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REPORT ON THE AGRICULTURAL EXPERIMENT STATIONS, 1942

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INTRODUCTION

The fiscal year 1942 has been one of unusual activity at the State agricultural experiment stations. Never in the more than half a century since the enactment of the Hatch Act of 1887 have these institutions been faced with heavier responsibilities or greater opportunities for service.

The war has brought forth a host of new demands of urgent character bearing directly upon the production and use of foods and other agricultural products for war purposes and for civilian defense needs. It has called for the speed-up of studies needed as a basis for these more direct war activities or for the maintenance of essential farming practices such as selection and improvement of plants to meet specific needs and the maintenance of soil fertility under intensive production and extension to new areas of essential crops.

The current report presents some examples of the contributions of the year by the experiment stations to the solution of emergency problems arising in the individual States and of their participation in programs directed to the needs in meeting production goals so essential to the welfare of the Nation as a whole.

In presenting this statement the direct cooperation of the Department with the State stations is noted in many instances. There are probably a large number of cases involving cooperation in some form,

[1] This report, prepared with the extensive collaboration of the contributors enumerated on the opposite page and the assistance of other members of the Office staff, is submitted in accordance with a requirement carried for many years in the acts making appropriations for the support of the Federal Department of Agriculture for a 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 period covered is the fiscal year ended June 30, 1942.

and credit due, which have not been mentioned. The reader should keep in mind the established policy of cooperative effort and integration of the research of the Department and the experiment stations in the respective States, by regions, and on the national level, which is followed as far as practicable considering the wide variety of conditions and problems to be met and the thousandfold local aspects which are primarily matters of State responsibility. One feature of this cooperation not mentioned in the discussions is the fact that to a large extent facilities of the State stations, such as housing, laboratories, lands, livestock, and farming equipment, constitute the base supply for Federal as well as State activities in order to minimize duplication of these expensive items. In times such as the present the maintenance of these needed facilities by the State agencies is a vital contribution to national needs. The construction or acquisition of new facilities and replacements must be kept to a minimum, if undertaken at all.

The setting up and attainment of national production goals for food and strategic agricultural products has required a great deal of background information of detailed local character as to productive capacities of soils and farm animals, labor and machinery requirements, varieties and breeds, fertilizer and feed uses, insect and disease hazards, and methods of harvesting, processing, storage, and marketing. Much general information of this type accumulated by the experiment stations in past research has been assembled, analyzed, and made available for immediate use.

Among the new problems imposed by wartime changes are those resulting from restricted supplies of commercial fertilizers, the nonavailability of ingredients normally used in rations for livestock and poultry, and the need for substitute materials in the control of insects and diseases. Wartime changes in the marketing and transportation of farm products and farm supplies have called for new studies to aid in conservation of trucks, tires, fuel, and men. Restrictions on imports of strategic and critical materials have made new demands on research to explore the possibilities of replacements with other products of domestic origin or of producing the needed materials in the United States. This is true of many oil, fiber, drug, condiment, and insecticide plants, of rubber-bearing plants and plant sources of synthetic rubber, and of seed stocks of certain vegetables, grasses, and legumes. Research on the preservation of food products by dehydration, including equipment, methods, conservation of nutritive values, and determination of varieties best suited to dehydration, has been intensified to provide information needed in order to prepare products for home use and for lend-lease and military purposes. Some unusual problems lying within the scope of the services and functions of the experiment stations have related directly to military operations.

Farmers of the individual States and State and local agencies, such as War Boards, nutrition councils, labor boards, and transportation committees, have looked to their State agricultural experiment stations for information and assistance through studies of State and local problems. Military establishments and defense industries, appreciative of the value of first-hand information applying directly to local conditions, have turned to the State stations for advice and research services where new facts are needed.

In short, through services on State and local levels the experiment stations have contributed research information essential to the make-up and functioning of national programs. Through full participation with Federal agencies in developing, assembling, and interpreting the local facts on which national programs must be based they have contributed essential services on national and regional levels.

FINANCIAL SUPPORT

In 1942 the Federal funds appropriated for use by the experiment stations in the States, Alaska, Hawaii, and Puerto Rico under authorizations of the successive Federal-grant acts aggregated $6,926,208. Each State received $90,000 under the authorizations of the Hatch, Adams, Purnell, and supplementary acts, while Alaska received $25,000, Hawaii $67,500, and Puerto Rico $50,000. These amounts were the same as those received during the fiscal year 1941, and the total of $4,462,500 under these authorizations was the same in both years.

The 1942 allotments to the States, Alaska, Hawaii, and Puerto Rico under Title I of the Bankhead-Jones Act were $2,463,708, an increase of $63,708 over the amount available in 1941. This increase was provided to prevent reduced allotments because of changes in relative rural population in the States and Territories revealed by the 1940 census. Under the terms of the act, the allotments are made on the basis of rural population as determined by the preceding decennial census.

The amount available to the experiment stations from non-Federal sources in 1942 was $15,738,633.91 or more than double the total of the Federal funds. These non-Federal funds included State appropriations, endowments, fellowships, and receipts from fees, sales, and miscellaneous sources.

A more detailed statement regarding the several funds appears on page 106.

In addition to these direct sources of support, the research work of the stations was aided and augmented by much cooperative effort. Extensive cooperation with the Department of Agriculture 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. Over 1,300 new or revised formal memoranda of understanding were active. These covered about 1,170 research undertakings by the State experiment stations in cooperation with research bureaus and 4 of the action agencies of the Department. The number of such cooperative undertakings varied from 10 to 55 per station.

From 12 to 25 stations continued to cooperate with each of the Bankhead-Jones regional laboratories. There was also widespread cooperation with the 4 regional research laboratories of the Department and participation by many of the stations in the work assigned for leadership to the subject-matter bureaus of the Department and financed by the Bankhead-Jones special research fund.

ADJUSTMENTS FOR WARTIME SERVICE

At the beginning of the fiscal year under report, approximately 20 percent of the station research projects active under Federal-grant funds during the previous year had been replaced by new work on problems of immediate significance or revised and redirected to include defense activities. During the year an additional 23 percent were closed and replaced or revised to meet war needs. The redistribution of the Federal-grant funds resulted in the undertaking of 3,472 studies in 1942, an increase of 237 over the previous year. There was also a similar revision of the 5,142 State-fund projects active in 1942.

In contributing to the solution of the complicated problems raised by the war the experiment stations have assisted State and Federal agencies in assembling and interpreting the facts needed for establishing local, State, and national goals. They assisted farmers to meet production quotas by making available an increasing volume of timely information in the form of clear, concise, simply written circulars and speeded up studies on phases of production problems that limit the realization of maximum yields, such as, for example, how to increase poultry and egg production with substitute rations, how to make limited supplies of nitrogen produce more food and fiber, how to protect plants and animals from disease and insect pests with reduced supply of insecticides, fungicides, and medicinal chemicals, and how to relieve and overcome critical shortages of farm labor and transportation facilities.

Many of the contributions of soil science are discussed later in the report in their relationship to the attainment of the production goals for the individual commodities. For example, in meeting the production goals for soybeans not only information on the selection and breeding of well-adapted, high-yielding varieties, but also facts on soil types and fertility conditions best suited for maximum production were required. This type of information was provided by several stations, including those of Iowa, Kansas, Missouri, Nebraska, South Carolina, North Carolina, Mississippi, Ohio, and Illinois. Similar information has been furnished for peanuts by the Virginia, Mississippi, Georgia, Alabama, Florida, and North Carolina stations. The above are cited only as typical examples of how a few of the stations have contributed facts effective to the solution of production problems and are obviously not intended to be inclusive, since such procedure would amount to a virtual listing of all stations for each crop required in the war effort in the particular region in question.

Attainment of crop-production goals necessarily involves the effective control of diseases and insect pests. Station workers have cooperated with national groups in studies directed to the finding of substitutes for fungicides and insecticides restricted because of military needs or the cutting-off of foreign sources of supply. New organic materials developed and tested in wide-scale studies have opened up promising possibilities for replacing restricted materials in sprays and dusts. Station studies have also pointed to ways of stretching supplies with little loss of effectiveness by reducing dosages or number of applications.

Goals for poultry products call for tremendous increases in production. Rations built over the years, involving milk byproducts now needed for food and industry, are no longer available in many sections. In practically all poultry-producing States the experiment stations have necessarily undertaken the responsibility of promptly developing satisfactory nutritive rations out of feed materials available locally. The problem is not an over-all one—because of transportation there are innumerable local aspects to be met.

Goals for certain specified crops call for the maximum production possible per unit of available land. In areas where nitrogen supplies are important limiting factors, every experiment station has vigorously increased activity to supplement available commercial fertilizers with additional production of legumes and improved techniques in the placement of fertilizer, including use of liquid forms, to secure maximum crop response. Again in this important field the local aspects to be met are thousandfold.

A considerable part of the effort of workers in soil science during the emergency is directed toward giving assistance on local problems connected with meeting the war production goals. This service has involved a variety of problems, such as making special surveys of soil type and fertility conditions, recommending soil-management practices, and the interpretation and publication of data already available so as to provide facts needed for the production of essential field and vegetable crops.

From cooperative studies with the Soil Conservation Service, many of the stations provided information on soil-management and tillage practices that were effective in increasing yields and also conserving valuable soil and water resources. The cooperative studies at the Indiana station showed an acreage yield of corn of 39 bushels per acre for untreated land cropped annually to corn in comparison with a yield of 61 bushels for adjoining areas treated with fertilizer, lime, and crop residues and cropped in a 4-year rotation of corn, corn, wheat, and clover, while at the Nebraska station it was found that the use of crop residues was effective in increasing the yield of wheat. Where land was plowed without a crop residue being added, a yield of 10.5 bushels per acre was obtained, while land having a crop residue and being subtilled produced a yield of 22.3 bushels per acre.

Crop losses from plant disease are now of the greatest concern to the Nation and its allies. They are among the serious obstacles which the farmer has to face constantly in his intensive wartime drive for increased food, feed, and fiber production. No crop is free from the danger of damage and destruction from various diseases unless adequate precautions are taken. In each State great responsibility, therefore, rests upon the small body of experiment station scientists who specialize on plant diseases and their control.

These investigators are now assisting agriculture to deal with problems of more than ordinary complexity growing out of the war situation. Not only must they develop methods of control over still unconquered diseases of essential crops in order to stop, if possible, the drain on production, but they must also try to find out how farmers and orchardists, in spite of emergency conditions, can keep up effective control over diseases for which preventive measures have been already worked out. Even now these scientists are helping growers to adjust disease-control programs to wartime shortages of critical chemicals and spraying and dusting machinery and to the growing scarcity of experienced labor.

Station plant pathologists have been called upon to deal with the increased disease hazards unavoidably created by the great regional expansion in acreages planted to important wartime crops and by the local intensification of their culture. Human experience has demonstrated that wherever large, continuous areas are devoted to individual crops, the pests and diseases peculiar thereto find conditions favorable for abundant multiplication. The problem of successful control is thus made doubly difficult. State stations are often working together to meet regional problems of this sort.

Another factor adding to the problem of disease control is the neglect inevitably resulting on many farms from shortage of help. Neglect of spraying allows diseases to multiply and spread to nearby orchards and fields, making the owner's job of protecting them more difficult than usual. Here plant pathologists can help work out systems of community cooperation with sharing of trained labor and available equipment.

Perhaps no more effective wartime service has been rendered by station plant pathologists than in giving aid to thousands of farmers who, to help their States reach war goals, are planting millions of acres to crops which they have never grown before and which are subject to diseases they do not know how to control. To meet this situation, the latest and best ways developed by research for the protection of such crops against important diseases have been set forth in clear and simple language. In all parts of the country emergency leaflets, folders, and circulars giving instructions on how to spray, dust, treat, or fumigate against crop diseases have been prepared and made available to the farmers and to agencies and individuals helping in the agricultural war production and Victory Garden programs.

Regional groups of station plant pathologists were also organized under the war emergency committee of the American Phytopathological Society. These groups arranged for an immediate assembly by specialists and exchange, among the States, in mimeographed form, of the latest research results on disease-control methods for crops of importance to the war effort. Under the same auspices came an acceleration of coordinated interstate investigations on new fungicides and on the extent to which standard fungicides could be justifiably diluted as a measure of wartime economy.

Examples of recent achievements in research on plant-disease control are discussed in the sections of this report dealing with the different classes of crops. These examples show how station workers, although often severely handicapped by the loss of assistants and laborers to military services and war industries and by restrictions on the use of gasoline and tires, are making progress in their search for ways by which farmers can avoid or lessen the losses caused by plant diseases.

For instance, when farmers throughout the South were faced with the problem of meeting wartime shortages of vegetable oils by growing more oil peanuts and peanut-planting goals were raised from less than 2 million acres in 1941 to 5 million acres in 1942, three experiment stations had already solved the problems relating to major diseases that were responsible for low yields, as indicated on page 85.

Peanut dusting with fungicides for leafhopper and leaf spot control had been proved a success by the Georgia, Virginia, and North Carolina stations, giving yield increases averaging 300 to 500 pounds of nuts per acre. Furthermore, poor stands were found to be due largely to rotting of the seed in the ground or blighting of the emerging sprouts. Tests showed that chemical seed treatment is an effective preventive. The result is that peanut seed treatment with fungicides is now incorporated in the general action program for increased wartime production in the United States.

This country is now also receiving manifold returns on its investment in agricultural experiment stations which made possible the development of disease-resistant varieties of fruits and vegetables as brought out in the sections devoted to these types of crops. The increased goals for canning and drying purposes would be difficult to attain except for the availability of either disease-resistant sorts or of methods for developing disease-free seed stocks or of providing effective chemical protection of fields during the growing season. The same is true with respect to the Victory Garden program. Every fruit and vegetable is subject to various destructive fungus, bacterial, and virus diseases. Experiment stations have by their research on disease hazards prevented a collapse in the production of nearly every major fruit and truck crop at one time or another in important areas. As new problems of the kind arise, and as they are intensified by conditions prevailing during the war period, the stations are attempting to readjust their research programs for attacking such problems with all available resources. Many new disease-resistant varieties are being introduced at this time.

Various aspects of labor problems, including availability of farm-family labor and the need for migratory labor, have received major attention in virtually all States. Typical of the work done is the information developed by the Maryland station indicating labor requirements for the State as a whole and on a per-farm and per-acre basis for use of farm-labor committees in reporting essential manpower needs to local draft boards. A detailed survey of labor requirements of canning plants throughout the State of Maryland provided data on 1941 labor needs and shortages and estimates of needs for 1942. A special study of the situation relating to potato-harvest labor for 1942 in Aroostook County by the Maine station served a similar purpose for the producers of an estimated 40 million bushels of potatoes.

Tangible aids toward the solution of transportation problems are being rendered by the stations in studies that are pointing to possible large reductions in milk-route mileage and more economical use of farm trucks and rail facilities in the movement of a variety of agricultural products and livestock. For example, studies by the Vermont station of milk assembly routes covering more than half of the State showed that reorganization within companies would effect mileage reductions of 25 percent and reorganization among companies would bring an additional 25 percent saving.

A marked intensification of research activity is being directed to the better use of food for national health and vigor, with aspects that have direct application to needs of the armed forces and lend-lease shipments. Many of the State stations and the Department are cooperating in research under the new national cooperative project on the conservation of nutritive values of foods. Progress is being made in developing dehydrators for home and community use and in assisting with home and commercial aspects of dehydration methods.

Investigations having to do with the production of fiber, oil, and drug plants are being accelerated and expanded in attempts to provide home sources of these critical materials. For example, there was an increase in the number of Federal-fund projects dealing with these crops from 58 to 86 during the fiscal year 1942.

Native plants as sources of rubber are being investigated by several stations, and many of the stations are cooperating in the national guayule and Russian dandelion studies.

Sugar shortages are being eased by new facts on production problems and new findings that permit wider use of substitutes for sucrose, such as the findings of the Massachusetts station that from 25 to 33 percent of the total sugar in most canned fruits, preserves, and jellies may be made up with dextrose without change in color or texture, and that the use of more than 30 percent of dextrose in sirups helps to prevent fermentation and mold. State and Department research on waxy starches in corn and sorghums is contributing to independence from imports of cassava starch.

A considerable amount of research aid has been directed by the stations to problems of locating and servicing military establishments and defense industries. Research problems that relate directly to military operations have been undertaken by the experiment stations at the request of the armed forces.

PROGRESS OF AGRICULTURAL AND RURAL-LIFE RESEARCH

A summary follows of the experiment station research carried on in 1942. This is based 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 been supplemented as source material by special reports from their directors as to current activities and significant accomplishments of the year.

The publications of the stations in 1942 comprised nearly 50,000 pages. This summary, therefore, does not attempt to cover all of the research projects and activities 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 to illustrate the findings having direct significance in local, regional, or national aspects of production and distribution of agricultural products for wartime needs.

In order to bring out more clearly the contribution of the stations to the war effort and related national problems, a departure has been made in the general plan of presentation from that of recent years. The major headings deal with rural adjustments, essential foods and feeds (including both production and marketing phases), essential critical and strategic materials, and services to war industries and the armed forces. Findings from all the various subject-matter fields are covered under these headings with the exception of home economics which, largely because of its specialized nature, will be otherwise covered.

RURAL ADJUSTMENTS

The necessity of producing huge supplies of foodstuffs and fibers essential to the war purpose is broadly recognized. The work of the State stations in providing basic information locally with which to establish consistent war production goals and later to help attain them is an essential service. The production of plant and animal products under the greatly enhanced production goals now contemplated, with much of the manpower leaving the rural districts for the war industries and the armed forces, and with limitations to the availability of farm machinery with which to compensate in part for manpower lost, is a task which is taxing not only the land and its occupants but also the resources and the resourcefulness of the War Boards and the agencies of agricultural research and education throughout the country.

Food and fiber production is dependent not only upon a sifting of the facts gained through the previous half century of research but also upon emergency studies and experiments made promptly as specific questions arise. Because of wide differences in such factors as soil, altitude, rainfall, temperature, crop and livestock adaptations, and the availability of labor and equipment, the problems connected with production vary greatly from one type-of-farming region to another, and constitute a high challenge and grave responsibility to the research institutions of every State.

During the past 2 years the experiment stations have radically redirected their efforts to make their services immediately and effectively available to the war purpose. With the space limits prescribed for this review it is, of course, impossible to enumerate all their varied activities. The following examples are indicative of the emphasis placed upon some of the more pressing problems of rural adjustments.

In accordance with a readaptation of its program to war conditions, the Iowa station is determining ways and means of increasing agricultural production and economizing on transportation and processing facilities related to agriculture. The station has also studied price policies as they affect production, processing, and transportation, and land values; over-all government policies and their effects; the effect on consumers of such measures as rationing; forced loans and social security taxes as inflation remedies; inflation dangers and tax remedies; inflation as affected by the Treasury's borrowing program; and a comparison of British and American income taxes.

Accumulated farm-management research data of the Kansas station were found to be of basic importance to the planning of production goals in Kansas. Information has been furnished the War Board upon labor and material requirements for crop and livestock production in different parts of the State. Under this project the ability of each type-of-farming area to increase the production of needed farm products is determined each year by taking stock of the resources of the type-of-farming areas and their present organization by types and sizes of farms.

The Utah station also made a number of studies which led to a report on the 1943 agricultural production goals for the State, and prepared a report dealing with a long-time State program.

Progress has been made by the Ohio station staff in studies designed to ascertain potential agricultural production, harmonize production with needs, and distribute goals according to the productive capacity of each region, area, and farm and the rapidity with which this productive capacity can or should be utilized. Goals for practically all farm products were set up, including the 1930–39 average, the 1940 and 1941 production, and estimates of the expected goals for 1942 and 1943, and long-time desirable goals, together with percentage changes.

The New Mexico station has examined the 1942 plans of Curry County farmers to determine what types and sizes of farms are best able to make the necessary adjustments and the ways and means of securing adjustments on those farms on which production of war commodities is uneconomical. The station has also aided the State committee on war production goals and their attainment by supervising the statistical phases of the project and in the preparation of the State report. Members of the staff have assisted in revising the State laws so that there will be less hindrance to the national war effort. They have also advised such other groups as the State War Board, the labor subcommittee of the State Interagency Council on the war labor shortage, the BAE-Land-Grant College Committee, and the School of Pan-American Affairs.

A member of the South Dakota station staff was chairman of a committee representing the various Federal and State agencies in an analysis of the agricultural productive capacity of the State, which has been divided into eight agricultural areas in such a way that the farmers and ranchmen can make their maximum contribution to the Food for Freedom program. The staff of the Alabama station consulted with the Agricultural Adjustment Administration regarding the food requirements of the farm population and with the Extension Service regarding a food-production program for the State.

The Idaho station made a special study of feed prices in relation to nutritive values in cooperation with the animal husbandry department and released the results to livestock men. For use, also, in planning 1943 goals, farm budgets representative of the dry-land area were assembled and analyzed.

The farm-mortgage situation was surveyed by the Delaware station for the period 1912 to 1938, and this station is also providing material for planning current production goals and also for post-war planning. Studies of land classification reported in bulletin form have indicated areas suited for intensive cultivation, extensive cultivation, and timber cultivation and wildlife preservation.

Farmers' sons going to war have created a demand for a new type of rental contract in Nebraska. Farmers fear the outcome if they pay as high a cash wage to inexperienced help as their former hired men are now receiving in some war industries. They are willing to share profits but unwilling to assume all of the risk involved. A 50–50 stock-share lease which divides the risk and the profits is considered an excellent solution in some cases if the prospective tenant has capital to purchase a one-half interest in the livestock and equipment. The landowners are willing to deal equitably with tenants but have asked the Nebraska station to determine how the division of income and expenses should be made. Members of the station staff have helped to do this by estimating the possibilities and limitations of food-production increase in different areas of Nebraska. They have assisted in making a survey of the farm-labor situation in the State and in the development of a program for a summer farm work camp. They have offered evening courses and Saturday work training for high-school students.

In a study of landlord-tenant rental arrangements in Georgia, the objective was to determine methods by which the rental arrangements used by landlords and tenants in Georgia can be improved. A manuscript was prepared which describes the renting practices in common use on Georgia farms, including rental arrangements on tractor farms and commercial livestock production under a share rental arrangement. This study should provide specific information needed by action agencies, farmers, and others in determining changes in leasing arrangements necessary in attaining production goals, in promoting desirable land use practices, livestock production, conservation, and improved landlord and tenant relations.

The State War Board of Rhode Island has been aided by members of the station staff in the preparation of data concerning the maximum capacity of farmers in that State to produce agricultural products with existing farm facilities.

The Washington station has conducted research to determine improved systems of farming and efficiencies in production and marketing. It has also conducted a survey of the activities of State eleemosynary institutions with a view to suggesting ways and means for them to become more efficient in their operations and less dependent on the open market for food supplies.

As a result of a study by the Wisconsin station of farm accounting in relation to economic agricultural production, that station has been brought into position to emphasize particular management activities on individual farms which result in increased production at lowest unit cost.

As a basis for adjustments, the Pennsylvania station has maintained an index of prices paid by Pennsylvania farmers for goods and services used in production which shows how changes in price relationships are affecting the farmers of the State. This has been useful as a guide to the establishment of milk prices under Federal orders in New York and Philadelphia markets and by the Pennsylvania State Milk Control Commission in other markets. The study has also been of service in establishing fair price ceilings for such products as potatoes.

A major problem of farmers in wartime is to hold down production costs and maintain a dependable farm income. Studies of the New York (Cornell) station showed that low-cost production is obtained chiefly by the efficient use of man labor and by moderately high rates of milk production per cow. Other important factors in the rate of milk production were found to be the rates of grain feeding, the amount and quality of roughage, and the size of cow. These data relating to cost and returns in producing milk have been used in administration of prices in the Federal-State milk-marketing orders in the New York metropolitan market and in the State orders in the Rochester and Buffalo markets. Increased price stability in these markets has encouraged increased milk production to meet the national goals for food production.

The Georgia station made a special study of peanut production for war needs in Sumter County. Cash expenses and returns per acre were shown for peanuts and the major competing crops, and a budgetary analysis was made of the organization of a representative medium-sized farm and of five alternative plans which could be followed in meeting the peanut goals. On a basis of prices that are roughly 85 percent of parity, the returns over cash expenses per acre were $20.51 for peanuts for oil, $16.29 for peanuts hogged-off, $31.28 for peanuts used in the edible trade, $39.65 for cotton, and $8.70 for corn. In a study of hog production, the station found that where continued grazing of crops was provided for sows and pigs throughout the grazing season, the profits were practically doubled when compared with an equal number of sows and pigs running on woodland until they were brought in for hogging-off peanuts in the fall.

Studies of rural population changes and mobility of farm labor by the Kentucky station are typical of studies throughout the country which are helpful to those dealing with farm and industrial production problems. Withdrawals of population from rural areas for military and defense industry, the possibility of chaotic return of these populations after the war, consideration of decentralization of industrial production, congestion of rural suburbs around defense industry concentrations, wartime provision for the welfare of dependent persons in rural communities, reestablishment of farm people displaced by new depots, camps, fields, and the like for branches of the military service—these are among the problems to the solution of which data on rural population gathered by the stations are contributing. Local and national policy in connection with the war emergency program has resulted in greatly increased demands upon rural areas for industrial labor. Further increases in these demands by industry and an expanding agriculture point to the need for greater efficiency in the use of labor in agricultural production. The impacts of these developments have become manifest, it was found, in increasing shifts among farm-tenure groups and in accelerated movement of workers from agriculture into industry.

At the Washington station a project vital to an understanding of migration, one of the major social phenomena of the defense period, is a study of the out and return migration in rural areas in connection with war activities. Information on how the industrial labor market is affecting rural activities, institutions, and population distribution is being sought.

A State-wide cooperative survey made by the North Carolina station and the Department (AMS, BAE) indicated that 44 percent of the 50,000 migrants who left farms of the State between December 1, 1941, and May 1, 1942, entered the armed forces and that the remainder went into war industries or other nonagricultural occupations. Of 28,000 single men between 20 and 45 years of age, about two-thirds went into the armed forces. Farm women, younger boys and girls, as well as the aged, were playing and must play an increasing part in meeting farm labor shortages. Women and girls already make up over 20 percent of the farm laborers on North Carolina farms and this group is increasing steadily.

The Ohio station is conducting a study of the migration of rural youth, its extent, and destinations. A recheck is being made of data obtained in 1940 in regard to 1,602 rural youths in Ross County. Many have since moved away, largely as a result of the war effort. The findings will be used by the Extension Service and other agencies as a basis for readjusting programs during the war and to aid post-war planning.

The Louisiana station made a study of the farm-labor situation relative to war. This study should stimulate the efficient use of farm labor in the State.

The Arizona station is conducting two closely related studies at the request of the State War Board. One has to do with the laborer population of the State and conditions under which it may be made available for farm employment. A second study has to do with a survey of available farm machinery in the State and methods for economizing its use in crop and livestock production.

The Maryland station studied the availability of labor for tomato-canning factories on the Eastern Shore and determined the possibilities of relocating plants and modifying equipment to meet labor shortages. It was found that because of heavy losses incurred in 1941 due to such shortages the growers adjusted the 1942 acreage to the prospective labor supply.

To assist the United States Employment Service and to serve as a guide in supplying farm labor during the peak labor load months, the Oregon station made a study of man-labor requirements per acre by operations for a number of the fruit, vegetable, and livestock enterprises of the State. The station has also aided the Oregon Milk Control Board to effect adjustments in the milk supply and milk prices to meet the impacts of the war program. Specifically the problem is to furnish large additional supplies of milk, the demand for which arose from the building of cantonments at Corvallis and Medford, Oreg., and Fort Lewis, Wash., and the shipyards and aluminum plants in Portland, Oreg.

The Texas station has brought together basic data on labor requirements for harvesting cotton, peanuts, and rice. Information on the number of laborers required for the 1942 harvest of these crops has been assembled for each type-of-farming area and distributed to agricultural agencies and farmers' groups planning to meet a sharply curtailed farm-labor supply.

The West Virginia station studied the farm-labor situation in the State, and is advising the United States Employment Service, Work Projects Administration, National Youth Administration, and educational institutions that may have youths to release for farm work and to work with Selective Service Boards. Thus the station serves as a clearing house on farm labor problems in the State.

Studies by the Arizona station of ways of saving labor and using machinery more efficiently in crop and livestock production have yielded information for the mobilization of manpower and machinery if this becomes necessary.

Wyoming station studies of the labor requirements for various farm and ranch operations have been helpful to the State War Board in its evaluation of the need of farm labor in the State. Data concerning the number of men required per thousand ewes for lambing and per thousand tons of hay harvested enabled the defense committee to adjust the labor-requirement figures more accurately than would otherwise have been the case. Knowledge of the carrying capacity of the ranges and of variations in the numbers of livestock has enabled members of the station staff to serve as consultants to the defense committee in setting up production quotas.

The South Carolina station is studying the farm-labor supply and demand in that State, where in many sections farmers are already finding the farm-labor supply to be the limiting factor in achieving production goals. Areas will be mapped showing different types of agricultural labor and variations in seasonal demands. Relations between wages and prices of commodities are included in the study. The Utah station has made a similar analysis, the data made available including a general view of the farm-labor situation and the shortage that exists in various parts of the State; problem areas with the seasonal labor requirements; the man-months of labor required and labor available, together with sources of additional labor supply; seasonal man-month requirements for the State by areas and for individual crops; the drain on agricultural labor by war activities, defense employment, and the nonagricultural employment; recommendations for obtaining additional labor; the method of organization, a summary of labor requirements with peak months for each crop and kind of livestock; and the apparent agricultural labor shortage for 1943 agricultural production, and the need for a definite agricultural labor policy and program to handle this problem in connection with 1943 production.

At the New Mexico station a study was made to determine the amount of labor required and the distribution through the season for critical operations requiring a large amount of hand labor. These operations included pinto bean harvest, cotton chopping, hoeing, and picking, broomcorn harvest and baling, and vegetable and fruit harvest. Close cooperation was maintained with the Federal Employment officials, WPA, and the labor subcommittee of the State Interagency Council. This was done so that the data could be worked up in the form which would serve the best purpose.

ESSENTIAL FOODS AND FEEDS

CONTENTS

FOOD AND FEED PRODUCTION

In this section an attempt has been made to present a connected account covering the station work associated with production of the various foods and feeds. Included, therefore, are items dealing with such matters as improvement of varieties and breeds, crop and livestock management, use of machinery, and disease, insect, and weed control. The treatment in each case is grouped around the individual commodity.

MEAT AND MEAT PRODUCTS

The significance of meat production as a phase of United States agriculture is indicated by 1941 data, which show a total production from cattle, sheep, and swine of 9.1, 0.9, and 9.5 billion pounds, respectively, the total of about 19.5 billion pounds yielding a gross return to farmers of approximately 3.5 billion dollars.

Because of the value of meat in the diet of a nation at war and the increased demand for meat to meet the needs of our armed forces and for aid to other nations, the 1942 production goal was set at the record-breaking peak of 21.7 billion pounds. Attainment of this goal involved not only a marked increase in the number of slaughter animals, but also improved feeding practices, maximum use of available feed supplies, optimum reproductive efficiency in breeding stock, and effective control of diseases and parasites which annually take a heavy toll in mortality and reduced efficiency in live-weight gains. Contributions of the experiment stations to the solution of many problems existing in these various fields are playing an important role in the attainment of desired levels of production.

Beef-cattle production.—The unprecedented demand for corn for livestock feeding, coupled with transportation problems in moving corn into deficient corn-producing areas, has stimulated research on the use of corn substitutes in cattle-fattening rations. Under the circumstances there is an urgent need for the most effective use of carbohydrate feeds which will serve as substitutes for corn and which are produced or are readily available in the local areas where livestock are to be fattened. Other cereal grains have frequently been used to partially replace corn, but further work has been justified in determining the most suitable combinations. Barley, the production of which has increased in many areas in recent years, may be substituted for shelled corn in the fattening ration for beef calves with nearly as satisfactory results as can be obtained with corn, according to findings of the Missouri station, and similarly the North Carolina station reports that a rotation of barley and lespedeza, using the barley as the sole grain for fattening, is a practical way to produce beef in the Piedmont area. Replacing one-half of the shelled corn in a normal fattening ration with ground oats did not significantly reduce the rate of gain in fattening cattle in trials at the Oklahoma station, and in the same series of experiments it was found that the feeding of ground kafir heads for the first 2 months of the feeding period and ground, threshed kafir grain for the rest of the period supported gains very similar to those on corn. In all cases, sorghum silage, cottonseed cake, and ground limestone were fed along with the grains under test.

The substitution of 42 percent of molasses and 21 percent of ground oats for equivalent amounts of corn had no significant effect on rate or economy of gains in fattening steers at the Illinois station, but the market grade of the cattle was lowered to such an extent that it appeared doubtful whether molasses was an economical substitute for corn at the levels used in this experiment. The nutritive value of ground ear corn was found to be only slightly less than that of an equal weight of shelled corn for beef cattle, and, in view of the weights per bushel of these two products, there was a distinct advantage in feeding the corn-and-cob meal, according to findings at the Ohio station. Technical experiments there indicated that the cobs have considerable nutritive value because they stimulate increased microbiological activity in the rumen of cattle. A locally adapted strain of grain sorghum was found by the Colorado station to be approximately 90 percent as valuable as corn for fattening steers when fed either as the sole grain or in a grain mixture.

In attempts to utilize rice byproducts, the Louisiana station found a mixture of rice polish and rice bran to have about 82 percent of the feeding value of ground corn when fed in combination with cottonseed meal and rice straw. A mixture of these rice byproducts with molasses had 80 to 90 percent of the feeding value of corn.

A ration of dehydrated sweetpotatoes and cottonseed meal proved slightly superior to a mixture of corn-and-cob meal and cottonseed meal as supplements to silage for fattening steers in trials at the Tennessee station, and preliminary experiments at the Mississippi station essentially confirmed this finding. Similarly, the Georgia and Texas stations found that rations of sweetpotato meal, cottonseed meal, and hay promoted practically as rapid daily gains as those containing an equal amount of corn instead of the sweetpotatoes. Combinations of ground corn and cottonseed meal in ratios ranging from 5:1 to 1:2 proved of about equal value as supplements to sorghum silage and legume hay in trials at the Mississippi station, indicating that cottonseed meal may comprise up to two-thirds of the fattening ration if prices justify its substitution for corn.

While corn or its substitutes form the basis of livestock fattening rations, such feeds are low in protein content and must be supplemented by protein-rich feeds to support the most efficient gains. Hence the source and amount of protein concentrates needed for optimum gains in cattle has also been the subject of extensive investigation. Accumulated data based on earlier experiments in this field are now being used advantageously as the basis for sound feeding recommendations. Fortunately it appears that most of the common vegetable proteins or oil cakes are of similar biological value, which means that the nearest available supply of protein concentrate may be effectively utilized, thus reducing transportation requirements to a minimum. For example, a comparison by the Michigan station of expeller, solvent, and toasted solvent soybean meals and a mixture consisting of equal parts of expeller soybean meal, cottonseed meal, and dry rendered tankage showed no noticeable difference in any of these supplements in either of two trials. Similarly, no significant difference was found in the value of cottonseed meal and soybean meal when used to supplement corn, clover hay, and either corn or sorgo silage in trials at the Indiana station. Ground lespedeza seed proved only slightly inferior to soybean meal as the protein supplement for fattening yearling steers in trials at the Missouri station. The reasonably satisfactory results obtained with the lespedeza seed indicates that it is a potentially valuable source of protein in view of the large acreage available for harvest.

The rapid expansion of livestock feeding is causing a rapid reduction in the supplies of feed grains, pointing to the necessity of using roughages to a maximum extent in the production of meat animals even though some sacrifice in finish of the slaughter animals may be involved. The Missouri station reported that yearling steers that have had all the good roughage they would eat in the winter and access to good pasture until the middle of July could be converted into "Good" slaughter animals by full-feeding on lespedeza pasture from July to October and then full-feeding for only 40 to 60 days in dry lot. Such a system obviously results in a marked saving in concentrate feeds as compared with the normal 150- to 180-day dry-lot feeding period. The same station has shown also that even greater use of pastures and roughage may be made by carrying steers to 2 years of age with practically no feeding of concentrates, followed by only a brief final fattening period. Under this system relatively heavy steers are produced at a very small expenditure of feed grains.

Numerous results became available from the stations on the relative merits of various types of roughage feeds in cattle rations. Alfalfa-grass silage proved more palatable than field-cured alfalfa hay and compared favorably with corn silage in the ration of fattening calves in trials at the Michigan station.

Studies on the effects of various degrees of acidity in silages at the Illinois station indicated that high acidity depressed the efficiency of utilization of the feed energy. The advisability of neutralizing silage acidity by the addition of finely ground limestone to the ration was suggested.

In wintering yearling steers on silage and hay, the Missouri station found that corn silage was far superior to other types tested, followed in order by Atlas sorgo silage, legume silage (mixture of alfalfa, sweetclover, and red clover), and small-grain silage. Actually 1 ton of the corn silage produced more gain than 2 tons of the small-grain silage and required considerably less hay per unit of gain.

When accompanied by a medium ration of cottonseed meal, corn silage fed ad libitum to steers at the Tennessee station proved decidedly superior to other forms of corn, including shock corn and crib corn. A yield of 877 pounds of beef per acre of corn was obtained from the corn silage-cottonseed meal ration, whereas the yields were below 800 pounds per acre when other forms of corn were fed. Either fresh sugarcane or sugarcane silage proved to be a valuable supplement to snapped corn and cottonseed meal for fattening yearling steers in trials at the Florida station, while the full-feeding of steers on good Dallis grass pasture promoted somewhat higher gains than were obtained with either the fresh or ensiled sugarcane.

A comparison of various locally produced roughages at the Georgia station showed peanut hay and kudzu hay to be particularly valuable supplements for a basic ration of corn and cottonseed meal for fattening cattle, followed in order by peanuts on the vine, Korean lespedeza, sericea lespedeza, and soybean hays. The same station found peanut hay somewhat superior to either lespedeza or grass hays for the wintering of the beef breeding herd.

The Mississippi station found kudzu hay somewhat difficult to feed to fattening beef cattle because of its viny nature and coarse stems, but showed that the plant was a valuable emergency feed for wintering beef cattle when other feeds are relatively expensive or unavailable.

Rations high in roughage produced reasonably well finished steers at the Texas station. Ground hegari fodder proved particularly desirable as a source of roughage, while the addition of a small amount of alfalfa hay further enhanced its value.

Certain species of *Crotalaria*, a legume widely grown in the South as a soil-improving crop, were found by the Florida station to be potentially valuable sources of livestock feed. *C. incana* and *C. intermedia* showed the greatest promise either as pasture or silage crops. Some of the species, particularly *C. spectabilis*, proved toxic to practically all classes of animals, and therefore neither the grain, forage, hay, or silage from this species should be offered to livestock.

Optimum use of our range lands also assumed greater significance because of the drive for greater meat production. Studies in range management at the North Dakota station showed that approximately 25 percent of the vegetation should remain ungrazed at the close of a season in order to provide normal maintenance conditions for livestock and not unduly deplete the range.

Under conditions of constant close grazing of cattle ranges, the California station found that about 50 percent more acreage was required to carry cattle during the dry season from August to February than from February to August. Such close grazing caused a material reduction in the calf crop, emphasizing the need of stocking ranges at a reasonable rate.

Weeds were found by the Colorado station to supplement advantageously native grama grass and buffalo grass pastures. Better gains were made on the weedy range than where the grass stands were nearly pure.

At the New Mexico station range grasses did not meet the requirements of cattle for minerals, and it was therefore necessary to supplement such rations with mixtures of steamed bonemeal and salt. There then resulted smaller death losses in newborn calves, larger numbers of calves weaned, greater weight of calves, and larger gains of calves and sheep than occurred in the livestock under normal local grazing conditions. On saltgrass range cattle consumed little or none of the calcium and phosphorus supplements.

Similarly a winter mineral feeding problem was encountered at the Idaho station, where beef cattle fed beet molasses or wet beet pulp according to appetite failed to consume enough alfalfa hay to meet their phosphorus requirements. Bonemeal as a mineral supplement at a rate to supply about 2 grams of phosphorus daily per 100 pounds of live weight corrected this deficiency. Cattle confined to locally produced feed were frequently found by the Florida station to exhibit symptoms of both copper and cobalt deficiency, emphasizing the need of supplying supplements containing these minerals where they proved to be deficient in the feed crops.

Sheep production.—While sheep are depended upon for only about 5 percent of the Nation's meat supply, their importance as a source of wool, in addition to their meat value, causes them to occupy an important wartime role. Examples of investigations pointing the way to better feeding and management practices for sheep included a study at the Indiana station showing that the feeding of protein supplements to breeding ewes in winter, even when alfalfa hay was fed, increased thriftiness and gain of the ewes during pregnancy and also the amount of wool produced, although not significantly affecting the birth weight of lambs produced. Cottonseed meal and soybean meal proved equally effective as supplements. It was further shown that a wintering ration consisting of yellow corn, corn silage, and oat straw was deficient in essential nutritive properties for pregnant ewes not entirely met by the addition of high-quality protein, cod-liver oil, and alfalfa hay, although these supplements markedly improved the ration. The exact nature of the nutritive factors involved has not been determined, although it was found to be abundant in artificially dehydrated young cereal grasses. Further evidence that nutritive deficiencies may occur in the ration of breeding ewes was demonstrated in experiments at the Maryland station, where replacing corn with distillers' dried grains reduced the vigor and increased the mortality rate in ewes and also adversely affected the birth weight of the lambs. A 9-year study at the Oklahoma station of the common practice of increasing the feed available to ewes just prior to and during the breeding season, commonly designated as "flushing," revealed little value in improving the breeding efficiency of the ewes or hastening the date of conception. Similarly the Wyoming station found that under normal range conditions an adequate amount of vitamin A was supplied in the green forage to meet the requirement of breeding ewes, making unnecessary the feeding of vitamin A or carotene-rich supplements to ewes prior to or during the breeding season.

The Wyoming station found that under normal range conditions an ample supply of green forage produced an adequate storage of vitamin A to meet the requirements of ewes for reproduction. Feeding vitamin A or carotene-rich supplements to improve fertility was probably not warranted during or prior to the breeding season.

Investigating the value of various root crops as sources of feed for ewes with lambs, the Washington station found potatoes, sugar beets, and rutabagas to be of about equal value on a dry-matter basis, and each could be successfully fed with alfalfa hay. It was further shown that beet molasses, while having a relatively high feed value, should be fed with care to sheep, since injurious effects were obtained when it was fed as the sole concentrate or in combination with corn or barley.

The North Dakota station, investigating the most desirable age for breeding young ewes, found that the total number and weight of lambs produced by those bred under 1 year of age considerably exceeded those of ewes bred for the first time at nearly 2 years of age. While the ewes bred at an early age were somewhat lighter in weight at 18 months of age, this difference was largely overcome by the time the ewes were 3 years old, indicating that no permanent stunting effect resulted from the early breeding.

In lamb-feeding tests, the North Dakota station showed that lambs weaned in early summer made as satisfactory growth during the summer as those allowed to run with their dams and supplied with creep feeding. Little difference was found in the supplementary value of proteins supplied from raw or heated soybean meals for lambs in trials at the New York (Cornell) station.

For fattening lambs, cottonseed meal had an average value of 81.3 percent that of yellow corn fed with alfalfa hay at the Oklahoma station. The cottonseed meal did not interfere with appetite, health, or production of desirable carcasses. Beet tops were used efficiently in lamb fattening rations at the Colorado station to improve the rate of gain and produce a desirable market finish. Ensiling the tops either in the stack or in trench silos was an effective way of preserving this crop, particularly in conserving the carotene content, whereas tops left in the field in rows or in piles showed a high loss of carotene during the early part of the storage period.

Hog production.—Under normal conditions the hog supplies approximately one-half of our total meat supply. Its importance as a converter of feed energy into edible meat products assumes added significance during a period of stress since, according to experiments as the New Hampshire station, pigs possess an extraordinary superiority over other farm animals in the relative proportion of digestible food energy stored, a condition probably accounted for by their better adaptation to changing conditions and heavier body insulation due to a greater covering of fat.

In the field of swine production one of the most serious and perplexing problems is the high rate of mortality in young pigs associated with inadequate nutrition. Losses of suckling pigs up to 40 percent of the total number farrowed are frequently reported. Nutrition investigations in recent years have led to a growing recognition that certain nutritive factors required by the brood sow and the young pig to insure good livability and growth of the pigs are not adequately supplied in many types of rations commonly fed. For example, the Missouri station has found that a ration for brood sows composed of corn, tankage, linseed meal, and alfalfa meal was deficient in nutritive properties to such an extent that losses in the young pigs sometimes exceeded 50 percent. While the specific factors involved have not all been identified, the provision of abundant supplies of fresh forage or pasture largely corrected the deficiency. Supplements of wheat germ, dried skim milk, dried yeast, and liver preparations also improved the ration. Fresh carrots did not increase its nutritive properties, indicating that vitamin A was not the limiting factor in this basal ration.

A series of experiments at the California station established the need of growing pigs for various members of the vitamin B complex, particularly thiamin, riboflavin, and pantothenic acid, and within narrow limits the amount of each required for optimum growth. While the extent to which ordinary rations may be deficient in these vital factors has not been fully determined, it has been noted that such supplements as fluid skim milk and various slaughterhouse byproducts have a nutritive value not entirely explained by the protein, fat, or carbohydrate values.

Other deficiency symptoms recognized by the Pennsylvania station were a muscular incoordination and a form of dermatitis which developed on a corn, tankage, soybean meal, and alfalfa-hay ration. Supplements of yeast, carotene, and beef liver carried factors which corrected these conditions. Similar conditions which developed in pigs fed barley, tankage, beet molasses, and alfalfa meal at the Utah station responded to the addition of alfalfa pasture and cane molasses to the ration. The exact nature of the deficiency here was not identified, since the condition did not respond to additions of vitamins A, D, or various members of the vitamin B complex.

A rachitic condition due to an insufficient amount of vitamin D in the ration was encountered at the Minnesota station. Exposure of the pigs to sunlight for 45 minutes per day even during winter months prevented rickets, but pigs allowed voluntary access to sunlight in winter developed abnormal conditions corrected by the inclusion of 5 percent of alfalfa hay of high vitamin D potency. Various hays used in the test, however, ranged from about 0.4 to 1.5 International Units of vitamin D, indicating why hay of low vitamin D potency will not exert a protective action.

Corn is the primary feed grain used in the fattening of swine, but under a program of greatly expanded pork production the extensive use of substitute feeds for corn and the optimum level of protein supplementation to obtain greatest returns from the starchy feeds is highly important. Extensive work in these fields in earlier years has laid the groundwork for sound feeding practices, but certain additional contributions along this line have been made during the past year.

Proso millet, a grain widely adapted in the Great Plains area, was found by the North Dakota station to be only slightly inferior to corn or barley as a grain for hogs when supplemented with tankage and linseed meal. The proso produced a slightly softer, although not objectionable, fat.

The North Carolina station has demonstrated that the hogging-off of mature soybeans is an efficient and economical way of utilizing this crop. To obtain firm carcasses, however, it was desirable that the pigs be removed from soybeans and given a ration of corn, tankage, and cottonseed meal during the late stages of fattening, under which conditions soft fat could usually be avoided. Soybean pasture was also efficiently utilized in swine production at the Mississippi station, with cottonseed meal as the primary protein supplement to corn in the fattening ration.

Pigs having access to good pasture require considerably less protein than those fed in dry lot, according to findings of the Pennsylvania station. With pigs having access to rape pasture, soybean meal proved to be a more efficient protein supplement than tankage in other trials at this station.

Peanut meal can largely replace tankage as a supplement to corn, as demonstrated at the Georgia station. A supplement made up of peanut meal and tankage in the ratio of 19:1 was only slightly inferior to a mixture of these feeds at a 9:1 ratio, thus indicating a way of utilizing the peanut meal produced in unprecedented volume this year.

The Indiana station found some advantage in using a mixture of protein concentrates as a supplement for fattening pigs either on pasture or in dry lot. A combination of meat and bone scrap, fish meal, soybean meal, cottonseed meal, and linseed meal in the ratio of 2:2:4:1:1 proved superior to any single supplement or other combinations tested. Substituting ground soybeans for the soybean meal in the mixtures lowered the rate of gain and failed to improve the economy of gain.

A comparison of various types of soybean meals at the Michigan station showed that either expeller or toasted solvent meal was superior, both in palatability and efficiency of utilization, to raw solvent meal.

The possibility of utilizing an unusual source of feed was demonstrated by the New York (Cornell) station, which showed infertile and unhatched incubator eggs, along with yellow corn and salt, to be a satisfactory feed for pigs. The swine appeared to be unique in their ability to digest raw egg albumen. It was calculated that 100 pounds of eggs had a replacement value of 14.4 pounds of yellow corn, 12.0 pounds of meat scrap, and 4.6 pounds each of linseed meal and ground alfalfa hay. Considering the volume of unhatchable eggs coming from the extensive hatchery industry in this country, this possibility of utilizing the waste eggs is of considerable importance.

Recognition that swine vary in their ability to transform feed energy into live-weight gains has led to extensive breeding and selection work at a number of the experiment stations, largely in cooperation with the Federal Regional Swine Breeding Laboratory at Ames, Iowa. Many strains and families of pigs, representing various degrees of inbreeding and crossbreeding, have been under test. While much remains to be done in this field, evidence to date points to great possibilities in the ultimate production of superior strains of swine.

Artificial insemination of livestock as a meat production factor.—A striking development in the field of livestock breeding in recent years is the rather extensive adaptation of artificial insemination as a way of extending the use of superior sires and also reducing the cost of providing the service of good sires. This practice is now quite widely used for cattle, and to a lesser extent for other animals. Probably the most important factor in preventing a wider use is the difficulty in maintaining viability in stored semen over a reasonable length of time. Marked progress in the development of suitable diluents and optimum conditions for prolonging the effective storage period has been made by a number of experiment stations. For example, the New York (Cornell) station has developed a so-called yolk-citrate diluter which, when employed with a slow rate of cooling, storage at low temperature, and then rapid warming immediately before use, has markedly extended the effective period for which semen may be held. The use of gelatin in the diluent for semen for artificial insemination of cattle by the Ohio station prolonged motility from an average of 8.3 days for 50 percent of the experimental material to 12.5 days.

Other technical studies in progress are pointing the way to lengthening effective storage. For example, the Wisconsin station has demonstrated that the sperm medium must contain an abundant supply of sugars which can be catabolized to lactic acid in order to provide the energy necessary for maintaining sperm motility over an extended period. Similarly, the Missouri station has shown that changes in the acidity of the medium are associated with the rate of respiration in the stored sperm cells, thus indicating the importance of adjusting the medium to the proper pH to permit of maximum storage. As a result of these extensive investigations, it now appears likely that methods will be evolved whereby semen samples may remain viable for a week or even longer, thus providing possibilities of transportation over considerable distances and much wider application of the practice of artificial insemination.

Disease as a factor in meat production.—Protection of animals against toxins, diseases, and parasites, always an important phase of livestock production, assumes greater importance against the background of production goals. Examples of recent significant contributions in this field of research follow:

A serious disorder of sheep, particularly under range conditions and commonly known as pregnancy disease, has been found by the Oregon station to be primarily a nutritional disease resulting from insufficient intake of feed during the last 6 weeks of pregnancy. It is reported to be the most important disease of Oregon ewes, amounting at the present value of sheep to an annual loss in the State of a half million dollars. The feeding of 4 pounds of good-quality alfalfa hay and ⅓ pound of barley or its equivalent per head per day, especially to ewes 5 years of age or older, is recommended where ewes are lot-fed during this period. While treatment should not be depended upon to control this disease, the lives of some affected ewes can be saved if treatment is started when the first symptoms develop. This consists in the administration by means of a stomach tube of 0.5 pound of commercial sugar, corn sirup, or molasses dissolved in 1 gallon of warm water, repeated daily until the ewe again feeds normally.

Investigations at the Colorado station have indicated that the feedlot meat-production problem due to urinary calculi is largely the result of an improper ration. It has been conclusively shown that a ration deficient in vitamin A is an important cause of calculi in sheep and cattle. An unbalance of minerals in the diet resulting in an abnormal excretion of minerals by the kidneys or the failure to consume the usual amount of water over a considerable period of time may often be the cause.

Toxicity resulting from a high selenium content in feeds grown on soils high in this element in certain sections of the Great Plains seriously limits the use of such feeds in livestock production. Experiments at the South Dakota station indicate that sodium arsenate fed at the rate of 5 parts per million in the drinking water for pigs will counteract the toxicity of the selenium (9 parts per million) contained in feeds on many farms in seleniferous areas. It appeared that arsenic prevents at least a part of the selenium from entering the tissues of the hog.

The large cattle losses in certain areas resulting from ingestion of oat straw and related feeds led the Wyoming station to investigations that have shown the potassium nitrate present in oat hays and straws to be the cause. Other cereal hays, corn, sorghums, and many weeds were sometimes found to contain as much as 8 percent of this toxic principle. In oats the nitrate was found mainly in the stems and leaves, with very little in the grain. The smallest dose causing death was about 25 grams per hundredweight. Smaller doses given daily for 2 months failed to produce any symptoms. An antidote has been worked out by administration of which livestock already poisoned by high nitrate-containing plants can be saved. Similar investigations by the South Dakota station of the cause of oat-hay poisoning in cattle in Colorado, Wyoming, and South Dakota indicate that it results from the reduction of nitrates in the rumen, brought about particularly by *Bacillus subtilis*.

Much of the heavy death loss of feeder lambs and loss of weight and condition from coccidiosis can be avoided by changing the management and feeding practices commonly used with lambs shipped to feed lots, according to findings of the Colorado station. Only 5 percent of the experimental lambs carried during the first 3 weeks on alfalfa or green pasture or fed alfalfa hay and cut corn fodder before being fed the fattening ration developed clinical coccidiosis, as compared with nearly 50 percent of lambs fed grain and hay from the start.

Methods advocated for the control of infectious abortion in cattle under confinement can be applied only partially to range cattle. In an investigation completed during the year by the Montana station in cooperation with the Department (BAI), the conclusion was reached that in a range or semirange herd where the breeding season is limited to about 2 months the infection may be eliminated even in the face of an acute outbreak of the disease by culling reactors in one or two annual fall tests. The presence of some reactor cows in a herd was found to be not a serious matter when the cattle are on the range throughout the year, but may be a source of serious outbreaks in a herd confined to feed lots late in the winter. As an aid in testing for reactors the station developed a whole-blood field agglutination test for use on range cattle.

An important contribution by the Michigan station toward reduction of disease losses in farm animals has been the discovery of an effective serum treatment for pneumonia in lambs. Blood serum from adult sheep which had been inoculated with a bacterin prepared from mixed cultures of pneumonia-producing organisms proved when injected into lambs to possess both preventive and curative properties in the control of pneumonia. The work is being continued to determine possibilities of extending this type of treatment to calves and pigs. The economic significance of the problem is emphasized by the fact that approximately one-third of all cattle, pigs, and sheep submitted to the station veterinary clinic for autopsy during the past year were victims of pneumonia.

In the treatment of sheep for the control of internal parasites, previous research by a number of experiment stations and the Department has shown phenothiazine to be an efficient remedy. At the Florida station the administration of phenothiazine for 14 consecutive treatments, each consisting of 25 grams mixed in 250 grams of concentrates and following a 24-hour period of fasting, reduced the death loss in an experimental flock of sheep, in which the mortality from parasite infection had become a serious problem, from 15.87 percent in 1939–40 to 1.54 percent the following year.

The Washington station has found that phenothiazine-medicated pellets afford a practical, convenient, and reasonably efficient method of treating sheep while on the range. A mixture of 5 parts of phenothiazine with 4 parts of molasses was convenient for the individual medication of sheep. This station also found the administration of

0.5 gram of lead arsenate per lamb to be a reasonably safe and effective treatment for use against another troublesome parasite, tapeworms (*Moniezia* spp.), in yearling lambs.

In the field of hog cholera control, a disease which takes a heavy annual toll in hogs, the introduction of tissue vaccine by the California station a few years ago was a highly significant contribution. This product is free from the disease-producing propensities of hog cholera virus, which is a serious objection to the use of the serum-virus method of immunization. Further confidence in the use of tissue vaccine has been gained from recent findings of the California station that pigs receiving a single 5-cubic centimeter intermuscular injection were protected against cholera for 8 months or longer. Furthermore, the pigs suffered little or no reaction from vaccination, thus demonstrating the safety and adequacy of the treatment. A positive diagnostic technique for hog cholera based on the differential staining properties of glandular and epithelial cells of the gall bladder in healthy and affected hogs also was contributed by the California station.

Noteworthy, too, has been the recently inaugurated cooperative research undertaking on the mode of transmission and methods of controlling swine, brucellosis, or infectious abortion, participated in by the California, Indiana, Iowa, Michigan, and Minnesota stations and the Department (BAI). While this disease has long been a vexing problem for the swine producer and has received considerable attention from the research worker in the past, many unsolved problems remain which it is hoped may be solved through this cooperative work.

Quality, curing, and storage of meat.—Meat investigations, particularly as related to the curing and storage of meat for home consumption, have occupied an important place in research activities of a number of the stations. Contrary to general opinion, findings of the Illinois station showed that moderate to heavy exercise in fattening steers did not result in tough meat. Steers exercised in a treadmill equivalent to walking nearly 9 miles per day produced somewhat more tender meat than those subjected to little or no exercise, and the color of the meat was not affected. It is significant, however, that the feed requirements of the heavily exercised steers were much greater than those not exercised.

With the advent of the commercial freezer locker and home freezing units, much attention centered around the possibilities of preserving fresh meat in frozen storage and best methods of preparing meat for such storage. In tests at the Indiana station with both pork and beef, pork cuts stored at 0° F. were edible after 16 months, although the fat of the cuts deteriorated somewhat in flavor after the eighth month of storage. The tenderness and cooking losses of the pork were not appreciably affected either by freezing or storage after freezing. Samples of beef similarly stored also were edible after 15 months of storage, with little deterioration in the flavor of the lean meat and only a slight loss in desirable flavor of the fat.

Cellophane was found to have marked superiority over waxed wrapping paper for wrapping of pork cuts to be frozen as regards freezer burn and shrinkage loss in freezing and storage, according to findings at the Illinois station. With cellophane as a wrapper the method of freezing had no effect on the shrinkage or degree of freezer burn, but similar cuts wrapped in paper suffered greater freezer burn and shrinkage loss when frozen in an air blast than when frozen in still air or on freezer plates.

Comparing various methods of freezing, the Iowa station showed that the more rapid the freezing the smaller the ice crystals and the less the leaching, hence the greater retention of food values. Roasts and other thick cuts of meat froze most rapidly in an air blast and slowest in still air, while in the case of steaks or other cuts of relatively large surface area the most rapid freezing was obtained on freezer plates.

The Washington station has obtained preliminary evidence that ultraviolet irradiation is effective in controlling bacteria on the surface of meat during the aging period. Experiments are being continued to determine the effect of different intensities of light and temperature during the aging period on the final quality of the meat.

Experimenting with modified storage atmosphere, the Michigan station found that a high concentration of carbon dioxide in the storage room maintained a relatively dry surface and greatly inhibited the growth and development of micro-organisms normally causing deterioration of meat.

As a result of an extended series of experiments at the Pennsylvania station to improve methods for curing pork on the farm, a process involving a simplified dry sugar-cure method in combination with the pumping of hams with an 85-percent pickle solution 1 or 2 hours after slaughter has been developed which practically eliminated the loss of hams due to souring and gave a very satisfactory cured product. In further studies on the possibilities of retarding the development of rancidity in bacon, the Illinois station confirmed the value of oat flour as a satisfactory antioxidant and also showed that the addition of 2 percent of a concentrated extract of corn markedly increased the average stability of bacon. These findings assume greater significance in view of the present need of transporting meat products over long distances, frequently without the benefit of refrigeration.

MILK AND MILK PRODUCTS

In the drive to increase the Nation's supply of essential foodstuffs to insure optimum nutrition of the people of the United States and her allies, milk and its products have occupied a key position. With a demand for an increase in total milk production of 8 percent, but with a possible increase of only about 3 percent in the number of milking cows, it became obvious that increased production per cow was the only way of obtaining this goal. Much of the dairy-husbandry research of the experiment stations during the past year has been directed to this end, including ways of utilizing available feed supplies to the best advantage.

Milk production.—Of particular interest among examples of activities and findings is a recently completed study on the relation of input to output in milk production conducted jointly by the Department and the New York State, Pennsylvania, Indiana, Delaware, Maryland, Virginia, South Dakota, Mississippi, Michigan, and New Jersey stations. In comparing feed intakes from approximately 30 percent below to 30 percent above a conventional feeding standard, it was strikingly demonstrated that milk production was increased with each increment in feed consumption up to the very limit of the cows' appetite. However, the law of diminishing returns was found to operate with increasing allowances of grain since increments of grain at the higher levels resulted in continuously decreasing yields of milk per unit of grain. Thus where maximum production is the goal heavy grain feeding may be justified, but the level of feeding from the standpoint of optimum returns to the producer must be determined by the ratio of feed prices to price for milk or butterfat.

Nutrients in hay alone are not utilized efficiently, according to reports from the Missouri and Michigan stations, which show that cows receiving good-quality hay as a sole ration will yield not more than 70 percent as much milk as cows receiving a well-balanced ration of roughage and grain. These findings, along with earlier reports from Washington, Oregon, and elsewhere, indicate that while this system might be desirable under certain economic conditions it cannot be recommended where high milk production is necessary. Similarly, the Washington station has found that yearling heifers receiving only roughage require considerably more nutrients per 100 pounds of gain in live weight than those receiving grain and hay.

That simple mixtures composed largely of farm-grown products will support good milk production was demonstrated by the Ohio station. Practically no difference in milk production resulted from feeding a simple ration of corn and soybean meal or a more complex mixture containing, in addition, oats, linseed meal, wheat bran, beet pulp, and molasses.

In view of transportation problems throughout the Nation, the maximum use of locally grown feeds assumes added importance. The Georgia station had found that sweetpotato meal can be substituted for cornmeal in the ration of milking cows with little or no sacrifice in milk production and with marked enhancement of the vitamin A content of the butterfat. The Missouri station has found that Korean lespedeza seed when finely ground is equal to cottonseed or soybean meal on a protein-equivalent basis for milk production. With an estimated 7 to 8 million acres of lespedeza in that State, yielding about 400 pounds of seed per acre, this represents a very large potential feed supply. Results at the Oklahoma station showing that cottonseed meal could be substituted for a normal concentrate mixture up to 50 percent of the total ration without impairing its milk-producing value have marked economic significance in the Cotton Belt, where cottonseed meal is frequently a cheaper source of nutrients than the cereal grains.

Studies at the New York (Cornell) station confirmed earlier findings that concentrate mixtures containing 4 to 5 percent of fat supported higher milk production than when less fat was present. In view of the tendency to a lowered fat content of byproduct feeds available for dairy cows, these findings are of significance where maximum milk production is the goal. Studies at the South Dakota station gave evidence that fine grinding of corn and oats for milking cows involves additional expense without improving the value of the feed. Actually, coarsely ground grains were as digestible and more palatable than the finely ground grains. On the other hand, studies at the Kansas station with sorghum grain indicated fine grinding to be desirable since a considerable portion of the whole or coarsely ground grains was indigestible.

Under conditions existing in most sections of the country, the maximum utilization of pastures is essential to the most economical production. Numerous experiments are in progress for determining ways of improving both the yield and quality of pastures and the selection of crops to give a maximum length of grazing season. Recent reports from the Louisiana and Michigan stations confirm reports from other sources in showing that reasonable fertilization of pastures yields substantial profit and markedly enhances pasture-carrying capacity. That bromegrass is a valuable pasture plant when grown in combination with alfalfa, whereas it is not desirable to grow this grass in pure stand because of its very high nitrogen requirement, has been established by the Michigan, Indiana, and Illinois stations. Trials at the Illinois and Kansas stations demonstrated a marked difference in palatability of various pasture crops, indicating that this factor should be considered in selecting pasture mixtures. The former found palatability closely related to the dry-matter content of the plant, with a Sudan grass-soybean mixture of low dry-matter content proving highly palatable, while alfalfa, bromegrass, sweetclover, and bluegrass showed increasingly higher dry-matter content but decreasing palatability. Comparing the common cereals used in winter pastures, the Kansas station found Balbo rye to be more palatable than common rye, followed by wheat and barley.

Dried hay still constitutes a major roughage in dairy-cattle feeding, and many States are devoting attention to ways of improving the quality of cured hays and determining the relative merits of different kinds of hay. The South Dakota station determined that 2 to 4 days of exposure to good sunshine are required to develop the maximum amount of vitamin D in alfalfa hay, whereas light showers tend to destroy some of the vitamin D which has previously developed in the hay. During 5 months' storage, the carotene in the hay was reduced to about one-fifth the original content but there was only a slight loss in vitamin D. With native prairie hay an important commodity in many midwestern States, the finding of the Oklahoma station that good-quality prairie hay when suitably supplemented with protein feed was practically equal to alfalfa hay for milk production is of marked significance. With alfalfa hay worth $14 a ton and cottonseed meal as a source of supplementary protein worth $50 per ton, prairie hay was worth approximately $11 per ton. Hay stored with relatively high moisture content so that it browned or burned in storage was less digestible and consequently lower in nutritive value than bright-cured hay, according to findings of the Kansas and Michigan stations.

Silages are a very important source of nutrients for the dairy cow throughout the country, particularly since recent experiments in many States have proved that the legumes and grasses as well as corn and sorghums may be effectively used in silage production by the addition of molasses or phosphoric acid as preservatives. With both of these products now critical war materials, much attention has been given to the possibility of ensiling legumes and grasses without preservatives. Recent reports from the Vermont, Missouri, Minnesota, and New Jersey stations have indicated that satisfactory silage may be produced from the grasses and legumes by reducing the moisture content of the ensiled crops to approximately 65 percent, with fine chopping and close packing of the ensiled material. The Wisconsin, Kansas, and other stations have also shown that the addition of such dry feeds as corn meal, chopped sorghum stover, and whey powder to the grain material at time of ensiling exerts considerable preservative action. These stations, as well as Pennsylvania, Ohio, and others, are continuing their search for suitable combinations of crops which will permit a still wider use of common crops for silage without the use of critical materials as preservatives.

There has been a growing recognition in recent years that dairy-cattle rations must be selected not only for their protein, fat, and carbohydrate contents but also with reference to their minerals and vitamins, and that this will insure the health of the cow and a maximum nutritive value of the milk produced. One of the most critical of these requirements is carotene, the precursor of vitamin A. The California, New Mexico, Oklahoma, Texas, and Michigan stations have confirmed that distinct deficiency symptoms, including night blindness, low blood carotene levels, edema, impaired reproduction, and decreased milk production, result from inadequate supplies of carotene, and from these researches the quantitative needs of the dairy cattle to meet their highly specialized functions are reasonably well established. Pastures, high-quality silage, and bright hay are now recognized as the primary sources of carotene for the cow, and this increases the significance of these products in the dairy ration. Studies at Alabama and New Mexico have further indicated that a high level of carotene in the ration from pasture is reflected in an increased carotene and vitamin A content of the butterfat produced. In this connection, the New Jersey station has demonstrated that not all yellow pigments in milk have vitamin A significance, indicating that milk color is not a true measure of its vitamin A potency. The New York (Cornell) station in studying the distribution of the carotenoid material in the butterfat found that it was concentrated in the liquid fraction and obtained evidence that the efficiency of absorption of carotene by an animal from its feed is influenced by the degree of unsaturation of the fat in the feed.

The specific requirement of the cow for vitamin D has been definitely established in experiments at the South Dakota station. A significant relation between the supply of vitamin D for the cow and her susceptibility to milk fever, which is now recognized as an acute calcium deficiency, was demonstrated by the Ohio station. Supplying the cow additional vitamin D in the form of irradiated yeast tended to maintain the supply of calcium in the blood of cows at calving time and greatly decreased their susceptibility to milk fever.

A process has been developed by the Michigan station for the extraction of carotene and other valuable constituents from dehydrated alfalfa-leaf meal. By irradiation of the extract from the meal large amounts of vitamin D also may be produced, and other useful constituents, such as chlorophyll and xanthophyll, are products resulting from the process. Through the processing of 1 ton of high-grade dehydrated alfalfa-leaf meal a yield of 200 grams of carotene, equivalent to 342,000,000 units of vitamin A and an estimated 32,000,000 units of vitamin D, can be obtained. The products obtained by this process may become important in human nutrition as well as for animal feeding.

Investigating the effects of feeding products of the sorghum plant as the sole ration for dairy cows, the Kansas station found such a ration to be grossly inadequate. Additions of cottonseed meal and bonemeal to the ration only partly corrected the deficiency, whereas further addition of alfalfa hay and wheat bran completely overcame it. While the exact nature of the deficiency has not been determined, it appeared that some constituents other than nitrogen, minerals, and carotene are involved.

The feeding of products produced in certain areas of Michigan resulted in a cobalt deficiency in cattle at the Michigan station. This finding, along with earlier reports from the Florida and Montana stations indicating a similar trouble in those areas, suggests that the deficiency of this element may be more widespread than has generally been recognized. The administration of very small amounts of cobalt salts to the animals overcame this deficiency.

Maintaining dairy cows in a sound healthy condition is no less important than proper nutrition in efficient milk production. Infection of the udder, commonly known as mastitis or garget, is the most common and, economically, the most significant ailment of dairy cows. Recent progress in station investigations for better control of mastitis, particularly by the infusion of various chemicals into the udder, has been most encouraging. Of the products worked with, tyrothricin, formerly known as gramicidin, has been found to be highly effective by several stations. Recovery in about 90, 82, and 89 percent of all cases treated were reported by the Michigan, California, and Idaho stations, respectively. The treatment was effective in lactating cows as well as in dry animals, although the California station points out that greater effectiveness and economy in the amount of therapeutic agent required may be secured by treating the cows when dry.

The injection of iodized mineral oil into the udders of lactating cows effectively rid the udders of infection in acute, chronic, and latent cases of mastitis in trials at the Florida station. Novoxil, a colloidal dispersion of silver oxide in light mineral oil, has also proved fairly effective, particularly in treating dry cows, in experiments by the Connecticut (Storrs) and California stations.

All of the above findings apply to the common types of mastitis resulting from infection with *Streptococcus agalactiae*, whereas staphylococcic infections usually have shown little response to such treatments.

It was found at the California station that *S. agalactiae* may be transferred to the udders of calves by sucking among pen mates fed on infected milk, and that the streptococci may persist there until the first parturition, and then be shed in the milk. The value of segregation and replacement of affected animals in the control of chronic bovine mastitis due to *S. agalactiae* has been demonstrated through the eradication of this infection from 24 herds by the Connecticut (Storrs) station. In Connecticut this species is responsible for 75 percent of such clinical cases and the incidence of infection in more than 40 percent of the dairy cattle.

Incomplete milking or the failure to strip cows infected with *S. agalactiae* was found by the California station to cause an increase in the severity of mastitis, followed by a drop in the average milk production. The increase in advanced mastitis cases in infected cows in a herd improperly milked was 54.3 percent as compared with only 16.6 percent in such cows as were thoroughly milked.

Significant contributions on methods of controlling infectious abortion in cattle were also made during the year. Further confidence in the use of Strain No. 19 vaccine developed by the Department for calfhood vaccinations against infection by *Brucella abortus* resulted from trials at the Indiana station, which confirmed previous findings that the virulence of the culture was not increased by successive passages through cattle. Furthermore, mature cattle showed much less effect from inoculations with Strain 19 than from infection with more pathogenic strains of *Brucella*. A rapid method of determining the pathogenicity of *Brucella abortus* cultures by measurements of the catalase activity of live cells was developed at the Michigan station, thus permitting a determination in 30 minutes which formerly required 4 weeks through biological tests with guinea pigs. According to a Minnesota station finding, the horse may be a carrier of brucellosis and play a role in the dissemination of this disease in cattle, indicating that affected horses should not be stabled or pastured with clean cattle. A diagnostic blood test for detecting infection with *Vibrio fetus*, another common cause of abortion in cattle, was perfected by the Connecticut (Storrs) station.

Bloat, an ailment in dairy cattle which commonly occurs when animals graze on succulent legumes and thus limiting the use of these valuable feeds, has been studied extensively by the California and South Dakota stations. The former found that bloat apparently results from a lack of coarse, fibrous material in the rumen of the animal, and that the feeding of straw or coarse hay prior to grazing on green legumes was an effective way of reducing or preventing bloat. The latter station has contributed information on the cause of death of cattle from bloat by showing that rumen gases during bloat are high in hydrogen sulfide, which is highly toxic, and that this factor, rather than the excessive pressure developed in the rumen is the probable cause of death.

The increased demand for milk for human consumption, and particularly the sharp increase in the amount of dried skim milk purchased for lend-lease has greatly reduced the supplies for animal feeding, causing a number of stations to investigate milk substitutes for calf raising. The substitution of dried buttermilk for dried skim milk in calf starter rations gave satisfactory results at the Montana station. The Alaska station found that the cost of growing dairy heifers could be greatly reduced on a prolonged milk feeding period by starting the calves on skim milk and then shifting them at 30 to 50 days of age to a dry ration composed mainly of locally grown grains plus a small amount of skim milk powder. At the Minnesota station lard or tallow, when emulsified in skim milk, was practically as good as butterfat in the ration of young calves, whereas corn oil, cottonseed oil, or soybean oil were relatively unsatisfactory.

Adequate supplies of vitamins are highly essential in the ration of the young calf, and the newborn calf seems particularly deficient in vitamin A. The Pennsylvania station demonstrated a marked seasonal difference in the carotene requirement of calves, as 12 micrograms of carotene daily per pound of body weight proved adequate in warm weather, whereas up to 27 micrograms appeared essential under average winter conditions.

The Wisconsin station has found that adequate amounts of vitamins A, B complex, and C are essential to prevent the occurrence of scours in young calves. The administration of shark-liver oil as a source of vitamin A plus members of the B complex proved highly effective in overcoming scours in a badly infected calf herd, with indication that niacin and pantothenic acid are members of the B complex particularly needed. This station further showed that the level of vitamin A in the blood plasma was a much more delicate measure of the state of vitamin A nutrition of the young calf than either growth or blood carotene.

The South Carolina and Pennsylvania stations found sulfaguanidine to be highly effective in the treatment of white scours in calves. An initial dosage of 5 grams, followed by one or more smaller doses at about 6-hour intervals, generally brought about rapid recovery.

Investigating ways of controlling pneumonia in young calves, which commonly caused a high mortality, the Missouri station showed that an inexpensive calf barn having a straw loft, plus the use of slatted floors in the calf pen, resulted in warm, dry conditions which practically eliminated the pneumonia problem. A study of calf pneumonia at the Pennsylvania station has shown the use of sulfapyridine and sulfaguanidine to be of considerable benefit in preventing a large percentage of the losses from this source. Work with a group of 362 calves indicated that regulation of the diet and the use of a specific serum was necessary to check severe outbreaks in some cases.

The fact that the growing of heifers to producing age represents a relatively long period of nonproductivity has led the California and Missouri stations to investigate the possibilities of stimulating earlier production. Both stations have shown that by feeding abundant amounts of well-balanced rations the growth rate can be significantly increased so that the heifers reach breeding size 4 or 5 months earlier than normal. The Missouri station found that, when bred to freshen at an earlier age, such heifers have not produced at a rate consistent with their size, suggesting that lack of maturity from an age standpoint may be a contributing factor. On the other hand, this station has shown that heifers raised on a ration of hay alone were considerably below normal at average freshening age, but that at 5 years of age they were practically normal in size, indicating that while growth rate was retarded, normal size was eventually obtained.

Milk processing.—Studies of milk-cooling methods at the Louisiana station indicated that prompt chilling over a surface cooler resulted in a lower bacterial count than when milk was cooled in cans by submergence in a cooling medium. A delay of 2 hours in cooling did not materially affect the quality of milk provided it was then rapidly chilled over a surface cooler, but a similar delay in milk cooled in cans resulted in a significant increase in bacterial count.

Because of the general labor shortage confronting the dairy industry, the legalization of short-time, high-temperature pasteurization in a number of the important dairy States is a significant aid, but has raised the question of effectiveness. The New York State station, in experiments under factory conditions, found that milk pasteurized by momentarily raising the milk to temperatures from 169° to 177° F. was slightly superior in quality to that pasteurized by the conventional vat-holder method. This work has confirmed earlier reports by this station and the New York (Cornell), New Jersey, and Illinois stations based on pasteurization studies under laboratory conditions.

A small holder-type electric pasteurizer designed for use on the small dairy farm confronted with compulsory pasteurization has been developed by the Maryland station. With this equipment, a 12-gallon batch of milk at an initial temperature of 90° F. can be pasteurized with about 2 kilowatt-hours of electricity.

The practice of marketing milk in homogenized form has increased rapidly in recent months. Extensive studies at the Michigan station have contributed to the solution of problems in milk homogenization, including the prevention of rancidity and the overcoming of foaming and bottle seepage in the homogenized product. The Pennsylvania station has shown that while a reasonably stable fat emulsion results from homogenizing milk in rotary- or centrifugal-type homogenizers, the rather stringent definition of homogenized milk set forth by the United States Public Health Service can be met only by processing the milk in piston-type machines at pressures above 3,000 pounds.

Interest in the production of soft-curd milk, particularly for infant feeding, has led a number of stations to investigate practical ways of producing such milk. The Pennsylvania station has shown that superheating and condensing milk in a vacuum pan to a concentration of 3 to 1, then cooling and diluting with water back to the composition of the original milk, and homogenizing result in a desirable soft-curd milk. The California and Illinois stations have shown that the addition of pancreatic extract in proper dilution will yield a desirable type of soft-curd milk. Investigating a wide range of evaporated milks, the New York State station showed that on reconstitution such milk has a curd strength considerably below that of commercially homogenized milk and well within the standard for soft-curd milk adopted by the American Medical Association.

A great deal of attention has been devoted to various off-flavors encountered in market milk and methods for their prevention. The Kansas station found that grass flavors commonly resulting from grazing animals on cereal pastures were largely eliminated on removing cows from pasture at least 4 hours before milking. Balbo rye was less objectionable than other cereals in this respect. In a study of the effect of various inhaled substances, the Minnesota station concluded that certain materials, such as turpentine or camphor, when inhaled by the cow, cause flavoring of the milk characteristic of these compounds, whereas the inhalation of many other substances, such as onions, silage, and decomposing manure, produces definite off-flavors although these are not characteristic of the substance inhaled.

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Marked progress was made by the Mississippi station in combating the bitterweed flavor in milk so prevalent in the South. A sensitive quantitative test was developed for determining the concentration of the bitter principle in milk, and by use of this test it was possible to dilute bitter milk with normal milk to a point where the off-flavor will be tolerated by the trade. This development was of particular significance in condensing or drying milk, as there the intensity of bitter flavor increases in proportion to the amount of water removed. Investigating the theory that milk cooled in tightly covered cans developed a so-called smothered flavor, the Michigan station demonstrated that such a condition was primarily due to unsanitary condition of the containers, and that milk sanitarily produced and placed in sanitized cans may be safely cooled in a closed container without development of the flavor.

Off-flavors, such as oxidized flavor and rancidity resulting from chemical and enzymatic action, in milk and stored dairy products also constitute a serious problem, particularly in those products which are transported over long distances or held for prolonged periods. A high carotene content in the cows' ration causes a significant increase in the carotene content of the milk and greatly reduces or eliminates the tendency for oxidized flavor to develop, according to reports of the New Jersey and West Virginia stations. Cooling milk with a minimum exposure to the air, partial evacuation of the gases, and storage under vacuum tended to maintain the vitamin C content of milk and greatly retarded oxidized flavor development—a finding of the Vermont station which confirmed earlier experiments at the New York (Cornell) station. Both the California and Michigan stations have shown that homogenization of milk aids in preventing this flavor defect.

Encouraging results from the use in dairy products of various antioxidants to retard the development of oxidized flavor also were obtained during the year. The Pennsylvania and Illinois stations found that the addition of small quantities of dried or condensed skim milk to milk or ice-cream mixes before pasteurization delayed the onset of this defect. Oat flour was successfully used by the Florida station in maintaining the quality of stored frozen cream and by the California station in improving the keeping quality of dried whole milk. Concentrated water extracts of cereal grains were similarly used in milk and butter by the Illinois station, which also found a pancreatic enzyme to be highly antioxidative and gum guaiac to be particularly useful in preventing oxidation changes in whole-milk powder. The California station confirmed the value of pancreatic enzymes and also found ascorbic acid to be a valuable antioxidant in the milk-drying process. The sizing with oat flour of paper stock for milk containers and parchment wrappers for butter as a means of improving their antioxidative properties was recommended by the Maryland and Illinois stations, respectively.

Rancidity resulting from the hydrolysis of milk fat may be largely prevented by prompt and rapid cooling and subsequent storage at low temperature, according to findings of the New York (Cornell) station. Rapid cooling through the critical zone of about 75° to 50° F. was particularly essential. It appeared that a slight degree of lipolysis was very commonly the cause of milk being judged as off-flavor even though the intensity was not sufficient for recognition as rancidity. The California station has shown that cows vary greatly in the amount of milk lipase present in their milk, which accounts for spontaneous development of rancidity in milk, particularly that produced on winter feeds. The station has described a test for determining the lipase activity of milk from individual cows and has shown that the mixing of lipase milk with normal milk shortly after milking is an effective way of preventing rancidity development and thus utilizing the milk from those cows producing milk with a high lipase content. Prompt pasteurization of cream at 150° is recommended by this station as the most effective way of preventing the development of rancid flavor in cream to be used for butter making. At the New York (Cornell) station a study of the temperature required to completely inactivate lipase in cream showed that 140° for 35 minutes or 155° for a holding time of zero was about the minimum requirement.

With reference to the development of rancidity in stored butter, this station found that the natural lipase remained active at 30° F. but was completely inhibited at 5° or lower. The station has also developed a rapid colorimetric method for determining the free fatty acid in milk or butter which promises to be particularly valuable in detecting those samples of inferior quality. The Florida station has shown that cream of high free fatty acid content consistently yields butter of inferior quality and that repeated washing of the butter is of little value in lowering the content of those acids causing rancid flavor.

Ways of improving flavor development in salted butter through the use of improved butter cultures, particularly strains capable of fermenting citric acid to give a high yield of diacetyl, the important flavor constituent in butter, have been developed by the Iowa station. The Oklahoma station has shown that high-quality starter culture may be added directly to the butter rather than to the cream before churning with a consequent improvement in flavor and a significant saving in the amount of starter required. Extensive studies at the Oregon station on the butterfat loss sustained during churning under commercial conditions have resulted in recommendations which would substantially reduce such butterfat losses. A study at the North Dakota station revealed that a very high percentage of creamery water supplies were yielding micro-organisms capable of causing decomposition of milk fats and proteins and, when introduced into butter, commonly produced rancid, cheesy, and tallowy flavors, indicating the importance of a sanitary creamery water supply.

Studies at the Michigan station on the quality of retail butter shows that there is little relation between the actual flavor and quality of butter and the price for which it sells or the claims made on the package as to quality and flavor. These findings are held to indicate the desirability of establishing a butter grading system, since at present the consumer has no reliable means of ascertaining the quality of butter available for purchase.

A method for producing pure butter oil of high keeping quality, developed at the New York (Cornell) station, may have particular value in the current war emergency. Complete separation of the oil from the rest of the milk constituents and protection of the oil from light will permit storage at room temperature for a considerable period without deterioration. Reconstituted butter can be prepared by recombining the oil with suitable amounts of water and skim milk powder and salt.

The recognition of cheese as an important foodstuff in wartime and the increased demand for lend-lease shipment has led many experiment stations to intensify their search for ways of improving cheese quality, particularly to reduce the amount of No. 2 cheese which is unsuitable for Government purchase. The pasteurization of cheese milk is widely recommended, although this practice is attended by problems in obtaining desirable ripening and flavor. The Texas station has shown that the use of a larger-than-normal amount of rennet extract in cheese manufactured from pasteurized milk and the curing of cheese at about 60° F. will hasten the ripening process and the development of desirable body and flavor. The New York State station has reported that the addition of 2 ounces of calcium oxide and three-fourths of a pound of sugar to each 1,000 pounds of cheese milk is an effective way of improving quality of Cheddar cheese. The Pennsylvania station attained considerable success in the use of a culture of bacteria isolated from an aged cheese which, when used to supplement a commercial cheese starter, has effectively hastened the ripening of cheese. Through its use desirable body and flavor were obtained in Cheddar cheese during a 3-week ripening period.

Investigating suitable wrappers and packages for cheese, the Wisconsin station has shown that pliofilm of suitable thickness not only is well suited to small cheeses but may be used effectively to protect large natural cheeses to be cut and packaged after curing. Its principal advantage is that cheese comes out of storage with no rind, practically free from mold, and free from off-flavors. However, the Nebraska station has reported that, while the use of parafilm coverings greatly reduces the moisture loss in cheese during curing, paraffined cheeses are generally of better flavor and show less defects in body than those covered with parafilm.

The New York State station showed that Cheddar cheese can be cured in sealed cans provided the milk is pasteurized to destroy most of the gas-producing bacteria, the cheese made without excessive moisture, and packed with 20 to 25 inches of vacuum. As a further aid, a small amount of calcium or magnesium hydroxide may be placed in the cans to combine with carbon dioxide evolved during ripening. Similarly, the Washington station showed that Cheddar cheese packed in cans under vacuum would keep in good condition for a year or longer when held below 52°, but when subjected to a 70° temperature for a few days gas production was resumed and the quality of the cheese was impaired. Confronted with a severe shortage of tinfoil, commonly used in covering blue cheese, the Minnesota station investigated the use of wax coverings and other substitutes for foil made necessary by the production of over 3 million pounds annually of this type of cheese in Minnesota.

Continuing its studies of factors affecting the quality and composition of Bel Paese cheese, the Washington station has found that if the pH is less than 5.1 when the cheese is removed from the brine a sour cheese will result. How much of the acid development should take place before setting, during draining, and during salting for optimum results is being studied. Bacteriological studies on the slime of ripening Bel Paese cheese have resulted in findings helpful in the curing of this cheese. The California station found that rennet paste was far superior to liquid rennet in the manufacture of Romano-type cheese, apparently because of the greater production of volatile acids in the cheese when the paste was used rather than to a specific type of lipolysis. The Wisconsin station has developed a so-called mild wash of the curd for use in the manufacture of brick cheese which has been effective in reducing high acidity and undesirable types of fermentation during the curing period. In an effort to develop methods for satisfactorily prolonging the storage period of cottage cheese, the North Dakota station has shown that the storage of fresh cottage cheese curds in 3- to 4-percent salt solution will retain their fresh flavor and desirable consistency for a period up to 2 weeks. The Washington station carried on studies of factors affecting the vitamins A and B content of cheese which are of significance in connection with the nutritive value of this important food product.

While ice cream may be regarded as meriting somewhat less attention as an essential food during wartime than other dairy products, it has continued to be manufactured in considerable quantity, and particular attention has been directed to the development of substitutes which might be used in place of more critical materials in its manufacture. Recent contributions from the Missouri, New York State, Illinois, Wisconsin, and Massachusetts stations have indicated satisfactory methods of utilizing considerable amounts of corn sweeteners as a partial substitute for sucrose in ice cream, and other stations, particularly Florida and Nebraska, are investigating improved methods of producing invert sugar which promise to reduce the amount of sucrose required. The Florida station has also indicated ways for substituting honey for a considerable proportion of cane sugar. The Oklahoma station is making a comprehensive study of various combinations of vanilla flavoring and vanilla substitutes which may prove satisfactory in the face of a shortage of high-grade vanilla extract.

Work at the Washington station is pointing the way to more liberal use of dried milk solids in bread making. While up to 3 percent is now commonly used, it is hoped that up to 6 percent may be satisfactorily included without impairing the quality of the baked products and with a corresponding increase in their nutritive value. This work covers not only dried skim milk but also casein prepared from fresh skim milk and also whey proteins.

POULTRY AND POULTRY PRODUCTS

The production of eggs and poultry meat in the United States has grown into a vast industry, rising in 1941 to over 44 billion eggs and 3 billion pounds of dressed chickens and turkeys and yielding an estimated gross income to producers of nearly 1½ billion dollars. Production goals for 1942 called for increases of 13 percent in eggs and 10 percent in dressed chickens and turkeys above 1941 levels in order to meet wartime demands. Actually, egg production for the first 6 months of 1942 was 16 percent above that for the corresponding period in 1941, an accomplishment largely attributable to sound breeding, feeding, and management practices based on research findings.

This high level of production is particularly striking in that it has been attained in the face of critical shortages of certain animal proteins and vitamin concentrates formerly considered indispensable to optimum growth, egg production, and hatchability of eggs. Numerous experiment station findings have contributed to this accomplishment, especially as regards the local aspects of the problem which must be met if high production is to be maintained. The following examples illustrate the problems involved and the approach to their solution:

The Maryland station found that riboflavin, an essential member of the vitamin B complex, ordinarily supplied for poultry primarily from milk byproducts, can be obtained from a fermentation byproduct obtained in converting molasses into butanol. By using this new material as a source of riboflavin, milk products could be entirely omitted from both growing and laying rations and soybean meal could be used as a primary source of protein, although the inclusion of small amounts of fish meal or other animal protein enhances the value of the rations.

Similarly, the California and Indiana stations have shown that distillers' dried solubles, a byproduct remaining after the alcohol and wet grains have been removed from distillers' mash, are rich sources of riboflavin and other members of the vitamin B complex which may be substituted for dried skim milk or dried buttermilk in poultry rations. A much more extensive use of vegetable protein than has formerly been considered feasible is thereby permitted. Corn distillers' dried grains were found by the Massachusetts station to constitute an excellent source of riboflavin and thiamine. This feed could replace substantial amounts of dried skim milk, soybean meal, and fish meal in the ration.

Rations containing up to 25 percent of soybean meal and only 2 percent of animal protein produced gains in broilers equivalent to those made by birds receiving a complex protein mixture, in trials at the Missouri station. In comparing a number of protein mixtures for growing chickens, the Mississippi station found that satisfactory and highly economical gains could be obtained by the use of a ration containing no milk products, but with the protein derived almost entirely from soybean meal, cottonseed meal, and alfalfa-leaf meal. A mixture of fish meal and soybean meal was found by the Washington station to possess a protein value superior to that of straight animal protein. Dried whey, fermentation byproducts, and distillers' dried solubles were found to be valuable substitutes for skim milk in chick growing rations. From this series of related investigations, all dealing with a common problem, it has been conclusively demonstrated that when properly supplied with adequate amounts of essential vitamins and minerals, the vegetable proteins can largely replace animal proteins in poultry feeding. This finding is highly significant in view of the reduced supplies of the common animal proteins for livestock feeding, coupled with the stronger competition for such feed due to greatly increased swine production.

Possibilities of developing a heretofore generally unused source of animal protein were indicated by the Iowa station. Meat scrap from chicken offal, following fat removal by rendering, made a good source of protein for poultry, comparing favorably with meat scrap and a mixture of meat scrap, fish meal, and soybean meal.

Another critical situation has arisen out of the shortage of fish-liver oils, which for years have been utilized as primary sources of vitamins A and D in poultry rations. There were findings at numerous experiment stations that green feeds, grass silages, and high-quality alfalfa-leaf meal, all of which are rich in carotene, may be depended upon to meet the vitamin A requirements of poultry when fed in proper combinations. Alfalfa-leaf meal in particular has assumed added importance since it may be obtained in seasons when other carotene-rich feeds are not available. It is also a fairly rich source of riboflavin, which in a measure can compensate for the reduction or omission of milk byproducts from the ration.

Artificially dried alfalfa meals proved superior to the naturally cured product as sources of both carotene and riboflavin, in studies at the Kansas station. This is an important consideration where a product of high vitamin potency is essential. A coarsely ground alfalfa meal was found to promote better growth of chicks than a finely pulverized meal at the Colorado station, where studies are being continued on the best methods of preparing alfalfa meal and incorporating it into poultry rations.

The feed requirements per dozen eggs were reduced from about 7 pounds in dry-lot feeding to about 6.3 pounds when the hens were given access to grazing on mustard, Italian ryegrass, or oats, in trials at the Mississippi station. The ryegrass gave the longest winter and spring grazing, but mustard gave best summer grazing.

Since earlier studies established the fact that D-activated animal sterols are equivalent to fish-liver oils on a vitamin D unit basis as a source of vitamin D for poultry, the loss of fish-liver oils has not created a serious problem in this respect. An efficient method devised by the Iowa station for extracting cholesterol, the basic material used in the preparation of the vitamin D concentrate, from wool fat greatly increases the potential supply of this important material.

Considerable interest has also centered around the possibilities of maximum utilization of locally produced grains in poultry production. At the Arizona station feed consumption, egg production, and mortality were not greatly different on rations made up largely of corn, barley, or red milo, provided proper protein supplements were added.

As good growth, egg production, and hatchability in poultry were produced by lightweight wheat, oats, and barley as by the heavier grains, provided adequate protein, vitamin, and mineral supplements were furnished, according to findings of the South Dakota station. Similar results were obtained by the North Dakota station with shrunken wheat weighing up to 40 pounds per bushel as compared with plump wheat weighing 60 pounds. No significant differences were found between locally grown and western grains or between stalk-cured and shock-cured yellow corn in the promotion of growth in broilers at the Maryland station.

The Hawaii station found a significant value in poultry rations for algaroba-bean meal, pigeonpea, koa haole-leaf meal, and grain sorghum. Their use was generally recommended as a means of approaching self-sufficiency in poultry-feed production on the Islands.

In addition to the more practical aspects of poultry feeding, technical research on the requirement of chickens for specific nutritive elements has been continued. Findings resulting from such work are of much value in the evaluation of feedstuffs and in the compounding of rations for maximum production efficiency. A finding of the California station that at least 0.5 percent of tryptophane and 1.0 percent of methionine are required in the ration for optimum growth of chicks helps to explain why certain sources of protein are of relatively low biological value and indicates the importance of a balanced protein ration.

Investigating further the riboflavin requirement of growing chicks, the Ohio station found that over 20 micrograms per chick daily were required in addition to that carried in yellow corn, wheat, casein, minerals, and cod-liver oil for optimum growth and prevention of curled toe paralysis. Actually the amount required to prevent the paralytic condition was greater than that needed for normal growth. Earlier investigations at the Ohio, New York (Cornell), and other stations had established within narrow limits the amount of this factor required for egg production and optimum hatchability of the eggs.

The Maryland station found no relation between the riboflavin content of the diet of hens and viability of their progeny. Variations of this factor in the diet of breeding stock, however, affected the severity of gizzard hemorrhages in the newly hatched chicks.

Studies of gizzard erosion at the California station showed that deficient formation of bile was correlated with the condition in the chick. Dried milk had no effect on the occurrence of the condition, but it was restricted by fresh and boiled whole milk and as cholic acid in the bile was increased.

Studying the possibilities of substituting ultraviolet irradiation for vitamin D in the ration, the Ohio station found that the S4 lamp with 1 to 7 hours of exposure per day was equal to or slightly better than A and D fish-liver oil for growth, hatchability, and egg production in poultry.

Perosis, or slipped tendon disease, a widely prevalent disorder of nutritional origin, has received further study. Investigating the possibilities that high levels of calcium or phosphorus in the diet may contribute to its occurrence, the Michigan station concluded that neither calcium nor phosphorus was responsible since bonemeal produced more perosis than oystershell but did not alter the blood or bone composition. At the same time, oystershell caused a high blood calcium, low blood phosphorus, and low bone ash. Further studies indicated that with rations normal in regard to calcium and phosphorus, three parts per million of acid-soluble manganese was sufficient to prevent perosis almost entirely, but when the calcium and phosphorus were in excess the acid-soluble manganese had to be greater. That inclusion of a suitable amount of manganese in the ration will usually prevent the occurrence of perosis has been confirmed in further studies at the Oklahoma and Massachusetts stations, although the former pointed out that factors other than manganese content of the ration are involved.

The need of chicks for choline was demonstrated by the Wisconsin station, where deficient rations produced inferior growth and perosis. At the Missouri station it was found that at least one nutrient in addition to choline and manganese is required to prevent perosis in chicks, and this substance is not identical with any of the recognized vitamins. Soybean phosphatides and lecithin as 1.5 percent of the basal ration were effective in promoting growth and controlling perosis in chicks at the Ohio station. In its perosis studies with chicks the New York (Cornell) station found an intimate relation between phosphatase activity of bones and manganese content of the diet, confirming the results of other workers on the rat. While none of the above research findings on perosis have provided a complete answer to the problem, taken together they throw a great deal of light on it. This is typical of the way in which concerted research effort eventually leads to the solution of a problem such as is here involved.

Among recent research contributions to practical poultry management is a contribution of the Washington station showing that the minimum amount of light necessary for optimum egg production is about 13 hours per day. There was no significant difference in the effect of light intensities varying from 1.0 to 31.3 footcandles or in the effect of Mazda, Mazda plus CX, ruby red, and red fluorescent light on egg production as long as the birds received this for 13 hours, but any decrease resulted in decreased egg production. By exposing pullets and hens to 14 hours of light, followed by 12-hour dark periods, the Maryland station found it possible to lengthen the clutch period of the hens and increase their annual egg production. This increase was thought to have been stimulated by the light period following laying which maintained the ovarian activity by maintenance of the pituitary in the artificial day.

A more economical practice of trap nesting, consisting in trapping the birds for 4 or 5 consecutive days each week instead of every day, was found by the Indiana station to be highly effective in indicating the total production at a considerable saving in labor costs.

In commercial brooding practices the Pennsylvania station found that an average of 11 square inches of electric brooder surface per chick was more practical than larger or smaller amounts of space. The growth rate of Barred Plymouth Rocks was related to the area available. An electric lamp brooder involving a minimum use of essential metals has been developed by the Ohio station which can be made in sizes to accommodate from 150 to 350 chicks. It is operated without thermostatic control, since it is found that the chicks adapt themselves to their heat requirements and comfort in a brooder of this kind, and it has a wide range of heat supply for special brooding requirements throughout the year. Essential construction is of plywood. Plywood of suitable type and thickness has also been adapted successfully to the construction of combination range shelter and brooder-house buildings for poultry by the Kansas and Indiana stations. The structures are light and strong and also portable, permitting their dual use.

Mechanical methods for air cooling poultry houses at the Washington station were found to practically eliminate mortality due to hot weather, and egg production was slightly increased. In studies of poultry housing, the Massachusetts station demonstrated that radiation losses from birds are less under insulated ceilings than under those uninsulated even though the same room temperature is maintained.

While breeding and selection have been employed for many years as means of improving the productive ability of poultry, particularly noteworthy accomplishments have recently been made in the field of breeding for greater livability and resistance to specific diseases. This field of investigation has received marked impetus in recent years through the cooperative effort of the Regional Poultry Research Laboratory, located at East Lansing, Mich., and 23 North Central and Northeastern State stations. The possibilities through this line of attack have been demonstrated in many instances.

The New York (Cornell) station found that mortality from all causes in fowls bred for resistance to disease was reduced from 64 to 38 percent in the fourth generation selected for viability. At the same time mortality in the lines selected for susceptibility was maintained at over 60 percent. Birds dying in the disease-resistant line were constantly and significantly longer lived than birds in the susceptible line. Deaths from tumorous growths among the progeny of 11 sires differed significantly, indicating that resistance to tumors was genetic and showing possibilities for breeding for disease resistance.

Similarly, the Maryland station has reported significant progress in the development of a strain of chickens resistant to pullorum disease, and the value of breeding as a means of controlling coccidiosis in poultry was demonstrated at the Louisiana station. In an investigation of the inheritance of viability in Barred Plymouth Rock fowls, the Maryland station found that pullets from the progeny showing greatest brooding mortality also produced excessive laying house mortality.

The length of the incubation period of chicks was found by the Massachusetts station to be related to subsequent mortality, age of sexual maturity, and egg production. A relatively short incubation period was preferable as to each of these characters, indicating the economic importance of selecting early emerging chicks for future breeding stock.

Certain new virus diseases affecting poultry came to light during the past year. For example, the New Hampshire station has shown that the prevalent poultry disorder variously described as blue comb, X disease, contagious indigestion, pullet disease, or sour crop is caused by a filtrable virus which has been isolated and propagated from four separate affected flocks. With this information at hand, the possibilities of developing means of immunization are promising. A filtrable virus distinct from others that infect chickens was shown by the California station to be the cause of the nervous disorder of chicks first observed in 1940. Chickens which survived inoculation were resistant to a second inoculation.

In the field of chemotherapy for control of various diseases and parasites, the Rhode Island station has shown that the administration of sulfathiazole at the rate of 0.2 gram per kilogram of body weight is an effective treatment against coryza, one of the respiratory infections, in fowls. From the standpoint of practicability it is necessary to keep sulfathiazole before the birds at all times to establish a constant effective level of the drug in the blood. This could be satisfactorily accomplished by incorporating from one-fourth to one gram of sulfathiazole per ounce of mash ration fed to the chicks.

Tests at the California station have indicated that sulfaguanidine may be of practical value in the treatment of outbreaks of cecal coccidiosis on poultry farms. The Washington station has shown that phenothiazine, an effective treatment for internal parasites of chickens, may be administered without ill effects at the rate of 0.5 gram per hen daily, which is a satisfactory single therapeutic dose. The addition of this drug to the mixed ration at the rate of 2,000 grams per ton of feed proved an effective way of administering the treatment without any deleterious effects upon body weight, egg production, or hemoglobin concentration. According to the Louisiana station the administration of flowers of sulfur to chickens proved to be of considerable value in the prevention of avian coccidiosis but was of little or no value as a cure.

In the field of turkey feeding and management, the total amount of grain consumed per unit of gain by standard and small-type turkeys and reciprocal crosses between them at the Michigan station was consistently increased by free-choice feeding of corn and oats as compared with feeding corn alone. Oats in free-choice feeding with barley, wheat, or corn checked the combined total consumption of the other grains.

More satisfactory growth was made by broad-breasted Bronze turkeys at the Washington station when fed a high-protein concentrate (39 percent protein) than with a low-protein concentrate (20 percent). In each case the birds had free access to grain feed.

The North Dakota station found that proso millet could satisfactorily replace part or all of the yellow corn in the mash and grain rations of poults. The rapidity of gain and market quality were as well maintained, although slightly more feed was required per unit of gain. Feeding the starter and grower mashes in pellet form promoted better growth, and the carcasses at marketing were of better quality and freer of pin feathers than for turkeys fed the same ration as a dry mash.

At the Oklahoma station growth was significantly retarded, and feather pulling became more prevalent, when turkeys were confined to from 10 to 15 square feet each, but when given access to a small bare yard no differences in the rate of growth were noted, as compared with those having access to more ample range. Mortality was not different in confined birds and those given access to range.

Turkeys fed in confinement without access to sunlight produced eggs of which the hatchability was very low, and in 48 days egg production ceased. When the Washington station furnished 100 AOAC chick units of vitamin D in cod-liver oil to each gram of the feed, egg production and hatchability were continued as well as with larger amounts of vitamin D.

A type of dermatitis occurring in turkeys on rations thought to be complete was prevented by the Pennsylvania station by the addition of residues of liver and yeast from alcohol and water extraction. Complete protection against the dermatitis was produced by additions of a biotin concentrate to a ration which otherwise caused 89 percent of the poults to be affected.

A protozoan parasite, *Hexamita meleagridis*, has been identified by the California station as the causative agent of infectious catarrhal enteritis in turkeys, a fact of practical importance in diagnosis and control. Experimental work by the Washington station indicated that the administration of mapharsen, an organic arsenic compound, in the treatment of blackhead of turkeys is safe and economical, and that it will save at least one-half of the birds, provided adequate treatment is given within a reasonable time after clinical symptoms appear.

No advantage for caponizing turkeys was found in studies at the North Dakota station. The mortality and growth of caponized and uncaponized toms were practically identical.

Handling eggs.—A major economic problem of the poultry hatcheryman is the incubation of infertile eggs, which after prolonged heating have no value except possibly as animal feed. When it is considered that about 5 percent of all eggs produced in this country are used for hatching, and that there are at least 10 infertile eggs in each 100 set, it means that close to 200 million infertile eggs went into incubation during 1941. This had the twofold disadvantage of rendering those eggs unfit for human food and of taking up space in incubators which should have been filled with hatchable eggs. Investigating the possibility of separating fertile and infertile eggs, the Alabama station found that by use of a suitable candling machine 95 percent of the infertile eggs could be separated after preheating for 15 hours at 100° F., with the result that infertile eggs so removed were available for human consumption. A simple candling machine costing only about $3.50 has been developed for this purpose. By use of a more elaborate candling machine, it was possible to detect approximately 70 percent of the infertile eggs without preheating. Approaching this problem through the application of a different technique, the New York (Cornell) station found that fertile eggs had a significantly lower conductivity in a highly sensitive electric circuit than infertile eggs. While this process has not yet been developed to the stage of commercial application, it appears to hold considerable promise as a means of separating fertile and infertile eggs before incubation. Among 2,300 eggs examined by the Michigan station, the hatchability was definitely correlated with the candling score.

The Wyoming station found that by reducing the ventilation, the humidity of the air to which hatching eggs were exposed could be raised from 60 to 75 percent. This increase in humidity increased the hatchability of the fertile eggs from 84 to 92 percent. It was pointed out that increase in moisture tends to reduce evaporation from the egg, which automatically tends to cool the embryo and retard its development.

Investigating ways of maintaining high quality in eggs held on the farm, the Maryland station found that under ordinary storage conditions freshly laid eggs showed an insignificant amount of deterioration during the first 24 hours. Earth-banked and water-evaporation egg coolers enabled Maryland farmers to maintain satisfactory quality in eggs for 1 week between laying and marketing except during the months of August and September, when more frequent marketing is recommended.

Studies were in progress at the Oklahoma and Washington stations to determine the preservative action resulting from dipping eggs in mineral oil or other suitable chemicals for closing the shell pores. In order to check the quality of eggs which are to be dried or frozen, for determining their bacterial content the Michigan station has developed a quick procedure which can be completed in less than 30 minutes after the samples have been collected. Its chief advantage over the longer conventional technique is that it can be completed before the eggs are finally dried or frozen. The method has been found applicable to either whole eggs or yolks.

CEREALS

Corn.—A Nation-wide survey in 1942 by the Department (BAE) revealed that 40,773,000 acres, or about 45 percent of the corn acreage in the United States, were planted with hybrid seed, developed chiefly as a result of cooperative research by the State stations and the Department (BPI). Corn Belt farms grew about 38,086,000 acres of hybrid corn in 1942, or 71.6 percent of the total in that area (12 States), a substantial increase over the 32,090,000 acres (64.7 percent) in 1941. If this contribution to the national economy is expressed in terms of bushels, the 2,270,921,000 bushels of corn in prospect in the Corn Belt on September 1, 1942, were about 300,000,000 bushels more than would have been produced with open-pollinated varieties, an increment attributable to the use of hybrid seed. In 1942 the percentages of the corn acreage planted in hybrids totaled in Iowa 98, Illinois 93, Indiana 91, Ohio 83, Minnesota 80, Wisconsin 76, Missouri 58, Michigan 52, and Nebraska 47 percent. Material increases continued in the Pacific Northwest and in two areas in the Northeastern States, and some advance occurred in West Virginia, Kentucky, and the upper Delta country. The development of adapted hybrids is in progress in the Southern States, and hybrid corn acreage in that region may be expected to expand as better hybrid combinations are obtained.

Corn improvement and distribution programs of the stations, the Department, and cooperating agencies continued to be potent factors in this phenomenal adoption of hybrid corn. The research and breeding phases have been supplemented by corn-performance tests, often State-wide in scope, which compare the newest experimental hybrid combinations with proven regular hybrids and open-pollinated varieties. Although these activities have been most intensive in the Corn Belt and adjacent States, stations in the Mountain, Pacific, Southern, and Eastern States also have programs of some magnitude. Besides outyielding the open-pollinated corn, superior hybrids are variously characterized by earliness; production of sound corn; resistance to lodging, plant diseases, insects, and other cropping hazards such as drought and heat; and adaptation to regions, altitudes, and soil fertility. Each of the stations working with the crop usually has had a number of promosing combinations being subjected to a series of performance tests prior to release to growers.

The value of hybrid corn for silage is a question naturally following the rapid increase in planting of such corn for grain. Carefully chosen corn hybrids, the Illinois station determined, are superior to open-pollinated corn for silage purposes because of their greater yield of forage on a dry-matter basis, higher proportion of ears in the crop, and greater lodging resistance. The experiments confirmed the station's recommendation that a dry-matter content of 30 percent in the corn crop is a good stage for silage harvest, and that kinds of corn which usually mature the grain should be chosen for the silage crop.

Timely improvements in machinery by the stations have enabled farmers to grow corn with less labor than formerly, and to control cornfield weeds with a minimum input of labor and power. The Iowa station, for example, found that, for early cultivation of corn, the spring-tooth weeder and the rotary hoe were effective in killing weed seedlings, particularly when the soil surface was lightly crusted by moderate rainfall. The best cultivator equipment when corn plants were small consisted of six sweeps per row and rotary-hoe shields, modified somewhat when first cultivation could be delayed until plants had about six leaves. For second cultivation under usual conditions one pair of disk hillers (with scrapers) throwing soil into the corn row and two pairs of sweeps per row were best. This equipment was also the best for the last cultivation, except that scrapers were not needed. A spring-tooth weeder rear attachment for a tractor cultivator effectively filled tractor-wheel tracks, leveled the soil between corn rows, and improved weed control. Cultivating programs for check-rowed corn have been suggested from this research.

By combining the picking and shelling operations in the field, the Illinois station was able to reduce costs, especially in labor, as compared with other methods of harvesting corn from areas larger than 45 acres.

Sound rotations and efficient fertility practices are essential in maintaining and increasing the yields and quality of corn and other feed crops. Working in southwestern Virginia, an important livestock-raising area, the Virginia station found that the 3-year rotation, consisting of 1 year each of corn, wheat (or barley), and red clover, returned the highest combined yields of all crops, gave economical use of atmospheric nitrogen gathered by the clover, and could be particularly recommended for dairy farms and other farms keeping young animals and sheep. In this rotation, liming resulted in marked increases in yield and quality of corn and clover hay and also in the efficiency of fertilizers. The largest percentage gains in crop yields and corn quality followed the use of phosphorus. The 4- and 5-year rotations, when they do not require plowing of steep land, are indicated for farms raising older beef cattle and horses. Where land is adapted to alfalfa and much hay is needed, the station suggests a rotation of corn 2 years, followed by alfalfa and timothy 4 years. On steep land, however, a cover crop of crimson clover and ryegrass or rye alone may advantageously be sown between the corn rows to reduce erosion and to provide some late-fall and early-spring grazing.

Studies of special current importance on the industrial utilization of corn dealt with properties of cornstarch, proteins, and sugars, and their use to supply wartime needs. The extraction of starch from waxy corn to replace tapioca (see p. 94) is an example of this type of investigation.

Wheat.—Current supplies of wheat are of such bulk that production goals for 1942 were fixed at 88 percent of the 1941 production. The stations in wheat States have stressed the problems of using to advantage present and potential stocks, controlling pests, and insuring desired qualities in our future supplies.

Hybrid 595, a complex crossbred wheat developed by the New York (Cornell) station, having a white kernel, stiff straw, and complete resistance to loose smut, has outyielded the Yorkwin variety and surpassed it for pastry flour. It is expected to gradually replace Yorkwin, which comprises 85 percent of the wheat grown in New York.

Comanche, a new variety developed by the Kansas station from Oro × Tenmarq wheat, combines excellent milling and baking qualities with high yield, good test weight, early maturity, stiff straw, and moderate resistance to stem and leaf rust, and seems to do best in the area extending from Kansas down through northern Texas. Pawnee (Kawvale × Tenmarq), developed by the Nebraska station and being multiplied for distribution, has been high yielding in Nebraska and States to the South, is slightly less winter hardy than Turkey, highly resistant to loose smut and moderately resistant to bunt and leaf rust, resistant to or usually escapes severe stem rust damage, resistant to hessian fly, and earlier than either parent. Vesta, a new awned wheat with the parentage Ceres × (Hope × Florence), developed by the North Dakota station and found best adapted to western North Dakota, yields well, holds the kernels tightly, has moderate straw strength, surpasses Rival and Pilot in resistance to stem rust although less resistant to leaf rust, and compares satisfactorily in milling and baking tests with Thatcher and other good bread wheats.

Winter wheats resistant to hessian fly and the rust, smut, and mosaic diseases common to the soft red winter wheat area, bred by the Indiana station and the Department (BPI and BE and PQ) are of promising grain quality and have yielded as well as old standard varieties of the region in 1941 when no hessian fly was present. Under the severe hessian fly outbreak of 1941–42 these resistant wheats have been practically uninfested by the flies when nearby common varieties were almost 100 percent infested.

Baart, White Federation, and Big Club currently comprise 60 percent of the total California wheat acreage. At the California station, the transfer by backcrossing of resistance to stem rust and to smut from nonadapted wheats to these three varieties was expected to have enough practical value to largely replace their prototypes in the region and increase their culture to 85 percent of the total State acreage within 5 years. Other improvements scheduled for early release included bunt-resistant strains of Federation, Onas, Escondido, Romona, and Bunyip wheats, and Poso wheat resistant to hessian fly.

Wheat yields in central Oklahoma, the Oklahoma station reported, cannot be maintained without fertilization, especially with phosphorus, and proper crop rotations. Methods of seedbed preparation which reduce soil loss by run-off water must be used on the sloping upland soils of this region. Preparing a seedbed for winter wheat with large sweeps has protected the land from the destructive effect of run-off water. Effects of terrace ridges on the production of winter wheat, the station found, may depend upon the nature of the soil, slope, and amount of rainfall. Advantages of proper fertilization were also determined by the Kansas station, which found that maintenance of available phosphorus and nitrate nitrogen at suitable levels resulted in successful control of the take-all disease.

The steady production of small grains, which has made possible war reserves, has been aided by fundamental scientific work on grain rusts and smuts by the Minnesota station and the Department (BPI). Continued study of innumerable specialized races of smuts and rusts, of factors for resistance that can be used in developing resistant cereal varieties, and of climatic and geographic and alternate-host aspects entering into the epidemiology of these diseases constitute a type of war insurance against such violent and sweeping rust outbreaks as have been experienced periodically in the past. An extremely virulent new race of stem rust of wheat was found in Peru by a Minnesota station worker. It attacks wheat varieties hitherto considered resistant, and apparently originated from the stage occurring on barberries. This discovery indicates the importance of maintaining the barberry eradication program and quarantines to hinder the spread of new types of plant disease to the United States.

In tests of wheat varieties, the North Dakota station found Rival, Mercury, and Premier markedly resistant to all the different races of stinking smut used. Shortages of copper or mercury that may result in abandonment of seed treatment for smut prevention need cause little alarm for growers of these and other wheat varieties resistant to this disease.

The Virginia station found high resistance to loose smut in several lines of wheat and has multiplied a selection (F–h–6) resistant and productive enough to be of special value in the war effort.

Illustrative of the practical utility of the stations' milling and baking research are the findings in a cooperative Minnesota station project. Of the newer rust-resistant wheats, Merit and Premier were of lower milling and baking quality than Pilot and Rival, and several Thatcher backcrosses appeared promising. Variations in flour yield due to differences in milling conditions had relatively little effect on loaf volume. Apparent specific gravity of wheat was correlated positively with test weight. Rate of moisture loss from flour was more rapid than the rate of regain. Stem rust of wheat had a greater effect than leaf rust on the biochemical properties of wheat. A knowledge of the biochemical changes induced by leaf and stem rust is of importance in estimating economic losses due to these parasites and in determining the best means of processing the wheat from infected plants. In the mature wheat plant, about 75 percent of the total thiamine B_1 was found in the kernels. Bacterial dough fermentation produced excessive dough slackening, but this might be decreased by potassium bromate. The cake studies have resulted in modifications in the method of processing lard for use as shortening.

Wheat-germ breads of improved quality, the Minnesota station finds, can be made by prefermentation of the wheat germ, coupled with suitable additions of potassium bromate at the dough stage. Under optimum conditions bread baked from 5 and 10 percent germ-flour mixture approached the quality of bread baked from patent flour alone except for crumb color.

Oats.—Wartime requirements for feed and forage, particularly in the meat-production part of the Food for Freedom program, were being met in part by new and more highly productive oat varieties, developed by the stations cooperating with the Department (BPI). A group of varieties derived from Lee × Victoria and combining resistance to crown rust and smut with winter hardiness and quality of grain included DeSoto by the Arkansas station, and Lega and Levic by the Georgia station. Stanton (C. I. 3855), of this parentage, was outstanding in station tests in the northern part of the winter oats belt. Letoria and Lelina, released earlier by the North Carolina station, also were being grown on increasing areas.

Boone and Tama, derived from Victoria×Richland and resistant to the smuts and stem and crown rusts and having stiff straw, have been released by the Iowa station. More than 1,000,000 bushels of seed of these two varieties and of Marion and Control oats were available for planting in 1942 in Iowa, and some 20,000,000 bushels were prospective for 1943. Adequate supplies of Vicland were planted in Wisconsin and of Marion (Markton × Rainbow) in Illinois to insure an abundance of seed for 1943. Ranger and Rustler (Nortex × Victoria) developed by the Texas station, resistant to the smuts and crown rust and moderately winter-hardy and good for both grain and winter forage, were showing excellent performance in Texas. Rangler, of like parentage and characteristics, was found adapted to south-central Texas and other regions.

That oats possessing considerable hardiness can be bred and that such hardiness can be coupled with excellent growth for winter pasture, with rust and smut resistance, and with good grain yields, was shown by exhaustive tests of varieties and hybrids by the Arkansas station. This station and other stations in the region, cooperating with the Department (BPI), were developing adapted hardy oats with such desirable characters.

Better oats production methods, evolved in the course of station experiments and published during the year, have aided in meeting the oats-production goals. The Missouri station, for example, has published on oats varieties and growing and harvesting methods for Missouri and also issued specific instructions for the lowland soils of southeast Missouri. The North Dakota station has appraised improved varieties of spring oats and has shown their adaptation. Similarly, the Illinois station published results of its spring oat varietal comparisons and has recommended growing practices.

Barley.—Barley, valued for feed grain and for pasturage, has a recognized place in the Food for Freedom program. Station research in cooperation with the Department (BPI) is providing improved barley varieties and better cultural practices to help growers attain production goals for meat as well as for feed. The Texas station, for example, has reported from its experiments in cooperation with the Department (BPI) on the adaptations, varieties, cultural needs, uses, and diseases of barley in Texas; the Illinois station on spring barley in Illinois; and the New Jersey station on growing winter barley in New Jersey.

Among the new barley varieties, Wong, being increased for release by the New York (Cornell) station, is high-yielding, stiff-strawed, resistant to mildew, and suitable for combine harvesting and is ex-

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pected soon to replace other barleys grown in New York. Texan, a smooth-awned barley resistant to mildew and moderately resistant to net blotch, selected by the Texas station and the Department (BPI) cooperating, will produce from either fall or winter seeding under Texas conditions and is recommended for fall seeding in the blackland area. The giant rust-resistant awnless barley released by the station in 1940 has continued to be popular as a winter forage crop in the lower Rio Grande Valley. Jackson, a productive smooth-awned barley developed by the Tennessee station, has vigorous growth, large heads, and is adapted to the less fertile upland soils. About 225 bushels of Tregal (Ns 2753) barley, a new smooth-awned high yielder expected to supplement or replace Trebi, was released by the North Dakota station to growers for increase. Nassau, a new variety recently developed by the New Jersey station and to be released for general distribution in 1943, is a high-yielding, smooth-awned, stiff-strawed, early-maturing, six-rowed winter barley. Sunrise (C. I. No. 6272), an awnless, stiff-strawed, six-rowed barley, resistant to mildew and highly resistant to covered smut, was being multiplied by the North Carolina station for release to growers.

Rice.—Aid was rendered to rice growers in achieving production goals when the Louisiana station, cooperating with the Department (BPI), developed and released for general use in 1942 the new leaf spot-resistant rice Blue Rose 41. This variety is resistant to the dominant biological race of the cercospora leaf spot fungus and usually has outyielded other strains of Blue Rose. Certain varieties, among them Zenith, were found by the Arkansas station to be resistant to blast, another cause for low rice yields, and this will be of special value in extending rice-growing into newer areas where the disease causes serious losses.

Rice production was aided further by other researches of the Arkansas, California, Louisiana, Texas, and Missouri stations in cooperation with the Department (BPI) concerning varietal, cultural, rotation, irrigation, fertilizer, disease, and harvesting problems. A practical current example of this cooperation was a comparison of the merits of direct seeding of the commercial crop as practiced in the United States and of transplanting, almost universal in the Orient. The average yields of Caloro rice for a 3-year period from direct seeding were higher than from transplanting, in Louisiana and California. The average yields of Early Prolific rice also were higher from direct seeding than from transplanting in Louisiana, California, and Texas, also for Arkansas Fortuna in Arkansas and Louisiana. None of three varieties at any of the stations produced significantly higher average yields when transplanted than when direct-sown.

The Louisiana station and the Department (BE and PQ), as a result of rice-insect research, have suggested control practices for the four major pests of this crop. Their findings indicate that occurrence of the rice stink bug may be decreased by burning or plowing under heavy grasses during the winter. These operations are also helpful in the control of the sugarcane borer and rice stalk borer, although the most effective control measures for these insects are the winter pasturing or winter dragging and flooding of rice stubble and not growing corn or sugarcane in the vicinity of rice fields. Delayed drainage or immediate reflooding of rice fields following appearance of the sugarcane beetle prior to harvest decreases losses from this pest.

Sorghums.—The sorghums are a feed crop of major importance in the Great Plains areas, especially in Kansas, Oklahoma, and Texas where there are broad areas particularly adapted to livestock production. At one time the infection with *Pythium* threatened to wipe out milo production from many parts of the Southwest, but the Kansas station showed the way to control this disease by developing resistant varieties. So rapidly have plant breeders in the several States succeeded that already new resistant lines are being grown on some million and a half acres of land and are contributing tremendously to livestock feed supplies. The Oklahoma station, however, has found that the root and stalk troubles in sorghums are not due to milo disease alone, since the lodging, or charcoal rot, disease, evident only when the plant nears maturity, also causes serious losses. Fortunately, inheritable resistance to this trouble also has been found in sorghum lines, and the station is working to combine it with resistance to *Pythium*.

Three new varieties of grain sorghum developed by the Texas station were distributed to farmers in the spring of 1942. Bonita, from feterita, kafir, and hegari parentage, is a dwarf, pithy, compact-headed, and white-seeded variety of high production which resembles hegari. Caprock and Plainsman, two dwarf types selected from kafir×milo crosses, are juicy, yellow-seeded varieties having dwarfed stout stalks resembling kafir. They have been developed to save labor and to effect other economies as they can be harvested with a combine. New strains of Sudan grass having sweet, juicy stalks, nonshattering seed habit, sienna glume color, and resistance to leaf spots were being increased for distribution. The merits of Leoti sorgo as a source of starch has been mentioned on page 94. The above research has proceeded in cooperation with the Department (BPI).

SUGAR CROPS

Sugar has assumed an important position in our wartime agriculture. This essential foodstuff is increasingly needed for production of industrial alcohol for munitions and other war purposes, food for both military and civilian use, and preservation of perishable foods. In peacetime the domestic production of sugar beets supplied about 23 percent of the national sugar needs and domestic production of sugarcane 7 percent. War production goals called for the growing of sugar beets and sugarcane up to processing capacity and set no limitations on plantings and no restrictions on acreage. The research of the stations and the Department has been a potent factor in aiding such expansion by providing information on disease-resistant seed stocks, labor-saving cultural methods and implements, and economical fertilizer practices.

Sugar beets.—Yields of sugar beets mechanically thinned by cross-blocking by the Colorado station cooperating with the Department (BAC and E), supplemented by laborers using long-handled hoes, did not differ much from yields in a hand-thinned field, and the labor time was cut about in half and stoop labor eliminated. Development of the single-seed ball planter resulted in an improved type of planting with consequent increase in number of single beet plants and appreciable saving in seed.

Results of a long study on nitrogen requirements of sugar beets, completed during the year by the Colorado station, were especially timely as an aid in increasing sugar production. Nitrogen was shown to be a much greater limiting factor than was previously believed. The study has led sugar-beet growers to increase the use of nitrogen fertilizers and to make better use of manure and alfalfa in rotations with sugar beets. Nitrogenous fertilizers used in field tests by the California station consistently reduced infection by the sclerotium rot fungus in sugar beets. Yields were also increased by disease control and by growth stimulation, but the method was economical only where the crop responded to nitrogen.

Fertilizers for sugar beets, the Michigan station has determined, should be placed in a single band 1½ to 2 inches below the seed and ½ to 1 inch to the side. An implement company has designed and marketed a machine to plant the crop and locate the fertilizer as recommended. Sugar beets, the same station found, will not thrive on a soil lacking in available boron, and almost fail on certain soil types when planted without borax. On highly alkaline Wisner silt loam the application of 7 to 8 pounds of borax per acre, costing 30 cents, resulted in a gain in yield of 7 tons of beets and an increased sucrose percentage.

Irrigation experiments with sugar beets grown for seed in the Hemet Valley of California, carried on cooperatively during five seasons by the California station and the Department (BPI), showed that when enough moisture was supplied during the blooming period, irrigation at 7-day intervals gave no better results as measured by yield and percentage of seed germinating than irrigation at 14- and 21-day intervals. The possible saving of water and labor is obvious. A variable-cut sugar-beet topper with roller-lifting device mounted on a rubber-tired tractor, developed by the California station, has a potential harvesting capacity of 60 tons a day and has proved quite successful. Nonexclusive manufacturing rights have been granted to three implement manufacturers.

Contributing to wartime production of sugar beets was the Montana station's proof that losses from the seedling disease condition called "black root" may be greatly reduced by planting sugar beets early, before the soil gets too warm, on land that has not just grown sugar beets or alfalfa but preferably some grain crop, and using a properly balanced fertilizer.

Sugarcane.—The research of the Louisiana station on sugarcane diseases has become a material aid to increased economical sugar production. In 1942 more growers than ever followed station recommendations for eradicating mosaic, which might reduce yields as much as 15 percent in a leading variety such as Co. 290. Treating seed cane with hot water to eliminate root rot, the station determined, will also speed up shoot growth and kill the spores of red rot, another serious disease of sugarcane. These tests also demonstrated the merits of the resistant canes developed cooperatively by the station and the Department (BPI), such as C. P. 29–103 and C. P. 29–120.

Chemical studies by the station revealed that certain sugarcane soils lacked phosphorus, while others needed potassium, and still others a complete fertilizer instead of the usual application of nitrogen, heretofore considered the first limiting factor. On soils deficient in these plant foods, such use of phosphorus and potassium in addition to nitrogen brought about desired increases in cane yield and also resulted in an average gain of $9 per acre in profit.

In connection with its sugar research program the station has developed two-row tractor cultivators and two-spinner cultivators for removing dirt and weeds from the top of the cane row. Both kinds of machines have been accepted and put into production by machinery manufacturers and are now used quite generally over the sugarcane territory in one form or another. The experimental results indicate in general an advantage in terms of increased sugar yields from deeper seedbed preparation.

Other sugar crops.—The sugar shortage has resulted in considerable emphasis on the use of sorgo sirup and an increase in the acreage of the sorgo crop. Profiting by its experiments and experience over several years with sorgo sirup and its manufacture, which have demonstrated that uniform sirup of good quality can be produced in considerable quantity by the use of rather inexpensive equipment, the Tennessee station cooperated with a group of McMinnville businessmen who installed sorghum equipment and made about 1,800 gallons of sirup as a trial operation.

Certain Iowa clays have been shown by the Iowa station to be capable of clarifying sorgo juice for the production of a sirup equal to or better than commercial products as regards taste, clarity, and color. The clays found effective for this purpose contain the clay mineral montmorillonite and appear to be available in abundance in Iowa.

The Vermont station has markedly reduced the lead content of maple products by eliminating terneplate and utensils exposing lead-tin solder to the material handled from the equipment used in gathering and processing of maple sap, sirup, and related material. The New York State station has contributed to the solution of the same problem, reducing the lead content of contaminated sirup to a few tenths of 1 part per million by a process of clarification only and to complete absence of lead by treatment of the sirup with a base-exchange material.

OTHER FIELD CROPS

Field beans.—The 1942 goals specified 2,600,000 acres of field beans, an increase of about 305,000 acres over the 1941 acreage, and offered price support for all-out production of certain varieties.

The development of the Robust bean and later the Michelite bean by the Michigan station has a direct bearing in the promotion of this country's war efforts. These varieties, now grown on 90 percent of Michigan's white pea-bean acreage and with the newer Michelite rapidly supplanting Robust, have averaged about 240 pounds an acre more than varieties formerly used. In 1941, Michigan growers, despite an unusually severe drought in July and one of the wettest harvest seasons on record, produced 5,976,000 bags, an increase of 38.7 percent over 1940 production. The saving in land, as compared with what would have been required before the introduction of these two varieties, amounted to 236,000 acres, the labor saving to 5,192,000 man-hours, and the monetary saving to $5,664,000.

Higher yields of beans will be possible through use of the disease-resistant varieties recently developed to check growing losses from infections so severe that many farmers have in the past given up bean growing because of them. Thus, the U. I. 15 Great Northern bean, highly resistant to both curly top and mosaic and developed and released by the Idaho station, proved opportune in view of the increased goal for dry-bean production.

Seed of New Mexico station pinto bean strains 295 and 291 are now entering commercial production. In 1942 a large percentage of the acreage planted to pinto beans was expected to be of these strains, as they were available in each bean-producing area. These strains are better yielders and more uniform as to marketing qualities than are the common seed.

Field-bean experiments by the New York (Cornell) station showed the merits of the Michelite and Red Kidney varieties, no differences of consequence in crops from large, small, or ungraded seed of Robust Pea or Red Kidney, and gains from superphosphate with or without manure. From 200 to 300 pounds per acre of such fertilizer mixtures as 6–18–6 and 4–12–4 were suggested where beans follow another cultivated crop. In a comparison, yields favored the bean planter over the grain drill for seeding and fertilizing beans because of shallower seeding, more compact surface soil, and closer placement of fertilizers. Three or four cultivations resulted in yields as large as those after six cultivations.

Seed of several lines of pinto beans resistant to the same diseases as isolated by the Idaho station is expected to be ready for release soon. Several white and pinto bean selections bred by the Nebraska station for resistance to halo and common blights, which are the most serious bacterial diseases of beans in the United States and cannot be controlled successfully by spraying or dusting, were also ready for local tests before general distribution. The growing of such varieties would result in more consistent yields. Red Kidney 789, a hybrid kidney bred by the California station, has had a superior performance record in California and New York (where many California disease-free beans are used for seed). In 1941 over 12,000 bags were grown, and in 1942 all beans intended for certified seed were to be of this selection.

Mung beans.—The war has stopped the importation of mung beans (*Phaseolus aureus*) for sprouting and canning and their subsequent use by Chinese restaurants and others for chop suey, chow mein, and other dishes. Commercial canners, having exhausted their seed stocks, have offered good prices. The Oklahoma station, in an area deemed ideal in soils and climate for mung bean production, has experimented with the crop and has reported on production practices. Green varieties have yielded from 12 to 15 bushels of seed per acre but only about half as much hay as the golden—1 to 2 tons of air-dry hay per acre and 4 to 5 bushels of seed. The crop is said to be more drought-resistant than soybeans and easier to harvest than cowpeas. Since mung beans have been grown on summer fallow without irrigation, the California station has been testing this phase in regard to varietal adaptation and cultural needs. High vitamin B_1 values in both dry beans and sprouts have led the station to recommend the crop highly.

Potatoes.—One of the most important staple food crops grown in the United States, the potato is also the source of a starch considered the finest of all starches for many uses. Perhaps no major food crop has suffered more severely from wide fluctuations in production. These have been brought about largely by waves of damage from diseases and their effects on prices and intentions to plant.

The new and promising potato varieties developed as products of the national potato-improvement program, in which the experiment stations cooperate with the Department (BPI), were being tested and studied before and after release to growers. The valued characteristics of these varieties may include high acre yields, adaptations to season and region, and resistance to or immunity from scab, late blight, viruses, and other diseases, insects, and drought. Market and culinary qualities also are important attributes.

Among the varieties made available during recent years were Earlaine, Mesaba, Nittany Cobbler, Red Warba, and Warba, early potatoes; and Katahdin, Chippewa, Houma, Earlaine 2, Golden, Pennigan, Pontiac, Sebago, and Sequoia, late varieties. It is of particular significance that their resistance to various diseases and insects enables some of these potatoes to produce satisfactory crops with less labor and less spray materials than the standard varieties. Certain ones, as Katahdin, are widely adapted; others are perhaps more limited in their range of adaptation. None of the new early varieties have yet entered into serious competition with Irish Cobbler and the Triumph.

The potato-improvement program in Minnesota, which received added impetus through special legislative grants, trust funds, and a special university grant for research, may be cited as an example of current local activities. Extensive variety trials were being conducted in many places in Minnesota in efforts to determine which new varieties are best suited for use in the table-stock market from the viewpoints of yield, reaction to diseases, tolerance to bruising during washing, and cooking and baking qualities. At present the potato industry in the State is geared around the production of potatoes for the seed-stock market, in spite of the fact that 60 percent of the potatoes are used for the table. Comprehensive local programs were active at other stations.

Practices for satisfactory and profitable yields of potatoes, based on experiments, were issued by several stations. The Iowa station recommendations covered choice and preparation of soils, fertilizers, varieties, seed treatments, planting, culture, spraying or dusting, and harvesting and storage. Cooperative experiments on potato production on the Cumberland Plateau enabled the Tennessee station to report on recommended varietal, cultural, harvesting, and handling practices conducive to profitable returns.

Suggestions for improving the fall potato crop, made by the Oklahoma station on the basis of its experiments on causes of failure, include use of quick-sprouting, early maturing varieties such as Triumph and Warba, storage of seed from the spring crop at ordinary cellar temperatures, 70°–80° F., cutting spring-grown seed just before planting, ethylene chlorohydrin treatment of seed, planting during the first week in August and when soil temperatures have been lowered by rainy weather, irrigation between planting and establishment, and the use of moderate to low ridges.

Experimenting in southern Ohio, the Ohio station found Chenango sandy loam to be an excellent soil for early potatoes, demonstrated the superiority of Warba and Irish Cobbler, and determined suitable fertilizer practices. Concerned with the problem of maintaining a soil suitably porous for potatoes, this station found that rye sown in August was the best winter cover to precede potatoes on Wooster silt loam, which forms no crumb structure. The mass of fine rye roots produced in the fall retains the soil porosity induced by wetting and freezing in winter, and spring rains do not recompact the soil under rye. From its fertilizer experiments the Oklahoma station has worked out formulas, rates, and other fertility practices for different parts of the State.

The ethylene chlorohydrin treatment of seed has been found valuable by the Florida station for the fall crop of Bliss Triumph, for by hastening sprouting many seed pieces are saved from decay and the crop usually matures early enough to escape frosts. When fall-crop potatoes provide seed for the spring crop, the treatment is needed to start growth early enough to produce a crop before hot weather prevents tuber setting. Increases in stand and yield have varied with stocks and seasons but in general have been important. A greater productiveness of seed stocks harvested when somewhat immature was shown.

In experiments on Aroostook Farm, the Maine station determined that reduction in the chloride content of fertilizers materially improved the cooking quality of potatoes. Potatoes receiving fertilizers low in both chloride and sulfate had small amounts of stem-end browning and net-necrosis. Studies by the West Virginia station disclosed that maximum benefits of growing certified seed potatoes depend upon properly timed planting and spraying and proper fertilization. Under these conditions all of the sprays tested greatly increased yields, with calcium arsenate and bordeaux surpassing bordeaux and nicotine sulfate.

The year 1942 witnessed unusually prolonged periods of wet weather in different parts of the United States which favored disastrous attacks of potato late blight from coast to coast. Spotted examples of heavy damage amounting at times to total destruction of the crop were reported from many sections. Fortunately, control practices worked out over many years by experiment stations in major potato-producing States enabled growers to forestall major damage on most farms where ample supplies of standard fungicides were available and where sufficient equipment and competent labor were on hand to give timely and adequate protection throughout the season.

No disease invasion from abroad has ever threatened the production of potatoes in the country as seriously as bacterial ring rot. Coordinated station work in many States has shown how this disease can be successfully held in check. Disinfection of the seed-tuber cutting knife has been found necessary to prevent its spread. While certain chemicals were found to be somewhat effective, the Colorado station has shown that plain boiling hot water is a fully effective and cheap means of knife sterilization. This method also gave good results at the Wyoming station, which found mercuric chloride and iodine to be very effective and cresol preparations also promising. Mercuric chloride also gave the best results for treating cut seed pieces. This station found no evidence that ring rot bacteria overwinter in the ground or in infected tubers left in the soil.

For elimination of ring rot infected potatoes from planting stock, the Montana station found that ultraviolet light examinations were 10 times as rapid and just as effective as the gram-stain method and were also useful in eliminating certain other internally tuber-borne diseases. The use of a circular cutting knife disinfected by corrosive sublimate solution was effective in reducing spread in cutting seed pieces. Resistance to bacterial ring rot, found in several lines of potatoes, was shown by the Maine station cooperating with the Department (BPI) to be heritable. The danger of planting where volunteer potato plants are allowed to develop was pointed out, as although ring rot is not carried over winter in the soil it may start up in plants from infected tubers left in the ground. The North Dakota station has discovered that chlorinated lime is effective for treating washed potatoes as it removes rhizoctonia scurf from the surface and prevents the spread of ring rot bacteria and the organisms of decay. It is also a good material for disinfecting contaminated potato sacks.

Throughout large potato-producing areas where high temperatures prevail during the growing season, the soil-borne fusarium wilt is an important and persistent cause of low yields. The Nebraska station has just released two wilt-resistant selections for growers who must use wilt-infested land. In testing potato varieties for resistance to fusarium wilt under irrigation, the station found Pontiac, Katahdin, Golden, Sebago, and hybrids B5 and B4–1 to be the least susceptible of any of the newer varieties tested. These will prove useful for war production in areas where wilt is prevalent. One of three different fungi causing potato wilt, compared by the Wisconsin station, was found so much more damaging than the others that the search for resistant varieties may be confined largely to tests with this one fungus. Bliss, Triumph, and Katahdin varieties were found less susceptible than Irish Cobbler and Rural New Yorker.

Large losses in stand result every year in many potato-growing areas from rotting of the seed piece in the ground. Under Kansas conditions the Kansas station found this can largely be prevented by treatment with corrosive sublimate or yellow oxide of mercury. The former is also helpful in killing tuber-borne *Rhizoctonia* and preventing spread of ring rot germs from diseased to healthy seed pieces in planting.

A yield-reducing potato virus, yellow dwarf, attacked as many as 56 percent of the Russet Rural variety in tests by the Wisconsin station. These also brought out the high resistance of Sebago, in which infection did not exceed 1 percent, so that this variety may be the answer to a most serious threat to wartime potato production in central Wisconsin.

In areas where yellow dwarf had completely stopped production of certified seed potatoes, some growers were reviving the industry with varieties shown by the New York (Cornell) station to be resistant to or escaping the disease. This station recently discovered that the common oxeye daisy is one of the most important natural hosts of the virus. Growers can reduce infection by keeping this weed away from potato fields.

Potato scab damage is a cause for discouragement in home gardens as well as commercial fields. The Minnesota station, selecting and breeding for scab resistance, has classified its tested lines into five groups on the basis of susceptibility, with promise of an early development of desirable resistant types superior to any now commonly grown. The finding of the Maine station that scab is rarely a problem on soils more acid than pH 5.5 will be helpful in choosing soils for the war production of potatoes.

In the Rocky Mountain area much loss has been sustained from so-called psyllid yellows, for which lime-sulfur has been the standard protective spray. The difficulty of hauling water and costs of spray equipment, however, have been handicaps to the adoption of spraying. The Wyoming station found that dusting with sulfur at the rate of 70 pounds per acre gave significant benefit, with higher potato yields than with lime-sulfur spray.

The increasing difficulty of obtaining supplies of mercurial salts for treatment of seed potatoes makes it imperative to obtain maximum effectiveness with the least amount of material. Addition of acetic acid was found by the Maine station to keep a mercurial solution effective for 25 successive treatments instead of only 5 to 6 when the acid was omitted.

The precooling of potatoes in 100-pound sacks from 80° to 50° F. by passing through a shower of 35° water allowed the tubers to undergo a 7-day transportation test in perfect condition, according to the California station. Severe surface discoloration of skinned tubers was reduced by refrigeration and was practically eliminated for the 7-day transit period by precooling in ice water. Less deterioration occurred by immediate cooling of cars to 50° by icing at once than by delayed icing, even though the temperature rose after the fourth day. Washing of potatoes at the Louisiana station increased the rotting tendency, but drying and cooling by bunker fans helped to prevent this decay.

Research conducted by the Idaho station has proved that the intermountain potato leafhopper was not causing "early maturity" or any other commercial damage to potatoes, and therefore that no spray program is necessary to control this insect. This finding may save growers thousands of dollars as well as conserve essential spray materials.

Sweetpotatoes.—The sweetpotato is essential in the war program as human food, as feed for livestock, and as a source of starch to meet increased national requirements.

Improved sweetpotato strains were being developed by the stations in producing States in cooperation with the Department (BPI), e. g., Georgia, Kansas, Louisiana, Mississippi, New Jersey, North Carolina, South Carolina, Tennessee, Texas, and Virginia. Sweetpotato breeding work by the Louisiana station and the Department has resulted in strains high in starch and containing less than 60 percent of moisture. This low water content is an important item in the cost of producing a ton of starch stock dry feed for livestock. The promising seedling L-4-5 is considered likely to replace Triumph as a starch and feed variety. Other contributions to the better nutrition programs are the superior mutant strains of Nancy Gold and Orange Little Stem sweetpotatoes developed by the Kansas station, which assay three times as high in vitamin A content as the parent varieties. Strains of Nancy Hall sweetpotatoes selected by the Tennessee station for flesh color have yielded as high as the common strain.

More effective production, curing, and storage practices were worked out by several stations. Experiments at the South Carolina station involving the use of electricity in the production of plants from roots bedded in hotbeds have yielded excellent results. Conditions for optimum production of plants include a soil temperature of 83° to 85° F., horizontal spacing of the heating cable of 9 to 10 inches, placing roots close together, using soil as bedding media, and supplementing the soil with fertilizer.

Planting methods designed to return highest yields of sweetpotatoes for starch or feed and harvest practices which would give the grower the best yields and at the same time permit longer and more effective operation of the mills are being developed by several stations in cooperation with the Department (BPI).

In fertilizer experiments with sweetpotatoes grown for starch, the Mississippi station determined appropriate formulas and rates and found that about half the nitrogen, the most important nutrient, could be supplied by winter legume cover crops. Fertilizers did not seem to affect the starch content or shape of Triumph sweetpotatoes materially. The station also has developed good plant production and spacing methods. Continuing research in cooperation with the Department (BPI, BAC and E) was concerned with the effects of spacings, times of planting and harvest dates, and fertilizer placement on yield, and of these factors and storage conditions on starch content.

Sweetpotatoes are subject to serious losses from many diseases. Fair control of sweetpotato scurf was obtained by the New Jersey station when Spergon, a nonmetallic organic chemical, was substituted without injury for mercurial or copper treatments of the sprouts, whereas these metallics caused considerable damage. Spergon also reduced stem-rot damage. In many areas of light soil, root-knot nematodes attacking the roots make it hard to start new plantings, so that the discovery by the Oklahoma station that heating sweetpotato roots in hot water at 116° F. or slightly higher for 65 minutes may safely eliminate root-knot infection takes care of an important problem.

One of the largest problems connected with sweetpotato production is the enormous losses that occur from rot and decay. These losses are matters of vital concern in connection with the war effort. Several stations have been investigating methods of reducing this wastage.

For instance, the Georgia station has been determining the effects of handling, curing, and storing. Where grading was done properly in the field and care used in handling the roots, loss in storage due to decay was negligible. If sound roots were used, weight losses during curing were under 11 percent. Benefits of borax-solution treatment applied just before cleaning and before packing for market were confirmed by the New Jersey station. Boraxed sweetpotatoes showed less than 3 percent of loss from soft rot after 11 days while untreated lots averaged over 40 percent of loss. The Maryland station has explained the failure to prevent rot of curing methods often employed by showing that uniform success in curing depends upon the proper curing temperature combined with the proper humidity. The South Carolina station in studies on the use of electricity in the curing and storage of sweetpotatoes determined that from 0.4 to 1.1 kilowatt-hours of electricity were necessary to cure each bushel of roots, and from 1.3 to 2.7 kilowatt-hours to store each bushel. An economical source of heat for curing and storing, electricity had the additional advantage of maintaining a relatively uniform temperature together with a uniform relative humidity, factors favorable for long storage life of the roots.

An important contribution by the Alabama station toward wider use of sweetpotatoes as a source of carbohydrates in livestock feeding is the development of an inexpensive method of preparing floors in the open for sun-drying shredded sweetpotatoes on the farm. Sun-drying retains about 90 percent of the carotene (provitamin A) in sweetpotatoes. Yields of dried sweetpotatoes just short of 5 tons per acre of drying surface were obtained as a daily average, including cloudy and rainy days. Building paper as a drying surface costs about 25 to 50 cents per ton of dried material, and a drying surface of soil treated with road asphalt priming oil, which should last for years, about 10 to 25 cents per ton. A simple shredder, consisting of the rear axle of a low-priced automobile, a vertical shaft, a plate with beet shredder attached, and an oil-drum hopper has also been designed by the station. Total costs for drying, with labor the larger part, were estimated at $2.25 to $3.50 per ton of dried material. The report on the experiments included practical instructions.

Desiccated sweetpotato products of excellent quality have been made in Tennessee station experiments, where a current problem is the prevention of caking of the powdered, dried material. The Nancy Hall variety appeared to make the best dehydrated product among the varieties tested in Tennessee.

Carotene in dehydrated sweetpotatoes was rapidly lost when the ground product was stored, at the South Carolina station, in cloth sacks or in loosely stoppered bottles. The carotene was stable, however, in sealed metal cans under vacuum or in an atmosphere of carbon dioxide or nitrogen. At this station carotene was found more stable in the raw sweetpotatoes than in the dehydrated sweetpotato flour.

Other root crops.—Introduced from Brazil and under test by the Puerto Rico University station, Brazil No. 1 cassava was described as a productive variety desirable for flour and starch manufacture, and for table use.

Taro was made into a flour at the Hawaii station, and successfully substituted for from 15 to 20 percent of wheat flour in a wide variety of baked products. It can be used also in various breakfast foods and in wheat-allergy diets.

Tobacco.—Current research on tobacco at the stations, usually in cooperation with the Department (BPI) and aimed at the attainment of goals as well as maintenance of normal production, has dealt with varietal improvement, cultural methods and field practices, fertilizers and rotations, harvesting and curing methods, pest control, and use of the various grades and byproducts.

Working with cigar-leaf tobacco, the Connecticut (State) Station found nitrogen as urea to be 14 percent more efficient than nitrogen as cottonseed meal in increasing yields, and for the same quantity of fertilizer nitrogen the grade index of the crop was uniformly higher. Calcium metaphosphate surpassed other phosphorus carriers when yield and grade of leaf were considered. Magnesian limestone or hydrated lime could be used with the same advantage as a magnesium source. Relatively weak starter solutions were found beneficial, although sodium nitrate alone probably would benefit growth and quality more than nutrient mixtures. On a sandy soil irrigation alone may be more harmful than beneficial, for it resulted in a reduction of 26 percent in crop value. Adding sodium nitrate to the irrigation water materially increased the yield and grade index, with a gain of 15 percent in crop value. When yield and quality only of cigar tobacco were considered, the Wisconsin station, cooperating with the Department (BPI), obtained best results with manure alone or in combination with commercial fertilizer. In fertilizer value, 1,000 pounds of a 2–8–12 (S) mixture about equaled a 20-ton manure application, although it did not maintain the general soil fertility at the level attained by manure.

A slow rate of absorption of plant food and development of flue-cured tobacco during the early growth stages (0–35 days) after transplanting, in contrast to the very rapid rates during later periods (36–63 days), was shown by the Virginia station. Nitrogen absorption was relatively low during the last interval of growth (50–63 days), while the absorption of the other nutrients was high. This emphasized the importance of having available during the latter part of the growing season plenty of nutrients except nitrogen, which should be low during the last 2 weeks.

For Burley tobacco, the Tennessee station and the Department (BPI) cooperating found that a 4-year rotation was superior to shorter ones. The best quality and yield of leaf were obtained after weeds, but they were not much better than those after forage legumes. When tobacco is grown in a 4-year rotation, the fertilizer supplemented with 10 tons of manure per acre, and the plants properly topped, average tobacco yields may be increased by at least 50 percent and quality of leaf improved in proportion. In this way labor and land may be released for other crops.

Inadequate potash or phosphorus in the soil, the Kentucky station found, can create added susceptibility to virulent attacks from bacterial leaf spot infections, which at times almost completely ruin the crop in some areas. Adequate and balanced fertilization is naturally indicated as essential to good health as well as to good yield and quality.

On heavily infected soil the Virginia station found that the black root rot fungus failed to develop on tobacco seedlings grown after 0.5 pound or more of urea per square yard had been applied and in which the reaction rose from pH 6.9 to more than 8.6 for some time from ammonia accumulation due to urea break-down. Weed growth was also suppressed by urea or calcium cyanamide applied in the fall to plant beds which were then covered with straw and not seeded until February.

The Florida station has found the use of bare fallow from July to October effective in reducing the soil-infesting root knot eelworm in the soil. Good tobacco crops may be grown successfully by this method on contaminated land, possibly until the station's breeding program has perfected a suitable resistant variety.

Of special importance during the emergency is the finding by the Department (BPI) cooperating with 11 State stations that under favorable conditions *Nicotiana rustica* consistently produced more nicotine than ordinary tobacco. On fertile soils under irrigation 150 pounds or more of nicotine per acre was obtained consistently, about twice as much as from ordinary tobacco. Brasilia appeared to be the most satisfactory variety currently available. For high yields of nicotine, stunting of *N. rustica* plants at any growth stage must be avoided, topping and suckering done at regular intervals, and the crop as a rule harvested late. The leaf was found to contain the bulk of the nicotine, but *N. rustica* stalks contained enough to justify their use also. Temporary drought during growth was an important weather hazard in most humid regions. New disease and insect handicaps in growing this crop were found in certain areas outside the present tobacco-producing regions.

Varnish, soap, insecticide, fiberboard, paper bags, and other commercial products can be developed from low and unmarketable grades of tobacco, the Kentucky station reports from its research. Estimates are that Kentucky and other tobacco States produce more than 10,000,000 pounds of low-grade tobacco each year, mostly of the dark kind. Varnishes produced from tobacco byproducts in the station laboratory gave a lustrous waterproof finish when applied to wood. The tobacco fiberboard is very hard and durable, and might prove usable in the construction of some parts of the body and wings of airplanes and automobiles. From other byproducts of the low-grade tobacco could be developed waxes, wrapping paper, cardboard, fertilizers, livestock feed, and a drying oil substitute for linseed oil.

FORAGE CROPS

Forage crops are important aids in the farmer's efforts to produce more milk, meat, and poultry products at lower costs during the war emergency. Among other advantages they save labor and relieve transportation for other uses.

Alfalfa.—A new departure in alfalfa breeding, in which hybrid alfalfas bred like hybrid corn in four-way crosses for superior qualities and the same kind of high production are prospective, is an early result of the recently intensified program of research into fundamentals of forage-crop breeding. The Nebraska station and the Department (BPI) in cooperation have reported in detail on the progress of this breeding program. Concluding that the principles of breeding alfalfa, with some modifications, are essentially the same as those established for corn, these cooperators have outlined a program to develop either a superior synthetic or a hybrid which includes the following steps: Careful choice of the original varieties; epidemic, breeding, and polycross nurseries; and production of hybrid alfalfa. The new wilt-resistant strain A–136, developed under the same cooperation, was under continued tests on many experimental fields, and seed was being grown in quantity for distribution. Another answer to the problem of constantly decreasing yields and short life of alfalfa stands have been given by the Kansas station in the new wilt-resistant productive variety Kansas A–147, now being increased for farm planting. Very promising new wilt-resistant winter-hardy strains of alfalfa for the dairy regions were being given final field tests by the Wisconsin station before release to farmers. Other stations were also making intensive studies on many other new strains of alfalfa.

The New Hampshire station found in experiments on several representative soils that alfalfa has made good responses to annual fertilizer applications, and when judiciously fertilized with liberal quantities of superphosphate, potash, and lime could be expected to give excellent returns even under dairy systems apparently having ample supplies of manure. Unless plenty of manure is used, some other nitrogen carrier is necessary for good alfalfa yields.

The productive life of alfalfa, the New York (Cornell) station found, may be shortened seriously by inadequate potash fertilization. Boron deficiencies also prevailed in certain sections. Methods perfected permit diagnosis by examination of the foliage of severe cases of boron and potash deficiencies. Boron deficiency in alfalfa soils, the Virginia station determined, might be corrected by applying from 10 to 20 pounds of commercial borax to the acre at planting or as top dressings before spring growth starts. Such applications of borax on boron-deficient soil increase alfalfa-hay yields greatly, stimulate seed production, and increase the thickness and duration of stands. The borax may be applied after any hay cutting if boron-deficiency symptoms, i. e., yellow and reddish-purple colored leaves accompanied by stunted plant growth and abortive bloom buds, have been noted.

The practice of mixing grasses with alfalfa on irrigated soil, the Colorado station determined, was not advantageous so far as hay yield, the protein, calcium, and phosphorus contents of the alfalfa, or resistance to bacterial wilt were concerned.

High food reserves in alfalfa roots as plants go into the winter and consequent increased cold resistance in the crown buds resulting from proper cutting practices, the Kansas station found, will result in more vigorous growth and an increased yield of the first cutting the next spring. Without some top growth on the plants in the fall dormant period there will be only a small number of crown buds.

That high food reserves will also increase seed production in alfalfa was shown by the Kansas station. In efforts to increase alfalfa-seed production, which has declined materially during the past 15 years, the Wyoming station was determining the relative efficiency of Caucasian and Italian bees as pollinators.

White clover.—White clover was found by the Ohio station to be very valuable in permanent sods since it improved their quality, growth, and color and helped to control weeds. Lime, where not abundant in the surface soil, has been essential to satisfactory development and the need for phosphorus has been a close second as a requirement. Control of grass growth in pastures and lawns is needed to maintain a satisfactory white clover content, which fluctuates in response to weather also. The New Jersey station in cooperation with the U. S. D. A. Regional Pasture Research Laboratory reported definite progress toward the goal of a white clover that will continue to produce during hot dry summer months. Several superior strains that have been isolated should improve milk quality and lower production costs.

In the Northeastern States, Ladino, a giant form of common white clover, is becoming rapidly the foundation of an intensive grassland agriculture. From their experiments and experience with the crop, the Connecticut (Storrs) and Maine stations and the Department (BPI) have reported on its cultural needs and uses and have encouraged wide use of the crop in the region.

Red clover.—In numerous tests throughout the portions of the red clover belt to which they are adapted, the new Midland and Cumberland red clovers, developed as a result of a breeding program of State stations cooperating with the Department (BPI) and crop-improvement associations, have produced from 1/4 ton to over 1 ton more hay per acre than varieties commonly used. Midland is a composite of four superior old red clover strains from Illinois, Indiana, Iowa, and Ohio, is winter hardy, is somewhat resistant to northern anthracnose, and has good growth characteristics. It is adapted to the middle section of the red clover belt, but should not be used where southern anthracnose is a factor in survival. Cumberland, composed of three superior old strains from Kentucky, Tennessee, and Virginia, has resistance to southern anthracnose and crown rot, has good growth charactertistics, and is adapted to the winter and summer conditions of the southern part of the red clover belt. Because of their good qualities, the use of Midland and Cumberland should conserve seed and labor and greatly lessen the risk of crop failure.

Crimson clover.—Crimson clover, the Georgia and other stations find, can be used in pastures to provide early and highly nutritious grazing. In permanent pastures it is sown in Bermuda sod, and in temporary pastures in mixtures with winter grains or ryegrass. In addition to its value for early grazing and as a nitrogen source to following crops, a cash seed crop can be obtained if grazing the clover is discontinued early. Also, since the seed can be grown on the farm, crimson clover can be sown without cash costs. Studies in progress at the Alabama station indicate that lime and boron amendments may make practicable the growing of crimson clover as a source of winter legume seed.

Winter legumes.—In the face of serious nitrogen shortages for agricultural purposes, winter legumes will be called upon to supply much of the nitrogen needed for economical yields of nonlegume crops. Of three varieties of vetch developed at the Alabama station, Lafayette Monantha has been released to farmers, while Monala and Auburn Woolypod are being multiplied for distribution. These vetches will produce seed on a commercial scale in Alabama and also produce good vegetative growth for turning under. The station finds them hardy enough for use in all sections of the State and highly satisfactory crops when grown for green manure. For lands poorly drained or low in fertility, however, only hairy vetch or woolypod vetch are recommended.

A similar solution of the nitrogen problem in Florida was resulting from the introduction by the Florida station of the blue lupine as a winter cover crop. From the many tons of seed released, the farmer can produce his own seed and in large measure provide nitrogen for use by other agricultural crops.

Wartime demands for seed of forage and cover crops, particularly of Austrian Winter field peas, hairy vetch, and Willamette vetch, will largely be supplied, following the development by the Oregon station of a simple and cheap dusting machine for use in controlling weevils and aphids, major pests of these seed crops. The dust is delivered through a tapered boom and the machine, mounted on bicycle wheels, is light and may be towed behind an automobile or other light vehicle. This duster, while somewhat less efficient than a machine developed earlier, can be built on the farm, is less expensive, and should come into more general use by growers. Approximately 300,000 acres of these forage-crop seeds were being grown in the Willamette Valley of Oregon in 1942 and had an estimated annual value of $11,820,000.

Hay.—The increased demands for greater livestock production have made it imperative that producers harvest all available hay crops. That station research has been aimed at high-quality hay production is evident in recent findings with practical applications. For example, effective cultural and fertility practices before cutting hay and curing and handling and storage practices after cutting have been outlined by the New Jersey station, following its research with high-quality hay as the objective.

Farmers producing alfalfa, timothy, and mixed-grass hay under New York conditions, the New York (Cornell) station reports, would not be justified in delaying the use of labor and machinery until the dew has dried from the standing crop. The hay when cut at 8 a. m., while wet with dew, usually has been drier at 5 p. m. than when mowed later, after the dew had dried.

Useful advances were also made in hay-making machinery. A hitch developed by the Missouri station permits adaptation of a horse-drawn mower to tractor power by use of the regular doubletree and allows much heavier cutting without added weight to the mower to provide traction.

At the Mississippi station, crushing large-stemmed hay plants, such as Johnson grass and soybeans, shortened the curing time. The crushed hay could be stored with a carotene content higher than that of mowed hay not crushed.

A quick, simple method evolved by the Ohio station for determining the moisture content of forages and grains—a factor of vital importance in establishing safe storage conditions—included the use of a balance constructed to be read directly in moisture percentage.

Grasses.—Sown by the Illinois station as about 40 percent of a pasture mixture in 1933, smooth bromegrass persisted to 1940 and was expected to continue as a dominant species (50 percent of the vegetation) in the turf. Yields and consumption were uniformly high as compared with other grasses, as were also pasture days and animal gains in all seasons. About 90 percent of the total growth has occurred before August 1, and indications are that this grass is drought-resistant and also drought-escaping.

From intensive grazing experiments with many combinations of grasses and legumes, the Michigan station has determined that a bromegrass-alfalfa mixture is a highly satisfactory pasture crop under conditions prevailing in much of Michigan. Practically unknown in the State in 1936, today this mixture is produced on over 500,000 acres, yielding an estimated average return of $20 per acre as pasture. Indirectly the growth of this crop has resulted in a thriving bromegrass-seed industry. Mixtures including either smooth bromegrass or timothy with legumes, especially alfalfa, produced more forage in the Upper Peninsula of Michigan than the pure cultures, and all mixtures with alfalfa produced more hay per acre than alfalfa grown alone.

That Italian ryegrass pastures may be valuable for winter-spring grazing was shown by experiments at the Georgia station. Italian ryegrass is especially adapted as a pasture grass for dairy cattle because of its high productiveness and carrying capacity and its ability to withstand close grazing. A ryegrass pasture of 1.4 acres, manured at the rate of about 10 tons per acre and sown on plowed land, intermittently took care of from 4 to 12 milking dairy cows between March 14 and June 12. The grass was grazed down closely several times and the cattle had to be placed on other pastures for a period. While the cattle were on the ryegrass pasture other feed costs were reduced one-third. This amounted to a saving in barn feed costs of 7 cents per cow per day, or a total saving for the season of $18.20 per acre of ryegrass.

Improved strains of Napier grass, developed by the Florida station in cooperation with the Department (BPI), were found to be resistant to the destructive eyespot disease and have been isolated into high-yielding, leafy, heavy-grazing types which are especially suitable for pasturing. New strains of Pearl Millet produce more feed, and by growing later than the commonly grown commercial strains extend the grazing period further into the autumn. Grazing tests during 1941 showed Napier grass, grazed rotationally, to be palatable and nutritious for both dairy and beef cattle. Animals consumed the grass readily during the entire grazing season. A stand of Napier grass may also be used for a fattening paddock for beef animals, as 2 to 3 months' grazing on it greatly augments their market value.

A discovery by the Hawaii station of Napier grass lines resistant to a suddenly appearing epidemic of eyespot disease which had impaired the use of this forage grass has been of much consequence to the imperative production of beef and dairy products in the Hawaiian Islands. This improved strain has been rapidly distributed to ranchers.

Two desirable lines of big bluestem developed by selection and breeding, three of little bluestem, and one of Kentucky bluegrass were being increased by the Kansas station.

An investigation of buffalo grass by the Kansas station, in cooperation with the Department (BPI), has pointed the way to permanent restoration of high-producing grass on millions of acres of wind-eroded lands. A superior strain with high seed yield has been developed, and machines for harvesting, cleaning, treating, and planting the seed have been devised. Seed is being rapidly increased for use by farmers in restoring land to high livestock-producing capacity.

An infrared electric seed drier and conditioner for red fescue and other seed has been devised by the Pennsylvania station with which seed can be dried by infrared radiant energy to a safe storage moisture content of 10 percent or less in from 2 to 5 minutes under static conditions without appreciable injury to the seed or its viability.

PASTURES AND RANGES

Pastures.—The fund of useful information derived from the extensive programs of pasture research of the stations, often in cooperation with the Department (BPI, BAI), is being applied widely in the current emergency in increased production of beef, mutton, pork, poultry, and dairy products, and often with little need for expenditure for additional labor and for concentrated feeds. Practical bulletins on pasture establishment and management were published during the year by the Florida, Georgia Coastal Plain, Mississippi, Vermont, New York (Cornell) (for Long Island), New Jersey, North Dakota, Kansas, Alaska, and other stations.

Complete fertilizer (10–10–10), especially when applied in early spring, resulted in outstanding improvement in dry-matter yields, vegetative composition, and herbage quality in Vermont station experiments. Nitrogen used alone did not prolong or stimulate the grass-hay stands. Vegetative composition was found to be determined by the plant-food level and by grazing management rather than by the nature of the mixtures sown.

While fertilization did not materially change digestibility or the utilization of the organic constituents as a whole, of the bluegrass herbage in Virginia station pasture experiments, it did increase the yield, the percentage of phosphorus in the plants, and the percentage of desirable plants, made a denser turf, and resulted in a greater palatability of the herbage.

Mineral fertilizers (phosphate, potash, and limestone) have been as effective in North Carolina station experiments as heavy applications of nitrogen in increasing the total grass-legume yield. On the basis of their results an investment of $3 per acre per year should result in an increase of $10 to $20 in the value of forage. According to this estimate, the 100,000 acres in cleared pasture land in eastern North Carolina could be made to produce additional forage valued at $1,200,000 after paying for the fertilizers.

The yield and mineral content of pasture plants were increased greatly by lime and fertilizer on soil types studied by the Alabama station. Fertilizer once in 3 years was found to be superior to the same amount in three annual applications.

Phosphorus has been the most profitable fertilizer element in Mississippi station studies except in the lower Coastal Plain areas, where phosphorus, potash, and lime have been needed for pasture production. Pastures in the deep brown loam area have responded more to mowing than to phosphates. Mixtures are recommended for Statewide use which include Dallis and Bermuda grasses, white clover, and common lespedeza, with certain changes for variations in soil fertility, soil moisture, and seed price.

Legumes seeded on established grass mixtures have given the best results in experiments of the Alaska station, while those sown alone, except the yellow-blossom Siberian alfalfa (*Medicago falcata*), have seldom survived longer than two or three winters. Native grasses will not persist when cut or grazed year after year. Mixtures of grasses have produced the heaviest yields.

Dallis grass plus Ladino clover outyielded any other mixture in North Carolina station experiments when limestone and phosphate were applied.

In pasture mixtures the Minnesota station found it more desirable to include Ladak alfalfa than Grimm because the former is less easily injured by close clipping. Increased forage yields accompanied delay in grazing until plants were about 8 inches high and also rotational grazing.

According to results obtained by the Arkansas station, a pasture mixture of either spring oats and Balbo rye or spring and winter oats will provide a maximum amount of grazing for livestock during the fall and winter if planted early. The early growth and upright habit of spring varieties of oats seeded in the fall will ensure the earliest possible grazing, and they will continue to make good pasture until the rye or winter variety of oats has made sufficient growth to be grazed.

The management practices favored in Mississippi station experiments included the establishment of all plant types before use and light grazing in the first season; timely mowing; prevention of overgrazing established pasture by use of supplemental crops; and return of animal manures. Fertilization should be for the benefit of pasture legumes.

The practice of deferred grazing on native pastures, the Kansas station has found, results in increased yields of pasturage and improved stands of grass as compared with season-long grazing. Delay in beginning grazing, however, may cause a serious reduction in the efficiency of utilization of tall grasses. Burning pastures early reduces the total yields to a greater degree than burning late in the spring, showing the need for exercising greater control over pasture burning. Native grasses, the station found, can be best sown in the spring and are aided by a surface mulch of plant litter.

In a comparison of methods of grazing Kentucky bluegrass, the Missouri station found that when cattle are rotated on bluegrass the quality and uniformity of the stand is improved and the animals thrive as well as cattle on bluegrass grazed continuously. On bluegrass supplemented with Korean lespedeza cattle could continue to gain in weight during the dry midsummer period when those on bluegrass tended to gain more slowly or sometimes to lose weight.

The high productivity and convenience of the grain-lespedeza rotation and the grass-lespedeza mixtures were shown by the Missouri station. A major result of these studies over a decade is the development of a highly successful system of pasture farming. In 1941, 92 percent of all Missouri farms grew Korean lespedeza and more than 40 percent grew it in annual rotation with a small grain. Rating lespedeza pasture at $8 to $10 per acre, the entire lespedeza crop appears to be worth between 64 million and 80 million dollars annually, and this is in addition to its value in maintaining the soil nitrogen supply and in control of erosion. Lespedeza in a rotation with small-grain crops furnishes pasturage unprecedented in length of season and carrying capacity, and its enrichment of permanent grass pastures is rapidly revolutionizing Missouri agriculture.

In restoring worn-out eroded, although originally productive, fields, uneven, steep, or eroded acreages were improved by the Kentucky station for profitable production of pasture and field crops by successive grubbing of bushes, filling of gullies, and terracing, followed by basic treatments of ground limestone and superphosphate. Most of the fields were planted to corn, followed by wheat or rye for cover and grain, and then sown to a clover-and-grass mixture. By the time the land had remained in pasture for 3 years or longer the fertility was improved enough to assure reasonably good crops.

The Tennessee station has found in experiments at Greenville that a productive year-round pasture can be had in most years in the region by growing crimson clover and ryegrass for winter grazing and supplementing permanent pastures with temporary summer grasses such as Sudan grass and browntop millet and alfalfa.

Sweetclover has an important place in the seasonal succession of Missouri pasture crops. Second-year sweetclover, the Missouri station finds, equals or surpasses all other crops for spring pasture, and first-year sweetclover, correctly managed, provides good pasture from October to December. The combined use of sweetclover and Korean lespedeza has furnished highly productive legume pasture in spring, summer, and fall.

Ranges.—Range specialists of the stations and the Department were working on an intensive program to help ranchers increase and maintain production. Conservation of range resources, better grazing practices, and the development and establishing of new forages for the vast ranges of the beef-cattle and sheep producers were major activities.

Methods of reseeding range have been developed by the New Mexico station for the various types of range sites located in the southwestern and northwestern semidesert areas, west-central plateau, high mountains, northern foothills, and eastern plains of New Mexico.

Spreading mature hay of native grasses on a shallow-tilled seedbed with a manure spreader and packing it in with a subsurface packer was shown by the Kansas station to be a practical way to revegetate areas in sections where native-grass pastures will provide seed material. Practices found essential included protection of the native pasture from grazing for at least 75 days before normal seed maturity, mowing at the right maturity stage, raking and stacking at once, and spreading the common species after at least one winter in the stack late in April or during May on firm fallow or disked stubble land. Western wheat grass should be spread in the fall or early spring. If rainfall permits, grazing may usually be practiced after the middle of the second season.

The spring-fall range in Utah, situated between winter-grazed deserts and summer-pastured forest lands, was originally largely covered with grass. Because of over-use and misuse, the grass has been replaced extensively by sagebrush, and grazing capacity has been reduced until 10 to 20 acres are required per animal month. Experiments by the Utah station, supplemented by demonstrations of stockmen, showed that plowing up the sagebrush lands and reseeding to crested wheatgrass or rye has corrected this condition and has increased the grazing from ten- to twentyfold. From 1 to 2 million acres in Utah are well adapted to this treatment and, if properly managed afterward, would support all of the range livestock of the State in most seasons for a 6 weeks' period. The adjustment would increase lamb weights and lambing and largely eliminate hazards encountered by breeding stock, and it would also increase the calf crop and put cows on the summer ranges in much better condition.

Finding that short grasses, *Bouteloua gracilis* and *Buchloë dactyloides*, yield more when harvested often at ground or crown level than when protected during the growing season and harvested after growth ceases, the Wyoming station indicated that on a short-grass range a grazing system which would use some forage during June and July and the remainder at the end of the growing season would give a greater amount of more palatable forage than grazing deferred until the growing season ended. Midgrasses yielded more when protected and harvested at the end of the season than when clipped frequently. Annual forbs also yielded less under frequent clipping, whereas perennial forbs. like the short grasses, yielded more under frequent clipping.

A system of range-forage appraisal developed by the Nevada station takes into account the density, or degree of ground coverage, and the quantity of air-dry forage produced by range plants under proper use. Determination of carrying capacity under proper use is facilitated by an animal-unit-month factor table and a grazing-capacity gage by which percentages of an area occupied by different plants may be converted readily into animal-unit-months of feed produced.

Improved or better adapted range plants are important factors in productive range. The Utah station, the Department (BPI, SCS, FS), and other agencies are cooperating in improvement work in efforts to replant vast acreages of public range land to hardy, palatable, drought-resistant perennial grasses. Smooth bromegrass and crested and other wheatgrasses were currently receiving special attention. A project of the California station was concerned primarily with improvement of native range grasses, particularly *Stipa* species.

Bronco grass (*Bromus tectorum*), an annual introduced from Europe, grows throughout the sheep and cattle ranges in varying degrees of density and has become a permanent feed source in northern and central Nevada range areas, where it is especially desirable for spring lambing. This grass in the green and succulent stage, the Nevada station finds, is palatable and nutritious to all classes of livestock. It compares favorably in nutrient values with the perennial range grasses—bluebunch wheatgrass, bluebunch fescue, and Sandberg bluegrass—at comparable stages of growth and maturity, although not quite as palatable, and it withstands untimely and heavy grazing better.

VEGETABLE CROPS

Vegetables in the fresh, canned, frozen pack, juice, and dried state constitute an important part of the Nation's food supply in ordinary times and become vastly more important in time of war, when large supplies are needed for our armed forces and allies. Fortunately, because most of the vegetables are annuals, production can be quickly increased. The Victory Garden drive initiated upon our entry into the war focused attention on the vital part that vegetables may play in increasing the Nation's food resources. In the months that followed, the State experiment stations issued practical bulletins for conditions and problems within the States on the growing and utilization of vegetables under home-garden conditions. The object was to make available promptly in concentrated and practical form the information most needed by home gardeners and new producers: Crops and what varieties to plant, where to obtain good-quality seed, how to select suitable sites for gardens, how to prepare and fertilize the soil, how to protect crops from insect and disease pests, when to harvest, and how to take care of the surplus materials. These more or less general bulletins were supplemented by individual statements for major crops, particularly those crops which had special significance in the nutrition of the armed forces and civilian population and for which increased volume was needed to meet the production goals.

The tomato, because of its wide adaptability, relatively easy culture, and high nutritive properties, received particular attention. The New Jersey station issued a circular prepared in the form of questions and answers on cultural requirements, handling the crop, and desirable varieties. The Oklahoma station also issued pamphlets giving general directions for the culture of the tomato and recommending early planting to bring the plants into bloom before the heat of midsummer would cause the blossoms to drop.

A new tomato, Pennheart, developed by the Pennsylvania station was recommended for its early maturity, uniformity, and the attractive red color of the fruit. The Bounty tomato, bred by the North Dakota station, proved valuable because of its good qualities and capacity to produce a crop in the short growing season of the North. Other new tomatoes, such as the Rutgers, developed by the New Jersey station, continued to occupy important positions in the tomato industry, not only of their home but adjacent States. The Missouri station continued its tomato-breeding program to develop varieties of tomatoes highly resistant to fusarium wilt. Resistance was obtained in crosses between the usual varieties of tomato and a small-fruited wild species. The investigation has proceeded to the point where new horticultural varieties will soon be available. The Texas station found that the root knot nematode rendered tomato plants more susceptible to fusarium wilt, and made the helpful suggestion that some root knot resistant crop be grown before tomatoes to reduce the number of nematodes in the soil. Bay State, a new variety of tomato selected by the Massachusetts station from the progeny of a cross between commercial kinds and the currant tomato, proved resistant to leaf mold, an organism which in greenhouse culture often ruins the tomato crop. The California station found material differences in the chemical composition of different types of tomatoes. The pear-type tomatoes contained 50 to 100 percent more insoluble solids and had a pectin content about 75 percent higher than the usual round varieties.

As a help in providing the large amounts of seed needed to plant the greatly increased acreage of tomatoes, the Indiana station devised a process of drying tomato seed, then stirring it in a disinfecting bath of some such material as mercuric chloride or copper sulfate, and at the same time skimming off the cracked and worthless seed, which tended to float at the surface. This simple technique proved to be an economical and effective way to clean and treat seed in one operation.

At the Connecticut (State) station tomato defoliation was definitely related to fruit load, the larger the crop the more severe the loss of leaves. It appeared that as the fruits are set the leaves are sapped of substances that lend resistance, suggesting that the recent fertilizer trend toward high phosphorus and low nitrogen to procure high fruit loads may be defeating its own end.

Progress was recorded in the testing of newer types of spray materials for controlling leaf spot diseases of the tomato. Yellow Cupric Spray and Tennessee Copper "34," materials used in experiments at the Tennessee station, were more effective than bordeaux mixture and caused less spray injury. Similar good results were reported by the Virginia station, where sprays and dusts of tribasic copper sulfate and copper oxide were found superior to bordeaux mixture.

In a study of the effectiveness of soil fumigants for root knot nematodes, the New York (Cornell) station obtained excellent control in a greenhouse sandy soil on a spring tomato crop by treating the soil the preceding fall with chloropicrin alone or in mixture with ethylene dichloride.

As one of the four vegetables which have contributed more than 80 percent of the seasonal vegetable pack in recent years (snapbeans, corn, peas, and tomatoes), the snapbean has received considerable attention from station workers. Particularly in the Southern States there has been a need for beans that are capable of setting pods during hot, dry weather, and that possess resistance to diseases such as bacterial blight, common bean mosaic, and powdery mildew. Considerable progress has been made in these directions by the Regional Vegetable Breeding Laboratory at Charleston, S. C., working in cooperation with 13 Southern State stations. Two wax beans, Ashley Wax and Cooper Wax, and the green bean Logan were released by the laboratory to seed companies for seed increase.

Two new varieties, Florida Bell and Florida White Wax, developed by the Florida station, have shown such resistance to bean rust, as well as other desirable qualities, that they have been released to seed producers for multiplication as an aid to wartime production. In Puerto Rico, where there is an acute shortage of proteins for the dense population, beans are unusually important because of their high protein and vitamin contents.. The University station at Rio Piedras helped greatly by distributing seed of an improved native red and an improved native white bean which are suited to Puerto Rico conditions. In 1942 the same station grew over 25 acres of these beans for seed to aid food production. The Federal station in Puerto Rico released for production the edible variety of soybean Semmole. This variety, selected and tested for Puerto Rico conditions, yields well. Two crops a year are possible, and the beans are being accepted locally as a valuable food new to the island. The station has maintained 4 acres for production of seed of this food crop to aid in expansion of production.

Valuable as a human food, and comparatively easy of culture, the carrot is one of the vegetables for which large increases in acreage are needed in 1943. The growing of sufficient seed to meet the increased requirements has been one of the current problems in carrot production. Because the irrigated areas of the West have proved ideal locations for producing seed of many kinds, it is logical to find the State stations in that area engaged in seed-production studies with several vegetables, including the carrot. The Idaho station found that fall-planted carrots could often be held over in the field to better advantage than if dug, producing in the ensuing year more seed than did roots stored during winter. Where mother carrots were overwintered in storage, losses were greatly reduced by holding the roots at temperatures of 36° F. or less. Other Western States, including California, Colorado, New Mexico, and Utah, initiated or expanded existing studies in vegetable-seed production.

Investigations at the Indiana station showed that carrots that are uniform in outward appearance may differ considerably in quality. An examination of several different lots of Chantenay carrots revealed well-marked differences with respect to soluble-solids content in the expressed juice. Some evidence was obtained that the higher-quality roots decay more readily under unfavorable storage conditions, with the result that a given seed stock may deteriorate in quality unless carefully handled. The dehydration of carrots became much more important with wartime needs, and work along this line was initiated during the year by the Tennessee and Texas stations.

The New Jersey station has made available timely information on the biology, habits, and control of the carrot weevil, a serious pest of celery, carrots, and parsley. Effective control was accomplished with a poison bait consisting of 95 pounds of dried apple pomace and 5 pounds of calcium arsenate broadcast at the rate of from 40 to 50 pounds per acre every 15 to 20 days.

Many valuable characteristics, including wide cultural adaptability, high productivity, important nutritive properties, excellent storage quality, and diverse uses combine to make the onion one of the most important vegetables. It is logical, therefore, that many of the State stations in widely separated areas are working with the onion in the development of improved varieties and in better methods of culture and handling. The Idaho station found that in certain areas of the State bulbs of the more hardy varieties, such as Ebenezer, White Portugal, and Yellow Globe, when reset in the field in the fall, will as a rule produce more seed the next season than will bulbs overwintered in storage. With spring planting, the earliest settings of bulbs produced the most seed. At the New Mexico station it was found, as a result of three seasons' irrigation work, that adequate moisture is essential to the production of satisfactory yields of good-quality onions. There was some evidence that fewer irrigations in the early season might be feasible as a means of saving water. This station continued its work on the improvement of the White Grano onion, a variety developed by the station, for adaptation to the State. The New York (Cornell) station worked on a method of spraying onion fields in late May with dilute sulfuric acid to kill weeds with a minimum of damage to the onions. Although a certain amount of hand weeding was necessary to supplement the spray, there appeared to be definite economic possibilities in the acid-treatment method.

Working on the storage requirements of the Ebenezer onion, the Massachusetts station found that low temperature and high relative humidity favored the keeping of the bulbs. Sprouting was minimized by holding the temperature close to 32° F. A study by the New York (Cornell) station of factors affecting the pungency of onions showed that certain varieties contained nearly three times as much volatile sulfur as others. Next to variety, the type of soil on which the onions were grown was the most potent factor affecting pungency. Within a given variety, onions grown on peat soil were twice as pungent as those produced on sandy soil.

The pepper has been shown to be a valuable source of essential vitamins and other food properties. In certain areas, such as New Mexico, the pepper is a standard article of the diet and the New Mexico station has made much progress in the selection of uniform and desirable varieties. The Georgia station published a bulletin on methods of pimiento pepper growing as an aid in the emergency food situation. A more technical paper by the same station showed that the pepper plant uses the greatest amount of nutrients during the third growing month. As a result, the station recommended a change in fertilizer practice to provide a portion of the nitrogen and potash as a side dressing during the period of greatest nutrient uptake.

In vegetable-producing areas many of the stations have furnished information on soil conditions and management practices found to be most satisfactory for maximum production. Because of changing fertilizer supplies and amounts of available labor and equipment, it is necessary that the grower be given whatever facts are available and applicable to his conditions as soon as possible. Special attention was given at many of the stations to the presentation, in popular form, of known facts on soil-management practices intended principally to assist in the Victory Garden program.

Sweet corn, both in the fresh and canned form, constitutes one of our most valuable vegetable products. Much progress has been made by the State stations working alone or in cooperation with the Department in the improvement of sweet corn. Hybrid sweet corns, because of their greater yielding capacity, uniformity in time of maturity, and in shape and size of ears, have received much attention, with several of the stations, including Connecticut (State), Indiana, Iowa, Illinois, Minnesota, New York State, South Dakota, and Tennessee, engaged actively in the development of hybrids suited to their respective areas. However, Golden Cross Bantam, developed by the Indiana station and the Department several years ago, was found difficult to surpass because of the productiveness, high quality, resistance to bacterial wilt, or Stewart's disease, and wide adaptation. The development of sweet corn varieties adapted to southern conditions is difficult because of abundance of insect and other pests. The Federal station in Puerto Rico has succeeded in developing a variety, U. S. D. A. 34, that thrives well under island conditions and also in some sections of the South. Four acres have been devoted to production of seed to aid in extending the production of this valuable contribution to the food supply.

In addition to work on the ways and means of producing larger and better quality vegetable crops, important help was provided by the various stations on disease and insect control. Much general information, based on earlier findings, was disseminated for immediate service to growers. As an example, the Florida station supplied information on the seed treatment of various vegetables, taking into due consideration the locality and the season of planting. *Phomopsis* infection of eggplant, a serious problem in some areas, was found by the Florida station to be controllable in part by the use of disease-free seed and the use of soil not before used for eggplant production. Some progress was made in the development of strains of eggplant resistant to the disease. The Rhode Island station reported that eggplant varieties differed in their resistance to the disease.

Substantial progress was reported by the California station in the development of an effective laboratory method of testing bean varieties for resistance to powdery mildew. The study revealed seven varieties that were resistant at all stages of growth. In view of the increased quotas asked for the production of beans, these findings were very timely. A substitute material for formaldehyde used in the treatment of onion soils infested with smut was developed in the form of an organic sulfur dust by the New York (Cornell) station. The Mississippi station reported that the fumigation of cabbage seedbeds with benzol was effective in checking the development of downy mildew in seedlings. After the seedlings emerged, treatment of the soil surface with Cuprocide and zinc oxide helped to control damping-off fungi.

Certain newly developed organic materials, such as Spergon, were found valuable by the New York State station for the treatment of vegetable seeds, such as peas, sweet corn, and lima beans. The use of these materials gave substantial increases in the yield of shelled peas and, at the same time, replaced compounds containing metallic elements needed in the war effort. Likewise the Florida station found that certain new organic sprays are effective substitutes for metallic fungicides used for vegetable-seed treatment or plant protection. Spergon, for instance, proved more effective than copper or mercury compounds for damping-off of lima beans and peanuts. Thiosan was equal to Spergon with these crops. Spergon also gave good results as a spray with celery though not with tomatoes. Fermate was found to be an acceptable substitute for spraying tomatoes and celery.

Florida station research has also shown that cabbage seedlings can be grown successfully in that State by the use of paradichlorobenzene, already widely employed against tobacco downy mildew.

FRUIT CROPS

Fruits are an important commodity in wartime, with vast quantities needed in the fresh, preserved, and dried state for feeding the general public and the armed forces at home and abroad. Because of the relatively long time required to bring tree fruits into production, increases in output cannot be obtained as quickly as is the case with most vegetables and cereals. However, many things may be done to improve existing crops and to assist in their conservation. In recognition of the value of fruits in the national diet, general information relating to the growing of fruit was published by the Iowa, Utah, and other stations.

The serious shortage of nitrogen fertilizers resulting from the use of nitrogen compounds in the manufacture of explosives and other essential war materials has limited the supplies available for fruit production. As a contribution to the emergency situation, the Missouri station discussed the use of substitutes for nitrogen fertilizers in orcharding and pointed out possibilities of greater use of leguminous cover crops, farm manures, and activated sewage sludge to meet this nitrogen shortage. The station warned that certain organic materials, such as straw and cotton hulls, may have a temporary harmful effect due to the fact that the organisms which decompose such materials may actually take up most of the available nitrogen.

In the irrigated fruit-growing districts of the West economy in the use of water is a vital matter, especially in certain years of limited water supplies. Studies by the California station showed that pears will grow normally under a rather wide range of moisture conditions and that harmful results, such as decreased fruit size and delayed maturity, occur only when soil moisture is reduced to the permanent wilting point during the growing season. The use of this information would mean a considerable saving in irrigation water and labor required in irrigating.

One of the outstanding developments of recent years in the fruit industry has been the use of certain growth-promoting chemicals, such as naphthalene acetic acid, as sprays for reducing the preharvest dropping of apples and other fruits. Retention of a greater percentage of the fruits on the trees means more hand-picked fruits, better coloring of the fruit, and a better distribution of the labor required in harvesting. The net result has been an increased income for the grower and better apples for the consumer. Certain facts have been established experimentally, among them that varieties differ greatly in their response to preharvest sprays, that temperature prevailing during the ripening period is an important factor in the success of the sprays, that timing of the spraying is highly important, and that thorough spraying in which each apple is contacted is essential. Apparently the chemicals retard the normal softening or weakening of the tissues between the stem and the spur at maturity. The widespread interest in preharvest spraying was manifested in a number of papers from the Indiana, Iowa, Massachusetts, New Mexico, New York (Cornell), Ohio, Rhode Island, and other stations. The Delaware station reported that naphthalene acetic acid could be used safely with certain other spray materials, such as derris and nicotine sulfate preparations. On the other hand, sprays containing lime reduced the effectiveness of the fruit-drop chemicals. Weathered spray deposits of lead arsenate, copper sulfate, and lime had no harmful effect on the preharvest spray materials.

The preservation of fruits and vegetables during the period between harvest and the time that such products reach the consumer is important in food conservation and a necessary adjunct to production. Very good results were obtained at the Florida station with several types of pliofilm wrappers for protecting fruits in storage. The pliofilm cover proved effective in reducing weight losses without limiting the escape of undesirable respiratory gases, and in the case of citrus fruits the wrappers aided in preserving the original color of the fruit as well as internal qualities. The Iowa station reported good results from lining boxes containing Jonathan apples with pliofilm. Following storage, the fruits were firmer, brighter in color, and much less affected with Jonathan spot than were the untreated lots. The pliofilm tended to increase the concentration of carbon dioxide within the package. In other experiments with Jonathan apples stored in sealed chambers in which the carbon dioxide content was maintained at different levels, the Iowa station found that at 35° to 36° F. a carbon dioxide concentration of about 7 percent gave good results as measured by color, flavor, freedom from Jonathan spot, and firmness. However, as the temperature was decreased to 32°, the development of brown heart and soggy break-down was increased by the higher carbon dioxide concentrations, suggesting that care is necessary in the use of this gas. Other stations, including New York (Cornell) and California, contributed to the knowledge of the use of modified atmospheres in the storage of fruits. Shriveling of apples, a serious handicap to the successful storage of certain varieties, such as Golden Delicious, was successfully overcome by the Maryland station by coating the fruits with a wax emulsion prior to storage.

The California station has studied artificial dehydration of fruits, which it found produced a dried product of better quality than is obtained by sun-drying. The yield is greater because of smaller losses from fermentation and respiration, dehydration insures against rain-damage losses, it reduces the drying time from several days to about one day, it is much more sanitary than sun-drying and protects against insect infestation, and the total costs need not be greater than those of a drying yard of equal capacity. On the other hand dehydration requires more skill than does sun-drying, and it is not possible to dehydrate such fruits as freestone peaches, apricots, nectarines, and pears to products similar in appearance to the sun-dried product unless they are first exposed to the sun for a day in order to fix the color of the fruit. Although flavor is not affected, the color limitation has definitely hindered the use of dehydration for cut fruits. The same station has also evolved an improved process for dyeing maraschino cherries, and has developed an improvement upon the current procedure in preparing and preserving the "juice" (actually a water extract) of dried prunes. Also at the same station pectin-precipitating enzyme preparations similar to those developed at the New York State station have been applied in the clarification of grape juices intended for wine making. Good clearing of all juices examined was obtained by heating to 175° F., cooling, adding sulfur dioxide, and further adding either of two widely used commercial preparations of the pectin-precipitating enzymes.

Good cider and vinegar have been shown by the Massachusetts station to be obtainable from McIntosh apples affected with medium to heavy corkiness. The corky fruit yielded about 53 percent of juice as against about 59 percent from noncorky fruit, and the sediment content of the juice from the corky fruit was relatively large. There was no off-flavor in the juice though it was so sweet as to require addition of acid or of a more acid juice. Thus, though not giving as high a yield per ton as noncorky fruit (by reason of the higher sediment and lower yield and acidity of the cider), corky apples of the McIntosh variety can be used successfully by the cider and vinegar industries.

The New York State station has produced and successfully marketed a blend of apple and raspberry juices. This product consisted of 75.8 percent of apple juice (Baldwin and Cortland 2 : 1), 20.3 percent of black and purple or red raspberry juice, and 3.9 percent of added sugar. A variation of 1 percent one way or another in proportion of raspberry juice, or the use of inferior fruit, affected the quality of the blend. From the favorable reception given the juice, which was far beyond expectation, it seems that the product has commercial possibilities.

Much of the research carried on by the stations in the control of fruit diseases and insects has increased importance in times of emergency. As a special study the Connecticut (State) station tested over 300 organic compounds for their possible fungicidal value. Evidence was obtained that it is possible to dilute certain of the usual sprays and still obtain a large degree of disease control. In many instances the combination of two materials, such as copper and zinc, increased the effectiveness of a spray and at the same time resulted in important savings in critical materials. As an aid in controlling scab, the most widespread disease of apple, the Wisconsin station reported progress in its study of the use of eradicant ground sprays applied in early spring before the leaves appear. Such sprays reduced greatly the first wave of infection and resulted in better control than was obtained with later sprays of less caustic materials applied to the tree itself. Rather encouraging results were obtained in the control of bacterial blight in apples by using a new organic material, known as Fermate, in place of bordeaux mixture, which often causes considerable russeting of the fruits. The use of the new material would result in saving copper, an ingredient of bordeaux mixture and a critical war material. The Maine station reported that certain mild sulfur sprays gave better control of apple scab than did lime-sulfur.

Among small fruits the strawberry is one of the most important, large quantities being used at home and shipped abroad to our allies and to our own troops. A relatively new trouble, known as the red stele disease and sufficiently devastating to eliminate strawberry growing in certain areas, was studied by several of the stations, including the Illinois, Maryland, and New Jersey stations. Fortunately, certain new hybrids developed by the Maryland station and the Department (BPI) were found practically immune to red stele disease and promised to restore strawberry production to a sound footing. A virus disease of the peach, known as yellow red virosis, was vigorously attacked by several stations, including Connecticut (State), New York (Cornell), and Utah, with practical evidence that eradication of nearby chokecherries would keep the trouble from peach orchards.

MARKETING STUDIES

Vital to the war purpose as production itself is the flow of produce from the farms and ranches to consumers, both at home and on our far-flung battlefronts. When times are normal and transportation facilities are abundant, the markets are sensitive to the preference of consumers and a maximum of perishables is delivered to consumers fresh. When conditions are abnormal and transportation facilities are restricted, however, it is often necessary to process and store perishable products which otherwise might go directly to consumers.

Thus the interferences of war with the normality of the marketing process create new problems in assembling, processing, packaging, storing, transporting, and retailing. New problems may also arise in the matter of financing production and in the prices paid and received by farmers relative to the goals set up. That the stations have been alert to their responsibilities of keeping abreast of the marketing situation and providing assistance is indicated by the following examples of their activities during the year.

An analysis of existing milk-delivery systems in typical towns and cities by the New York (Cornell) station revealed that in retail delivery, because of route duplication, the total route mileage averaged three to four times as great as the minimum mileages that would have to be covered if only one delivery vehicle were used in an area. A switch from every-day to alternate-day delivery would save approximately 38 percent in both time and truck mileage. Schemes for route simplification have been developed on the basis of these findings. Similarly, the Louisiana station found considerable overlapping in routes covered, resulting in added use of rubber, gasoline, trucks, manpower, and other vital war materials in connection with milk marketing from the farms in the Florida parishes of the State. As a result, four milk routes have been consolidated and further consolidations are anticipated. Tire rationing boards have used some of the data as a basis for tire allocation by parishes and by individuals who apply for new tires or for recapping of old tires.

Principles established by the Connecticut (Storrs) station as governing the efficiency of milk assembly were found to have general application to milk marketing and the assembly of other agricultural products, including eggs. A study completed during the year of the delivery of wholesale milk to markets in Connecticut indicated that in one instance the daily travel of about 18,000 miles could be reduced to about 8,000 miles by reorganizing the milk routes. Costs of milk assembly could be reduced about one-third. Plans for reorganizing the milk assembly of the State were being drafted on the basis of these findings by the Connecticut Dairy Conservation Committee and the Country Milk Assembly Committee of the United States Department of Agriculture.

Vermont station studies of milk assembly routes covering more than half of the State have resulted in definite recommendations to milk-plant operators and truckers as to changes that can and should be made. Reorganization within companies would effect an estimated reduction of 25 percent in mileage traveled and reorganization among companies would bring about an additional 25 percent reduction. One of the chief handicaps to reorganization is the early-morning hour stipulated in regulations of the Boston milk market for delivery of uncooled milk to receiving stations.

In New Hampshire a new State law requires the combining of milk routes to conserve tires and reduce delivery costs. Studies by the New Hampshire station recently completed will serve as a basis for State regulations, and the station has been asked to work out a plan of administration.

With a view to eliminating unnecessary travel and conserving rubber and gasoline, the Kansas station made a survey to determine ways and means of modifying the milk distribution system of the city of

Manhattan and applying the findings elsewhere in the State. The New Jersey station made a study, with similar objectives, of the routes traveled in hauling milk from creameries and dairies in the State, which is expected to have at least indirect application to many other areas and other communities.

Because reported shortages of fluid milk in some areas of Alabama are such that milk is either being rationed or sold out before some customers can make their purchases, the Alabama station is studying present supplies of all classes of milk and the possibilities of increasing supplies of fluid milk. Information will be obtained on present and potential consumption by areas, and the importance of various factors tending to limit supplies will be evaluated. The work is cooperative with the State Milk Control Board, the State Department of Health, and the Extension Service.

The necessity for shipping huge quantities of foodstuffs abroad in highly concentrated form has led to studies of price differentials and processing facilities which help in putting farm products into concentrated forms. The Wisconsin station made a study of paying producers for fat and solids-not-fat in milk with the result that it worked out formulas in which solids-not-fat, as well as fat, are given proper weight in determining price differentials. A short time after the results were made available, 15 or more factories were buying milk on the basis of these new formulas and processing it into cheese, dried milk, and other more concentrated products and byproducts.

Minnesota station studies indicated that of 104 milk-drying plants in the State, 40 were drying milk for human consumption the past year. This compared with 25 plants drying milk for human consumption a year before.

To help conserve the farm products grown in the State, the Louisiana station made a study of the economic phases of the fruit and vegetable processing industry as to present location and capacity of all its branches, including a determination of the raw products used and the finished products marketed during the calendar year 1941 and estimates for 1942. Another purpose was to study the business practices within the industry and the methods used in selling the finished products and their geographical distribution. The results should help farmers and canners in Louisiana to produce and conserve a maximum of food, and from the study may come suggestions concerning the required canning-plant capacity of the geographic areas in which the crops can be produced economically for such plants. Such information will be particularly valuable in making plans for agricultural production in 1943 and subsequent years.

The South Carolina station made a study to determine the available capacity of community canning facilities in the State and how effectively these facilities are being used. This study was in cooperation with the South Carolina Council for National Defense.

From a study of grain storage and transportation the Kansas station predicted a shortage of storage space for wheat and other small grains produced in the State during the 1942 season. The study indicated that less than one-third of the prospective crop could be stored in commercial storage. The station urged farmers to do everything possible to provide storage space on farms and conferred with officials of the Department (AMA) to determine what steps should be taken.

The development of storage bins for processed feeds has been studied by the California station. The station has prepared and distributed to builders plans from which many such structures have been built for farmers.

A contribution of direct application was a report of the California station on egg marketing in the Los Angeles area. Included was a description of the local egg-market organization, price structure, and price-making processes, and criticisms of the Los Angeles process, as well as chapters on egg-quality deterioration, the consumer's viewpoint, and the supply and demand for eggs. The report concluded with suggestions for the improvement of egg marketing in the area.

By organizing temporary means for assembling eggs in parishes that are ordinarily noncommercial egg-producing areas, the Louisiana station obtained a guaranteed selling price 1 week in advance, enabling farmers with only a few dozen eggs to receive a cash price of at least 5 cents per dozen above what local prices otherwise would have been. In 2 parishes, in March 1,000 cases and during April 1,250 cases of eggs were assembled and sold under this plan.

To help with the consumption of potatoes, the Kansas station made a study of market preferences and a quality analysis of potatoes sold in the retail markets and restaurants of six Kansas cities and by dealers on terminal markets.

The Iowa station studied current price relationships within the livestock, feed, and wheat complex, and their effects on agricultural production, as a contribution to a price policy for agriculture. To help solve the transportation problem as it relates to farm produce the station also made systematic studies of tire rationing and truck transportation of farm products and their effects on markets and marketing. Included in these studies were the basic elements of economizing on truck transportation, egg routes, and tire rationing.

The Kansas station also has been making available information on price and production trends of agricultural products for use in making production and marketing programs on Kansas farms. Requests for aid of this kind are growing steadily, it is reported, and the study is said to constitute one of the most valuable of the contributions of the station to the war effort.

A study by the Minnesota station revealed that no appreciable change had taken place in the margin between prices paid the farmer and prices paid by the consumer of farm products. Thus far, increased prices paid by consumers for Minnesota products appear to have been passed back to the farmers in full.

As a help to the wool growers, the Wyoming station has supplied the sheepmen of the State with information on average wool prices on the farms and ranches and in Boston and on the parity prices of wool at various times and under various conditions. This has enabled the grower to deal more intelligently with wool manufacturers and officials in arriving at ceiling prices for wool.

Some of the western stations have been studying the problem of wool marketing in the light of the shortage of wool sacks and of transportation facilities. To help the wool growers market their

1942 and later wool clips, the Colorado station has been experimenting with the baling and pressing of wool from the college flock and sending different types of bales to market with the regular wool sacks. To determine what savings could be made in burlap covers and shipping and storage space, the Montana station, cooperating with the Department (AMA), tested an experimental wool-baling machine. Baling wool from the 1942 clip resulted in a reduction of more than 50 percent in the amount of space required in shipping and storing, and a reduction of approximately 30 percent in the amount of burlap needed to complete covering the wool bales as compared with the use of sacks. With a critical burlap situation, these studies may prove of great value in the movement of wool from ranch to market.

The Kentucky station made a study of the marketing, transportation, and prices of farm products as related to the development of national plans for agricultural production for 1943. The study is designed to help meet the present national emergency by furnishing information that will fit into national plans for developing a program of increased agricultural production. The information will be used also in the development of State and county production goals for 1943, and in the formulation of programs designed to attain these goals.

With the Puerto Rico export market destroyed by war, and transportation facilities on the island drastically curtailed, the Federal station made a study of the marketing of locally grown foodstuffs. This study should be helpful in the reorganization of the marketing of farm produce despite adverse conditions. A closely related study is a survey of the processing and storage facilities of the island.

Grain storage problems.—A circular, all-plywood grain-storage bin which can be erected on the farm by the farmer and a helper or prefabricated by a lumber dealer and hauled to the farm has been developed by the Kansas station. The bin is entirely free from vertical framework, thus making full use of the strength properties of the plywood.

A study by the Iowa station and the Department (BE and PQ) to determine the species of insects most likely to cause damage in shelled-corn bins indicate that the red rust flour beetle and the sawtooth grain beetle are the most dangerous stored-grain pests. Although the flat grain beetle, the foreign grain beetle, the hairy fungus beetle, and several other species are present in large numbers in bins, these have not caused serious damage. Since the two insects which at present appear most dangerous thrive best on cracked grain and on grain of high moisture content, the storage of dry, clean grain will do much to reduce the numbers of these pests. Results of two spring surveys show rather conclusively that under Iowa conditions winter mortality is an important factor in the natural control of stored-grain insects; shelled corn, therefore, should be stored in small fully exposed storage buildings so that the maximum benefits from winter temperature may be obtained.

In this connection, a study of the penetration of toxic gases into corn of various degrees of moisture content varying from 9 to 30 percent, and of various degrees of fineness from whole corn to meal of less than 20-mesh, indicates that moisture content and the presence of masses of broken kernels have an important bearing on the penetration of gases, consequently upon their effectiveness for the control of corn-infesting insects.

Farmers who fumigate shelled corn stored in metal bins can protect their grain from reinfestation by stored-grain insects by spraying the top surface of the grain with a light application of oil, according to research by the Illinois station in cooperation with the Department (BE and PQ). The oil should be used at the rate of 2 gallons per 1,000 bushels of stored corn and should be either technical white or other refined oil having a viscosity of S. A. E. 10 or less. The oil may be applied at the time of fumigation with the last 2 gallons of fumigant so it forms a protective coating over a shallow surface layer of the grain.

One of the most difficult flour-storage problems is that of keeping it free of insects. Unless flour is free from insect life when it is placed in storage, the product will not remain in satisfactory condition for human consumption. Tests have been made at the Iowa station with the Entoleter machine which indicate that flour subjected to this treatment is sterile insofar as insect life is concerned.

That bin-burning of wheat high in moisture content can be retarded by the use of ethylene gas in the storage bins and without detriment to baking quality was found by the Department (BAC and E) and the Kansas station cooperating. The gas, at a concentration of about 1 part in 10,000 of air in the bin, when blown into the bin while damp wheat was being stored caused the wheat temperature to remain below 103° F. for several days, while similar untreated wheat reached 110° and was damaged considerably. The treatment reduces the rate of heating and permits the farmer or grain handler to store high-moisture wheat for about 2 weeks. In wet harvesting seasons, wheat often spoils before it can be run through a drier. With wheat allowed to mature fully before harvest, the gas apparently hastened the aging process through which wheat must go before it will make flour of satisfactory baking quality.

Weathered or wetted wheats which show no other damage than lowered test weights, changed external appearance, and increased mealiness, the Kansas station found, may be penalized unduly by the wheat-grading system. Damage from sprouting appeared to have been greatly reduced or almost eliminated with the combine system of harvesting.

Food preservation.—The shortage of tin has imposed major readjustments in the canning industry, and the shortage of canning supplies and sugar has limited home canning. These limitations, coupled with a probable curtailment of transportation facilities for moving bulky fresh or canned foods, have given impetus to food preservation processes that require the minimum of strategic materials and sharply reduce the bulk of the food product. Preservation by quick freezing and by dehydration or sun-drying are procedures which fit in with these requirements and are methods which have received attention in experiment station research during the past year.

Special problems concerned with freezing and freezing storage of meats are considered elsewhere in this report (p. —). Other studies have involved determination of local varieties of fruits and vegetables adapted for sharp freezing and suitable from the standpoint of yield

(North Dakota); the food value, particularly the vitamin C content, of frozen-pack peas (Washington); the preparation, freezing, storage, and utilization of frozen eggs (Georgia); the freezing of pimientos (Georgia), this being work actually done about 2 years ago and regarded at that time by others as of little importance but now forming the basis for freezing 500,000 pounds of pimientos in 1942, thus saving the usual containers; work on the utilization of bottom fish not commonly used for freezing or canning (Oregon), as a result of which study one of the large Oregon packing firms is using the method developed for freezing a type of sole fish formerly not used for food; and development of a method for estimating the quality grade of frozen peas (New York State) which avoids the personal judgment element by relating the specific gravity of the thawed peas to the fancy, standard, and substandard grades.

ESSENTIAL CRITICAL AND STRATEGIC MATERIALS

CONTENTS

OIL SEEDS, OILS, AND FATS

Fats and oils are important to the war effort, since they are widely used in the production of munitions and industrial products and provide a large part of the food supply. Increase in the production of these commodities in the United States in 1942 was urgently needed to meet wartime requirements. The 1942 production goal for peanuts was increased to 5,000,000 acres, or 255 percent of 1941 production; soybeans, 9,000,000 acres and 154 percent; and flaxseed, 4,500,000 acres and 134 percent of 1941.

Seed flax.—Flax holds a position of importance in the Nation's needs—vast quantities of linseed oil are used in paints and waterproofing finishes in both military and commercial fields. Research by the stations, cooperative with the Department, has aided in increased production of the seed-flax crop.

Practical information on flaxseed production in the North Central States, based extensively on their prolonged investigations and published by the Department (BPI) in cooperation with the North Dakota station, is typical of the help to growers. The flax-breeding and improvement program at that station and studies of the chemistry of flaxseed and linseed oil have been notably expanded. The influences of inheritance, growing conditions, and farm practices on yield and oil content and quality have been receiving much attention in research projects. Numerous strains of seed brought from Argentina are under test, and about 3,000 selections are being grown on flax-sick soils in the field with the aim of further selection for resistance to wilt and rust.

Viking flax released by the North Dakota station and Biwing by the Minnesota station compare favorably with Bison, itself a good flax, in acre yields and oil content and produce an oil of better drying quality.

Redson, of parentage similar to that of Biwing, was released by the Minnesota station to the Wisconsin station for increase and distribution to Wisconsin farmers.

The California station has been studying varieties for adaptation to the San Joaquin Valley, where the flax acreage has expanded to more than 100,000 acres. Punjab is currently the main variety grown there, yet certain other varieties and strains show much greater resistance to anthracnose disease, which has caused much loss in the valley.

Seed flax has been planted by the Louisiana station to determine its adaptation in that State, and seed has been distributed to farmers. The crop has produced well and furnished a normal amount of good oil.

Peanuts.—In the production of peanuts for oil, the stations in the South were helping their farmers to meet the goals with information gained in current research and in new projects.

Practical recommendations were made by the stations on selection of soils and varieties, cultural methods, fertilizer and liming practices for the older and newer peanut areas, and rotations. The North Carolina station reported that greater returns in yield and oil content would follow liming and application of potash, and also determined effective placements of fertilizers for peanuts. The Alabama station began an extensive research program to determine for peanuts fertility needs in the State. Its current studies showed that inoculation is needed for maximum yields on land growing peanuts for the first time.

GFA Spanish, a superior strain of small Spanish peanuts developed by the Georgia station and available in 1942 in quantity sufficient to plant more than 400 acres, is uniform in size, shape of pods, and seed, and has outyielded other Spanish strains. Other good strains have been developed by the Virginia, North Carolina, South Carolina, and Florida stations.

Results of recent experiments by the Virginia, North Carolina, and Georgia stations on the control of peanut leaf spots indicate that dusting sulfur will insure protection against serious losses caused by these diseases and the potato leafhopper and promote maximum yields. In Virginia, 4 years' results showed an increase of 20 to 50 percent in yield of nuts and sometimes twice the hay yield, and 20 demonstrations in 1940 gave an increased crop value of $11.75 per acre. In North Carolina, increased yields were worth $15 per acre, and in Georgia the 4-year average increase from sulfur dusting was 329 pounds of peanuts per acre. In North Carolina alone estimates are that full use of these methods of protection against disease and leafhopper damage would have saved about one-third of the seed planted and increased the 1941 yields by 75,000,000 pounds. With double the acreage in 1942, the actual benefits from even partial use will count high in the war effort.

Georgia station studies of methods of harvesting, curing, and handling peanuts showed that peanuts with the least rot, minimum discoloration, lowest fatty acids, and highest-quality oil were obtained when stacked within 48 hours after digging and allowed to cure slowly and continuously for 2 to 3 weeks. Lying on the ground, exposure to sun, or alternate drying and wetting were all detrimental.

A special study of farm organization to help planters in Sumter County meet production goals for peanuts in 1942 has been completed and published by the Georgia station. Cash expenses and returns were determined for peanuts and major competing crops. Scarcity of labor at digging time, a prime limiting factor in increased peanut production, may be met by the proposal that planting dates be staggered and the acreage divided between early- and late-maturing varieties, thus permitting a larger portion of the harvesting by family labor.

The Georgia and Tennessee stations have worked out more efficient methods for extracting peanut oil. The Georgia station is also studying uses for surplus peanut meal, which will present a problem where large quantities of the nuts are used for oil extraction, and is investigating the possibilities of substituting peanut oil for olive oil and coconut oil.

Recently, sulfonated oils have come into extensive use in the textile industry as wetting agents and as detergents in place of soap. A sulfonated peanut oil has been made on a commercial scale by the process developed by the Georgia station and is being used in a textile mill.

Soybeans.—Research of the stations and the Department as well as by private breeders had provided growers with improved yellow-seeded soybean varieties of high oil content, and the soybean goals specified price support for U. S. No. 2 yellow of recognized varieties recommended by the stations. In addition to the varieties already in extensive cultivation, a number of superior kinds valuable for oil were made available by the stations in cooperation with the Department (BPI), including Ralsoy from Arkansas, Chief from Illinois, Gibson and Patoka from Indiana, Magnolia from Louisiana, Boone from Missouri, Seneca and Ontario from New York (Cornell), Granger (an Ohio selection) and Ogden and Volstate from the Tennessee station.

Timely and practical instructions on growing and handling the crop based on experimentation and published by the Iowa, Mississippi, Missouri, Nebraska, North Carolina, and other stations, dealt with varieties, cultural and harvest practices for grain and hay, handling the products, and the place of soybeans in the farm economy.

The need for increased acreages of soybeans and other oilseed crops presented a problem of locating soil areas where the increase might be made most effectively. This has been accomplished in several States by use of soil survey and land use information already assembled. The Iowa station and the Department, for example, prepared a map of Iowa showing counties in which soybean acreage could be expanded to different extents, taking into consideration maximum production with minimum loss of soil.

The Illinois station, from its experiments and experience, published useful advice on harvesting and storing soybeans. Combining, it stated, should begin soon after the pods dry, the leaves fall, and the moisture content of the beans is preferably below 14 percent. It appeared that increased production, possible transportation shortages, and limitations in elevator space would compel farmers in many areas to store most of their 1942 crop on their own farms. Mature soybeans with a moisture content of 10 to 12 percent will keep well in storage if handled like other grains, and beans with a moisture content up to 14 percent should be safe for storage, at least over winter. When soybeans must be harvested by the combine at moisture levels unsafe for farm storage, they should be examined often and if necessary turned and air-dried. Insects infest soybeans much as they do other grains, but may not cause serious damage during the first year in storage except under bad moisture conditions. Merits of different storage structures have been appraised. Finding that split soybeans have a much higher rate of respiration than whole soybeans, probably due to micro-organisms, the Minnesota station recommended the reduction of the moisture content of the beans to avoid spoilage in storage.

Cottonseed oil.—Considering factors involved in improving cottonseed by breeding, the Tennessee station showed that oil and nitrogen contents were definite plant characters stable within a variety but differing among varieties. The possibility of obtaining a cotton high in both attributes was mentioned.

The same station was perfecting a simple, compact, self-contained oil-expressing unit which would greatly reduce labor requirements and give 10 percent more cottonseed oil. A new plastic board, developed from cottonseed hulls, will take paints, can be sawed or drilled, withstands considerable shock, and compares favorably with other structural boards.

Other oil plants.—Production possibilities and processing methods for special oil crops to meet war shortages were stressed by many of the stations.

The castor-bean plant, grown in the United States for many years as an ornamental, has many possible values in wartime economy. Castor oil is a major commodity for a number of industries, its use being notable in the paints and varnishes and textile-finishing industries and in special lubrications and some plastics. It is increasingly being used as a substitute for tung oil. The Department began in Texas in 1941 an emergency seed-production program designed ultimately to furnish a supply of adapted seed stocks in the event defense developments should require increase of domestic castor-oil production in 1942. State stations suitably located are cooperating in this program. Commercial cultivation of the castor-bean in this country has been limited because of the hand labor required, but improved machinery may solve harvesting problems. A new type of simple and inexpensive castor-bean sheller, developed by the Tennessee station, is semiautomatic in feeding and is easily adjusted for different varieties. It hulls and cleans a high percentage of the beans in one operation with very little injury and conveys all dust away from the operator.

Seed of an extensive collection of castor-bean varieties grown by the California station averaged 51.5 percent of oil, and one high oil selection with 56.4 percent was also high yielding and resistant to frost. Yields ranged from 800 to 1,200 pounds per acre. The Nebraska station found that castor-beans differ in adaptation and that suitable varieties may give fairly good yields. Yields of the better varieties, in Illinois station tests over several years, have averaged about 1,000 pounds per acre. About six varieties were regarded as promising. Uniformity of ripening time is being sought in new varieties being bred. The station has also had other oilseed plants under investigation for several years.

Safflower (*Carthamus tinctorus*), an oil plant producing a drying oil with characteristics valuable for certain industrial uses, the California station found, could be grown in many parts of the State. Although this plant, akin to the thistle, is very spiny and disagreeable to handle, the progress made in the station's breeding work indicates that a satisfactory spineless form will soon be available. The acreage of safflower produced in Texas in 1941 as a source of industrial oil to replace former imports was expected to be expanded greatly in 1942. Since this crop can be grown with ordinary farm equipment, combined like wheat, and the seed crushed with cottonseed-oil-mill machinery, it is of special importance in the cotton region of Texas. Seeking the best use of safflower meal, the Texas station undertook short-time trials to determine its feeding value for beef cattle and whether the bitter principle in the meal will affect the meat flavor. The indications were that safflower meal may prove a satisfactory supplement in livestock feeding.

Emergency investigations by the Alabama station dealt with such special crops as castor-bean, safflower, perilla, abutilon, and flax as oil producers. The Nebraska station was studying these plants and also rape, sesame, and sunflowers for the same purpose.

Several varieties of sunflowers have been planted by the Washington station in the dryland area of the State to test their possibilities for producing oil under semiarid conditions.

That okra may be a source of vegetable oils was evident in studies by the Louisiana station. Okra seed was found to contain as much oil as cottonseed, and estimates were that possibly twice as much oil per acre could be obtained from okra as from cotton. Proper methods for fertilizing and cultivating tung trees, worked out at the Louisiana station, were serving as a basis for increasing production of tung oil.

A method of extracting oil from pecans through pressure and heat, developed by the Florida station, was expected to contribute in a measure to the national oil supply. The method uses parts of the kernels usually considered waste, and with machine shelling now replacing the hand operation much more material of this type may become available in the future for processing. Some 22,000 pounds of oil was produced in 1940 in pecan areas of northern Florida and southern Georgia, of excellent quality and with many commercial uses.

Because of uncertainty as to the supply of origanum oil, used in soaps, the Federal Puerto Rico station investigated the possibilities of obtaining a substitute from *Lippia helleri*, a native plant which produces an oil with similar properties.

FIBERS AND FIBER CROPS

Cotton.—The United States held huge cotton reserves when it entered the war, but the need was urgent for more long-staple cotton, 1⅛ inches to at least 1¼ inches or longer, to meet military requirements. Therefore, the 1942 cotton goal was increased by 1,000,000 acres and premiums were paid to encourage production of long-staple cotton. The five or six available productive varieties having the desired staple were grown in certain areas of the Mississippi Valley, in the Carolinas, and in irrigated sections of the Southwest. These cottons had been developed by the stations, the Department, and commercial breeders.

While a number of very promising new strains were available in certain areas, there was not enough seed for quantity production. In meeting this problem, the stations and other agencies helped planters obtain seed from such sources as large cotton breeders, one-variety communities, and certified seed growers. Continuing their efforts to meet normal needs of processors as well as emergency demands, the stations in cotton-growing States were also developing improved adapted strains characterized by high acre yields, longer, stronger, and more uniform lint, earlier maturity, and resistance to drought, insects, and diseases.

The Louisiana station, which had originated and introduced a number of the important long-staple varieties, cooperated with the War Production Board in providing information and assistance in the growing of long-staple cotton and in supplying 10 tons of seed of long-staple strains best adapted to the State's river lands.

As a result of the successful breeding program of the New Mexico station, about 20,000 pounds of seed of improved cotton of superior staple length was distributed to about 10 cotton-growing communities in that State.

The Florida station cooperated with the Department (BPI) in growing about 400 acres of 1¾-inch staple sea-island cotton, the seed from this acreage to be available to growers for 1943. About 654 acres of three strains of sea-island cotton were registered for certification, and nearly 6,000 bushels of certified seed are expected to be available for 1943 if cotton of 1½- to 1¾-inch staple is needed.

Prolonged careful selection by the Puerto Rico University station resulted in a strain of sea-island cotton with lint 2 inches or longer. The Commodity Credit Corporation of the Department contracted with independent growers and a cooperative for produtcion of this extra-long-fiber cotton in quantity, and the station agreed to grow about 30 acres annually for seed to be distributed among growers.

Yield and quality tests of improved varieties of cotton by several stations and subsequent planting of outstanding strains have resulted in substantial profits to growers. In North Carolina, 93 percent of the 1941 crop was 1 inch or longer as compared with 60 percent in 1936 and 5.4 percent in 1928. This improvement in staple length, attributable largely to North Carolina station research, resulted in a greater demand for North Carolina cotton, higher prices for farmers, and a more uniform and higher-quality product for the manufacturer. As a result of Tennessee station experiments and recommendations, 80 percent (estimated) of the acreage in Tennessee in 1941 was planted to the Deltapine and Stoneville varieties. Yield of lint per acre had shown a constant increase for the past 4 years, amounting to an average of 410 pounds in 1941, the lint quality rose measurably, and there was only 2 percent untenderable cotton as compared with about 28 percent 10 years ago. In 1941, the two new strains—Acala 1517 and Acala 1064—distributed as the result of New Mexico station research, were grown for the first time on practically all cotton farms in New Mexico, and the cotton in the State stapled 78.6 percent 1⅛ inches or longer. Also, these strains brought premiums of $15 to $20 per bale (about $1,500,000) more than the kind of cotton grown previously. Georgia station work in cotton breeding has resulted in improvements in yield, earliness, boll size, lint percentage, and fiber strength.

Efficient and timely cultural practices not only return higher crop yields but also save power and labor. Fall and winter seedbed preparations at the Mississippi station produced the highest acre yields of seed cotton, and deep preparation slightly higher yields than shallow preparation. Cultivation to control weeds could be done most efficiently about every 10 or 12 days and should be shallow to minimize injury to cotton roots, especially after plants are from 6 to 8 inches high. The injury to cotton stands due to soil-crust formation, the Alabama station found, can be reduced by proper preparation of the seedbed before and at the time of planting, as planting of cotton on compacted seedbeds affords a firmer footing for the young plant in breaking through the crust. The same station completed tests which indicated that planting on the countour reduced annual losses from cotton land to about one-half those which occurred when the rows were planted with the slope. Use of a winter cover crop of vetch on land in continuous cotton reduced annual erosion losses to about half of those from land not so protected. The Texas station in cooperation with the Department (SCS) found that the yield of lint cotton was increased 68 pounds per acre on contoured land with level terraces when compared over a 12-year period with land not terraced or contoured.

Seedling diseases have also been a serious cause of poor stands. The Georgia, South Carolina, Tennessee, Oklahoma, North Carolina, and Arkansas stations showed that reduction in seedling blights and increased yields followed chemical treatment and mechanical acid delinting of seed before planting.

Proper fertilizer practices may control diseases as well as increase yields. The Arkansas station and the Department (BPI) found that damage from fusarium wilt and "rust" due to potash deficiency, important causes of low cotton yields in the alluvial eastern Arkansas area, can be curtailed markedly by use of a properly balanced fertilizer having a high unit content of potash. Where nitrogen, and particularly where phosphorus, were in excessive proportions, both troubles were intensified. The Alabama station and the Department (BPI) showed the value of resistant and highly tolerant varieties of cotton for use in areas where fusarium wilt brings severe losses. Regardless of wilt severity the order of resistance of cotton varieties remained the same under comparable conditions, but they differed in needs for potash to overcome wilt and maintain the highest yields. Contrary to the earlier assumption that the cotton wilt fungus would attack only cotton and that rotation would help keep it from increasing in the soil, the South Carolina station found that some strains will attack tobacco, okra, and coffeeweed.

In Arizona, where long-staple cotton of high wartime value is grown under irrigation, phymatotrichum root rot is a major disease of the crop. The Arizona station carried on a cooperative control experiment with a farmer who had sustained 50-percent loss from root rot on 550 acres of cotton in 1939. Where deep plowing was followed by grain sorghum, pasture, and cattle feeding in 1940, cotton grown in 1941 suffered only about 1 percent loss from root rot. A recently completed study by the same station and the Department (BPI) on correct irrigation procedures for producing long-staple American Egyptian cotton was also having very direct application in the attainment of the increased production goals.

Recurring shortage of labor for cotton picking in Texas has been alleviated by the Texas station. The cotton stripper developed in its research, when mounted on a new-model tractor, was satisfactory in performance and efficiency. The average percentage of cotton harvested was 89.4 at College Station and 98.5 at Lubbock. With slight changes in mounting and drive arrangement the harvester could be mounted on almost any type of row-crop tractor and used to harvest suitable cotton varieties as efficiently as the grain combine or corn picker harvests grain. Strains of cotton being developed for mechanical harvesting showed promise of outyielding many common varieties.

Other fibers.—The strategic plant fibers other than cotton are abaca (Manila hemp), flax, hemp, henequen, jute, kapok, sunn, and sisal. The current problem is to find ways to maintain adequate supplies of them or to provide substitutes. The greater wartime demand for flax fiber and improvements made in methods of production and processing indicate an increasing production in the United States and elsewhere in the Western Hemisphere as well.

The flax plant is exacting in climatic and soil needs, and growing the crop and processing the fiber call for specialized knowledge. To stimulate production of fiber flax in western Washington, the Washington station published a bulletin based extensively on station experiments and experience of growers on the soil, fertility, and climatic needs of fiber flax, varieties, cultural and field methods, harvesting and storage practices, and ways to dispose of the crops.

The Oregon station in cooperation with the Department (BPI, BAC and E) was conducting research on agronomic problems as well as research on retting and scutching plants to provide the linen fiber formerly imported. Three farm organizations were assisted by the station in obtaining priorities for critical materials necessary in the construction of three fiber-flax-processing plants in the State, each of which are to handle about 1,500 acres of fiber-flax production. Assistance was also given in securing priorities for critical steel supplies for construction of 50 flax pullers required in harvesting the additional fiber-flax acreages. A new project of the station involved a short-time supplemental study of problems relating to fiber-flax marketing, so as to provide factual data needed for determining the extent to which the State flax acreage, production, and processing facilities can be increased to meet war demands. The study was to ascertain the methods of operating present processing plants, grading procedures, and the basis of paying growers for their product.

Although flax may be considered in the experimental stage in Georgia, the Georgia station and cooperating agencies have obtained promising results with both fiber and seed flax and have determined the fertility and cultural requirements in this section. A pilot plant constructed in cooperation with the Georgia Engineering Experiment Station and the Tennessee Valley Authority produced from 10 to 15 pounds of fiber an hour. All flax yarns could be spun on cotton equipment and woven into a fabric if the quality was good enough for cotton-mill processing, but this was not yet the case for the fiber produced in the pilot plant from retted or unretted flax straw as regards the practical spinning of 100-percent flax yarn on cotton equipment. Flax fiber might, however, be blended with cotton and other fibers.

A program to improve the fiber yield of seed flax was started by the California station to increase the value of this straw as a source of cellulose. A number of varieties were surveyed for fiber percentage after perfection of the techniques of determining the fiber content of individual plants. Hybrids between seed- and fiber-flax varieties, made to study inheritance of fiber characteristics, may serve as a step in developing flaxes with a higher fiber content.

For many purposes hemp can be substituted for both abaca and jute, needed in the manufacture of rope, binder twine, burlap, and heavy cloth. The United States planned to double its acreage of hemp for fiber in 1942 and, with the assistance of the Kentucky station, launched a program for increased seed production. Active in the development of new and better strains of hemp, the Wisconsin station was aiding in the design and construction of new and enlarged plants for processing it, since the increased acreages would require enlarged factory capacity.

Possible fiber-producing crops were included in a Florida station study of new and potentially useful plants. Many different species collected by this station and desert plants collected by the New Mexico station were sent to the Institute of Paper Chemistry at Appleton, Wis., for testing as possible substitutes for hemp.

Native fibrous materials were being studied by the Puerto Rico Federal station and the Department (BE and PQ) with the aim of replacing jute in the weaving of usable bags. Results thus far show that a satisfactory bag for sand can be woven from pandanus leaves, mahoe bark or hibiscus bark, and cattail. If the tests continue to indicate practicability, such bags may be woven at home from suitable local materials for use as sandbags and possibly as substitutes for sacks in marketing vegetables and other products.

The Alabama station was determining the possibilities in that area for producing fiber crops such as flax, ramie, *Crotalaria juncea*, and hibiscus. While the station tests indicated that ramie can be grown in Alabama, further information is needed on fertilization, stage for harvesting, and use of machinery for decortication. For some time, too, the Florida station has given attention to the production of ramie and especially to its fertilizer needs and soil requirements. This station reports that private groups in the State have been seeking economical methods for harvesting, decorticating, and degumming the plant, and have planted fairly large areas to provide material for their investigations.

Yucca grows abundantly in parts of the Southwest, and the fiber is known to be tough and of long staple. The New Mexico station began a study of the qualities of, and methods of extracting fibers from, the four species of *Yucca* growing in that State.

Milkweed floss resembles kapok, the tropical floss used in life-preservers, pillows, and heat-insulation coverings. The North Dakota station began research on the behavior of milkweed under cultivation in order to develop suitable cultural practices for production of its fiber.

RUBBER PLANTS

The shortage of rubber in the United States has led to a search for new sources of supply in native and introduced plants and in synthetic forms derived from farm crops and products. In this search the stations have cooperated with the Department.

In the national program for the production of guayule (*Parthenium argentatum*) for rubber, the Texas station has aided by making available information on special soil characteristics suited to the growth of this plant under Texas conditions. The station recently has made a survey to review and study certain areas in western Texas where guayule plants formerly grew naturally, and has assembled its findings on plantings of improved strains and on the occurrence and importance of diseases. Nurseries for production of guayule seedlings were being established at several substations in cooperation with the Forest Service, and assistance was being given in other phases of the Department's work. Cooperating with the Department in growing guayule, the Arizona station has planted 2 acres of seedlings in a badly infested root rot area to determine its susceptibility to this and other diseases.

The merits and adaptations of Russian dandelion (*Taraxacum koksaghyz*), which is a relative of the common dandelion but contains a higher content of rubber in its roots and other parts, were being determined by 42 State stations and the Alaska station in cooperation with the Department (BPI).

In addition to their active cooperation in the guayule and dandelion studies, a number of the stations were studying native plants. The Colorado station was collecting samples of wild lettuce (*Lactuca scariola*) at several maturity stages, showy milkweed, pingue, and rabbitbrush for determination of rubber content. It has also compiled a list of Colorado plants, with their content of rubber, and completed a bibliography of publications on native rubber-bearing plants of the United States. A bulletin on plant-source possibilities for rubber production in Colorado has been printed to answer the numerous demands for information on this subject. The rubber contents of about 35 plants growing in its vicinity were determined and published by the South Carolina station.

Many native and other species of plants were being observed by the New York (Cornell) station through the growing season as to their rubber content, to find natural sources of rubber as substitutes for *Hevea*. A rapid microchemical method developed enables the determination of the presence of rubber in plant tissues in about 3 minutes. Improvements were also made in techniques for determining the quantity and quality of rubber in plants.

The Minnesota station was investigating the possible use of the latex from leafy spurge, a noxious weed in that State, both for rubber content and as a potential adhesive.

From its research findings with rabbitbrush (*Chrysothamnus nauseosus*) as a possible rubber source, the Nevada station published a circular on the growth habits, species, age at which plants may be harvested, methods of extracting and quality of the rubber, and other factors involved in the utilization of this native rubber.

Test plantings of the Mexican rubbertree (*Castilla elastica*) have been made by the Florida station for the purpose of attempting to extract rubber-bearing latex by grinding the entire plant when about a year old. The possibility of utilizing this species, which grows throughout the Caribbean area, was also being studied by the Puerto Rico stations.

STARCHES

Since tapioca starch derived from cassava can no longer be obtained in quantities needed for important industrial and food uses, extensive domestic sources are being developed for substitute starches. Iowa station research showed that starch of certain varieties of waxy corn can replace tapioca starch in many commercial uses. As a consequence, waxy corn, developed cooperatively by the station and the Department (BPI), was being grown on acreages large enough to insure commercial plantings in 1943. Since extensive starch manufacture would release quantities of protein corn byproducts to supplement livestock and poultry rations, the station was expanding its studies of feeding values of protein fractions in field corn to include those of waxy corn to provide information on how to use the new proteins efficiently. Among other stations working on waxy corn, the Wisconsin station has developed strains with waxy starch which may be useful.

Early in the fall of 1941, the Nebraska station found that the waxy starch of Leoti sorgo had properties indicating that it could replace tapioca starch. Since Nebraska in 1942 raised from 150,000 to 200,000 acres of Leoti, these findings became of added importance on the declaration of war. Commercial production, milling processes, and use of the waxy starch for adhesives and sizings were studied in cooperation with commercial interests. In a survey to locate waxy seed for 1942 planting, the station determined that only about 10 percent of the Leoti grown in Nebraska in 1941 was pure enough for the waxy endosperm character to be suitable for processing. The station has informed farmers about the cultural needs of the crop. The Kansas station also has demonstrated that the sorghums with waxy endosperm contain starches having similar or superior qualities. The station has encouraged increased planting of pure-strain seed of this type, and its preliminary studies indicate that the wet milling process may be adapted successfully to starch extraction from sorghums having colorless seed coats. Blackhull kafir with waxy endosperm, developed by the Texas station, has been increased for distribution.

FORESTRY AND RELATED PRODUCTS

Unprecedented emergency needs for lumber and other wood products led various stations to undertake or intensify research directed toward the conservation of farm woodlands and the more effective use of wood products. Among such studies were the wider use of wood to replace critical metals and fuel oil and the development of various wood products to replace those formerly imported.

In Arizona, where steel fence posts have been largely used in the past, experiments were undertaken by the station on the culture of tamarisk as a source of posts and farm lumber. The tamarisk grows very rapidly and is well adapted to Arizona climate and conditions. The Minnesota station explored the possibilities of using granulated birch bark in the lining of bottle caps, for innersoles for shoes, and in other devices for which, prior to the war, cork from Spain and other countries was used. The Georgia station investigated the possibilities of substituting peanut shells for cork in bottle caps. With thousands of tons of peanut shells available, there was almost unlimited basic material. Other possible uses for peanut shells, such as substitution for cork in linoleum manufacture and for fiber in wallboards, were also explored by that station. At the Oregon station the department of dairy husbandry collaborated with the school of forestry in seeking woods other than spruce that might be used in manufacturing butter containers that would not affect the flavor of the butter.

A wood-burning attachment for use with coal or oil furnaces was being developed by the Connecticut (State) station in a project conducted jointly with Yale University and the Department (FS). The essential feature is a wood-burning chamber built in front or at the side of the existing furnace and connected therewith by a flue which carries the gases into the main chamber for final burning. With the exception of a cast-iron door, the entire unit may be made of nonstrategic material.

The New Mexico station supplied a large quantity of yucca-plant tissues to the Institute of Paper Chemistry to assist them in their search for materials that might be used in the manufacture of manila paper. As a measure for conserving the large quantities of paper that annually are converted into pasteboard containers for transporting baby chicks, the Washington station investigated methods for cleansing and disinfecting used containers. It was determined that painting the interior of cleansed boxes with a solution of one-half water and one-half water glass (sodium silicate) destroyed dangerous organisms, strengthened the boxes, and caused no harmful effects upon the chicks.

The West Virginia station published a bulletin on the management of woodlands in the State, written primarily to serve war and defense needs, and developed a successful portable pulpwood peeler which was expected to prove helpful in meeting the paper shortage.

In cooperation with the General Education Board, the Kentucky station initiated a comprehensive study of the forest resources of the eastern-Kentucky highlands. The investigation was expected to reveal ways in which forest products previously wasted might be utilized to advantage and in this direction was expected to be a distinct contribution to the war emergency. The long-time objective of the study was the development of forestry practices that would support sustained yields of worth-while forest products and thereby stabilize and greatly improve the general economic conditions of the area.

MEDICINAL, CONDIMENT, AND ESSENTIAL-OIL PLANTS

The supplies of many medicinal and condimental plants and culinary herbs in which seed or vegetative portions of the plant are used have for many years come from foreign sources. A great amount of interest in their production as specialty crops has been expressed throughout the United States. Important limiting factors in their production are degree of adaptability, market demand, and availability of propagating material. Many of the stations, cooperating with the Department (BPI), were concerned with problems involved in the development of American sources of supplies of these plants.

Information on medicinal, herb, and other little-known crops, published by the Texas station, considered imports of the crop, commercial areas, type of plant, cultural and soil needs, and possibilities. The Arizona station reported tests on the growth and seed production of a number of common herbs, including chicory, dill, coriander, anise, summer savory, parsley, sage, sweet basil, sweet marjoram, and caraway. These and other condimentals were also being studied by the Colorado, Florida, Oregon, Washington, and other stations.

The Georgia herb project, a timely cooperative enterprise involving the Georgia and Georgia Coastal Plain stations, the Georgia College of Pharmacy, and commercial interests, was set up to determine whether herbs can be grown in Georgia. The investigations deal with both culinary and medicinal herbs. The Idaho station, under a grant from commercial interests through the State Chamber of Commerce, was investigating specialty crops, including condiment, drug, and oil plants. Dill has been produced commercially in Idaho for some years, and trial plantings of coriander have been made by growers.

The production of paprika by a group of farmers in Dillon County, S. C., was being promoted by research of the South Carolina station. Tested strains have been imported by these growers, but problems arising from the different behavior of the crop in the United States have presented new phases for study.

Many plants in Florida have been appraised by the Florida station as possible sources of condiments, drugs, essential oils, fixed oils, and substitutes for cork. As a result 55 plants have been placed under trial at different branch stations, and their products may become important.

Shortages of spices, vanilla, and essential oils have given greater importance to the research program with these materials of the Puerto Rico Federal station, in conjunction with the insular government. Promising results have already been obtained in the studies under way. Plant materials of the crops from which these products are obtained have been made available and have been sent to other countries of the Western Hemisphere.

The desirability of local sources of supply of important drugs has stimulated station research on this problem. The Puerto Rico University station, for example, has begun a study of the possible commercial development of anthelminthics from plants of *Chenopodium ambrosioides* which occur abundantly in the island. The South Dakota station is determining possibilities of producing plants of *Hyoscyamus* of high alkaloid content. The same station, cooperating with the State College of Pharmacy, has already made substantial progress in studies of the production of *Ephedra* and *Chenopodium*.

The Tennessee station is seeking information on the adaptation, harvesting, and marketing of belladonna, henbane, and sage. Sage is already grown to a limited extent in this area and could be increased through more information on its culture. The station has been cooperating with the Department (BPI) in the growing of nearly 100 acres of belladonna near Clarksville. A tobacco drier is used for drying the leaves. The Wisconsin station also has cooperated with Federal agencies on the growing in that State of a considerable acreage of belladonna. The Pennsylvania station was investigating factors influencing the production and curing of belladonna and control of its insect pests.

Responding to demands of farmers, greenhouse men, and drug manufacturers, the Ohio station and College of Pharmacy initiated a research project to determine the best methods of propagating, cultivating, selecting, and improving belladonna, digitalis, coriander, and wormseed, as well as to ascertain their quality and probable value as commercial crops for Ohio growers. The Puerto Rico Federal station has been investigating new areas which might be suitable for growing cinchona, the bark of which is the source of quinine, and is studying related plants as to alkaloid content, possible value as a source of quinine, and suitability as grafting stock for the higher-yielding varieties of cinchona.

Directions have been issued by the Hawaii station for the production from papayas of papain, an enzyme, to supply the United States drug trade. The finding that papayas have twice as much vitamin C as do oranges led the station to encourage wider use of this palatable and low-cost fruit in Hawaii.

Agar has been rationed for essential uses, including uses by hospitals and research laboratories. Formerly considerable amounts were used in making cultures for inoculating seed of legumes to increase production. The New York State station has found that charcoal and humus cultures are as good as agar for legume cultures, and the Texas station has made definite progress in formulas involving other readily available materials as substitutes for agar in laboratory work.

About three-fourths of the peppermint produced in the United States is grown in Indiana and Michigan. From 1929–39 Indiana averaged about 2,000 acres grown on muck soil and each acre averaged 18.6 pounds of oil. The Indiana station from its investigations has reported on culture and harvest, weeds and storage factors affecting yield and quality of oil, distillation, the mint flea beetle, and other harmful insects; and has also published an economic analysis of the production of peppermint and spearmint oils in Indiana. A current objective is to increase the menthol content of peppermint.

FERTILIZERS AND SOIL AMENDMENTS

In addition to direct assistance on food-production problems referred to elsewhere in the report, the stations have contributed information on suggested methods of keeping up production in view of the nitrogen-fertilizer shortage, obtaining maximum yields from available fertilizer materials, developing fertilizer substitutes, and testing promising new fertilizer materials. The following are some of the contributions made by the stations on these problems during the year:

In the Southeast, where nitrogen is a critical factor, emphasis has been placed on the use of legumes for adding nitrogen to the soil so as to increase crop yields and maintain soil fertility. The Alabama station found that turning under summer legumes in the spring rather than during the fall conserved up to 50 percent of the added nitrogen. Also, with this system, the amount of potash lost was greatly reduced. From the crop yield standpoint, it was found that nitrogen from a 5-ton application of manure increased the yield of seed cotton 1,341 pounds per acre and the yield of corn 36.7 bushels. A 325-pound application of nitrate of soda over no-nitrogen treatment resulted in an increase in yield of 1,056 pounds of seed cottton and 26.9 bushels of corn. For winter legumes, the increase was 986 pounds of seed cotton and 26.9 bushels of corn. The station further pointed out that the cheapest nitrogen was obtained from the winter legumes. Along a somewhat similar line, the Georgia station reported on the importance of cowpeas and soybeans for providing needed nitrogen.

Another phase in the utilization of legumes for supplying nitrogen is illustrated by the work of the Wisconsin station on nitrogen-fixing bacteria. That the addition of nitrogen to the soil by leguminous crops is accomplished by so-called nitrogen-fixing bacteria, which are located in nodules on the roots of these plants, is well known, but this station has also found that the amount of nitrogen fixed varies with different strains of these bacteria. Accordingly, the station has been attempting to obtain strains with the greatest possible effectiveness for nitrogen fixation.

Another practical aid in meeting the nitrogen shortage involves the efficient utilization of barnyard manure and of other materials around the farm that have fertilizer value, though previously considered as waste. Several States have provided information on ways of utilizing manure for maximum returns. While the addition of superphosphate to manure in stable gutters is not new, the Vermont station found the practice to be particularly important under present conditions of fertilizer shortage, since the phosphate resulted in a saving of 10 to 25 percent of the nitrogen and the manure also increased the availability of the phosphoric acid in the superphosphate by decreasing fixation. The practice is spreading rapidly and it is estimated that by its use in the State of Vermont alone a saving of approximately one million dollars' worth of nitrogen per year is attainable. This station also found that it was possible to save labor by adding limestone directly to the loaded manure spreader without material loss of plant nutrients. The Georgia, Colorado, South Carolina, Mississippi, and Ohio are only a few of the other stations that have pointed out the importance of saving and utilizing barnyard and stable manure efficiently if farmers are to make up for possible shortages in nitrogen fertilizers. The Washington station found that applications of liquid manure diluted approximately 10 times with the water used in washing the barns gave increased yield on pasture areas without decreasing palatability of the grass or causing burning injury. The Oregon and New Jersey stations tested methods of utilizing various local farm wastes and legume crops so as to be able to reduce the amount of commercial fertilizers required.

Previous results from several States on fertilizer placement have shown that the largest yields are obtained when the fertilizer is placed in bands on both sides of the seed or plant. In this connection, the New York State station reported that the plowing under of fertilizers has several advantages in vegetable production. There is a reduction in the amount of labor required during the rush of planting since the fertilizer is applied while plowing; the fertilizer is deposited in an area where it is more accessible to the plant roots and is less rapidly fixed in an unavailable form, thus can be more effectively used by the crop; burning injury is avoided; and with the deep placement the plants are able to continue growth during drought periods. In extending the work, the plowing-under method of placement has shown considerable promise with soybeans in Indiana, with canning peas in Maryland, and with sugar beets and canning beets under Ohio conditions.

Liquid fertilizers have shown important possibilities for reducing the amount of fertilizer required and also increasing the yields of needed vegetable crops. For example, the New Jersey station found that an application of only 160 pounds of a 4–16–4 mixture in liquid form gave the same yield of tomatoes (12 tons per acre) as was obtained when 500 pounds of the same type of fertilizer was applied in the standard way. Much of the earlier work on liquid fertilizers was done with certain high-analysis materials which are readily soluble, but the station ascertained that, in general, standard fertilizers also can be used in this way by taking into account certain modifications which have been described in detail. The station has developed a cheap and efficient liquid-fertilizer distributor which can be made from scrap materials already available on the farm.

Soil and plant-tissue tests are playing an increasingly important role in determining how much and what kind of fertilizer to apply to obtain maximum crop yields. Many of the stations have been testing soils and plants and making direct recommendations to guide growers, and station workers are developing soil or plant tests that can be used by the county agent as a guide for his recommendations.

As a means of increasing the amount of actual plant nutrients delivered to the farmer with the facilities available for moving fertilizer materials, many of the stations have pointed out the necessity for the elimination wherever possible of inert materials used as fillers.

The above items on fertilizer practice present some of the factors involved. Obviously, the nature and extent of the problems are such that they involve the consumer as well as the producer. To work out these mutual problems, many station directors or representatives designated by the directors, as well as representatives from other agricultural agencies, at the request of the Department (OAWR), have discussed in regional conferences various fertilizer problems and methods of working them out with fertilizer manufacturers.

The Florida station reported that various members of the staff have spent considerable time obtaining information on the needs for fertilizer materials, commercial fertilizers, and minor-element fertilizers. Under Florida soil conditions, fertilizer materials and minor elements are much more important than in many other States, and to insure maximum production it is essential that these materials be available. The data on needs have been carefully compiled and submitted to the State Defense Council, as well as to the technical fertilizer committee of the Office of Agricultural War Relations. Further working out of the needs of agriculture for chemicals, both for fertilizer and other usages, is being handled by a station director who has been appointed consultant on agricultural chemicals for the War Production Board.

Many of the stations have also cooperated with fertilizer manufacturers by testing promising new materials. For instance, the Louisiana station conducted experiments in cooperation with manufacturers on the use of nitrogen fertilizer in liquid form in place of the ordinary dry nitrogen sources and assisted in designing a distributor which will make the use of the liquid nitrogen fertilizer feasible.

A shortage of imported peat moss has developed as a result of reduced shipping under present emergency conditions. Peat moss is of considerable importance for soil improvement and of special value for increasing the water-holding capacity of light sandy soils. Attempts are being made to meet this shortage with various natural organic materials from local sources in several of the States. Among the States where surveys have been made or are being made to determine the nature and extent of local supplies are Connecticut, Louisiana, Maine, Michigan, and New Jersey. Experimental work is being carried on by some States to determine whether the local materials may be substituted for peat moss. In this connection, the Connecticut (State) station found that the native swamp muck and peat could replace imported peat moss. As a result of this and similar findings, there is beginning an industry for developing and handling various local organic materials needed for soil improvement.

INSECTICIDES

Important in any program to increase the production of food are measures to cut the toll taken by insects. During the past year research entomologists have continued work on methods of control for insects, particularly those which damage field, forage, fiber, oil, truck and garden, and fruit crops of importance in the war effort. Examples of their findings, besides those mentioned below, may be noted under various commodities discussed elsewhere in this report.

The results of research with insecticides have taken on new significance due to serious shortages caused by war conditions. Station entomologists have concentrated their efforts on effective substitutes, more efficient use of scarce materials, and American sources for an adequate supply.

For several years the Texas station has grown devil's-shoestring in order to make studies on its content of rotenone—a valuable but now scarce insecticide. The results have shown that by careful selection strains may be isolated which have a rotenone content of as much as 6 percent. In certain areas of the United States the native devil's-shoestring does not contain any appreciable amount of rotenone and for that reason has been discounted as a potential source, but recent findings of the station in cooperation with other stations have shown that it is possible to transfer high-rotenone strains from Texas to a region yielding only mediocre material and from one soil type to another and still retain the toxicity. It has been shown also that highly toxic plants when isolated tend to produce offspring of similar toxicity.

Specifically, the New Jersey station has found that although the devil's-shoestring which grows wild on the sandy soils of southern New Jersey carries too little rotenone to be of value, rotenone-bearing strains from Texas retain their original levels of rotenone content when grown in New Jersey. Seed from Texas of a selected variety that analyzes from 4 to 6 percent of rotenone, a figure which approaches the average percentages of rotenone present in derris and cube roots, has been planted in experimental beds in several localities. The Alabama station, too, is growing and testing for insecticidal efficiency high-rotenone strains of devil's-shoestring.

Approximately 300,000 cuttings of derris were planted in experimental nursery beds by the Puerto Rico Federal station in an expansion of planting material of rotenone-producing plants. Experiments have been continued on budding a superior strain of derris from Costa Rica, the best age of harvest of derris, and nitrogen requirements of the plant.

Pyrethrum plants high in pyrethrin content are being developed by the Tennessee station and distributed to growers. This plant, formerly imported extensively, but with much of the supply now cut off, is the source of an important insecticide used in household and barn sprays as well as in sprays and dusts for combating several species of insects attacking vegetables, sugar beets, berries, tobacco, and fruit. Under a new project the Oregon station has speeded up its search for substitute insecticides, particularly rotenone-bearing materials, and the development of more efficient methods of applying insecticides. Both achievements should help relieve the strain caused by shortage of various materials. The volume and scope of laboratory work is being increased and special equipment is being provided, as many problems can be developed to the stage of field testing much more quickly and economically in this way.

The Kansas station has cooperated with a powder company in testing insect-killing chemicals that may be used as substitutes for pyrethrum and rotenone. A new insecticide that has been made from southern pine extracts promises to be a satisfactory substitute in fly-killing sprays for use in homes and dairy barns. Tests made at this station with this new product have given highly satisfactory results.

A study has been initiated by the Maryland station of concentrated sprays in water or oil suspensions, and the best means of applying them in the field so that minimum dosages may be achieved for maximum kill of insects and freedom from plant injury. The development of successful concentrated sprays and spray machinery promises a method of control more effective in killing some species than any now used, more economical of materials because of the reduction of the run-off attendant in the use of dilute aqueous sprays and the waste of dusts by wind, and saving in labor, time, and transportation expenses by cutting the amount of water required in application and by reducing the weight of machinery and spray load. The use of concentrated sprays has special appeal to canners and market gardeners since it offers light, economical, low-cost equipment in the place of heavy, expensive dusting and spray equipment. There is great interest in this method of insecticide application not only in Maryland but throughout the country. If successful methods can be developed, concentrated spraying seems likely to be immediately and widely adopted on a commercial scale.

Laboratory investigations by the Delaware station have been continued with naval stores products, and further advances have been made in the substitution of new ingredients in household and horticultural sprays for those which are becoming increasingly scarce. The toxicity to insects of pine oil and several terpene derivatives, including ethylene glycol ether of pinene and fenchyl thiocyanoacetate, has been fully demonstrated, and substantial quantities of each are now being marketed as insecticides. Research with fruit and vegetable insects has been directed mainly toward improving spray combinations and dust mixtures, establishing the critical periods for application, and thereby assisting growers to protect their crops from damage at a time when the shortage in both materials and labor is extremely acute.

An attempt to conserve insecticides and at the same time control a destructive pest is being made by the Delaware station in cooperation with the Department (BE and PQ) and the Delaware State Board of Agriculture. A State-wide program for the colonization of the milky disease organisms for controlling Japanese beetle larvae has been started, and a total of 2,289 one-half-acre disease plats have been established. More than 200,000 larvae were inoculated with this disease as a step in the production of the spore dust needed for field distribution during 1942. This work should aid greatly in reducing the population of this insect and thereby prevent severe injury to many agricultural crops. Studies are also in progress to develop effective substitutes for certain ingredients of the sprays commonly applied against the adult beetle.

The plum curculio is a destructive apple pest for which previous research has shown that sprays should be applied just before periods of high temperatures to be most effective. This, however, has meant dependence upon weather forecasts which are no longer available. Recent research by the Massachusetts station has shown that sprays applied when young apples are five-sixteenths of an inch in diameter are sufficiently effective to justify the use of fruit size as a substitute for weather forecasts.

The Louisiana station is working on the development of a new spreader-activator for contact sprays that will be locally made and distributed in Louisiana. It will be made in part from forest products (resins, etc.), and will substitute for imported coconut-oil hard-water soap, which is difficult to obtain at the present time. The same station has been testing soap as a substitute for imported rotenone for the control of a number of sucking insects.

Insecticides such as roach powders have contained from 50 to nearly 100 percent of sodium fluoride, but this poison is now needed for processing and hardening war steel and, therefore, has been given a high priority rating. The insecticide industry had used more than 4 million pounds annually in their products. A new insecticide formula for household pests, developed by the Tennessee station, requires a much smaller percentage of sodium fluoride than has been used because what is used is rendered highly effective by an activator.

In the cranberry industry organic dusts of pyrethrum, derris, and rotenone have proved very satisfactory in the control of certain injurious insects. They not only accomplished results but also were considered especially desirable because they were free from any harmful effect on the foliage. This resulted in their general use, and when the supply was cut off growers were not familiar with either the existence or the use of substitutes. The Massachusetts station, because of numerous tests of other spray materials, is prepared to make safe recommendations of substitutes that can be obtained and will give satisfactory control. Information is also available regarding methods of application that will protect the grower against the hazards of plant injury involved when untried spray materials are put to use.

FUNGICIDES

Among the emergency problems growing out of wartime conditions are those created by shortages of some of the standard chemicals employed in plant protection. Several of the experiment stations have been working on substitutes for copper and mercury fungicides and for formaldehyde, all of which are critical materials needed in producing munitions or combat equipment. The Connecticut (State) station, within a 3-year period prior to Pearl Harbor, tested more than 6,000 new chemical compounds for possible usefulness against plant diseases. Only about one in a thousand proved to be so outstandingly active against plant-disease organisms and at the same time so safe for use on plants that it was deemed worthy of further study. Among the few, however, are included materials that promise not only to be satisfactory substitutes for certain standard sprays or dusts, but also in some respects even superior. These will naturally have wartime value as well as permanent advantage to agriculture. It is imperative that emergency tests be conducted with such materials so as to learn as promptly as possible the range of uses for which they are best fitted in crop protection and also to discover their limitations, since these too must be known if they are to be employed effectively and safely. Many stations are engaged in such tests, involving a wide range of plant diseases, crops, soils, and climates. As the reports from these tests come in, the number of plant diseases known to be as successfully controllable by the new materials as by the older fungicides is growing steadily.

A number of stations have found the new organic compounds known as Spergon (tetrachloroquinone) and Arasan (tetramethyl thiuram disulfide) useful in place of older materials for treating certain kinds of seeds. The New York State station in tests covering two seasons with Spergon-treated peas showed that an average outlay of 70 cents per acre for this chemical gave returns ranging from $12 to $21 per acre.

In addition to the problem of available substitutes for critical fungicides, economy in the use of critical materials is of extreme importance to the war effort. The Maine station showed that acetic acid in the mercuric chloride solution generally employed for treating seed potatoes makes it possible to handle a greatly increased quantity of tubers with the same amount of active chemicals. The Connecticut (State) station has begun a study of the extent to which various spray materials and dusts can be diluted without seriously reducing their effectiveness against different plant diseases. Other stations have actively carried on similar work. The results have often been astonishing and usually encouraging. In many cases well-known fungicides can be used at one-half standard strength or even less without seriously reducing their protective values. In tests by many stations new combinations of sprays and new spreaders and stickers for them have been developed and their superior qualities demonstrated. These advances are now being put to good use in securing better protection against losses from disease.

Station workers have long been cognizant of the huge losses suffered annually in all parts of the country and with almost all kinds of crops because of poor stands and the blighting of young seedlings due to attacks by seed- and soil-borne fungi and bacteria. In 1941, 31 agricultural experiment stations in the United States and Canada united in a program of cooperative testing of materials for the treatment of vegetable seed. Uniformly planned tests were conducted with seed of a number of important truck crops. This was the second year of the cooperative program. Other group experiments were conducted on the seed treatment of cereal grains and of cotton. The pooled results are now in active use, and more properly treated seed will be planted in connection with the agricultural war production program than ever before. Through group research more needed information has been secured each year than any one agency alone could normally have arrived at in several years of intensive effort.

ASSISTANCE TO WAR AGENCIES

At the request of the War Department, the Utah station furnished a map of the arable land in selected areas of the State to determine the suitability of portions of the area under the Utah Central Canal for resettling the Japanese. This station also analyzed soil samples for the Engineer Corps to assist in providing information necessary in connection with plantings for the grounds of a shell-loading plant.

Not only is the land-classification information already available from several stations or currently being completed of special value in planning war-production goals, but in addition to this important agricultural use, recently completed surveys by the Delaware station have been of assistance for defense purposes since they are the most up-to-date surveys available showing corrected coast line, highways, and timberland. Reports of these surveys have been supplied in quantity to Army and Navy officials for coastal-defense purposes.

Recent work in soil bacteriology at a few of the stations has revealed startling possibilities on the use of various soil organisms for the production of valuable chemical substances. The New Jersey station has already isolated substances that have strong bacteriostatic and bactericidal properties. Because of the possibilities of these antibiotic substances, especially in the treatment of wounds, the New Jersey station was requested by the National Research Council to make a systematic survey of the occurrence of organisms in the soil which produce substances destructive to pathogenic bacteria. The work includes isolating from soils and composts various organisms and then testing their action against several disease-producing organisms.

Food supply problems.—Of direct service to the war industries and armed forces are research findings and contributions of a number of the stations on problems concerned with food supplies. The increased use of dehydrated vegetables necessitates not only increased production but also further knowledge of how the dried products compare in food value with the fresh. Information available at present on the dehydration of vegetables has been summarized by the California station in a special bulletin for the Quartermaster Corps. The effect of commercial drying and dehydrating processes on the nutritive value of fruits and vegetables has been discussed in a technical bulletin issued by the New York State station. This information, based on a review of the literature, was prepared at the request of the committee on fats, vegetables, and fruits of the food and nutrition board of the National Research Council. Special studies at the Louisiana station of the carotene (provitamin A) content of sweetpotatoes as affected by different treatments are being considered by the Army as a basis for dehydrating potatoes in a commercial plant at St. Francisville.

Work on food preparation at the Georgia station involves the use of peaches, strawberries, and other fruits, which are being preserved with sulfurous acid and then made into marmalade, jams, preserves, jellies, etc., to meet British needs. The British Food Ministry and the Department (BAC and E) were serving as advisers.

Considerable attention was given to improving the diets of workers in war industries. The problem was approached from the standpoint of improving the usual diet both by better food selection and by having workers take vitamin concentrates. Basic data to guide these attempts were obtained at the New York (Cornell) station from diet and life-span studies with rats. Additional research with other animals promises to be useful in guiding the design of rations for use by men when faced with such situations as being stranded in lifeboats for long periods of time with only limited food supplies.

On account of war conditions there is a shortage of cod- and other fish-liver oils which are relied upon as the chief source of vitamin D and which also constitute an important source of vitamin A. A process, developed by the Michigan station, made available, however, an important plant source of these vitamins. By this process carotene, which is known as provitamin A and is convertible to vitamin A in the body, is extracted along with other valuable constitutents from dehydrated alfalfa-leaf meal. By irradiation of the extract from the meal, large amounts of vitamin D also may be produced. Through the processing of 1 ton of high-grade dehydrated alfalfa-leaf meal a yield of 200 grams of carotene, which is equivalent to 340 million units of vitamin A, and an estimated 32 million units of vitamin D can be obtained. On this basis the needs for the entire population of 130 million people with respect to vitamins A and D could be supplied from approximately 600,000 tons of dehydrated alfalfa-leaf meal. This is less than the amount of alfalfa raised in Michigan alone.

Insect control.—Mosquito control in its various phases has received increasing attention by the Delaware station. This station has been responsible for the planning, development, and operation of a $62,693 WPA antimosquito project for an area where the situation is especially serious because of the usual prevalence of malaria-transmitting species. Approximately 80 percent of the lowlands within 2 miles of an important military post were effectively treated between July 1 and December 31, 1941. A somewhat similar WPA project in the amount of $36,095 is now in operation about two other military reservations. In anticipation of demands for antimosquito work in the vicinity of Wilmington, Del., the necessary surveys were completed during the early spring of 1942. This section of the State includes more than one-half of its population, most of its industrial plants are concentrated here, and from the standpoint of national defense it is one of the most important centers along the Atlantic seaboard. The entomology department of the station has also operated mechanical traps throughout the State and has identified the mosquitoes thus collected. Such work provides desirable information on the effectiveness of various abatement measures carried out by the Mosquito Control Division of the State Highway Department.

The Puerto Rico Federal station has furnished military authorities with suggestions on spray material for airplane fumigation, use of paris green in nests and main tunnels of termites for the protection of gas masks and other supplies in crates, and the use of crude creosote or zinc chloride for preventing termite attack in 2×4 lumber used in piling shells and ammunition.

The Alabama station assisted military authorities by giving information on the control of roaches in hospitals and mess halls. Suggestions were also made on control of crab lice, ants, flies, and mosquitoes; the identification of poisonous snakes and treatments for snake bites; the control of brown dog ticks in living quarters; and fish-pond management.

Vegetative covers.—Grass is needed urgently for sodding airfields, training and parade grounds, camps and fortifications, and for the surroundings of munitions factories. By providing information and facilities for the establishment of such ground covers, the experiment stations were aiding the armed services and defense industries on this important problem. The Michigan station, for example, has cooperated with the Army in the grassing of airports and other fields in sandy or blowing areas and the New Jersey station has applied its results widely to the varied conditions in its State. Trees, shrubs, and grasses for planting on Army and Navy cantonments and airfields and information on their establishment and care have been supplied by the Florida and Vermont stations and the Federal and University stations in Puerto Rico. The Puerto Rico stations, cooperating with the Department (SCS), have also provided numerous plants for camouflaging and rendered other direct services. The Nebraska station has responded to requests for advice on grassing bomber plants and airfields and for information on planning runways on certain types of soil. Similar services were rendered by the Alabama and Colorado stations, the latter with special reference to research on dry-land grasses for use for turf on emergency landing fields in arid regions.

Strains of grasses were being developed and improved by the Wisconsin station to provide vegetative cover for airfields, munitions factories, highway cuts and fills, and similar areas where large surfaces of newly moved earth must be established and protected. A superior strain of buffalo grass developed at the Kansas station in cooperation with the Department (BPI) has proved suitable for grassing airfields. Seeds are being increased rapidly for distribution.

A rapid method of growing sod, developed in 1942 by the Pennsylvania station, should aid in the quick grassing of military areas under the conditions of that State. Sod is shredded into fine bits, mixed with fertile soil or compost, lime, fertilizer, and seed, and distributed by a manure spreader over the area to be sodded, which is then rolled. Good turf has been established by this method within a month. The prolonged experience of the Rhode Island station in grassland research is having a very practical and timely bearing on the establishment of turf for airports, emergency landing fields, rough border planting, and sand stabilization in the region. Current experiments give special emphasis to the problem of developing a closely cut, dense turf that will grow well without artificial watering, withstand wind erosion from propeller blasts, and heal quickly after tail-skid injuries.

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, 1942; 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 1942 was 4,927, an increase of 172 over 1941. The increase consisted of 101 full-time research workers and 80 whose time was divided between research and resident teaching or extension, less a decrease of 9 in those whose time was divided between research and both teaching and extension work. Of the 4,927 technical workers in 1942, 2,404 gave their full time to research while the time of the other 2,523 was devoted partly to research and partly to resident teaching or extension work or both.

The publications of the experiment stations in 1942 included 975 bulletins and circulars in the regular series, 2,157 articles in scientific journals, and 670 miscellaneous publications. The comparable figures for 1941 were 834, 2,411, and 701, respectively.

INCOME

The total income available to the stations for 1942 was $22,664,840.99 as compared with $22,433,550.29 in 1941. The 1942 income consisted of $6,926,207.08 from the four Federal-grant funds and $15,738,633.91 of non-Federal funds, including State appropriations, special endowments and fellowships, fees, sales, and miscellaneous.

Federal grants.—Federal grants to the States, Territories, and Puerto Rico for agricultural research in 1942 amounted to $6,926,-207.08 as compared with $6,862,500 in 1941. An increase of $63,707.08 (Bankhead-Jones funds) was provided to prevent reduced allotments because of changes in relative rural population in the States or Territories revealed by the 1940 census. Under the terms of the Bankhead-Jones Act, the allotments are made on the basis of rural population as determined by the preceding decennial census.

Non-Federal funds.—The amount of funds made available by the States in 1942 was $15,738,633.91 as compared with $15,571,050.29 in 1941, an increase of $167,583.62. The income of the stations from sources other than Federal-grant funds was approximately $2.27 for each $1 of income from the Federal grants.

EXPENDITURES

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, 1942, to each State, Alaska, Hawaii, and Puerto Rico for agricultural experiment stations under the Hatch, Adams, Purnell, and Bankhead-Jones and supplementary acts.

TABLE 1.—*Organization, personnel, and publications of the experiment stations for the year ended June 30, 1942*

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	38	36	1		75	10	284	26	200	36	121
Alaska	May 2, 1929	May 1, 1931	4	1	2		7	1	42				
Arizona	Mar. 19, 1889	July 1, 1889	21	41	1		63	13	499	19	199	23	126
Arkansas	Mar. 7, 1889	Apr. 2, 1888	20	46	2	2	70	9	303				
California	Mar. 12, 1889	Mar. 13, 1888	99	199			298	30	1,894	267	2,232	322	7,576
Colorado	Mar. 25, 1889	Feb. 20, 1888	28	42	1	1	72	12	296	21	97	20	84
Connecticut:													
State	May 18, 1887	May 18, 1887	57				57	22	814	25	127	9	17
Storrs	do	Apr. 1, 1888	14	16	1	6	37	5	301	5	128	4	18
Delaware	Apr. 14, 1887	Feb. 21, 1888	8	12	4	4	28	7	322	19	87		
Florida	June 7, 1887	Mar. 16, 1888	82	13	4	6	105	25	995	94	407	60	89
Georgia	Dec. 24, 1888	Feb. 18, 1888	47				47	11	315	11	56	4	11
Hawaii	Mar. 31, 1911	July 1, 1929	25	17			42	6	179	11	111		
Idaho	Jan. 23, 1891	Feb. 26, 1892	17	33	2	6	58	7	128	6	31		
Illinois	May 11, 1887	Mar. 21, 1888	52	96	4	6	158	13	792				
Indiana	Jan. 19, 1889	July 1, 1887	97	39	5	2	143	23	966	70	295	14	104
Iowa	Mar. 1, 1888	Feb. 17, 1888	93	127	22	11	253	31	2,133	126	1,258	32	512
Kansas	Mar. 3, 1887	Feb. 8, 1888	32	108			140	9	234	100	114		
Kentucky	Feb. 20, 1888	Apr. 29, 1888	68	27	1	7	103	20	739	39	165		
Louisiana	July 12, 1888	Apr. 5, 1887	50	38		1	89	13	402				
Maine	Mar. 16, 1887	Feb. 16, 1888	39	6			45	11	694	7	56	3	8
Maryland	Mar. 6, 1888	Mar. 9, 1888	17	34	4	13	68	14	355	35	70	11	22
Massachusetts	Apr. 20, 1887	Mar. 2, 1888	71	19			90	25	621	28	137		
Michigan	Apr. 12, 1889	Feb. 26, 1888	60	87	6	7	160	24	1,269	68	561	1	76
Minnesota	Feb. 4, 1889	Jan. 26, 1888	49	120	5	2	176	17	727	73	73	9	45

Mississippi	Jan. 31, 1888	Spring 1888	40	23		2	65	36	1,002	12	12		
Missouri	June 11, 1889	Jan. 31, 1888	17	93		1	111	60	1,489				
Montana	Feb. 16, 1893	July 1, 1893	28	17	1	10	56	18	357	11	11	6	152
Nebraska	Mar. 31, 1887	June 14, 1887	22	47	1		70	15	506				
Nevada	Feb. 8, 1889	Dec. 1887	19	2			21	5	160				
New Hampshire	Aug. 4, 1887	Feb. 22, 1888	5	40	1	5	51	15	329	1	8		
New Jersey:													
College } State }	Mar. 16, 1887	Mar. 5, 1888	110	22	1		133	38	537	61	61	6	24
New Mexico	Feb. 28, 1889	Nov. 14, 1889	10	22	1	1	34	32	547	2	13	4	8
New York:													
Cornell	Mar. 30, 1887	Apr. 30, 1888	32	143	7	21	203	30	1,309	420	2,431		
State	(1)		81				81	34	671	59	59		
North Carolina	Mar. 7, 1887	Dec. 5, 1889	56	37	2	9	104	9	308	5	38		
North Dakota	Mar. 8, 1890	Oct. 15, 1890	26	26		1	53	18	559	12	84	24	308
Ohio	Mar. 16, 1887	Apr. 2, 1888	138				138	20	655				
Oklahoma	Oct. 27, 1890	Aug. 14, 1891	26	63	1		90	30	795	47	237	4	65
Oregon	Feb. 25, 1889	July 2, 1888	58	51		7	116	43	633	31	31		
Pennsylvania	June 3, 1887	June 30, 1887		157		1	158	15	478	56	358	12	120
Puerto Rico	Aug. 16, 1933	Nov. 14, 1935	56				56	18	667			3	23
Rhode Island	Mar. 31, 1887	Nov. 3, 1881	16	6		5	27	8	295	12	46	3	75
South Carolina	Dec. 22, 1887	Jan. 1888	63	22	2	1	88	11	594				
South Dakota	Mar. 11, 1887	Nov. 17, 1887	9	41	1	3	54	26	686	12	36		
Tennessee	Mar. 29, 1887	July 24, 1887	67	21			88	11	308	9	65		
Texas	Apr. 2, 1887	Jan. 25, 1888	173	3			176	16	1,211	25	182	37	138
Utah	Mar. 8, 1888	Nov. 16, 1889	26	38	1	5	70	6	202	23	174		
Vermont	Nov. 1888	Feb. 28, 1888	18	16	1		35	27	1,306				H
Virginia	Feb. 29, 1888	June 13, 1888	51	11	2	5	69	23	834	17	91		
Washington	Mar. 9, 1891	May 1, 1891	71	38			109	31	920	41	233	19	332
West Virginia	Feb. 22, 1889	June 11, 1888	26	40	1	7	74	4	145	18	112	4	32
Wisconsin	Session of 1889	July 1, 1887	54	83	8	24	169	10	432	232	232		
Wyoming	Jan. 10, 1891	Mar. 27, 1891	18	26			44	8	253	1	14		
Total			2,404	2,245	96	182	4,927	975	33,492	2,157	10,932	670	10,167

[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, 1942*

Station	Federal grants [1]			Non-Federal						Grand total
	Hatch, Adams, and Purnell [2]	Bankhead-Jones	Total	State appropriations	Special endowments, industrial fellowships, etc.	Fees	Sales	Miscellaneous	Total	
Alabama	$90,000	$82,695.12	$172,695.12	$168,611.47	$26,688.04		$343,211.00		$538,510.51	$711,205.63
Alaska	25,000	2,252.44	27,252.44	5,625.00			20,626.34	$686.89	26,938.23	54,190.67
Arizona	90,000	13,285.16	103,285.16	98,452.16			48,388.70		146,840.86	250,126.02
Arkansas	90,000	63,983.20	153,983.20	171,102.01			47,611.92		218,713.93	372,697.13
California	90,000	81,893.64	171,893.64	1,093,719.08	149,704.39		119,296.78		1,362,720.25	1,534,613.89
Colorado	90,000	22,430.96	112,430.96	121,453.07	5,181.86	$1,024.89	94,026.88		221,686.70	334,117.66
Connecticut:										
State	45,000	11,253.66	56,253.66	138,052.51	11,965.02				150,017.53	206,271.19
Storrs	45,000	11,253.66	56,253.66	50,616.55	6,465.87				57,082.42	113,336.08
Delaware	90,000	5,189.96	95,189.96	39,825.00	14,512.06		24,653.83		78,990.89	174,180.85
Florida	90,000	34,782.16	124,782.16	568,149.00		148,334.05			716,483.05	841,265.21
Georgia	90,000	87,522.92	177,522.92	40,000.00	31,386.47		39,041.06		110,427.53	287,950.45
Hawaii	67,500	9,186.40	76,686.40	85,429.00	236.62		24,469.11		110,134.73	186,821.13
Idaho	90,000	14,219.84	104,219.84	36,575.13		735.00	38,411.72		75,721.85	179,941.69
Illinois	90,000	86,736.52	176,736.52	438,515.63	25,949.13		93,529.46		557,994.22	734,730.74
Indiana	90,000	62,900.44	152,900.44	332,314.35	70,229.39	20,074.57	316,264.99	18,362.16	757,245.46	910,145.90
Iowa	90,000	64,854.64	154,854.64	260,478.82	94,042.83		107,650.76		462,172.41	617,027.05
Kansas	90,000	50,050.96	140,050.96	168,662.06			90,058.12	2,560.00	261,280.18	401,331.14
Kentucky	90,000	81,533.32	171,533.32	87,500.00		115,608.57	52,847.65	3,134.93	259,091.15	430,624.47
Louisiana	90,000	56,502.80	146,502.80	190,094.12	36,431.57				226,525.69	373,028.49
Maine	90,000	20,692.16	110,692.16	108,609.04	1,826.63		15,615.00	16,943.53	142,994.20	253,686.36
Maryland	90,000	30,259.72	120,259.72	100,961.99	16,999.33		52,919.81		170,881.13	291,140.85
Massachusetts	90,000	18,674.92	108,674.92	139,255.49	11,555.51			150.00	150,961.00	259,635.92
Michigan	90,000	73,566.60	163,566.60	276,901.95			30,713.32		307,615.27	471,181.87
Minnesota	90,000	57,269.04	147,269.04	409,722.98	28,121.46		55,620.70	7,294.43	500,809.57	648,078.61

Mississippi	90,000	72,651.40	162,651.40	132,936.94	7,563.83	5,496.55	141,818.02	5,578.91	293,394.25	456,045.65
Missouri	90,000	76,967.80	166,967.80	99,952.45	26,075.47	42,121.07	57,431.88		225,580.87	392,548.67
Montana	90,000	15,503.16	105,503.16	90,950.00			85,941.43		176,891.43	282,394.59
Nebraska	90,000	38,776.60	128,776.60	118,674.30			97,655.64		216,329.94	345,106.54
Nevada	90,000	2,734.64	92,734.64	623.29			18,692.86		19,316.15	112,050.79
New Hampshire	90,000	8,507.40	98,507.40	10,613.00			10,865.44		21,478.44	119,985.84
New Jersey	90,000	31,260.32	121,260.32	397,834.00	100,697.68				498,531.68	619,792.00
New Mexico	90,000	14,516.00	104,516.00	31,490.93			63,813.47		95,304.40	199,820.40
New York:										
Cornell	81,000	85,030.40	166,030.40	716,692.98		38,843.88	90,635.73	5,678.04	851,850.63	1,017,881.03
State	9,000	9,447.84	18,447.84	361,668.88			23,721.40		385,390.28	403,838.12
North Carolina	90,000	106,085.56	196,085.56	154,904.94	16,466.60		28,558.79		199,930.33	396,015.89
North Dakota	90,000	24,675.76	114,675.76	62,194.37	1,256.54		39,012.22	2,255.18	104,718.31	219,394.07
Ohio	90,000	93,717.64	183,717.64	1,001,687.70			236,845.83	16,085.52	1,254,619.05	1,438,336.69
Oklahoma	90,000	68,450.84	158,450.84	164,574.66	5,046.20	64,792.65	87,957.75	5,995.85	328,367.11	486,817.95
Oregon	90,000	22,790.32	112,790.32	215,725.16	11,505.22	67,469.49	57,435.72		352,135.59	464,925.91
Pennsylvania	90,000	135,322.64	225,322.64	158,784.86	39,336.29		42,679.61		240,800.76	466,123.40
Puerto Rico	50,000	53,213.24	103,213.24	178,880.07			11,559.58		190,439.65	293,652.89
Rhode Island	90,000	2,449.04	92,449.04				9,286.52		9,286.52	101,735.56
South Carolina	90,000	59,464.96	149,464.96	112,480.00			159,763.11		272,243.11	421,708.07
South Dakota	90,000	24,432.44	114,432.44	27,760.00	8,069.65		62,372.32		98,201.97	212,634.41
Tennessee	90,000	77,136.04	167,136.04	107,595.34			49,807.86		157,403.20	324,539.24
Texas	90,000	149,364.76	239,364.76	433,004.41	10,129.06		372,249.86	47,965.48	863,348.81	1,102,713.57
Utah	90,000	10,503.68	100,503.68	40,464.28	4,478.61		17,293.81		62,236.70	162,740.38
Vermont	90,000	10,471.60	100,471.60			10,471.60			10,471.60	110,943.20
Virginia	90,000	71,144.56	161,144.56	110,175.07			16,998.30	480.00	127,653.37	288,797.93
Washington	90,000	33,254.64	123,254.64	198,324.18	2,486.84		56,937.20		257,748.22	381,002.86
West Virginia	90,000	55,859.16	145,859.16	70,610.00			55,863.45		126,473.45	272,332.61
Wisconsin	99.000	60,224.88	150,224.88	344,269.00	164,397.00		71,746.00		580,412.00	730,636.88
Wyoming	00,000	6,759.52	96,759.52	54 054.58			52,182.75		106,237.33	202,996.85
Total	4,462,500	2,463,707.08	6,926,207.08	10,527,601.80	928,805.17	514,972.32	3,634,083.70	133,170.92	15,738,633.91	22,664,840.99

[1] Includes unexpended balances from the previous year as follows:
Hatch—Connecticut Storrs, $0.30; Illinois, $0.79; Oklahoma, $8.46; Rhode Island, $30.69.
Adams—Delaware, $92.85; Hawaii, $419.56; Puerto Rico, $10.25; Vermont, $401.64.
Purnell—Delaware, $824.74; Puerto Rico, $2,177.36; Rhode Island, $293.68.
Bankhead-Jones—Connecticut Storrs, $2.15; Puerto Rico, $211.36.

[2] 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; $2,500 for Alaska; $37,500 for Hawaii; and $20,000 for Puerto Rico.

TABLE 3.—*Expenditures and appropriations under the Hatch Act (Mar. 2, 1887)*[1] *for the year ended June 30, 1942*

Station	Expenditures													Unexpended	Appropriation
	Personal services	Supplies and materials	Communication service	Travel	Transportation of things	Publications	Heat, light, water, power, and fuel	Contingent	Employer contributions to retirement	Equipment	Land	Structures and nonstructural improvements	Total		
Alabama	$12,623.30	$1,053.73	$357.50	$18.24	$43.51	$121.20	$100.84	$44.77		$636.91			$15,000.00		$15,000
Alaska	10,889.35	959.67	46.16	543.05	34.66		1,400.70			1,123.50		$2.91	15,000.00		15,000
Arizona	14,041.84	235.22	5.27	256.72	.88					460.07			15,000.00		15,000
Arkansas	9,755.67	1,897.47	172.52	593.47		935.93	24.99		$228.72	1,201.73		189.50	15,000.00		15,000
California	15,000.00												15,000.00		15,000
Colorado	14,827.05								172.95				15,000.00		15,000
Connecticut:															
State	7,470.00	28.68	1.32										7,500.00		7,500
Storrs	3,365.95	2,221.36	74.86	572.44	20.82		122.70			1,101.30		20.27	7,499.70	$0.30	7,500
Delaware	9,639.52	860.87	957.68	557.70	23.65	1,569.98	41.33	9.20		1,340.07			15,000.00		15,000
Florida	15,000.00												15,000.00		15,000
Georgia	9,685.16	1,123.73	277.69	807.24	10.67	1,135.14	847.17	122.04		840.34		150.82	15,000.00		15,000
Hawaii	11,782.82	946.79	10.30			581.43	280.41	5.00		1,393.25			15,000.00		15,000
Idaho	9,969.35	1,075.16	1,361.88	1,374.57	12.03	1,074.69				132.32			15,000.00		15,000
Illinois	14,614.56								384.65				14,999.21	.79	15,000
Indiana	15,000.00												15,000.00		15,000
Iowa	15,000.00												15,000.00		15,000
Kansas	14,224.51	157.23	42.60	275.30		29.34	13.77			257.25			15,000.00		15,000
Kentucky	13,162.55	694.73		398.38	.45	717.26		26.63					15,000.00		15,000
Louisiana	12,440.38	764.14	43.97	240.68	3.72	752.33	26.35	110.39		604.64		13.40	15,000.00		15,000
Maine	10,719.40	970.46	538.30	628.17	123.29	29.82	944.41	27.91		1,018.24			15,000.00		15,000
Maryland	12,717.62	1,275.96	73.69	383.05			281.81			229.37		38.50	15,000.00		15,000
Massachusetts	1,260.00	12,889.81		232.49						617.70			15,000.00		15,000
Michigan	15,000.00												15,000.00		15,000
Minnesota	11,459.53	671.54		187.13	.80	1,162.07			338.93	1,180.00			15,000.00		15,000

Mississippi	9,766.78	667.00	395.12	910.29	84.43	2,068.92	211.05	43.80		589.72		262.89	15,000.00		15,000
Missouri	14,579.75								420.25				15,000.00		15,000
Montana	11,579.39	1,023.41	307.47	304.05	30.93	511.95	683.11			399.82		159.87	15,000.00		15,000
Nebraska	15,000.00												15,000.00		15,000
Nevada	9,547.63	3,333.73	541.53	82.04	70.16		372.27	4.78		880.63		167.23	15,000.00		15,000
New Hampshire	10,368.78	605.09	459.80	658.66	335.61	361.04	700.00	5.00		1,330.98		175.04	15,000.00		15,000
New Jersey	12,198.10	497.78	99.00	548.44		247.68	19.80	18.00		1,358.47		12.73	15,000.00		15,000
New Mexico	12,340.19	591.78	24.89	223.31	31.25	1,343.30	7.55	190.58		247.15			15,000.00		15,000
New York:															
Cornell	10,940.84	1,024.33	7.65	252.50						1,274.68			13,500.00		13,500
State	1,050.00	275.29		133.71						41.00			1,500.00		1,500
North Carolina	11,150.00	618.86	265.92	914.91	.85	1,511.81				537.65			15,000.00		15,000
North Dakota	12,390.65	639.29	35.00	153.11	.67	375.96				836.88		568.44	15,000.00		15,000
Ohio	7,532.64	4,348.39	118.91	292.62	242.23	798.00	62.54			1,604.67			15,000.00		15,000
Oklahoma	9,321.75	2,451.81	20.30	910.32	44.18	850.90	28.25			1,364.03			14,991.54	8.46	15,000
Oregon	13,254.56	92.19	48.02	183.03		934.64				487.56			15,000.00		15,000
Pennsylvania	12,378.25	223.14			.71	1,992.01	15.78			390.11			15,000.00		15,000
Puerto Rico	11,108.54	1,065.34	202.21	284.12						2,339.79			15,000.00		15,000
Rhode Island	11,541.54	1,175.47	339.18	323.85	10.60	661.35	83.39	23.59		389.17		391.17	14,939.31	60.69	15,000
South Carolina	10,930.83	1,434.46	316.20	355.49	2.64	698.80	1.25		88.01	1,168.43		3.89	15,000.00		15,000
South Dakota	10,542.13	1,829.29	71.36	502.49	17.79	1,434.56				602.38			15,000.00		15,000
Tennessee	11,892.85	621.72	363.74	127.89	97.92	1,064.56	41.63	10.29		779.40			15,000.00		15,000
Texas	12,962.34	765.83		841.51						430.32			15,000.00		15,000
Utah	12,568.79	2,032.17	4.50	42.00	29.60		10.00			312.94			15,000.00		15,000
Vermont	5,357.58	838.12	543.17	495.94	25.30	3,368.39	2,872.02	3.60		1,027.22		468.66	15,000.00		15,000
Virginia	12,751.40	807.66	53.42	32.49		367.95	14.00			379.90		593.18	15,000.00		15,000
Washington	12,798.52	401.43	3.27	925.97		396.54			156.84	278.33		39.10	15,000.00		15,000
West Virginia	13,069.95	689.23	77.00	342.91	103.79	230.89	3.15	1.54		463.27		18.27	15,000.00		15,000
Wisconsin	14,464.90	151.40	.91	365.02		12.37				5.40			15,000.00		15,000
Wyoming	9,963.00	2,247.68	127.75	211.99	220.96	577.27	391.89	.75		1,258.71			15,000.00		15,000
Total	603,000.24	58,278.44	8,390.06	17,487.29	1,624.10	27,918.08	9,602.16	647.87	1,790.35	32,915.30		3,275.87	764,929.76	70.24	765,000

[1] Extended to Hawaii by act of May 16, 1928; to Alaska by act of Feb. 23, 1929; and to Puerto 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, 1942*

Station	Expenditures											Total	Unexpended	Appropriation
	Personal services	Supplies and materials	Communication services	Travel	Transportation of things	Heat, light, water, power, and fuel	Contingent	Employer contributions to retirement	Equipment	Land	Structures and nonstructural improvements			
Alabama	$11,452.73	$1,659.30	$21.13	$339.19	$31.02	$540.45			$927.71	$7.50	$20.97	$15,000.00		$15,000
Alaska	5,625.24	1,790.01							84.75			7,500.00		7,500
Arizona	12,307.79	844.52	21.31	1,256.26	37.70		$3.07		413.43		115.92	15,000.00		15,000
Arkansas	11,629.00	1,736.28	6.00	288.82	21.60	187.25	1.20	$483.36	634.43		12.06	15,000.00		15,000
California	15,000.00											15,000.00		15,000
Colorado	13,413.16	415.64	2.90	37.49		74.28	.34	549.27	501.42		5.50	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	12,604.09	1,023.06	9.75	576.17	11.70	97.52			559.86	25.00		14,907.15	$92.85	15,000
Florida	15,000.00											15,000.00		15,000
Georgia	12,090.49	2,019.97	1.47	17.25	13.70	24.73			789.85		42.54	15,000.00		15,000
Hawaii	13,453.67	686.30			6.53				433.94			14,580.44	419.56	15,000
Idaho	13,598.35	1,016.34		55.31	10.51		4.00		297.49		18.00	15,000.00		15,000
Illinois	14,636.51							363.49				15,000.00		15,000
Indiana	14,410.53	536.05	25.39	23.34	4.69							15,000.00		15,000
Iowa	15,000.00											15,000.00		15,000
Kansas	13,956.18	855.87		150.00	14.44				23.51			15,000.00		15,000
Kentucky	14,618.55	337.10			4.35		40.00					15,000.00		15,000
Louisiana	13,102.81	1,295.62	9.30	436.72	17.80	1.11	2.55		132.69		1.40	15,000.00		15,000
Maine	12,777.27	1,291.14	.10	189.89	.78	183.82			506.30		50.70	15,000.00		15,000
Maryland	11,956.66	2,233.25	37.16			22.07			519.40		231.46	15,000.00		15,000
Massachusetts	15,000.00											15,000.00		15,000
Michigan	15,000.00											15,000.00		15,000
Minnesota	14,043.24	370.82						444.94	41.00		100.00	15,000.00		15,000

Mississippi	12,297.39	1,430.68	19.99	10.94	44.04	630.35			566.61			15,000.00		15,000
Missouri	10,764.05	3,150.25	69.63	9.24	61.81	63.35		154.10	625.16		102.41	15,000.00		15,000
Montana	13,652.98	320.02	2.70	828.34	5.09				190.87			15,000.00		15,000
Nebraska	15,000.00											15,000.00		15,000
Nevada	12,609.50	2,221.64	12.35	70.11	5.00				81.40			15,000.00		15,000
New Hampshire	13,159.63	899.31	14.55	127.25	9.72	1.76			738.37		49.41	15,000.00		15,000
New Jersey	12,013.40	1,377.93		6.00		684.77	10.49		867.06		40.35	15,000.00		15,000
New Mexico	12,398.84	1,383.87	5.51	224.38	101.44	225.88	160.57		483.74		15.77	15,000.00		15,000
New York:														
Cornell	11,989.52	940.19							570.29			13,500.00		13,500
State	1,500.00											1,500.00		1,500
North Carolina	12,942.23	624.10	26.95	458.93	.28	1.00			694.16		252.35	15,000.00		15,000
North Dakota	13,206.57	920.72	13.25		2.00		2.75		755.61		99.10	15,000.00		15,000
Ohio	12,407.07	2,199.02		35.73	19.92				338.26			15,000.00		15,000
Oklahoma	10,670.24	2,156.55			4.39				1,945.27		223.55	15,000.00		15,000
Oregon	12,670.91	1,151.46	25.78	512.01	25.25	2.00	1.32		611.27			15,000.00		15,000
Pennsylvania	15,000.00											15,000.00		15,000
Puerto Rico	11,919.45	1,327.71	7.05	417.64	16.00	23.93			1,277.97			14,989.75	10.25	15,000
Rhode Island	14,872.50	64.47	7.16	32.45					16.64		6.78	15,000.00		15,000
South Carolina	12,525.96	681.21	202.53	422.31	2.87	377.22		115.40	326.97	37.00	308.53	15,000.00		15,000
South Dakota	10,778.27	2,275.81	40.38	677.94	84.48	34.68			1,064.87		43.57	15,000.00		15,000
Tennessee	13,807.88	533.54	5.75	231.30	12.85	16.28			166.61	27.50	198.29	15,000.00		15,000
Texas	14,905.00	93.80	1.20									15,000.00		15,000
Utah	13,167.17	1,317.88	2.91	173.09	12.26				97.01		229.68	15,000.00		15,000
Vermont	13,709.63	357.02	7.52	56.23	2.15	11.75			443.48		10.58	14,598.36	401.64	15,000
Virginia	12,618.38	2,124.83	10.29	168.74					77.76			15,000.00		15,000
Washington	13,489.53	748.94	2.55	313.89				181.50	263.59			15,000.00		15,000
West Virginia	13,459.15	719.79		133.48	3.58		8.75		628.13		47.12	15,000.00		15,000
Wisconsin	14,759.94	240.06										15,000.00		15,000
Wyoming	13,307.85	999.31	27.75	118.74	16.36	4.83	5.31		434.74		85.11	15,000.00		15,000
Total	671,279.31	48,371.38	640.31	8,399.18	604.31	3,209.03	240.35	2,292.06	19,131.62	97.00	2,311.15	756,575.70	924.30	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, 1942*

Station	Expenditures													Unexpended	Appropriation
	Personal services	Supplies and materials	Communication service	Travel	Transportation of things	Publications	Heat, light, water, power, and fuel	Contingent	Employer contributions to retirement	Equipment	Land	Structures and nonstructural improvements	Total		
Alabama	$49,172.98	$5,407.01	$80.81	$433.80	$110.79	$576.78	$1,791.27	$32.05		$2,366.46		$28.05	$60,000.00		$60,000
Alaska	2,020.88	434.12								45.00			2,500.00		2,500
Arizona	46,221.41	6,201.81	70.73	2,503.24	193.77	1,104.97	604.43	6.62		2,579.08	$90.00	423.94	60,000.00		60,000
Arkansas	48,530.96	3,888.61	172.36	1,359.08		1,581.22	557.12	1.20	$999.18	2,884.04	25.00	1.23	60,000.00		60,000
California	60,000.00												60,000.00		60,000
Colorado	48,085.85	2,699.76	101.06	2,429.92	87.13	38.36	233.64	11.60	860.23	5,413.46		38.99	60,000.00		60,000
Connecticut:															
State	27,031.50	1,623.61	7.19	115.04	3.04	38.30	79.11	16.77		411.53		673.91	30,000.00		30,000
Storrs	27,031.51	1,774.38	68.72	369.25	28.17	33.59	6.55			497.86		189.97	30,000.00		30,000
Delaware	44,043.53	5,896.90	14.40	2,255.27	61.12	3,137.68	293.24	28.80		3,078.86	254.16	111.30	59,175.26	$824.74	60,000
Florida	52,009.18	3,491.24	1.68	1,995.88	14.82	743.26	23.20			1,665.69		55.05	60,000.00		60,000
Georgia	36,449.33	12,832.89	110.18	1,924.70	164.37	2,002.00	1,404.00	15.70		4,895.94		200.89	60,000.00		60,000
Hawaii	35,987.19	953.55					1.50			557.76			37,500.00		37,500
Idaho	50,507.65	3,772.70	147.87	2,780.64	251.52		50.39	.90		2,291.76	100.00	96.57	60,000.00		60,000
Illinois	48,485.49	2,039.43	60.92	1,774.39	9.21	2,292.67			644.98	4,692.91			60,000.00		60,000
Indiana	53,513.52	1,727.85	387.38	2,888.67	29.83		75.96	10.00		1,346.79		20.00	60,000.00		60,000
Iowa	59,763.13									236.87			60,000.00		60,000
Kansas	54,979.04	2,474.15		554.37	41.60	132.74				1,809.10	9.00		60,000.00		60,000
Kentucky	52,244.70	982.40	94.18	2,753.38	31.05	2,733.06	379.81			781.42			60,000.00		60,000
Louisiana	50,376.53	3,874.21	30.50	2,641.65	107.30	256.59	43.55	134.48		3,042.12		93.07	60,000.00		60,000
Maine	49,800.35	3,617.48		1,842.54	30.68	321.75	814.30	.91		3,505.82	10.00	56.17	60,000.00		60,000
Maryland	47,287.08	4,876.13	227.02	1,647.36	430.87	1,253.81	268.58			2,696.34	79.00	1,233.81	60,000.00		60,000
Massachusetts	54,945.38	1,924.66	7.92	879.34	2.25	919.52				1,320.93			60,000.00		60,000
Michigan	51,083.80	4,430.32	2.70	1,603.90	27.40	2,305.32	51.60	35.80		459.16			60,000.00		60,000
Minnesota	50,696.56	4,119.04	65.75	1,456.30	379.78	465.23		53.35	726.10	2,034.91		2.98	60,000.00		60,000

Mississippi	41,087.51	6,407.03	445.08	1,006.85	381.53	1,845.70	2,311.33	158.15		6,119.12		237.70	60,000.00		60,000
Missouri	40,236.79	9,834.66	122.88	3,230.36	154.88	694.27	79.55		516.24	4,180.19		950.18	60,000.00		60,000
Montana	54,020.97	2,411.06	10.94	1,009.31	8.66	254.66	38.94	5.48		1,644.27		595.71	60,000.00		60,000
Nebraska	47,281.06	5,713.47	131.93	1,265.63	4.42	1,938.46				3,423.98		241.05	60,000.00		60,000
Nevada	48,275.27	6,937.98	561.17	2,009.66	54.06	226.21	362.07			1,085.01		488.57	60,000.00		60,000
New Hampshire	50,475.84	3,288.81	34.27	1,154.88	82.50	1,470.12	2.48	12.65		1,527.48	266.00	1,684.97	60,0000.00		60,000
New Jersey	49,839.39	4,139.05	73.90	784.46		465.33	337.68	28.01		3,806.81		525.37	60,000.00		60,000
New Mexico	42,901.00	5,554.38	240.50	3,251.86	365.84	1,683.12	290.74	371.31		4,754.18	212.50	374.57	60,000.00		60,000
New York:															
Cornell	41,846.95	2,681.89	97.10	945.24	6.37	3.00	9.30	4.55		8,387.09		18.51	54,000.00		54,000
State	5,850.00	129.38		20.62									6,000.00		6,000
North Carolina	43,193.28	5,849.03	403.97	4,239.47	22.17	1,382.79	349.68	673.40		3,745.84		140.37	60,000.00		60,000
North Dakota	46,837.35	5,677.34	91.93	1,185.93	21.55	1,229.01	168.13			3,788.24		1,000.52	60,000.00		60,000
Ohio	45,606.00	7,572.61		706.57	7.80	23.87	498.59			5,584.56			60,000.00		60,000
Oklahoma	43,167.20	10,615.37	14.36	865.00	41.38	869.36		19.20		3,680.20		727.93	60,000.00		60,000
Oregon	49,554.16	3,466.03	595.75	1,787.88	43.77	485.52	98.72	62.17		3,854.35	46.65	5.00	60,000.00		60,000
Pennsylvania	50,549.12	3,551.31	129.84	1,777.05	58.31		197.83			2,486.54	1,250.00		60,000.00		60,000
Puerto Rico	15,643.66	909.07		1,269.91									17,822.64	2,177.36	20,000
Rhode Island	45,676.06	7,859.18	1.00	317.96	6.36	747.93	1,377.82	7.35		3,357.15		355.51	59,706.32	293.68	60,000
South Carolina	47,913.70	4,913.62	564.04	1,047.13	39.31	1,412.60	520.84	20.08	419.84	2,518.17		630.67	60,000.00		60,000
South Dakota	48,248.46	3,884.13	510.23	1,401.53	87.30	2,277.74	12.43			3,039.58		538.60	60,000.00		60,000
Tennessee	53,098.77	2,194.92	59.42	815.90	75.04	230.42	298.74			2,690.67	20.00	516.12	60,000.00		60,000
Texas	54,439.06	2,096.39	216.50	1,386.24	26.46		118.62	35.63		1,664.59		16.51	60,000.00		60,000
Utah	53,153.84	2,217.23	11.59	832.22	78.82		36.90	66.50		2,411.98	765.00	425.92	60,000.00		60,000
Vermont	50,638.52	3,683.83	60.82	2,033.65	5.60	557.64	29.53	7.81		1,773.71	35.00	1,173.89	60,000.00		60,000
Virginia	49,548.96	1,957.28	13.92	1,343.81	1.08	4,390.29	17.01			2,339.57		388.08	60,000.00		60,000
Washington	50,205.46	2,673.25	173.04	1,165.50		2,292.01		4.76	472.97	3,013.01			60,000.00		60,000
West Virginia	47,865.92	6,218.12	72.75	1,743.11	220.52	758.90	100.14	3.01		2,838.11		179.42	60,000.00		60,000
Wisconsin	57,518.76	1,229.37	.75	687.39	9.35	22.88	140.15			391.35			60,000.00		60,000
Wyoming	46,731.24	9,001.40	35.80	1,704.19	146.53	384.43	21.39	11.27		1,816.10		147.65	60,000.00		60,000
Total	2,421,671.85	211,709.44	6,324.85	74,598.03	3,954.31	45,583.11	14,096.86	1,839.51	4,639.54	134,535.66	3,162.31	14,588.75	2,936,704.22	3,295.78	2,940,000

[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, 1942*

Station	Expenditures													Unexpended	Appropriation
	Personal services	Supplies and materials	Communication service	Travel	Transportation of things	Publications	Heat, light, water, power and fuel	Contingent	Employer contributions to retirement	Equipment	Land	Structures and nonstructural improvements	Total		
Alabama	$59,493.06	$10,950.78	$136.81	$2,344.33	$318.50	$1,280.95	$1,916.05	$9.12		$4,329.41		$1,916.11	$82,695.12		$82,695.12
Alaska	1,689.90	554.34								8.20			2,252.44		2,252.44
Arizona	10,631.71	141.87	125.46	1,343.76	7.67	559.22	25.64			306.30	$100.00	43.53	13,285.16		13,285.16
Arkansas	48,375.43	6,141.75	80.82	1,915.56	300.90	1,456.57	344.47		$880.22	4,114.06		373.42	63,983.20		63,983.20
California	81,893.64												81,893.64		81,893.64
Colorado	18,819.31	886.96	48.09	665.54	.60		110.47		201.50	1,642.47		56.02	22,430.96		22,430.96
Connecticut:															
State	9,955.64	612.54		42.40	1.06	19.01	21.00			562.96		39.05	11,253.66		11,253.66
Storrs	9,109.64	1,033.67	12.62	43.47	4.12	4.28				1,043.71			11,251.51	$2.15	11,253.66
Delaware	3,809.92	821.75			.78		59.25			9.01		489.25	5,189.96		5,189.96
Florida	23,307.17	5,858.20		883.75	255.55		536.85	1.75		2,286.65		1,652.24	34,782.16		34,782.16
Georgia	54,937.94	11,615.87	393.13	2,519.05	285.70	778.31	2,447.13	99.31		9,141.93	3,180.00	2,124.55	87,522.92		87,522.92
Hawaii	7,810.80	1,320.60										55.00	9,186.40		9,186.40
Idaho	10,325.09	1,690.09	2.60	881.89	25.60	23.50	11.79	2.60		1,009.18	240.00	7.50	14,219.84		14,219.84
Illinois	63,831.25	6,149.54	56.18	3,232.68	193.51	168.18	585.82		942.26	10,876.11	180.00	470.99	86,736.52		86,736.52
Indiana	47,449.91	7,588.53	17.68	2,486.90	91.00	.30	35.96			4,529.70	121.00	579.46	62,900.44		62,900.44
Iowa	58,678.58	5,476.23			1.38					698.45			64,854.64		64,854.64
Kansas	41,342.62	5,466.70		1,092.76	144.50	59.11				1,848.40		96.87	50,050.96		50,050.96
Kentucky	71,829.91	7,092.35	.60	747.21	58.05	1,405.25		119.87		230.08			81,533.32		81,533.32
Louisiana	43,469.55	5,632.36	32.38	1,714.10	119.38	112.11	228.17	103.93		4,704.79		386.03	56,502.80		56,502.80
Maine	17,547.54	802.09	2.93	956.14	1.71	2.84				1,313.91	65.00		20,692.16		20,692.16
Maryland	22,739.63	3,494.62	57.70	546.87	10.62	511.47	12.59			2,073.05	250.00	563.17	30,259.72		30,259.72
Massachusetts	18,674.92												18,674.92		18,674.92
Michigan	63,366.26	5,186.80	2.26	917.31	41.87	31.74	39.29	108.58		3,722.99	149.50		73,566.60		73,566.60
Minnesota	43,094.11	5,800.72	32.06	2,719.08	257.22	388.05	7.15	177.69	538.77	3,861.61		392.58	57,269.04		57,269.04

Mississippi	55,001.90	5,445.69	574.91	1,387.36	178.00	1,667.97	2,781.22	7.02		5,148.48		458.85	72,651.40		72,651.40
Missouri	51,253.95	15,116.55	321.08	409.76	155.35	1,598.77	1,185.38	10.59	379.11	4,749.59		1,787.67	76,967.80		76,967.80
Montana	14,485.35	531.66		28.85				2.22		421.80		33.28	15,503.16		15,503.16
Nebraska	32,096.43	1,841.34	10.04	845.46	4.02	655.83				2,484.83		838.65	38,776.60		38,776.60
Nevada	2,312.93	112.00		287.23	15.88		6.60						2,734.64		2,734.64
New Hampshire	6,968.06	536.64	14.91	636.49	18.40	146.63				161.63		24.64	8,507.40		8,507.40
New Jersey	25,317.21	2,886.14	11.80	1,369.52	1.55	43.26	60.75			1,299.55		270.54	31,260.32		31,260.32
New Mexico	9,536.36	968.97	102.40	710.88	27.23	435.75		1.57		2,077.30	166.73	488.81	14,516.00		14,516.00
New York:															
Cornell	69,332.31	7,335.66	3.46	1,639.73	147.61	230.72		18.00		6,133.25	35.00	154.66	85,030.40		85,030.40
State	7,465.76	1,309.46	4.59	251.50		42.79	49.95			323.79			9,447.84		9,447.84
North Carolina	82,430.14	9,237.59	255.08	4,169.23	238.56		677.80	28.34		7,947.62	1,044.95	56.25	106,085.56		106,085.56
North Dakota	18,031.13	3,800.83	31.28	254.21	66.88	433.66	96.39			1,842.20		119.18	24,675.76		24,675.76
Ohio	77,534.72	7,799.12		1,299.03	67.78	21.99	579.78			3,956.33	380.00	2,078.89	93,717.64		93,717.64
Oklahoma	41,737.57	15,623.86	38.58	341.45	171.58	1,114.19	495.31			6,012.92		2,915.38	68,450.84		68,450.84
Oregon	19,950.95	594.65	33.26	1,115.06	1.98	212.22	37.50			827.00		17.70	22,790.32		22,790.32
Pennsylvania	116,748.95	9,800.61		3,372.32	153.22	1,022.98	330.42			3,763.80		130.34	135,322.64		135,322.64
Puerto Rico	36,190.01	5,198.33		617.45			262.57			9,056.68		1,676.84	53,001.88	$211.36	53,213.24
Rhode Island	2,420.68		15.12							13.24			2,449.04		2,449.04
South Carolina	43,664.92	6,114.67	226.33	455.34	60.33		1,327.70	3.85	216.92	6,908.62	32.00	454.28	59,464.96		59,464.96
South Dakota	19,583.13	3,216.84	22.71	640.73	30.18	180.30	7.20			693.17		58.18	24,432.44		24,432.44
Tennessee	55,920.03	5,357.27	130.77	1,442.72	314.10	715.92	426.55	2.95		7,921.20	141.34	4,763.19	77,136.04		77,136.04
Texas	124,795.48	12,810.13	111.96	3,593.44	101.75	4.20	94.75	18.15		7,505.26	12.50	317.14	149,364.76		149,364.76
Utah	9,658.05	334.50	15.03	287.02	27.58		12.25			144.25	25.00		10,503.68		10,503.68
Vermont	7,603.72	854.36		96.16	3.00		104.47	1.30		1,076.61	10.00	721.98	10,471.60		10,471.60
Virginia	53,444.08	8,173.13	5.51	1,998.77	17.06	527.50	411.49			2,469.51	147.50	3,950.01	71,144.56		71,144.56
Washington	25,033.13	4,541.09	15.62	1,377.02	4.00		37.87	13.60	163.75	1,477.50		591.06	33,254.64		33,254.64
West Virginia	44,829.08	4,260.34	37.25	2,497.28	161.19	439.02	217.29	7.54		3,180.58		229.59	55,859.16		55,859.16
Wisconsin	59,364.39	517.28	.99	181.36	19.50	16.75				124.61			60,224.88		60,224.88
Wyoming	5,287.26	129.84	15.00	397.71	25.00	199.80	67.95			636.96			6,759.52		6,759.52
Total	1,950,181.21	228,766.91	2,999.00	56,805.88	4,131.45	16,511.14	15,652.82	737.98	3,322.53	146,721.25	6,280.52	31,382.88	2,463,493.57	213.51	2,463,707.08

TABLE 7.—*Expenditures from non-Federal funds for the year ended June 30, 1942*

Station	Personal service	Supplies and materials	Communication service	Travel	Transportation of things	Publications	Heat, light, water, power, and fuel	Contingent	Employer contributions to retirement	Equipment	Land	Structures and nonstructural improvements	Total
Alabama	$133,063.99	$44,913.94	$1,603.45	$8,481.85	$1,777.23	$783.01	$9,381.83	$24,763.33		$20,853.15	$280.38	$10,142.58	$256,044.74
Alaska	13,765.56	3,471.95	229.86	439.43	960.27	932.33	2,355.83	1,093.79		1,721.87		1,883.22	26,854.11
Arizona	86,347.25	17,097.06	1,687.87	2,877.59	429.13	2,126.50	2,521.15	296.01		16,407.56	691.90	1,596.75	132,078.77
Arkansas	118,926.85	38,120.05	2,504.71	4,413.30	203.84	76.54	4,263.50	4,213.73	$1,523.32	29,814.84		14,653.25	218,713.93
California	844,202.11	111,119.15	15,945.70	52,604.24	4,534.90	68,429.88	36,631.22	8,437.15		50,858.37		66,345.19	1,259,107.91
Colorado	78,824.93	17,939.62	1,513.45	5,222.83	1,533.34	2,424.39	5,245.92	1,154.60	619.98	21,731.76	458.09	1,299.26	137,968.17
Connecticut:													
State	111,109.99	14,992.44	1,419.43	2,163.18	51.13	148.14	2,333.78	558.59		15,439.10	17.30	1,784.45	150,017.53
Storrs	43,898.33	8,741.84	663.29	885.49	285.89	99.73	563.57	362.71		1,581.57			57,082.42
Delaware	26,686.21	14,497.11	1,016.54	1,607.86	321.68		4,018.89			6,882.01	7,615.00	8,482.01	71,127.31
Florida	366,368.39	84,641.19	3,540.92	16,596.41	3,192.95	7,409.95	19,923.22	13,441.31		30,969.68		28,780.84	574,864.86
Georgia	51,403.00	5,016.76	948.48	4,480.59	648.07	267.32	6,698.37	2,398.40		12,321.71	3,835.00	6,728.57	94,746.27
Hawaii	74,875.32	19,556.54	1,006.65	740.71	184.91	163.72	3,536.32	5,542.64		2,724.59	674.51	898.30	109,904.21
Idaho	24,204.48	14,000.00	300.00	3,000.00	450.00	600.00	1,500.00	750.00		10,000.00	2,300.00	9,000.00	66,104.48
Illinois	369,741.61	121,050.47	8,400.00	23,800.00		16,800.00				18,202.14			557,994.22
Indiana	314,341.93	112,252.09	4,910.12	13,000.24	2,407.18	5,298.11	16,794.25	8,794.90	3,100.00	35,210.58	4,381.50	21,207.47	541,698.37
Iowa	231,454.41	83,658.79	2,740.85	11,128.86	1,234.75	20,709.12	746.88	26,533.40		19,325.65	8,000.00		405,532.71
Kansas	120,293.21	28,787.20	2,331.71	3,952.09	1,866.27	1,125.72	8,035.67	1,237.50		46,056.11	5,629.97	15,924.21	235,239.66
Kentucky	150,709.13	39,688.05	1,577.15	3,980.80	1,514.29	1,648.66	10,943.21	12,071.57		3,121.40		33,836.89	259,091.15
Louisiana	122,426.89	27,323.82	2,290.25	9,245.08	593.76	583.25	1,995.07	6,699.35		53,826.58		1,541.64	226,525.69
Maine	62,401.86	14,117.17	548.64	8,258.84	1,966.65	4,822.11	4,285.86	605.12		9,447.60	450.00	31,544.79	138,448.64
Maryland	58,472.42	34,094.85	1,257.41	3,216.84	456.31	1,248.68	2,161.59	1,074.82	7,991.00	12,553.18	264.00	760.67	123,551.77
Massachusetts	127,933.95	10,961.25	1,532.79	2,472.01	354.25	2,554.69	1,244.01	104.03		3,564.85		239.17	150,961.00
Michigan	213,198.59	32,233.39	763.44	10,425.28	985.80	19,559.19	2,791.00	3,248.06		19,089.45	651.85	4,669.22	307,615.27
Minnesota	342,857.02	64,390.40	4,046.14	8,293.51	2,701.85	5,472.09	24,445.04	9,606.96		26,741.21	448.80	11,806.55	500,809.57
Mississippi	122,886.09	19,292.78	1,483.23	7,705.72	1,266.89	2,829.70	4,642.83	3,856.08		42,635.09	100.00	6,304.08	213,002.49
Missouri	93,552.47	41,698.46	1,578.05	8,373.29	763.69	8,282.76	1,166.56	1,406.44		8,145.20	3,694.95	3,015.92	171,677.79
Montana	80,870.52	26,066.27	1,631.66	3,484.17	782.34	2,540.43	3,455.68	708.62		19,710.34	5,978.18	2,409.69	147,637.90
Nebraska	99,223.35	53,444.77	1,773.37	3,610.62	818.57	2,602.62	7,475.69	1,415.74		33,806.58		12,158.63	216,329.94
Nevada	583.91	864.49	69.00	1,235.98	134.44	539.60	396.92	822.43		6,560.36	40.00	2,755.65	14,002.78

New Hampshire	9,602.57	1,191.35	58.60	455.60	187.09	53.82				1,289.61	20.00	39.64	12,898.28
New Jersey	316,411.53	68,831.16	8,683.38	14,381.25	451.85	6,550.85	18,588.04	4,248.42	59.26	9,908.36	357.00	25,469.55	473,943.65
New Mexico	22,210.94	6,277.29	740.83	1,191.06	422.51	163.31	315,29	1,959.13		3,800.79	9,037.50	194.65	46,313.30
New York;													
Cornell	619,480.61	73,824.41	5,942.88	25,087.80	2,083.19	9,954.18	54,755.66	5,609.82		33,876.44	1,265.00	19,970.64	851,850.63
State	301,997.32	21,794.46	2,468.42	13,567.26	2,253.37	6,877.64	15,454.95	1,290.04		6,847.31	3,483.24	9,356.27	385,390.28
North Carolina	89,879.56	25,419.92	1,789,87	9,806.94	237.12	500.00	2,127.53	1,084.71		27,907.32	17,525.75	17,220.83	193,499.55
North Dakota	43,914.01	13,438.10	643,45	1,847.57	497.76	2,394.86	22,691.48	1,929.86		11,342.93		4,397.08	103,097.10
Ohio	415,061.18	94,117.67	3,641,73	8,902.03	3,866.67	34,937.21	18,169.61	3,826.33		49,342.80	27,040.32	3,305.65	662,211.20
Oklahoma	199,709.94	45,756.25	1,423.43	7,054.89	671.75	2,930.55	1,413.86	5,038.37		16,589.52	3,440.50	8,572.63	292,601.69
Oregon	237,919.75	44,625.31	3,263.45	12,061.95	1,279.13	2,443.41	7,417.29	5,719.52		27,976.92	4,093.55	5,335.31	352,135.59
Pennsylvania	160,023.42	39,619.11	1,272.90	10,465.43	18.37	2,289.88	279.33			10,532.23	1,727.28	5,040.54	231,268.49
Puerto Rico	123,249.06	13,475.14	1,251.71	1,905.53	340.37	1,941.63	5,279.28	7,155.62		15,842.13	1,913.81	10,570.66	182,924.94
Rhode Island	3,968.79	895.35	378.66	157.34	148.82	134.51	413.72	190.85		676.33		653.69	7,618.06
South Carolina	99,417.69	61,636.01	1,631.41	4,299.23	1,506.91	1,013.61	9,909.22	8,459.72	675.69	33,053.85	1,882.39	28,386.83	251,872.56
South Dakota	30,695.64	15,024.31	182.90	1,460.49	619.54	831.03	804.98	37.80		25,801.04		1,028.33	76,486.06
Tennessee	54,084.26	15,882.60	1,039.63	1,983.73	1,259.79	846.36	2,166.73	1,556.07		22,645,55	47,758.21	8,180.27	157,403.20
Texas	392,135.07	84,082.57	3,084.20	8,819.59	1,700.61	5,268.90	12,453.13	63,023.96		65,845.94	11,072,50	19,619.71	667,106.18
Utah	29,151.40	6,433.97	862.77	3,884.34	317.95	1,892.42	972,64	915.94	1,747.28	2,334.61	4,382.44	982.19	53,877.95
Vermont	9,053.25	520.37		42.11	2.69		179.41	553.30		120.47			10,471.60
Virginia	83,576.12	8,142.97	1,791.63	6,978.92	612.26	2,201.47	3,151.60	792.43	3,577.05	11,369.23	1,442.89	4,016.80	127,653.37
Washington	171,362.62	33,910.34	2,133.68	10,619.33	829.39	4,663.01	9,593.36	1,707.05	1,738.88	15,082.25	397.50	5,710.81	257,748.22
West Virginia	56,006.20	27,856.79	876.07	3,122.15	348.15	1,179.87	4,475.95	734,11		13,284.41	707.96	2,222.98	110,814.64
Wisconsin	445,486.00	81,030.00	2,212.00	8,363.00	215.00	2,328.00	3,027.00	1,597.00		25,213.00		10,941.00	580,412.00
Wyoming	36,850.48	14,656.49	775.10	1,052.19			1,794.60	400.06		2,526.81	6,562.78		64,618.51
Total	8,435,871.18	1,902,473.84	115,462.86	383,206.54	52,293.67	271,474.76	384,988.52	259,027.39	21,032.46	1,012,512.38	189,622.05	490,985.06	13,518,950.71

TABLE 8.—*Disbursements from the U. S. 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 1888–1942	Adams Act 1906–42	Purnell Act 1926–42	Bankhead-Jones Act 1936–42
Alabama	$824, 199. 34	$521, 619. 89	$920, 000. 00	$444, 486. 27
Alaska	165, 000. 00	37, 500. 00	7, 500. 00	11, 884. 18
Arizona	789, 467. 73	524, 995. 61	919, 986. 80	67, 633. 86
Arkansas	823, 127. 12	524, 900. 00	920, 000. 00	343, 909. 70
California	825, 000. 00	524, 926. 84	920, 000. 00	370, 389. 71
Colorado	824, 718. 82	523, 638. 93	920, 000. 00	120, 566. 41
Connecticut	824, 957. 68	525, 000. 00	919, 648. 85	112, 840. 66
Dakota Territory	56, 250. 00			
Delaware	823, 382. 87	521, 075. 11	916, 924. 01	27, 109. 59
Florida	824, 966. 06	524, 996. 06	916, 523. 74	169, 539. 33
Georgia	820, 593. 43	512, 092. 87	920, 000. 00	470, 435. 70
Hawaii	194, 919. 17	149, 951. 14	170, 000. 00	49, 376. 90
Idaho	749, 824. 13	520, 842. 22	920, 000. 00	74, 238. 54
Illinois	823, 114. 90	524, 718. 69	917, 264. 29	465, 816. 01
Indiana	824, 901. 19	520, 000. 00	920, 000. 00	335, 074. 35
Iowa	825, 000. 00	525, 000. 00	917, 965. 17	348, 593. 69
Kansas	824, 995. 00	525, 000. 00	920, 000. 00	269, 023. 91
Kentucky	824, 996. 57	525, 000. 00	920, 000. 00	426, 887. 24
Louisiana	825, 000. 00	525, 000. 00	920, 000. 00	297, 711. 60
Maine	824, 999. 62	525, 000. 00	920, 000. 00	111, 220. 36
Maryland	824, 967. 40	524, 236. 48	920, 000. 00	155, 168. 07
Massachusetts	824, 617. 70	525, 000. 00	919, 997. 65	98, 222. 05
Michigan	824, 676. 10	521, 341. 60	920, 000. 00	366, 550. 90
Minnesota	824, 917. 78	524, 345. 74	920, 000. 00	305, 758. 71
Mississippi	825, 000. 00	525, 000. 00	920, 000. 00	390, 501. 28
Missouri	820, 097. 24	524, 999. 90	920, 000. 00	413, 701. 92
Montana	735, 000. 00	522, 417. 04	920, 000. 00	83, 329. 49
Nebraska	824, 932. 16	525, 000. 00	919, 995. 00	208, 424. 22
Nevada	823, 331. 08	521, 145. 10	920, 000. 00	13, 499. 94
New Hampshire	824, 250. 00	525, 000. 00	920, 000. 00	45, 070. 15
New Jersey	824, 959. 97	524, 392. 06	920, 000. 00	164, 810. 87
New Mexico	789, 509. 05	525, 000. 00	920, 000. 00	74, 720. 38
New York	824, 757. 54	524, 189. 22	919, 831. 15	487, 443. 65
North Carolina	825, 000. 00	525, 000. 00	920, 000. 00	555, 083. 06
North Dakota	781, 491. 45	524, 605. 60	919, 737. 21	132, 541. 61
Ohio	825, 000. 00	523, 514. 02	920, 000. 00	500, 657. 22
Oklahoma	756, 919. 88	512, 842. 65	919, 907. 72	367, 414. 88
Oregon	810, 156. 64	520, 000. 00	920, 000. 00	111, 059. 45
Pennsylvania	824, 967. 43	524, 995. 41	920, 000. 00	724, 589. 29
Puerto Rico	119, 762. 63	108, 734. 53	81, 525. 96	258, 534. 23
Rhode Island	824, 996. 93	519, 423. 07	919, 964. 30	12, 180. 85
South Carolina	824, 541. 37	523, 360. 12	920, 000. 00	319, 624. 16
South Dakota	768, 250. 00	520, 000. 00	920, 000. 00	131, 324. 36
Tennessee	825, 000. 00	525, 000. 00	920, 000. 00	404, 315. 52
Texas	825, 000. 00	522, 592. 26	920, 000. 00	802, 835. 58
Utah	790, 000. 00	524, 821. 94	920, 000. 00	56, 457. 28
Vermont	825, 000. 00	524, 900. 00	920, 000. 00	56, 284. 85
Virginia	823, 766. 58	523, 544. 94	919, 994. 27	382, 402. 01
Washington	763, 414. 70	521, 080. 11	920, 000. 00	162, 385. 92
West Virginia	824, 804. 16	521, 263. 82	919, 942. 89	291, 292. 96
Wisconsin	825, 000. 00	525, 000. 00	920, 000. 00	323, 708. 05
Wyoming	780, 000. 00	523, 850. 59	920, 000. 00	36, 332. 42
Total	39, 553, 501. 42	25, 407, 853. 56	44, 406, 709. 01	12, 952, 963. 34

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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*, C. O. Braininen, 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 Station, Baton Rouge*, W. G. Taggart, 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, 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), A. J. Heinicke, Director; *Ithaca* (Cornell Station), C. E. F. Guterman, Director.
NORTH CAROLINA.—*State College Station, Raleigh*, L. D. Baver, 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*, F. F. Lininger, Director.
PUERTO RICO.—*Mayaguez* (Federal Station), K. H. Bartlett, Director; *Rio Piedras* (College Station), J. A. B. Nolla, Director.
RHODE ISLAND.—*Kingston*, M. H. Campbell, 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.
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WISCONSIN.—*Madison.*, C. L. Christensen, Director.
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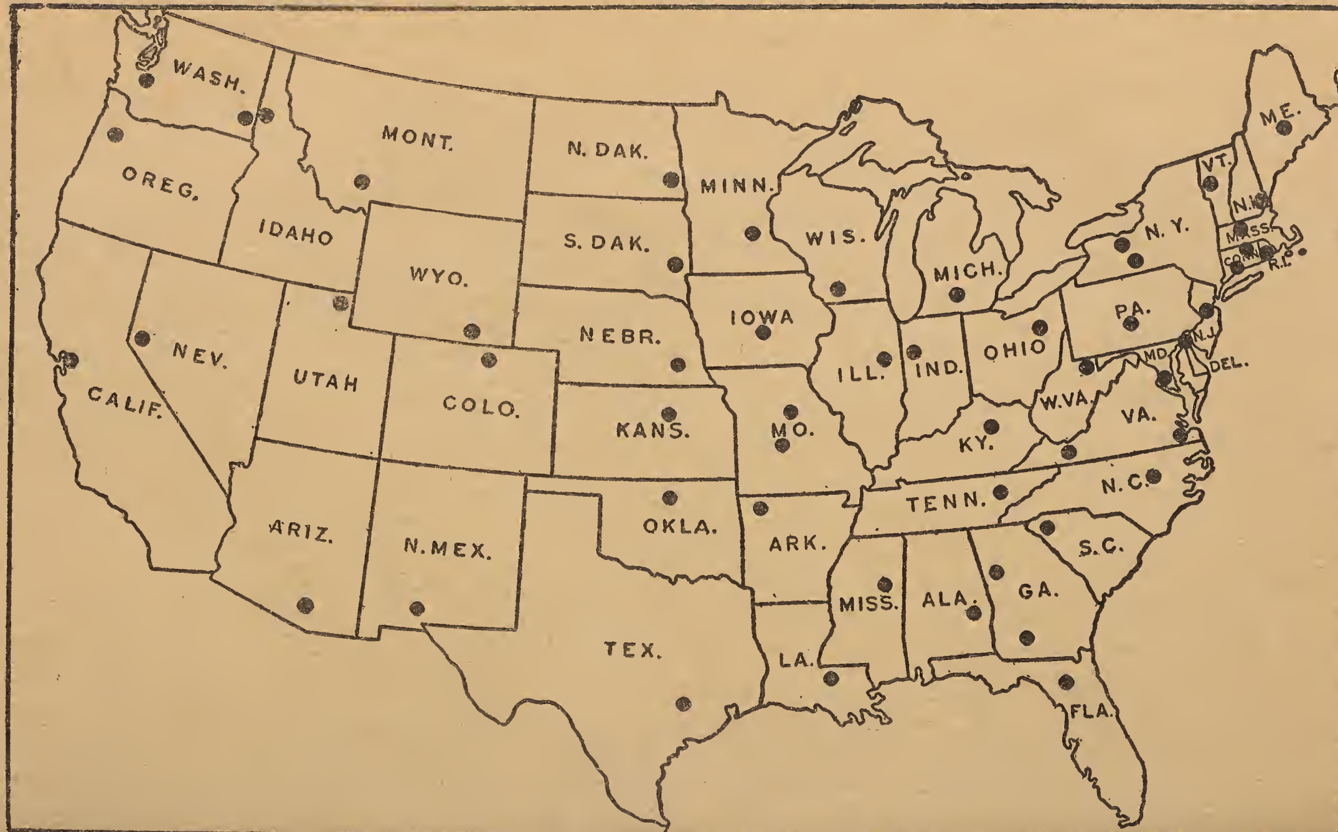
NOTE.—The full official titles, locations, and personnel of the agricultural experiment stations will be found in the list of Workers in Subjects Pertaining to Agriculture in Land-Grant Colleges and Experiment Stations, published annually by the United States Department of Agriculture.



Headquarters of State Agricultural Experiment Stations