72,536.00		518,157.00	668,381.88
Wyoming	90,000	6,759.52	96,759.52	56,951.32	7,986.35			24,537.30		89,474.97	186,234.49
Total	4,448,750	2,400,000.00	6,848,750.00	1,439,193.55	9,407,909.45	509,076.42	637,310.21	2,018,540.46	355,968.52	14,367,998.61	21,216,748.61

[1] Hatch, $15,000 for each State, Alaska, Hawaii, and Puerto Rico.
Adams, $15,000 for each State, Hawaii, and Puerto Rico; and $7,500 for Alaska.
Purnell, $60,000 for each State; $30,000 for Hawaii; $15,000 for Puerto Rico; and $1,250 for Alaska.

[2] Includes unexpended balances from the previous year as follows:
Hatch—Connecticut Storrs, $19.08; North Dakota, $0.20; Puerto Rico, $37.25.
Adams—Illinois, $62.01.
Purnell—Arizona, $13.20; Connecticut Storrs, $43.58; Illinois, $105.99; New York Cornell, $41.89; Puerto Rico, $102.64.
Bankhead-Jones—Connecticut Storrs, $6.86; Illinois, $71.92; Puerto Rico, $96.75.

TABLE 3.—*Expenditures and appropriations under the Hatch Act (Mar. 2, 1887)* [1] *for the year ended June 30, 1940*

Station	Expenditures												Unexpended	Appropriation
	Personal services	Supplies and materials	Communication service	Travel	Transportation of things	Publications	Heat, light, water, power, and fuel	Contingent	Equipment	Land	Structures and nonstructural improvements	Total		
Alabama	$12,808.67	$543.87	$135.45	$7.65	$83.46	$39.17	$183.43	$59.43	$979.85		$159.02	$15,000.00		$15,000
Alaska	11,083.37	453.44	10.01	52.05	250.83		1,167.49	8.12	1,703.24		271.45	15,000.00		15,000
Arizona	14,999.98		.02									15,000.00		15,000
Arkansas	10,062.93	2,009.42	113.20	245.47		1,468.52	267.55		825.11		7.80	15,000.00		15,000
California	15,000.00											15,000.00		15,000
Colorado	14,860.00			140.00								15,000.00		15,000
Connecticut:														
State	7,500.00											7,500.00		7,500
Storrs	5,488.86	140.65	5.03		27.38				1,831.70			7,493.62	$6.38	7,500
Delaware	11,398.26	745.41	495.59	435.27	6.63	572.42	180.29	1.80	1,146.23		18.10	15,000.00		15,000
Florida	13,916.98				2.42	998.10			82.50			15,000.00		15,000
Georgia	9,010.47	1,172.44	192.07	979.44	18.06	658.88	468.77	59.37	2,376.06		64.44	15,000.00		15,000
Hawaii	13,915.73	323.29				746.44		14.54				15,000.00		15,000
Idaho	9,601.24	2,171.15	599.51	1,266.66	7.40	791.08	4.36	90.00	415.25		53.35	15,000.00		15,000
Illinois	14,999.71											14,999.71	.29	15,000
Indiana	15,000.00											15,000.00		15,000
Iowa	14,500.00					500.00						15,000.00		15,000
Kansas	13,525.28	254.53	25.04	257.91		40.57			650.57		246.10	15,000.00		15,000
Kentucky	13,422.47	73.51		266.84		1,215.70			21.48			15,000.00		15,000
Louisiana	13,318.36	344.05	86.40	227.07		824.19		10.68	189.25			15,000.00		15,000
Maine	11,538.86	428.04	407.28	464.73	70.75	120.05	895.19	28.16	941.11		105.83	15,000.00		15,000
Maryland	12,296.70	1,403.41	56.36	236.55	.75	12.32	227.08	20.80	729.03		17.00	15,000.00		15,000
Massachusetts	14,635.04			318.76					46.20			15,000.00		15,000
Michigan	15,000.00											15,000.00		15,000
Minnesota	14,613.72	240.99		11.15					134.14			15,000.00		15,000
Mississippi	8,255.01	206.54	220.76	1,053.31	25.36	1,886.00	150.74	7.80	2,448.83		745.65	15,000.00		15,000
Missouri	15,000.00											15,000.00		15,000
Montana	11,302.46	782.78	428.39	497.69	83.47	996.53	265.40		636.60		6.68	15,000.00		15,000
Nebraska	15,000.00											15,000.00		15,000
Nevada	10,755.50	1,644.77	452.49	342.77	55.21	484.13	230.18	58.63	464.91		511.41	15,000.00		15,000

New Hampshire	9,337.11	1,338.77	254.36	498.12	323.54	579.67	700.00		1,968.43			15,000.00		15,000
New Jersey	12,687.17	526.36	135.00	474.64	10.00	14.50		22.23	1,071.49		58.61	15,000.00		15,000
New Mexico	12,446.95	711.70	113.72	228.67	68.35	541.39	24.08	81.06	770.09		13.99	15,000.00		15,000
New York:														
Cornell	11,704.10	801.25	12.26						982.39			13,500.00		13,500
State	850.00	17.68							632.32			1,500.00		1,500
North Carolina	9,472.87	468.32	162.94	292.50	.10	356.98	40.89		3,469.92		735.48	15,000.00		15,000
North Dakota	13,620.46	463.56	103.68	129.73	14.98	409.61	6.48		242.16			14,990.66	9.34	15,000
Ohio	9,535.00	3,466.67	258.55	264.27	49.21	379.96	557.34		489.00			15,000.00		15,000
Oklahoma	11,349.25	1,536.49	13.54	402.30	20.59	50.45	31.55		1,560.12		35.71	15,000.00		15,000
Oregon	12,172.99	581.58	12.83	580.18	2.05	1,304.64	70.84	4.73	270.16			15,000.00		15,000
Pennsylvania	9,053.63	124.23		399.98	9.29	3,127.89			1,530.26		754.72	15,000.00		15,000
Puerto Rico	14,133.20	143.79	178.79	272.07					272.15			15,000.00		15,000
Rhode Island	11,319.75	1,180.32	188.90	125.81	61.25	331.86	517.70		1,120.28		151.41	14,997.28	2.72	15,000
South Carolina	11,385.44	1,050.54	341.72	295.99	.39	626.36	13.79		1,279.09		6.68	15,000.00		15,000
South Dakota	10,320.48	1,521.27	88.49	458.40	36.96	1,472.80	104.61		844.30		152.69	15,000.00		15,000
Tennessee	11,375.25	663.66	491.68	110.06	94.84	1,514.21	48.32	20.62	656.41		24.95	15,000.00		15,000
Texas	13,897.50	146.75		880.24		2.50			60.12		12.89	15,000.00		15,000
Utah	10,859.43	2,447.61	17.10	665.71	33.73	207.75	15.50	79.78	575.39		98.00	15,000.00		15,000
Vermont	6,879.01	702.20	398.78	568.11	21.14	1,874.01	2,856.47		951.50		748.78	15,000.00		15,000
Virginia	12,809.71	508.41	53.29	7.55	2.82	282.72	9.35		1,288.60		37.55	15,000.00		15,000
Washington	12,058.52	418.80	19.63	714.43		1,609.79			178.83			15,000.00		15,000
West Virginia	12,341.25	766.20	.36	392.46	4.05	222.95	551.62		721.11			15,000.00		15,000
Wisconsin	14,665.31	72.67	.30	261.47					.25			15,000.00		15,000
Wyoming	11,302.40	1,830.45	389.77	253.95	1.58	320.62	742.11	1.00	158.12			15,000.00		15,000
Total	628,386.38	34,427.57	6,463.29	15,079.96	1,386.59	26,584.76	10,331.13	568.75	36,714.55		5,038.29	764,981.27	18.73	765,000

[1] Extended to Hawaii by act of May 16, 1928; to Alaska by act of Feb. 23, 1929; and to Puerto Rico by act of Mar. 4, 1931.

TABLE 4.—*Expenditures and appropriations under the Adams Act (Mar. 16, 1906)[1] for the year ended June 30, 1940*

Station	Expenditures											Unexpended	Appropriation
	Personal services	Supplies and materials	Communication service	Travel	Transportation of things	Heat, light, water, power, and fuel	Contingent	Equipment	Land	Structures and nonstructural improvements	Total		
Alabama	$10,993.93	$1,398.62	$11.00	$159.40	$56.76	$608.56	$3.75	$1,690.38		$77.60	$15,000.00		$15,000
Alaska	5,700.57	1,628.60	.24		.93		14.35			155.31	7,500.00		7,500
Arizona	12,762.79	653.15	14.15	1,380.00	15.45		4.91	169.55			15,000.00		15,000
Arkansas	11,704.76	1,943.60		565.67	1.00	348.59		417.07		19.31	15,000.00		15,000
California	15,000.00										15,000.00		15,000
Colorado	15,000.00										15,000.00		15,000
Connecticut:													
State	7,500.00										7,500.00		7,500
Storrs	7,500.00										7,500.00		7,500
Delaware	11,599.03	877.71	2.45	551.82	26.07	66.45		1,876.47			15,000.00		15,000
Florida	15,000.00										15,000.00		15,000
Georgia	10,946.45	1,947.70	8.54	52.29	27.46	128.38	7.70	1,881.48			15,000.00		15,000
Hawaii	13,837.25	889.11			3.75		5.50	264.39			15,000.00		15,000
Idaho	11,885.06	1,701.39		338.59	2.78	5.84	4.70	1,061.64			15,000.00		15,000
Illinois	14,999.49										14,999.49	$0.51	15,000
Indiana	14,433.80	391.91	2.92	.60	1.57			169.20			15,000.00		15,000
Iowa	15,000.00										15,000.00		15,000
Kansas	13,674.30	971.59		108.08				239.32		6.71	15,000.00		15,000
Kentucky	14,715.34	276.99			4.11			3.56			15,000.00		15,000
Louisiana	12,715.91	1,112.61	.58	408.75	25.44		1.80	570.56		164.35	15,000.00		15,000
Maine	13,335.64	786.42		130.34	17.98	241.33		488.29			15,000.00		15,000
Maryland	13,733.29	514.77	55.69		7.10			678.55		10.60	15,000.00		15,000
Massachusetts	15,000.00										15,000.00		15,000
Michigan	15,000.00										15,000.00		15,000
Minnesota	14,432.68	266.87						300.45			15,000.00		15,000
Mississippi	12,597.20	561.62	4.42	24.65	30.28	588.09		1,089.30		104.44	15,000.00		15,000
Missouri	9,481.84	4,274.01			126.48	62.89	20.75	737.24		296.79	15,000.00		15,000
Montana	13,134.40	498.05	.57	574.27	4.21	2.00	1.64	784.86			15,000.00		15,000
Nebraska	15,000.00										15,000.00		15,000
Nevada	13,819.50	442.06	40.92	266.95				430.57			15,000.00		15,000

New Hampshire	13,899.86	632.93	14.17	58.25	16.97			347.82	$30.00		15,000.00		15,000
New Jersey	11,895.00	1,232.03	.24	3.50	1.00	446.30	28.54	1,347.42		45.97	15,000.00		15,000
New Mexico	12,320.09	913.48	68.19	140.49	105.49	228.66	157.78	1,057.42		8.40	15,000.00		15,000
New York:													
Cornell	13,461.16	38.25	.59								13,500.00		13,500
State	1,500.00										1,500.00		1,500
North Carolina	12,591.00	771.66	21.54	584.42	1.80	4.60		1,008.26		16.72	15,000.00		15,000
North Dakota	13,219.96	748.72	8.93	36.30	15.32	44.71	7.37	886.11		1.01	14,968.43	31.57	15,000
Ohio	12,837.27	1,377.02	20.94	15.58	7.71			643.74		97.74	15,000.00		15,000
Oklahoma	10,832.52	2,707.23	.96		6.29			1,219.95		233.05	15,000.00		15,000
Oregon	13,065.19	1,148.36	2.73	307.88	1.10	2.60	2.97	457.93		11.24	15,000.00		15,000
Pennsylvania	15,000.00										15,000.00		15,000
Puerto Rico	11,338.00	1,254.22	4.67	686.76	20.86	124.92		1,570.57			15,000.00		15,000
Rhode Island	14,790.92	209.08									15,000.00		15,000
South Carolina	12,680.58	410.76	146.76	339.38	.95	462.24		909.99		49.34	15,000.00		15,000
South Dakota	11,022.99	1,543.98	6.75	641.20	84.68	6.99		1,693.41			15,000.00		15,000
Tennessee	13,725.33	480.90	1.49	214.26	11.82	127.72		386.20	44.50	7.78	15,000.00		15,000
Texas	14,675.00							225.00		100.00	15,000.00		15,000
Utah	12,917.00	957.02		486.43	19.36			617.59		2.60	15,000.00		15,000
Vermont	13,542.15	650.90	5.27	55.40	6.70	28.92		710.66			15,000.00		15,000
Virginia	13,029.27	942.95	10.40	290.27	17.00	65.36		644.75			15,000.00		15,000
Washington	13,587.73	723.45	1.29	275.39				412.14			15,000.00		15,000
West Virginia	14,200.00	651.39		62.20	2.91			83.50			15,000.00		15,000
Wisconsin	14,393.77	423.92	.37	44.95				136.99			15,000.00		15,000
Wyoming	13,016.00	904.63	37.15	263.34	18.30		1.84	553.56		205.18	15,000.00		15,000
Total	674,044.02	39,859.66	493.92	9,067.41	689.63	3,595.15	263.60	27,765.89	74.50	1,614.14	757,467.92	32.08	757,500

[1] Extended to Hawaii by act of May 16, 1928; to Puerto Rico by act of Mar. 4, 1931; and to Alaska by act of June 30, 1936.

TABLE 5.—*Expenditures and appropriations under the Purnell Act (Feb. 24, 1925)*[1] *for the year ended June 30, 1940*

Station	Expenditures												Unexpended	Appropriation
	Personal services	Supplies and materials	Communication service	Travel	Transportation of things	Publications	Heat, light, water, power, and fuel	Contingent	Equipment	Land	Structures and nonstructural improvements	Total		
Alabama	$46,962.78	$3,357.72	$78.90	$1,592.72	$141.12	$1,195.03	$984.86	$64.82	$4,604.99		$1,017.06	$60,000.00		$60,000
Alaska	1,218.15	31.85										1,250.00		1,250
Arizona	44,463.97	6,015.82	51.84	2,591.82	111.74	1,660.33	431.61	13.51	4,065.41		593.95	60,000.00		60,000
Arkansas	50,440.34	2,181.52	40.82	1,728.54	40.92	1,998.78	527.78		3,020.20	$12.50	8.60	60,000.00		60,000
California	60,000.00											60,000.00		60,000
Colorado	53,545.45	2,594.54	124.23	1,860.08	11.29	54.19	34.42	1.75	1,705.55	49.00	19.50	60,000.00		60,000
Connecticut:														
State	26,407.60	1,854.23	10.00	166.23	13.24	25.86	934.91	11.92	532.45		43.56	30,000.00		30,000
Storrs	26,151.31	1,116.55	348.77	839.80	10.22			39.41	1,493.73			29,999.79	$0.21	30,000
Delaware	45,518.01	3,625.87	7.12	3,285.72	55.05	2,705.11	493.65	90.14	3,942.02	90.00	187.31	60,000.00		60,000
Florida	51,549.00	2,500.52	.54	2,294.87			19.32		3,635.75			60,000.00		60,000
Georgia	39,717.87	8,529.55	230.06	1,029.20	144.41	215.06	4,201.79	38.40	4,320.76		1,572.90	60,000.00		60,000
Hawaii	29,468.56	447.39			41.40				42.65			30,000.00		30,000
Idaho	51,033.25	2,920.31	243.43	2,477.42	96.56	449.18	98.67	201.72	2,236.76		242.70	60,000.00		60,000
Illinois	46,269.44	3,504.60	561.84	1,557.24	11.20	2,236.71		.06	5,810.40		48.51	60,000.00		60,000
Indiana	52,131.62	1,848.04	389.73	3,652.05	158.89	.90	7.08	41.12	1,723.57		47.00	60,000.00		60,000
Iowa	59,604.21					350.00			45.79			60,000.00		60,000
Kansas	55,916.28	2,163.15		648.05	49.22	31.41	17.71		1,123.11	6.00	45.07	60,000.00		60,000
Kentucky	52,071.40	835.58	6.55	3,313.86	12.77	1,408.00			2,351.84			60,000.00		60,000
Louisiana	51,312.19	3,353.96	68.69	1,455.69	100.36	523.67	14.80	65.62	2,846.19		258.83	60,000.00		60,000
Maine	47,418.05	4,523.29	6.15	2,209.23	88.53	30.06	808.33		4,901.96		14.40	60,000.00		60,000
Maryland	48,157.05	2,794.31	406.42	3,465.59	34.87	1,681.72	256.23	8.40	3,006.21	125.00	64.20	60,000.00		60,000
Massachusetts	54,051.56	2,539.20		934.20		731.97			1,743.07			60,000.00		60,000
Michigan	52,982.08	3,046.86	133.03	1,331.50	15.81	504.86		29.14	1,956.72			60,000.00		60,000
Minnesota	54,575.04	2,945.50	39.40	1,363.95	266.45	14.23			795.43			60,000.00		60,000
Mississippi	42,653.81	5,159.15	378.35	1,600.58	115.79	672.68	2,111.55	12.37	5,148.18		2,147.54	60,000.00		60,000
Missouri	36,906.42	10,001.20	121.43	1,951.30	186.43	2,003.89	122.67		4,808.65	3,009.20	888.81	60,000.00		60,000
Montana	54,375.56	1,785.86	58.59	2,001.60	8.34	583.22	113.36	9.44	967.39	12.25	84.39	60,000.00		60,000
Nebraska	46,252.10	4,194.67	36.06	1,012.01	46.18	997.63	48.61		5,581.31		1,831.43	60,000.00		60,000
Nevada	48,417.97	4,422.46	466.60	2,226.98	3.00	492.39	347.29	19.45	2,656.25		947.61	60,000.00		60,000

New Hampshire	52,523.91	2,388.95	116.11	2,120.85	53.21	1,020.08	28.25	8.73	1,181.59	394.00	164.32	60,000.00		60,000
New Jersey	50,365.57	3,463.54	112.98	759.07	10.75	212.31	317.57	46.23	4,575.48		136.50	60,000.00		60,000
New Mexico	42,472.59	5,213.25	422.47	2,743.37	270.65	2,058.07	433.90	541.07	5,148.02	112.50	584.11	60,000.00		60,000
New York:														
Cornell	42,293.75	2,725.89	254.02	902.64	17.53	3.80		51.55	7,682.82		42.06	53,974.06	25.94	54,000
State	5,012.13	680.38	2.38	4.54					300.57			6,000.00		6,000
North Carolina	45,732.76	4,857.21	276.53	3,816.33	26.75	450.01	316.98	1.32	4,522.11			60,000.00		60,000
North Dakota	46,382.71	5,662.26	221.25	894.25	121.30	1,173.59	74.12	24.26	4,691.84		647.29	59,892.87	107.13	60,000
Ohio	44,408.33	4,489.40	24.28	840.87	325.26	242.48	534.37		7,742.29		1,392.72	60,000.00		60,000
Oklahoma	43,481.37	7,883.32	9.54	458.12	63.35	772.36	4.00	20.00	4,453.43		2,762.23	59,907.72	92.28	60,000
Oregon	51,579.86	3,483.20	299.48	2,218.58	20.50	839.84	45.92		1,401.32		111.30	60,000.00		60,000
Pennsylvania	50,208.99	3,860.27	108.68	2,559.44	355.75	305.85	185.94		1,876.68		538.40	60,000.00		60,000
Puerto Rico	12,813.77	288.57		1,131.64		163.82			602.20			15,000.00		15,000
Rhode Island	50,338.30	4,734.43	193.07	211.26	30.13	614.68	846.77		2,216.70		806.35	59,991.69	8.31	60,000
South Carolina	49,605.29	3,259.86	787.53	1,524.02	3.79	1,330.42	207.26		3,152.07		129.76	60,000.00		60,000
South Dakota	43,841.87	4,957.85	351.21	2,185.22	211.15	4,221.10	74.09		3,278.46		879.05	60,000.00		60,000
Tennessee	54,193.77	2,143.50	13.24	667.54	141.27		333.02	1.50	2,333.64		172.52	60,000.00		60,000
Texas	52,597.93	2,607.19	355.38	1,798.52	35.64		21.23	19.45	2,289.50		275.16	60,000.00		60,000
Utah	50,737.00	2,049.39	54.35	2,485.92	67.66	362.87	88.80		2,398.01	1,175.00	581.00	60,000.00		60,000
Vermont	52,261.38	2,442.01	66.32	1,160.94	58.25	.35	85.22	10.73	1,265.06	20.00	2,629.74	60,000.00		60,000
Virginia	48,949.20	1,875.94	21.31	2,369.36	17.36	1,679.51	159.51	.75	4,860.00		67.06	60,000.00		60,000
Washington	50,947.95	2,595.46	46.53	2,355.40	20.01	1,261.80		17.42	2,693.83		61.60	60,000.00		60,000
West Virginia	47,910.76	4,692.42	35.18	2,215.01	25.56	574.29	376.44	5.11	3,893.56		271.67	60,000.00		60,000
Wisconsin	58,042.73	1,294.55	6.97	498.75	1.11		59.38		20.48		76.03	60,000.00		60,000
Wyoming	46,931.30	8,052.27	24.38	1,542.80	232.09	761.50	2.40	114.88	2,174.58	25.00	138.80	60,000.00		60,000
Total	2,423,204.29	173,994.81	7,611.74	84,054.67	3,872.86	38,615.61	15,769.81	1,510.27	149,820.58	5,030.45	22,531.04	2,926,016.13	233.87	2,926,250

[1] Extended to Hawaii by act of May 16, 1928; to Puerto Rico by act of Mar. 4, 1931; and to Alaska by act of June 20, 1936.

TABLE 6.—*Expenditures and appropriations under the Bankhead-Jones Act (June 29, 1935) for the year ended June 30, 1940*

Station	Expenditures												Unexpended	Appropriation
	Personal services	Supplies and materials	Communication service	Travel	Transportation of things	Publications	Heat, light, water, power, and fuel	Contingent	Equipment	Land	Structures and nonstructural improvements	Total		
Alabama	$56,248.55	$9,369.37	$119.74	$2,289.65	$486.10	$531.73	$1,734.26	$40.56	$6,179.99		$5,695.17	$82,695.12		$82,695.12
Alaska	1,975.81	254.77			.25				5.65			2,236.48		2,236.48
Arizona	9,898.27	381.22	39.90	1,172.65	3.86	255.84	32.63		599.95		38.24	12,422.56		12,422.56
Arkansas	46,668.27	4,376.81	50.82	2,676.04	18.81	1,467.46	233.83		6,902.48		1,588.68	63,983.20		63,983.20
California	65,941.96											65,941.96		65,941.96
Colorado	17,171.91	2,211.68	16.48	2,117.34	1.75				529.60		382.20	22,430.96		22,430.96
Connecticut:														
State	9,550.00	201.04		30.80	.95		532.45		13.80			10,329.04		10,329.04
Storrs	8,539.20	857.45	2.70	15.10	.51			4.50	905.68			10,325.14	$3.90	10,329.04
Delaware	3,789.12	648.44		55.70	7.07		20.70		6.17		483.00	5,010.20		5,010.20
Florida	20,174.19	4,054.78		944.68	33.95		457.11		2,027.44		3,109.49	30,801.64		30,801.64
Georgia	53,987.68	7,597.64	298.72	2,438.43	1,647.01	798.69	3,853.30	39.14	13,716.18	$2,050.00	1,096.13	87,522.92		87,522.92
Hawaii	8,892.08	294.32										9,186.40		9,186.40
Idaho	10,195.48	2,217.70	4.36	306.05	13.51	1.97		240.00	110.88		628.61	13,718.56		13,718.56
Illinois	66,204.31	4,594.36	296.39	3,690.45	286.86	438.01	1,277.34		8,031.25		1,914.94	86,733.91	2.61	86,736.52
Indiana	42,424.51	7,479.61	41.84	2,181.46	92.31		7.18	15.09	7,858.79	6.00	2,615.81	62,722.60		62,722.60
Iowa	53,007.44	57.20							379.12		11,410.88	64,854.64		64,854.64
Kansas	39,835.49	4,015.88		1,135.01	3.94	12.15			4,734.45		314.04	50,050.96		50,050.96
Kentucky	69,415.51	3,546.88	94.07	1,381.86	69.59	855.71			2,386.51		1,187.91	78,938.04		78,938.04
Louisiana	44,070.50	3,640.76	34.35	1,501.85	57.06	310.70	11.23	23.05	4,142.71		1,341.23	55,133.44		55,133.44
Maine	18,996.00	790.70		649.51	35.44				220.51			20,692.16		20,692.16
Maryland	22,627.25	2,473.79	120.60	1,074.58	13.50	108.12	125.63	1.67	1,929.24		76.10	28,550.48		28,550.48
Massachusetts	18,182.20											18,182.20		18,182.20
Michigan	57,921.63	2,316.77		757.58	78.94	61.09	136.00	17.80	5,533.80		144.23	66,967.84		66,967.84
Minnesota	42,774.59	5,701.33	51.75	2,860.24	120.97	44.51	16.67	75.00	4,138.10		1,014.48	56,797.64		56,797.64
Mississippi	41,445.74	7,831.27	295.10	1,321.90	826.39	351.35	2,907.02	35.20	13,266.88	461.67	3,908.88	72,651.40		72,651.40
Missouri	49,538.03	12,491.25	218.27	479.90	374.68	769.35	714.63	16.94	6,378.68	1,310.00	4,676.07	76,967.80		76,967.80
Montana	14,672.28	406.71	1.75	104.07				9.54	278.59		30.22	15,503.16		15,503.16
Nebraska	33,251.37	1,690.08	.44	1,173.91	17.14	174.19			1,887.71	83.00	498.76	38,776.60		38,776.60
Nevada	2,041.32	143.90		275.42								2,460.64		2,460.64

New Hampshire	6,930.61	253.03	52.21	199.32	29.97	144.67			747.39			8,357.20		8,357.20
New Jersey	22,122.72	4,124.65	40.65	1,793.69	10.80	56.22	200.70		1,923.58	100.00	152.83	30,525.84		30,525.84
New Mexico	8,814.94	1,273.14	116.40	531.78	78.20	54.14	22.99		1,562.03	148.73	1,158.65	13,761.00		13,761.00
New York:														
Cornell	61,867.52	6,714.33	15.00	1,633.68	45.77	26.26	53.75		10,154.98		297.80	80,809.09	39.39	80,848.48
State	6,349.01	1,809.11	16.35	275.18		48.85			484.66			8,983.16		8,983.16
North Carolina	78,021.99	7,060.11	176.20	5,921.26	169.61	19.43	341.68	2.20	9,853.46	799.15	262.91	102,628.00		102,628.00
North Dakota	20,858.14	1,188.02	103.45	703.72	93.55	10.00	11.51	39.71	1,149.04		452.82	24,609.96	65.80	24,675.76
Ohio	68,693.91	6,722.22	6.97	973.87	28.89	93.48	568.26		13,161.30	380.00	2,385.86	93,014.76		93,014.76
Oklahoma	42,673.14	12,626.06	22.20	561.70	103.51	382.61	519.61	5.00	7,270.66	2.20	3,775.77	67,942.46	508.38	68,450.84
Oregon	16,647.59	537.43	11.50	1,370.98	16.62	18.69	37.50		1,530.49		5.00	20,175.80		20,175.80
Pennsylvania	107,794.98	8,124.46		5,280.69	271.96		178.44		5,455.46		7,583.53	134,689.52		134,689.52
Puerto Rico	29,347.15	3,234.84		3,176.67		319.19	108.83		7,469.80		4,895.68	48,552.16		48,552.16
Rhode Island	1,788.99								302.36			2,091.35	172.49	2,263.84
South Carolina	42,789.46	5,836.12	254.32	803.44	19.13	91.23	942.33		5,883.39		2,845.54	59,464.96		59,464.96
South Dakota	17,187.56	3,642.88	34.41	389.71	30.43		74.19	2.30	2,155.61		915.35	24,432.44		24,432.44
Tennessee	55,236.13	5,055.21	202.79	1,820.49	621.09		302.12	6.71	7,490.83	2,328.75	1,719.76	74,783.88		74,783.88
Texas	117,725.14	12,701.99	351.08	3,089.86	83.19		124.31	53.50	12,254.49		2,990.20	149,364.76		149,364.76
Utah	8,556.18	234.96	17.37	1,242.79	3.84		5.20	2.00	400.34		41.00	10,503.68		10,503.68
Vermont	9,426.18	394.12	3.76	98.94	4.49		126.85	1.00	302.95	20.00	93.31	10,471.60		10,471.60
Virginia	54,652.19	6,197.25	16.47	2,260.74	30.14	181.73	266.70	3.40	6,163.45	12.50	1,359.99	71,144.56		71,144.56
Washington	23,201.24	2,119.75	24.29	1,464.56			37.42	10.64	2,447.44		210.38	29,515.72		29,515.72
West Virginia	43,570.73	4,148.30	152.96	2,729.39	208.75	315.66	71.76	1.72	1,655.37		958.80	53,813.44		53,813.44
Wisconsin	58,039.76	1,660.62		437.89	4.50				54.11	25.00	3.00	60,224.88		60,224.88
Wyoming	5,000.07	363.61	11.95	734.75	5.10			5.95	638.09			6,759.52		6,759.52
Total	1,836,736.02	185,637.92	3,317.61	68,120.28	6,050.13	7,943.03	16,054.13	652.62	192,675.44	7,727.00	74,263.25	2,399,207.43	792.57	2,400,000.00

TABLE 7.—*Expenditures from non-Federal funds for the year ended June 30, 1940* [1]

Station	Personal services	Supplies	Communication service	Travel	Transportation of things	Publications	Heat, light, water, power, and fuel	Contingent	Equipment	Land	Structures and nonstructural improvements	Total
Alabama	$124,799.63	$35,182.58	$1,874.33	$12,275.59	$2,713.64	$1,259.55	$9,014.02	$4,295.38	$27,195.94	$11,743.54	$8,725.29	$239,079.49
Alaska	13,765.11	1,103.24	148.37	107.06	442.92		1,204.25	219.85	792.90		909.60	18,693.30
Arizona	88,501.05	9,808.45	1,541.53	3,738.24	588.52	1,716.44	2,367.35	991.04	12,425.35		609.07	122,287.04
Arkansas	74,021.41	20,502.38	1,476.93	2,001.40	285.42	241.95	3,305.74	1,240.04	15,269.11		7,155.16	125,499.54
California	799,127.84	110,763.45	12,618.36	36,779.80	2,627.27	57,343.93	28,739.40	7,501.58	55,821.94	13,346.95	232,580.16	1,357,250.68
Colorado	75,945.69	15,815.16	1,496.75	4,474.21	1,615.87	3,475.41	6,980.21	286.09	19,137.61	1,321.65	4,838.73	135,387.38
Connecticut:												
State	226,226.38	8,450.81	2,060.53	9,357.54	71.01	136.15	5,322.32	728.90	9,891.50		2,147.52	264,392.66
Storrs	42,040.41	8,165.91	400.76	717.89	281.01	115.47	676.45	180.76	1,299.95			53,878.61
Delaware	23,434.85	11,900.62	787.15	373.12	236.73	29.28	3,465.32		1,830.43		1,808.48	43,865.98
Florida	305,125.12	57,685.12	6,444.96	22,274.85	1,848.14	3,441.29	16,049.10	3,028.93	24,324.07	18.00	12,771.81	453,011.39
Georgia	69,280.74	17,051.63	1,068.51	4,872.83	426.83	327.61	3,575.77	3,163.16	11,360.60	13,230.47	8,607.39	132,965.54
Hawaii	66,298.62	16,985.06	952.21	809.52	217.20	1,382.52	3,226.75	6,279.49	5,840.33		3,090.84	105,082.54
Idaho	30,344.24	11,050.00	350.00	2,301.07	400.00	100.00	2,750.00	2,250.00	2,925.90	1,000.00	2,717.41	56,187.72
Illinois	368,056.90	85,845.38	6,000.00	18,000.00		12,000.00			26,020.02			515,922.30
Indiana	379,675.85	116,132.18	7,941.95	22,883.30	2,991.63	8,377.25	17,451.88	8,866.31	59,379.11		23,262.08	646,961.54
Iowa	222,767.28	53,037.70	1,643.00	11,812.68	1,172.62	16,740.07	1,518.73	6,522.67	17,954.67	7,037.55	1,438.45	341,645.42
Kansas	100,160.61	24,538.62	2,384.26	4,331.68	1,867.02	1,315.62	6,594.05	809.38	22,214.60	2,318.98	4,945.57	171,480.39
Kentucky	197,487.69	41,823.47	3,745.52	11,522.66	1,117.74	1,782.70	10,372.95	5,668.52	14,690.99		11,516.13	299,728.37
Louisiana	84,697.34	10,932.01	1,264.60	4,254.08	417.63	427.76	1,785.01	753.41	7,075.53	572.22	5,264.34	117,443.93
Maine	53,558.71	12,280.71	558.74	4,959.88	843.07	6,082.91	3,024.66	591.12	7,955.92	260.50	6,789.16	96,905.38
Maryland	67,736.24	26,713.55	949.29	2,483.11	503.19	1,113.29	1,939.99	8,158.74	6,991.24	582.50	5,601.53	122,772.67
Massachusetts	176,589.36	16,160.33	2,086.67	5,475.08	1,611.02	3,146.09	1,313.62	262.94	5,471.15		958.56	213,074.82
Michigan	186,625.96	22,778.99	487.29	8,361.00	703.02	10,801.44	1,341.24	1,512.78	14,128.47	217.50	847.93	247,805.62
Minnesota	322,647.45	55,793.38	2,585.06	7,557.69	1,803.54	2,543.31	19,571.88	8,974.57	27,664.82	90.00	16,775.72	466,007.42
Mississippi	105,908.84	18,232.23	1,389.26	2,776.67	917.38	3,033.34	4,292.65	2,053.05	21,884.80	125.00	18,982.32	179,595.54
Missouri	95,976.50	19,710.59	1,563.88	7,257.24	958.75	6,322.72	1,096.39	3,405.20	10,165.13	3,343.39	10,105.12	159,904.91
Montana	75,419.23	13,399.67	1,835.34	3,754.49	435.29	1,616.33	7,521.85	667.32	7,820.36	4,229.65	2,048.48	118,748.01
Nebraska	98,457.20	44,239.82	2,077.46	3,221.86	1,109.37	2,253.14	8,168.36	2,435.71	31,516.01		5,782.77	199,261.70
Nevada	771.06	965.37	195.46	1,275.30	201.01	54.35	1,300.81	971.16	4,560.63	728.72	4,633.54	15,657.41
New Hampshire	26,021.41	5,376.09	338.62	1,571.95	68.59	312.13	52.69		6,296.34		110.00	40,147.82
New Jersey	374,798.67	56,072.58	7,881.23	5,256.11	580.45	4,987.68	16,898.88	16,076.58	6,342.87		2,778.58	491,673.63
New Mexico	20,589.49	5,436.07	360.40	1,187.66	329.92	839.19	444.45	1,284.02	1,279.09		971.03	32,721.32
New York:												
Cornell	585,146.02	66,092.38	6,110.74	26,228.13	1,543.41	8,223.52	50,027.94	6,876.20	31,236.46	1,642.00	43,325.94	826,452.74
State	296,074.35	28,295.79	1,823.19	6,874.58	2,833.47	6,385.98	18,555.04		7,557.65	3,259.00	10,864.49	382,523.54

North Carolina	54,292.54	10,383.30	1,054.11	9,414.64	187.17	21.00	1,280.88	521.72	10,544.75	9,443.18	11,228.62	108,371.91
North Dakota	38,228.72	12,621.91	396.24	1,059.46	407.96	1,314.07	22,682.41	3,468.19	10,742.14		1,946.09	92,867.19
Ohio	385,547.21	78,108.02	2,944.80	6,844.73	2,401.73	25,313.84	13,636.80	6,116.97	30,361.15	14,798.54	1,568.63	567,642.42
Oklahoma	183,112.69	23,701.76	1,031.35	6,914.05	763.56	2,890.99	1,457.07	925.11	31,738.57	4,149.50	2,050.55	258,735.20
Oregon	230,634.44	36,245.17	2,282.75	15,081.74	2,601.02	2,286.07	7,923.27	3,837.44	20,744.53	4,444.75	1,275.34	327,356.52
Pennsylvania	129,221.84	41,550.74	927.60	7,187.45		2,314.01			7,819.88		2,348.74	191,370.26
Puerto Rico	117,363.83	6,597.15	1,132.76	2,661.14	162.24	2,547.02	4,495.58	3,532.68	9,280.63		18,533.87	166,306.90
Rhode Island	564.13	379.70	28.97	5.17	19.20	525.19	172.51	4,282.77	871.89		11.94	6,861.47
South Carolina	82,995.50	50,219.52	866.10	2,731.64	534.13	1,115.29	5,826.35	3,313.16	23,567.41	6,633.29	31,228.60	209,030.99
South Dakota	24,687.01	11,068.58	184.04	1,157.55	396.92	1,326.62	564.23	134.48	10,432.36		2,378.09	52,329.88
Tennessee	49,029.65	13,458.59	796.70	2,414.65	982.44	483.98	1,710.41	796.51	20,816.37	4,843.00	4,364.91	99,697.21
Texas	381,117.11	85,577.81	2,937.09	23,893.89	1,195.18	8,607.73	10,011.04	54,597.57	64,430.34	3,000.00	37,853.03	673,220.79
Utah	46,472.20	6,291.65	824.66	3,367.63	230.27	1,403.01	625.68	589.71	3,419.80	3,656.55	586.58	67,467.74
Vermont	11,133.50	641.08	148.61	1,640.64	79.11	1,291.75	550.44	65.88	108.50	12.00	14.71	15,686.22
Virginia	75,510.08	7,977.77	1,324.43	6,821.78	565.29	993.03	1,401.08	251.77	10,085.28	2,904.79	3,150.33	110,985.63
Washington	144,823.92	27,870.78	1,923.97	7,669.42	789.21	1,511.42	10,349.30	7,050.93	12,493.91		8,258.49	222,741.35
West Virginia	47,051.62	16,521.69	914.22	1,891.62	264.38	95.57	4,064.04	1,153.93	5,162.37	900.00	14,626.07	92,645.51
Wisconsin	373,690.00	62,102.00	1,228.00	11,509.00		4,406.00	1,876.00	1,169.00	18,182.00	2,800.00	41,195.00	518,157.00
Wyoming	33,425.12	11,374.42	1,100.00	1,255.06	248.00		1,999.43	256.00	2,759.36	2,172.24	4,525.97	59,115.60
Total	8,186,978.36	1,551,012.96	106,488.75	374,649.53	45,590.49	226,375.01	350,576.27	198,118.72	819,881.83	124,825.46	650,108.76	12,634,606.14

[1] For non-Federal income, see table 2.

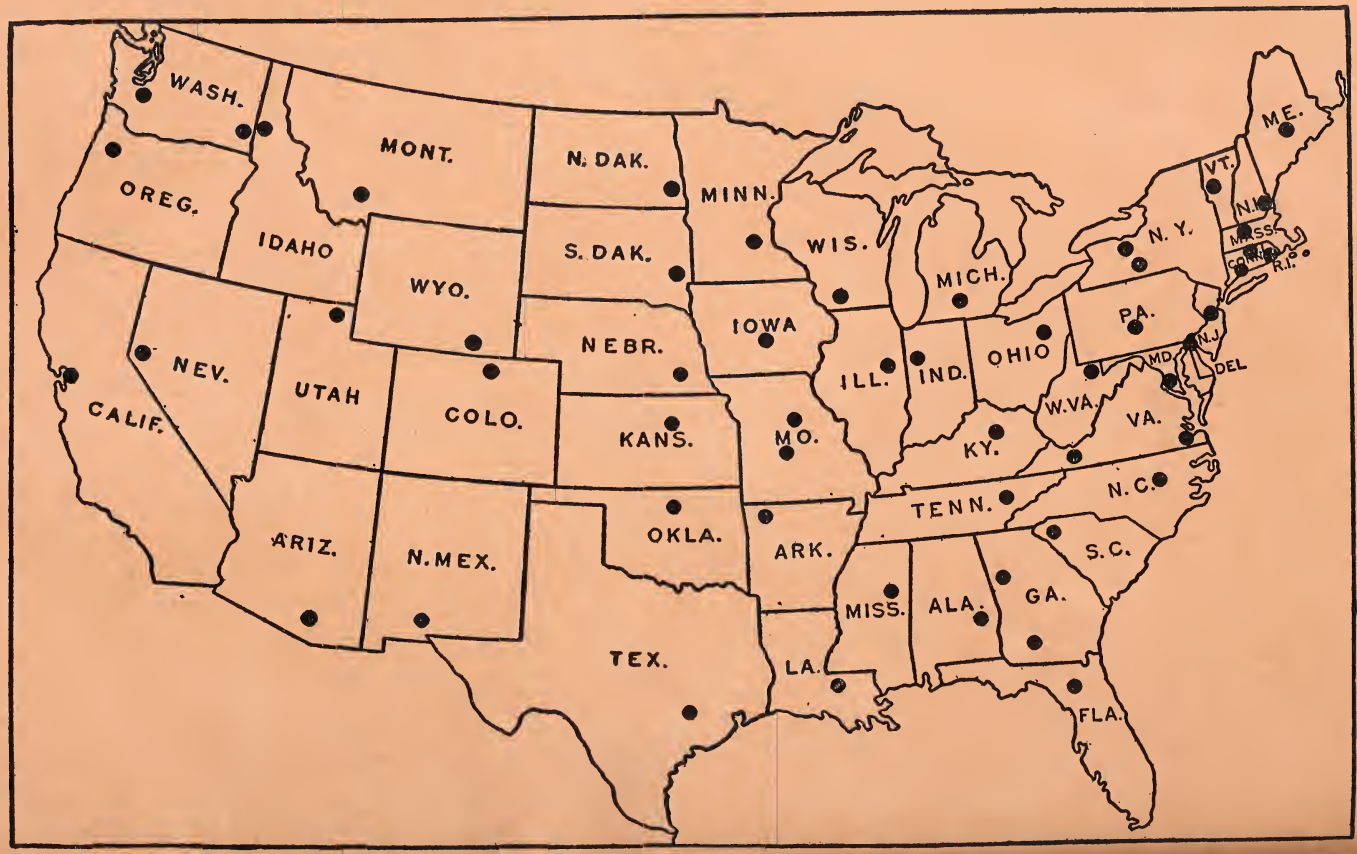
TABLE 8.—*Disbursements from the United States Treasury to the States and Territories and Puerto Rico for agricultural experiment stations under the Hatch Act (Mar. 2, 1887), Adams Act (Mar. 16, 1906), Purnell Act (Feb. 24, 1925), Bankhead-Jones Act (June 29, 1935), and supplementary acts*

State or Territory	Hatch Act, 1888–1940	Adams Act, 1906–40	Purnell Act, 1926–40	Bankhead-Jones Act, 1936–40
Alabama	$794,199.34	$491,619.89	$800,000.00	$279,096.03
Alaska	135,000.00	22,500.00	2,500.00	7,395.26
Arizona	759,803.10	494,995.61	799,986.80	41,926.14
Arkansas	793,127.12	494,900.00	800,000.00	215,943.30
California	795,000.00	494,926.84	800,000.00	222,554.11
Colorado	794,718.82	493,638.93	800,000.00	75,704.49
Connecticut	794,974.98	495,000.00	799,888.75	69,685.28
Dakota Territory	56,250.00			
Delaware	793,382.87	491,075.11	796,924.01	16,909.43
Florida	794,966.06	494,996.06	796,523.74	103,955.53
Georgia	790,593.43	482,092.87	800,000.00	295,389.86
Hawaii	164,919.17	119,951.14	95,000.00	31,004.10
Idaho	719,824.13	490,842.22	800,000.00	46,300.14
Illinois	793,115.19	494,719.20	797,339.72	292,345.58
Indiana	794,901.19	490,000.00	800,000.00	209,451.31
Iowa	795,000.00	495,000.00	797,965.17	218,884.41
Kansas	794,995.00	495,000.00	800,000.00	168,921.99
Kentucky	794,996.57	495,000.00	800,000.00	266,415.88
Louisiana	795,000.00	495,000.00	800,000.00	186,075.36
Maine	794,999.62	495,000.00	800,000.00	69,836.04
Maryland	794,967.40	494,236.48	800,000.00	96,357.87
Massachusetts	794,617.70	495,000.00	800,000.00	61,364.93
Michigan	794,676.10	491,341.60	800,000.00	226,016.46
Minnesota	794,917.78	494,345.74	800,000.00	191,692.03
Mississippi	795,000.00	495,000.00	800,000.00	245,198.48
Missouri	790,097.24	494,999.90	800,000.00	259,766.32
Montana	705,000.00	492,417.04	800,000.00	52,323.17
Nebraska	794,932.16	495,000.00	800,000.00	130,871.02
Nevada	793,331.08	491,145.10	800,000.00	8,304.66
New Hampshire	794,250.00	495,000.00	800,000.00	28,205.55
New Jersey	794,959.97	494,392.06	800,000.00	103,024.71
New Mexico	759,509.05	495,000.00	800,000.00	46,443.38
New York	794,757.54	494,189.22	799,862.27	303,181.66
North Carolina	795,000.00	495,000.00	800,000.00	346,369.50
North Dakota	751,500.79	494,637.17	799,993.86	83,274.42
Ohio	795,000.00	493,514.02	800,000.00	313,924.82
Oklahoma	726,919.88	482,842.65	800,000.00	231,021.58
Oregon	780,156.64	490,000.00	800,000.00	68,093.33
Pennsylvania	794,967.43	494,995.41	800,000.00	454,577.13
Puerto Rico	89,762.63	78,734.53	41,525.96	156,768.83
Rhode Island	794,999.65	489,423.07	799,974.38	7,640.46
South Carolina	794,542.15	493,360.12	800,000.00	200,694.24
South Dakota	738,250.00	490,000.00	800,000.00	82,459.48
Tennessee	795,000.00	495,000.00	800,000.00	252,395.60
Texas	795,000.00	492,592.26	800,000.00	504,106.06
Utah	760,000.00	494,821.94	800,000.00	35,449.92
Vermont	795,000.00	495,000.00	890,000.00	35,341.65
Virginia	793,766.58	493,544.94	799,994.27	240,112.89
Washington	733,414.70	491,080.11	800,000.00	99,615.56
West Virginia	794,804.16	491,263.82	799,942.89	181,620.36
Wisconsin	795,000.00	495,000.00	800,000.00	203,258.97
Wyoming	750,000.00	493,850.59	800,000.00	22,813.38
Total	38,023,867.22	23,892,985.64	38,527,421.82	8,090,082.66

ADDRESS LIST OF AGRICULTURAL EXPERIMENT STATIONS

ALABAMA.—*Auburn,* M. J. Funchess, Director.
ALASKA.—*College,* L. T. Oldroyd, Director.
ARIZONA.—*Tucson,* P. S. Burgess, Director.
ARKANSAS.—*Fayetteville,* W. R. Horlacher, Director.
CALIFORNIA.—*Berkeley,* C. B. Hutchison, Director.
COLORADO.—*Fort Collins,* H. J. Henney, Director.
CONNECTICUT.—*New Haven,* W. L. Slate, Director; *Storrs,* E. G. Woodward, Director.
DELAWARE.—*Newark,* G. L. Schuster, Director.
FLORIDA.—*Gainesville,* Wilmon Newell, Director.
GEORGIA.—*Experiment,* H. P. Stuckey, Director.
HAWAII.—*Honolulu,* J. H. Beaumont, Director.
IDAHO.—*Moscow,* E. J. Iddings, Director.
ILLINOIS.—*Urbana,* H. P. Rusk, Director.
INDIANA.—*La Fayette,* H. J. Reed, Director.
IOWA.—*Ames,* R. E. Buchanan, Director.
KANSAS.—*Manhattan,* L. E. Call, Director.
KENTUCKY.—*Lexington,* T. P. Cooper, Director.
LOUISIANA.—*University,* C. T. Dowell, Director.
MAINE.—*Orono,* F. Griffee, Director.
MARYLAND.—*College Park,* R. B. Corbett, Director.
MASSACHUSETTS.—*Amherst,* F. J. Sievers, Director.
MICHIGAN.—*East Lansing,* V. R. Gardner, Director.
MINNESOTA.—*University Farm, St. Paul,* C. H. Bailey, Acting Director.
MISSISSIPPI.—*State College,* Clarence Dorman, Director.
MISSOURI.—*Columbia,* M. F. Miller, Director.
MONTANA.—*Bozeman,* Clyde McKee, Director.
NEBRASKA.—*Lincoln,* W. W. Burr, Director.
NEVADA.—*Reno,* S. B. Doten, Director.
NEW HAMPSHIRE.—*Durham,* M. G. Eastman, Director.
NEW JERSEY.—*New Brunswick,* W. H. Martin, Director.
NEW MEXICO.—*State College,* Fabian Garcia, Director.
NEW YORK.—*Geneva* (State Station), P. J. Parrott, Director; *Ithaca* (Cornell Station), C. E. Ladd, Director.
NORTH CAROLINA.—*State College Station, Raleigh,* R. M. Salter, Director.
NORTH DAKOTA.—*State College Station, Fargo,* H. L. Walster, Director.
OHIO.—*Wooster,* Edmund Secrest, Director.
OKLAHOMA.—*Stillwater,* W. L. Blizzard, Director.
OREGON.—*Corvallis,* W. A. Schoenfeld, Director.
PENNSYLVANIA.—*State College,* S. W. Fletcher, Director.
PUERTO RICO.—*Mayaguez* (Federal Station), Atherton Lee, Director; *Rio Piedras* (College Station), J. A. B. Nolla, Director.
RHODE ISLAND.—*Kingston,* B. E. Gilbert, Acting Director.
SOUTH CAROLINA.—*Clemson,* H. P. Cooper, Director.
SOUTH DAKOTA.—*Brookings,* I. B. Johnson, Director.
TENNESSEE.—*Knoxville,* C. A. Mooers, Director.
TEXAS.—*College Station,* A. B. Conner, Director.
UTAH.—*Logan,* R. H. Walker, Director.
VERMONT.—*Burlington,* J. L. Hills, Director.
VIRGINIA.—*Blacksburg,* A. W. Drinkard, Jr., Director.
WASHINGTON.—*Pullman,* E. C. Johnson, Director.
WEST VIRGINIA.—*Morgantown,* C. R. Orton, Director.
WISCONSIN.—*Madison,* C. L. Christensen, Director.
WYOMING.—*Laramie,* J. A. Hill, Director.

NOTE.—The full official titles, locations, and personnel of the agricultural experiment stations will be found in the list of Workers in Subjects Pertaining to Agriculture in Land-Grant Colleges and Experiment Stations, published annually by the United States Department of Agriculture.



HEADQUARTERS OF STATE AGRICULTURAL EXPERIMENT STATIONS