UNITED STATES DEPARTMENT OF AGRICULTURE
AGRICULTURAL RESEARCH ADMINISTRATION

REPORT ON THE AGRICULTURAL EXPERIMENT STATIONS, 1945

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UNITED STATES DEPARTMENT OF AGRICULTURE

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Washington, D. C. January 1946

REPORT ON THE AGRICULTURAL EXPERIMENT STATIONS, 1945[1]

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HIGHLIGHTS OF THE YEAR IN STATION RESEARCH

As in previous war years, the State agricultural experiment stations in 1945 were again taxed to the limits of their resources to keep pace with the demand for facts needed to assure maximum production of agricultural products and their effective use to promote the war effort. Each of the stations developed and made available new information helpful in the solution of local problems and shared with Federal agencies in the assembling and interpretation of data on which national and regional agricultural programs were based. The continued high level of farm production achieved has been aided in no small measure by the steady output of timely research information by the stations.

Some of the progress made during the year in discovering new facts and principles or in developing applications for earlier research findings are related in this report. These and other results

[1] Submitted in accordance with the requirement that the Secretary of Agriculture shall 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, 1945.

of station work are aiding in the production of maximum yields of plant and animal products without soil depletion; the transportation, processing, and marketing of these products to best advantage; and the improvement of living conditions on the farm.

Examples are cited of research results that contribute to better understanding of soil management and use of fertilizers. Because of new information coming out of research by the stations, production of food and other agricultural supplies has been maintained at a high level and yet soil losses have been reduced and soil fertility conserved or even improved. Better knowledge of crop requirements, especially as to minor elements; methods of applying fertilizers such as in bands, liquid form, and deep placement; and new basic facts relating to physical, chemical, and biological properties of soils have provided the answers to a number of problems and helped to prevent the waste of soil resources that followed World War I.

The breeding and prompt release of new improved varieties of crop plants have helped to assure needed supplies, lowered production costs, and provided the consumer with better quality products having higher nutritive and industrial properties. In number and value the new cereals, fruits, vegetables, forage crops, and grasses developed in the past few years have exceeded any previous period in the history of agriculture. Many combine resistance to groups of diseases and some to insect pests. More of the latter are in the making. The new varieties cited in this report represent only a part of the program. They were not developed overnight. Years of plant exploration, inbreeding, crossing, selection, and testing are back of them. They stand as a tribute to the farsightedness and hard work of many scientists in the stations, the Department, and elsewhere.

New chemicals developed through research of the stations and cooperating agencies are finding use along with older materials for combating insects and diseases. Shortages of insecticides and fungicides during the war intensified the search for substitutes. Thousands of new organic chemicals were made, tested, and discarded to get a few outstanding fungicides that are finding a place in the spray or dust program of the fruit and vegetable grower. Several new insecticides besides rotenone and pyrethrum have been obtained from plant sources. They are promising results of this research effort. DDT, most promising in pest control, has been studied in a preliminary way by a number of stations, and a beginning has been made as to its possibilities and limitations.

Growth-regulating chemicals used in stimulating the rooting of cuttings, then in delaying drop of orchard fruits, and increasing fruit set of tomatoes are the subject of a considerable volume of research by the stations as to dosage, methods of application, and other possible uses.

Likewise, great advances have been made in the use of chemicals for weed control. Hand weeding of acres of carrots and onions is slow, laborious, and costly. The new selective sprays that kill the weeds and spare the crops are proving their worth and promise to save many times the costs of the research that led to

their development. Better pastures as well as better lawns are in prospect because of these new weed killers, and there is promise that sprays for destroying weeds in orchards to conserve moisture at critical periods may prove cheaper than cultivation.

Station research related to animal production has provided important new information leading to better practices in the breeding, feeding, and management of livestock. The continuing high demands for meat, milk, and eggs has placed great value on getting best results from all available feeds. The stations have responded with facts showing how greater returns may be secured from pastures and ranges, how to prepare and use silage and hay crops, how to use concentrates more efficiently, and ways of providing essential vitamins and minerals. Examples of station aids to better feeding practices are cited later in this report.

Progress of the year in maintaining health of farm animals has been achieved by discovery of new information that helps to prevent losses from diseases and parasites and new findings relative to poisonous plants. Advances have been made in breeding for disease resistance, especially with poultry. The antibiotics, notably penicillin and streptomycin, show promise for the treatment of certain diseases of animals caused by bacteria. Much additional research is needed before the full possibilities of these and similar substances are known. Newly acquired knowledge of the use of sulfa drugs and phenothiazine is proving helpful. Important findings have also been made in the development and use of vaccines and in determining causes of hitherto unexplained diseases.

In anticipation of a widespread postwar demand for additional facts relating to the freezing preservation of foods, the stations have already acquired much new information on processing methods, varieties best adapted for home and commercial uses, and new products. The research that contributed so effectively to the dehydration of food during the war is continuing on a modified scale to help determine peacetime applications. Practically all of the State stations have participated in the release of new findings concerning the nutritive properties of some 75 different kinds of foods largely as a result of teamwork under the National Cooperative Project on Conservation of the Nutritive Values of Food. These results point the way to better health through better eating.

The economic and social studies of the stations during the war years were directed largely to the assembling of information needed in formulating and carrying out broad national programs, including the attainment of agricultural production goals and the evaluation of the total productive capacity of American farms. A large amount of useful data were obtained and applied in helping to meet farm labor shortages, determine prices of farm products, and solve transportation and marketing problems. The information acquired is finding uses in the transition period and will serve well in the adjustment of agriculture to postwar.

Many of the research results presented in this report were the products of cooperation between the stations and the Department or of research projects conducted cooperatively among the sta-

tions. Many man-hours of technical workers were saved through this cooperation. Costs of facilities, such as equipment and land, were reduced because of dual use, and results were speeded up.

During the year station directors and technical workers were active as never before in planning and carrying on cooperative research in problems of common concern to groups of States. The experiment stations of the north-central region and the Department, for example, continued to make effective progress in cooperative marketing studies. Joint publications were issued. The experiment stations of the northeastern, southern, and western regions were also planning and carrying out joint attacks on specific problems that cross State lines in these regions. At this time the stations in the cotton States are giving major attention to problems of the cotton industry and extensive new research programs are under way or planned in cooperation with the Department and other agencies.

The National cooperative research projects discussed in earlier reports were continued and yielded much useful information. Results of the survey of the vitamin A content of butter made by the Bureau of Dairy Industry and the Office of Experiment Stations in cooperation with 19 State agricultural experiment stations were published. Details are given later in this report. Findings under the National Cooperative Project on Conservation of Nutritive Values of Food are likewise reported in detail under the section on foods and nutrition.

The volume of cooperative research in progress during the year is reflected in part by the fact that 1,151 formal memoranda of understanding were in effect during the year as a basis for cooperation between the stations and the Department. Much inter-State cooperation was in effect. In the 12 Northeastern States, for example, the stations were cooperating in research on 37 different subjects, with 142 instances of participation by individual stations. This was in addition to the research carried on by these stations in cooperation with the Department and with experiment stations outside the region.

Statistical information relating to income and expenditures of the stations during the year is presented in a special section of this report, together with data relating to personnel and publications. Research under the Federal grants was carried out under a total of 3,434 projects supported by Adams, Purnell, and Bankhead-Jones funds, of which 516 were new and 134 revised during the year. Including the funds from non-Federal sources the research programs of the 53 State experiment stations receiving Federal-grant funds embraced 8,195 projects, of which 4,761 were supported wholly from non-Federal sources.

EXAMPLES OF RESEARCH RESULTS

Some 150 examples of research results of the State agricultural experiment stations were selected in agreement with the directors for use in advance of the publication of this report. They were chosen as representing new discoveries of significance or results that reached practical farm application during the year. These examples are shown at the beginning of the subject-matter

section to which they relate. Many additional results of like merit are cited in the reports that follow these examples.

INCREASING SOIL PRODUCTIVITY

EXAMPLES OF RESEARCH RESULTS

Phosphate fertilizer applications may be greatly reduced or omitted entirely for a few years without lowering yield or quality of the potato crop in many Long Island fields, according to investigations of the New York (Cornell) station. Applications of mixed fertilizer over a number of years had resulted in such an accumulation of phosphate that little or no additional amounts were required for maximum yields. Similarly, the Maine station reported high residual phosphorus in Aroostook County fields, where frequent and heavy applications of fertilizer had been made. As a result, the phosphorus content of potato fertilizers in Maine has been reduced about 25 percent, effecting appreciable savings to growers. These findings were a part of a cooperative study by the New York (Cornell), Maine, New Jersey, Maryland, and North Carolina stations and the Department. A committee of soil scientists from the cooperating agencies developed uniform methods of soil analysis as a basis for the work.

Building soil fertility, particularly phosphate which is largely retained by the soil, during the present period of good prices is a sound investment, according to results reported by the Kentucky station. On limed plots on a soil not well supplied with phosphate, an application of 300 pounds of 16-percent superphosphate to the acre in a rotation of corn, wheat, and mixed grass and hay brought an increase of 14 bushels of corn to the acre, 6 bushels of wheat, and nearly a half ton of hay. Where 600 pounds were used, corn yields were increased 27.5 bushels, wheat nearly 8 bushels, and hay almost a ton. Most of the increase was produced by the phosphate, as the soil was not badly in need of lime.

Phosphate gives greater crop returns when applied with barn manure, according to Vermont station investigations. In soils that tend to fix phosphate and make it unavailable for plants, availability for most crops is increased when the phosphate is applied to the soil with manure instead of applying the two separately. The manure absorbs the phosphate and keeps it in a form plants can use.

Corn grown in rotation with soybeans and cotton and side-dressed with 200 pounds of nitrate of soda per acre by the Louisiana station produced 8.9 bushels more per acre, at a cost of about 42 cents per bushel, than with no nitrogen. The cotton in the rotation received 600 pounds per acre of a 6–8–4 fertilizer. Where corn and soybeans had been grown continuously, an annual application of 300 pounds per acre of a 6–8–4 fertilizer produced an average of 41.2 bushels per acre at a cost of fertilizer materials of about 27 cents per bushel of corn.

Deficiencies of the minor elements have limited crop yields in many areas. Findings of the stations that small additions to the soil of such elements as boron, magnesium, manganese, zinc, and copper result in large yield increases are leading to general use by

farmers of the needed element in particular areas. Thus, Vermont farmers are beginning to apply boron widely over the State. One community used a carload, or enough to treat 50,000 acres. The studies of the Vermont station extending over a dozen or more years and covering tests of 46 soils to a 3-foot depth have shown that small amounts of boron greatly increase production and quality of a number of crops, including alfalfa, apples, potatoes, clover, sweet corn, tomatoes, cabbage, lettuce, beets, beans, and turnips. For example, 40 pounds of borax gave 3 more tons of alfalfa hay during a 3-year period. The borax cost $1.20, the extra hay was worth $36. Vermont fruit growers are using it to prevent internal cork in apples.

Borax applied with rather high amounts of potash in addition to normal applications of phosphate and lime, according to recent experiments by the Alabama station, will insure successful growth of alfalfa on lands formerly considered unsuitable to this crop. Yields of 3 to 5 tons of alfalfa hay per acre are being produced on such soils. Farmers have materially increased their alfalfa acreage because of these results of station research.

Conservation farming pays in increased wheat yields in the Great Plains area of Texas, according to results of cooperative experiments of the Texas station and the Department. Terracing and contour farming gave consistent yield increases of wheat, averaging 2.99 bushels per acre, partly because of greater accumulation of soil moisture and partly because of more efficient utilization of rainfall during the crop-growing season. The total effect of terraces as measured in the experiment was to increase the yield 2.15 bushels of wheat per acre and that of contour farming 0.84 bushel.

More vegetation and 30 to 50 percent greater sheep gains were obtained on range land treated with an eccentric one-way disk plow in tests of the Wyoming station and the Department. The machine gouges out pits about 18 inches long, 16 inches apart, and 3 inches deep, giving the treated range a waffled appearance. This renovation cultivates and stimulates the plants, and the depressions catch and retain water during each heavy rainfall. Benefits are greatest on hard land with dense, short-grass cover, although waffling has been profitable on areas with high percentages of western wheatgrass and needle-and-thread grass.

Plowing to turn under vegetation and clean cultivation to destroy weeds are long-established practices in South Carolina as in other States. The South Carolina station in cooperation with the Department obtained higher yields of corn by a system of mulch culture that left residues from winter cover crops on the surface of the land. Oats planted directly in lespedeza stubble, using a deep furrow drill with no ground preparation gave as good yields as where the stubble was disked thoroughly and the oats seeded with an ordinary grain drill. The mulch culture methods saved labor and gave much better control of erosion.

Crop residues left on the soil surface greatly reduced soil and water losses in experiments by the Nebraska station and the Department. Cornland plowed to turn under residues lost 16.8 tons of soil per acre by erosion, whereas land subtilled with resi-

dues left on the surface lost only 1.8 tons. Rotary treaders proved effective in preparing the seedbed, when used with subsurface tillers, and destroyed many weeds.

The effect of a preceding crop on the growth or yield when certain crops follow each other in rotation has been shown by the California station to be caused in large part by the effect of residue from the preceding crop on the soil flora and thus on the nitrogen cycle. This phenomenon is apparently closely related to enzyme activity.

Lack of farm manure for spreading on land has been an important contributing factor to the decline of many soils and to increased soil erosion in recent years, according to the New Jersey station. In experiments by the station good-quality artificial manure, comparable to composted cow manure, was made from cornstalks within 3 months and from cereal straw within 4 to 6 months. By adding inorganic fertilizers, procedures have been developed for converting a wide variety of plant residues into materials useful for restoring soil organic matter or soil humus.

Something of the wide variety of conditions and problems that are involved in attempts by station research workers to find ways of increasing soil productivity is shown in the foregoing examples of results and in those that follow. They reflect some of the recent progress made in the use of fertilizers and minor elements, in soil management and soil conservation practices, and in the knowledge of physical, chemical, and biological properties that affect the use of soils.

The demand of the war years for large production of crops and the continuing need for the greatest possible efficiency in the use of soil resources call for better understanding of soil management and use of fertilizers. Consequently, soil technologists have sought and are seeking new facts and ways of applying information available through previous field and laboratory studies on the properties of different soils that influence the yield and quality of crops. The aim in this research is to help farmers get the needed production by means of management practices that promote more efficient use of soil resources and plant nutrient supplies; avoiding loss of soil and destruction of soil fertility such as occurred during the first World War.

To these ends the stations have obtained and made available information from their research in soil technology that has been useful throughout the wide ranges of soil types and crop requirements of the Nation's farms in attaining high yields with maximum efficiency of production. The end of the war presents new opportunities and challenges to the soil scientist.

MORE EFFICIENT USE OF FERTILIZERS

How corn production might be increased most efficiently on Mississippi soils was determined from fertilizer tests by the Mississippi station. These experiments showed that on most soils phosphorus and potash do not increase corn yields and are not profitable investments for corn. On certain soils deficient in phosphorus and potash these nutrients should be added with

nitrogen. The greatest benefit was obtained from nitrogen, and the research workers point out that if all of Mississippi's cornland were properly fertilized with nitrogen the average State yield would be increased from 15 to 25–30 bushels per acre. This would mean about 30 million more bushels of corn than is currently produced.

Larger increases in yield of corn were obtained under Nebraska conditions from the application of nitrogen fertilizers as a side dressing at the last cultivation than from applications either at planting time or in the bottom of the plow furrow. Ammonium nitrate applied in the irrigation water during the first irrigation gave almost as large an increase in yield as was obtained from the side-dressing application at the last cultivation.

Pasture yields and quality were increased with treble superphosphate and manure applications, as reported by the Utah station. Fertilized areas produced almost 100 percent more forage than did unfertilized areas. With the cost of phosphate at $3 per 100 pounds and manure at $2 per ton and with butterfat valued at 70 cents per pound, the gross return was approximately $4 for each $1 spent for fertilizer. When the increase in the amount and quality of the forage produced was taken into account, 167 percent more phosphorus and 113 percent more protein were produced per acre from fertilized than from nonfertilized plots.

Use of liquid manure on pastures in western Washington, as reported by the Washington station, resulted in an increase in total digestible nutrients of over 15 percent on upland mineral soil and nearly 19 percent on bottom land muck soil. Although phosphate fertilizer alone gave no apparent increase in the yield of total digestible nutrients, when added to liquid manure it increased the yield 16 percent over that with liquid manure alone.

Heavy fertilization, in addition to an application of manure, was found to get results under Wisconsin conditions, as reported by the Wisconsin station, where 60 bushels more of corn per acre were obtained from heavy fertilization and manure, as compared with manure alone. The calculated cost of the extra corn was 8 cents per bushel. In another experiment, heavy fertilization produced 17 bushels more barley to the acre, at 16 cents per bushel, and 1 ton more hay, at $2.47.

Tomato yields, according to the Indiana station, were increased by heavy fertilization. On a poor, light-colored silt loam soil, an application of 1,000 pounds per acre of a 2–16–8 fertilizer on the plow sole plus 200 pounds in the row produced a yield of 9.5 tons per acre, whereas an application of 400 pounds in the row gave a yield of 5.69 tons per acre.

Alaska soils need fertilizer, according to results obtained with potatoes by the Alaska station. Six hundred pounds per acre of a 4–6–10 fertilizer were found to produce the greatest number of tubers per hill, the largest total weight, and the highest total yield per acre. Plots receiving the complete fertilizer gave a yield of 429 bushels per acre in comparison with 245 bushels per acre for areas not fertilized. The potatoes receiving fertilizer also possessed the highest starch, ash, and dry matter, which are important factors in determining food value.

The plow-under method of applying fertilizer was not found to be the most effective under Michigan conditions, according to results from the Michigan station. Results from 11 years of experimentation revealed an average yield of 35.85 bushels of corn per acre where the fertilizer was placed on the bottom of the furrow and 39.0 bushels where it was broadcast on the surface and plowed under, but applying fertilizer in the row was followed by a yield of 40.94 bushels. Putting the fertilizer on the bottom of the furrow was the poorest of eight methods tried. The workers point out that results of these and other experiments reported with sugar beets and soybeans do not support the findings in other States that applying fertilizer by means of the recently developed attachment to the plow is a very effective means of using large or moderate quantities of fertilizer.

Starter solutions were not beneficial, according to results from the Oklahoma station, where no benefit was obtained whether a given amount of fertilizer was applied as a starter solution at the time of setting tomato and cabbage plants in the field or applied in dry form in the row. The use of delayed fertilizer applications, either liquid or dry, in connection with starter solutions had no special advantage over the application of fertilizer at the time of setting the plants. These findings, which are contrary to previous results from several stations under different soil and climatic conditions which have shown responses from starter solutions, illustrate further that fertilizer practices must be investigated under local conditions before they can be recommended.

That soil and climatic conditions affect response from fertilizer was shown in fertilizer-placement studies conducted by the Pennsylvania station at several places in the State. Applying fertilizer in the plow sole for tomatoes resulted in significantly greater yields than did surface applications, at both Lancaster and Erie. At State College, best yields were obtained from the plots on which the fertilizer had been broadcast.

Quenched silicate slags were found to vary in fertilizer value for supplying phosphate and lime, according to results obtained by the Tennessee station. That farmers should be cautious about the source of any slag that they might purchase was shown in a comparison of different slags, wherein it was found that one type is decidedly superior to a similar product that has been distributed extensively. This superiority was shown for both liming effectiveness and phosphate content.

Acidifying materials used on calcareous soils did not benefit plant growth or increase yield under Utah conditions. Field, greenhouse, and laboratory experiments by the Utah station with several crops and with different soils and various acidifying materials led to the conclusion that there is insufficient evidence to date to warrant any widespread recommendations regarding the use of such treatments.

MINOR ELEMENTS

Research into the effect of minor elements on plant growth has given striking results where a deficiency condition of that element exists. Although experiments with such minor elements as

boron, iron, zinc, manganese, copper, etc., have been under way for several years, our understanding of the interrelation of the different effects on the physiology and growth of plants under various soil conditions is such that there is need for more intensified effort. Some progress has been made on the requirements of certain minor elements, the effect of one minor element on another, and the effect of some of the minor elements on the utilization and physiology of some of the major plant nutrients by economic plants. A few examples of the accomplishments on these problems are given below.

Boron needs of various crops and soils for successful production have been investigated by several stations. The results from the Vermont station discussed in the examples of research illustrate the practical application of this effort.

Boron deficiency in the olive was found by the California station to result in pitted fruits, leaf tips showing pale color, and shoots and branches dying back. These difficulties were eliminated by treating with borax or boric acid either through branch injection, application to the soil, or spraying, though the effect of spraying was transitory on severely affected trees. About a pound of borax per tree broadcast on the soil seemed necessary to cure the malady completely in one district of Butte County.

Boron deficiency of rutabagas was found by the Virginia station to be the cause of a difficulty known as water core. The center of the rutabaga becomes water-soaked, and in extreme cases the water-soaked section rots. The skin of the water-cored roots is usually rough and barklike. Since the symptoms appeared to be those reported as caused by a deficiency of boron, an experiment was conducted on two farms where water core was known to have occurred. Borax applied at the rate of 10 pounds per acre effectively prevented the development of water core.

Why boron is needed was the purpose of investigations by the Wisconsin station with garden beets and cabbage. The workers found that, if the boron deficiency was acute, cell division was speeded up but normal development of the cell walls and cell contents could not take place and death of cells followed. The products escaping from the dead cells, in turn, injured the growth of nearby cells. The formation of the delicate tubes that carry water, minerals, and food through the plant is first affected, thus hindering the development of other tissues and organs of the plant.

Boron in relation to other nutrients is under investigation with different crops at several stations. The Arizona station, for example, found that a ratio of calcium to boron of less than 80 on citrus leaves indicates boron injury to the leaf. Apparently a similar ratio holds true for alfalfa. The results show that irrigation water containing less than 0.50 part per million of boron should be used for citrus and other boron-sensitive crops, whereas water containing 6 to 10 times that amount should be used only for tolerant crops, such as alfalfa.

The Florida station investigated the relation of boron needs to nitrate and phosphate level for the tomato plant and found that plants grown with ample nitrates required many times more boron than did nitrate-starved plants. This indicates that boron

functions in normal protein metabolism probably through a direct effect on carbohydrate utilization. Plants grown with solutions deficient in phosphates required more boron that did plants receiving ample phosphates. The workers thus report that the phosphate and boron nutrients may function interchangeably as essential juice buffers, or in precipitating out excess bases which form relatively insoluble salts with nitrate or phosphate, or in both of these functions. Large applications of these major nitrogen materials may aggravate any boron deficiency which may be present. With respect to the boron-phosphate relationship, the results indicate that boron deficiency might be expected to limit growth on soils naturally low in phosphate, irrespective of nitrogen and potash levels.

Boron needs as related to calcium-boron balance, studied under greenhouse conditions by the Indiana station, showed that plants take up quantities of calcium and boron depending upon the availability of these elements in the soil, and that each plant has a specific need for calcium and boron, but the range varies greatly among crops. Normal growth occurs only when a certain balance exists in the intake of calcium and boron. If this balance is upset by a small intake of calcium, as on acid soils, the plant will have a very low tolerance for boron. On strongly acid soils that contain a small quantity of available calcium, small additions of borax applied to the soil may cause boron injury. On soils of the humid region that have a very high calcium content, as alkaline or overlimed soils, the plants require more boron than on the acid soils.

Continuing important earlier contributions on the needs and function of boron, the New Jersey station investigated the potassium-boron and calcium-boron relationships in plant nutrition. Symptoms of boron toxicity at high boron levels, like deficiency symptoms at low levels, were progressively accentuated with increasing potassium concentrations. At any given boron level there was a progressive increase in the boron content of the plants as the potassium concentration in the nutrient solution increased, especially at high boron levels. With increasing concentration in the nutrient solution, calcium and potassium were found very similar in their capacity to accentuate the symptoms of boron deficiency. Boron toxicity at the high boron levels decreased markedly with increasing concentrations of calcium, however. In this respect the influence of calcium is opposite to the accentuating effect of potassium, there being a marked decrease in both total and soluble boron in the plant tissue at the high boron levels with increase in the calcium concentrations in the nutrient substrate. At any given calcium and boron level, within limits, the ratio of calcium to boron decreased markedly with increase in the potassium concentration of the nutrient substrate. Calcium, on the other hand, within the limits of the experiments reported upon, had little or no significant effect upon the potassium-boron ratio values.

Boron supply was found to affect the carbohydrate metabolism and distribution in the radish, according to results obtained by the Kentucky station. A concentration somewhere in the range of

0.25 to 0.50 part per million of boron was indicated by yield of both roots and tops; 5.0 parts per million was slightly toxic and reduced slightly the weight of tops and roots. No difference in quality of the roots within the range studied was noted.

An iron deficiency in tung trees, investigated by the Florida station, was found to occur in acid or alkaline soils. The symptoms of the deficiency were described, and a remedy worked out by spraying the leaves with a 1-percent solution of iron sulfate. In another investigation the Florida station found that 2 pounds of 65-percent manganese sulfate applied around mature tung trees corrected frenching, or manganese deficiency.

The effect of sodium on cotton yield was reported by the South Carolina station. From comparisons covering two 5-year periods the station found that during the first 5-year period where no potash was used the addition of sodium increased the yield of seed cotton 215 pounds per acre, or 70.3 percent, whereas with an application of 60 pounds of potash the increase for sodium was 182 pounds, or 15.1 percent. In the second 5-year period, however, where no potash was applied and sodium was used, the yield was decreased 213 pounds of seed cotton per acre, whereas when 30 or more pounds of potash was used with sodium the yields were increased. The results indicate that if the soil contains, or there is applied, approximately 25 pounds of potash, sodium may be as effective as potash in increasing the yields of cotton. The potash supply of the soil was apparently high enough during the first 5-year period to meet this demand.

Sodium was found to be beneficial to beets, in experiments conducted by the New York State station. Five hundred pounds to the acre of common salt applied to beets, either before planting or later as a side dressing, increased the yield substantially and produced larger and greener foliage. The results indicate that beets need more sodium than they can get from most soils. The symptoms of sodium deficiency are dark red leaves blotched with purple, with a tendency for the plants to grow slowly. Side dressings of salt at any time the deficiency symptoms are evident will usually remedy the trouble within 2 to 3 weeks. That sodium was not functioning as a partial substitute for potassium was shown by the failure of additional potassium to increase yields as did the common salt.

Copper deficiency was found to retard the growth of tomatoes grown in nutrient solutions, in experiments reported by the Kentucky station. With plants supplied with 0, 0.01, 0.05, or 0.10 parts per million of copper growth was normal, but when plants had not received copper the growth was very much restricted.

CONSERVATION PRACTICES

That soil conservation can be effectively carried out and crop yields increased was further demonstrated by the work of several stations in cooperation with the Department. During the past several years of high production demand, the supply of the plant nutrients essential for crop production has been decreased in the soil because of crop removal and intensive cultivation methods. Efforts are directed not only to methods that will make a more

balanced condition between removal and replacement of plant nutrients but also to land-management systems that will build a reserve of fertility.

Listing was found to be profitable on erodible potato land by the Maine station and the Department. A comparison of plowing, listing, and subsurface tillage showed that listed land is ready for spring work 7 to 10 days ahead of plowed land and gives consistently higher potato yields and better soil condition than plowed land. Erosion was reduced and yields increased also by subsurface tillage.

The cost of erosion in terms of plant nutrients lost is illustrated by results obtained by the New Jersey station and the Department in comparing the removal of nutrients from the soil by crops and erosion. Quantities of nitrogen, phosphoric acid, and potash removed by tomatoes and sweet corn and the quantities removed by erosion were determined for a crop year. Erosion losses of nitrogen, in comparison with crop removal, were small in all cases. Erosion losses of total phosphric acid, where no conservation practice was used, were double the quantity removed by tomatoes or sweet corn. Where cover crop or cover crop and manure were used annually, the erosion loss continued to equal the quantity of P_2O_5 removed by either crop. The removal of K_2O by erosion, where no conservation practices were employed, exceeded the removal of K_2O by tomatoes and was nearly four times as much as the removal by sweet corn. Where conservation practices were employed, the removal of total K_2O by erosion was more than one-half as much as that by tomatoes and continued somewhat to exceed the quantity removed from the soil by sweet corn. While it is recognized that all the plant nutrients lost through erosion are not in a form available for plant use, the loss is still a serious one and indicates that control of erosion is a key factor in the maintenance of soil productivity.

The Wisconsin station and the Department found that the loss of topsoil by erosion had a marked effect on crop yields. Grain yields, for example, averaged only 43 bushels to the acre where all but 3 inches of the topsoil had been lost, as compared with 50 bushels for fields with 4 to 6 inches of topsoil and 65 bushels where 6 or more inches remained. Similarly, corn averaged 60 bushels to the acre on severely eroded land, as compared with 67 on moderately eroded and 80 on slightly eroded fields.

Methods of straw disposal show varying results, depending on rainfall and soil conditions. The Kansas station reported that partial incorporation of the residues has had only a slight effect on crop yields when compared with plowing the residues under. Leaving a part or all of the straw on the surface, as by use of the duckfoot or chisel, did not give consistent results and had relatively little influence on crop yields. The principles underlying stubble-mulch tillage appear to be sound, but the final proof of the value of the method in the light rainfall regions will be its acceptance by farmers, who will measure the value of the system by its influence on crop yields. Value may not be reflected immediately in increased yields and, therefore, may be overlooked. Immediate benefits accruing from stubble-mulch tillage may be

reflected in the influences on the condition of the surface soil by checking the rate of flow of water across the field and by reducing erosion by wind and water.

Burning of straw was found by the Idaho station and the Department to be the greatest single factor contributing to erosion of cropland in the southwest dry-farm area of the State. The station has prepared a bulletin outlining in detail recommendations to be followed in managing the crop residue from wheatlands according to the yield of wheat obtained. For wheat yields and erosion control, surface utilization of straw was found to be superior to mixing it with the surface soil or turning it completely under.

The Ohio station points out that the burning of straw destroys a valuable source of soil organic matter. Many farmers burn the straw after combine harvesting to make plowing and seedbed preparation easier and avoid possible nitrogen deficiency in the succeeding crop from large additions of straw. When burning straw, the farmer should consider that for each ton of straw burned about $1.25 worth of nitrogen goes up in smoke—nitrogen, which would have contributed to the soil supply of this element had the straw been plowed under. In terms of crop production, it has been shown by tests at several stations that the return of straw, when properly done, has resulted in immediate crop increases worth $2 to $3 per ton of straw plowed under. The long-time beneficial effect is also considerable. Nitrogen deficiency conditions from the addition of straw can be overcome by simple fertilizer practice.

SOIL PROPERTIES THAT INFLUENCE USE AND PRODUCTIVITY

A high level of plant nutrients in a soil is usually associated with high productivity. After long periods of production of one crop or a particular system of soil management, however, there are soils where the productivity has greatly declined even though the level of essential nutrients may remain relatively high. Soil conditions that bring about these changes are thus determined by properties other than plant nutrients. Such factors as the physical condition of the soil, chemical form of the nutrients in the soil, and the air-moisture relations, only to mention a few, have been found to be closely related to soil productivity and use. The evaluation of these soil properties and of the possible effect of one on the other constitutes the foundation of soil science research and has required a considerable part of the effort of soil technologists at the stations. A few examples of the research into various soil properties are given below.

The supply of soil nutrients and the isolation of areas where deficiency of a particular element was restricting production continued to receive attention at a large number of stations. The Texas station, for example, conducted investigations to determine deficiencies that exist in soils of nitrogen, phosphates, organic matter, and other elements. Results showed a general need for nitrogen and organic matter, as well as phosphates in many instances. When these elements were supplied to the soil by use of adapted legumes and by other methods of application, marked

increases in acre yield have been obtained. As a result of this work, a State-wide program of replenishing needed elements in soils has been instituted. This movement holds great promise of increasing acre production and lowering the cost of unit production.

Rate of phosphorus fixation or conversion to a form not available for plant use was studied by the Iowa station. Phosphorus fixation occurs at a rather rapid rate on certain acid soils as shown in field trials where 150 pounds of superphosphate per acre with oats at seeding time was as effective as 300 pounds applied 3 months before seeding. On alkaline soils, 200 pounds per acre at seeding time was as effective as 300 pounds applied earlier.

The Iowa station also found that soil organic phosphorus, which as such is not available for plant use, is changed into a form that can be used by plants at a sufficiently rapid rate, under certain conditions, to meet the requirements for high crop production.

Potassium fixation and the rate of potassium release by different soils in relation to cropping practices have been investigated by several stations. The limited supply of potash fertilizer for crop use has made it particularly important that available supplies be used as efficiently as possible. Thus, the potash that is chemically fixed or changed to a form not available for plant use and the rate at which the potash of the soil becomes available through the action of soil organisms or chemical changes within the soil are important.

From studies of different soils, the California station found the type of potassium fixation that takes place in a soil important in developing fertilizer recommendations where potassium is deficient. Cropping or addition of organic matter to some soils may increase the fixing power of the soil and make the application of potash from fertilizer necessary for crop production.

Attempting to provide information on potassium fertilizer needs, the New Jersey station investigated the potassium-supplying power of 20 New Jersey soils. With alfalfa as a test crop under greenhouse conditions, the most reliable index to the capacity of a soil to supply potash to a crop is not the total supply in the soil but the amount that exists in available form. The soils studied varied greatly in their capacity to renew the amount of available potassium from the total amount in the soil. Some soils continued to release a large amount of potassium throughout the study, whereas others with a high total supply released the element slowly and showed a need for potash fertilization.

Under Corn Belt conditions, the Illinois station found that the exchangeable or available potassium in the surface layer of Corn Belt soils is directly related to the ability of the soils to supply potassium to crops. The station developed a practical test to determine if potash is needed, the extent of the deficiency, and approximately how much crop yields will be increased by the use of adequate amounts of potash.

Fungus threads, or so-called mycorhiza, were found by the Wisconsin station to help tree roots get potassium and phosphorus. An important factor in helping to understand the bene-

ficial role of fungus threads growing on the roots of many types of trees was demonstrated by the station when it was found that red pine seedlings raised in a sand containing a slowly available form of potash got more potash and grew better in the presence of a fungus than when the fungus was not present.

The colloidal material of a soil is found in the clay and organic-matter fractions and consists of very finely divided material which has a large surface area because of this fineness of division. The large surface area makes the colloidal material a very active fraction in all chemical and physical changes taking place in the soil. All soils do not contain the same kind of colloids nor do the different colloids behave the same, and thus it is important that the kind of colloid and its chemical behavior be studied to obtain information needed in fertilizer practice for different crops and soils.

The North Carolina station, investigating the effect of the kind of soil colloid on the response of the peanut plant to various nutrients, found that when the same amount of calcium was provided from a mineral colloid and from a colloid of the organic matter of the soil a higher percentage of good peanuts was produced with the mineral colloid. From a practical standpoint these results indicate that a peanut crop on soils having a high content of organic matter will require more calcium or lime than would be required on a mineral soil low in organic matter. The results are helpful also in explaining some of the variations in fertilizer response obtained with peanuts under different soil conditions.

The acidity, or pH, of a soil is an important factor in determining the supply of available nutrients and, consequently, the kind and yield of crops that can be expected. The pH affects the nutrient absorption by roots and also the physical properties of the soil. A new method, using a soil paste, of obtaining the pH value of the soil, developed by the Arizona station, was found to give a more correct measure of the conditions existing in Arizona soils, where the presence of soluble salts in the soil complicates pH determination and interpretation.

Physical properties of the soil, such as amount of air or water, have been shown to influence crop yields greatly. There has been difficulty in developing technic and equipment for expressing the physical condition of the soil in some units of moisture availability or air tension so that results with different crops and different soils might be compared. Progress on this problem was reported by the Alabama station, where an apparatus was developed for determining soil porosity. The apparatus will also aid in measuring other physical properties, such as specific gravity, moisture content, and the extent of shrinkage and swelling of clay soils.

Under irrigation where the water table can be maintained at definite levels, it is important that the level most favorable for the growth of a particular plant be known. Because of the importance of water and air relations in soils on plant growth, the California station investigated the effect of the water table level on several crops. Results showed that alfalfa plants grew best where the water table was maintained at a 3- to 5-foot level and

poorest at a 6-inch level. Sugar-beet roots were short where the water table was maintained at 6-inch and 1-foot levels and became progressively longer as the distance to the water table increased. Bean plants maintained over shallow water tables showed small growth, and best growth was obtained when the water table was at about a 3-foot level.

EFFECTIVE USE OF ORGANIC MATERIALS

During periods of limited supplies of commercial fertilizer, the effective use of farm manure offers an important source of plant nutrients, according to information from the Michigan station. The station points out that Michigan farm animals produce more than 27 million tons of manure annually. If it were possible to save all of this manure and use it effectively in crop production, it could produce an annual increase in crop yields worth over $80,000,000. This would be the equivalent of more than $400 for each farm in the State. The plant food in this quantity of manure, if purchased in the form of commercial fertilizers, would cost about 10 times as much as Michigan farmers spent for fertilizers in 1942.

Poultry manure was found to be a good source of nitrogen and to produce good yields in studies by the Pennsylvania station. Poultry manure applied at the rate of 3 and 4 tons per acre gave yields similar to those obtained with 9 and 12 tons of fresh stable manure. The crop-producing values of the two manures are in approximate proportion to their nitrogen content, that is, a ratio of 3 to 1.

An effective step in conservation and utilization of a waste material for soil improvement and maintenance was made by the Pennsylvania station with the development of a method of converting waste liquor produced by the sulfite-process paper mills into a form that can be used as a soil amendment. The 27 million tons of waste liquor which annually are poured into the streams of the country constitute a serious problem of pollution. This liquor contains a million and a half tons of lignin, a major constituent of the original wood used. Lignin, a humus-forming material, is precipitated when added to soils as a result of chemical and biological processes. In station experiments, the addition of this material to freshly plowed ground after certain constituents harmful to crop growth have been removed brings about, in the course of time, the formation of water-stable granules which render the soil more permeable to air and water.

PRODUCING FIELD-GROWN FOOD AND FEED CROPS

EXAMPLES OF RESEARCH RESULTS

Hybrid popcorns, developed by the Indiana and Kansas stations and the Department cooperating, have made yield increases from 9 to 68 percent over corresponding open-pollinated varieties and have better standing ability and extra good popping quality. The best of the hybrid popcorns turn out a half-greater volume of popped corn from the same quantity of grain, and the popped corn is tenderer and better flavored than the old varieties. Purdue

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No. 38, an outstanding hybrid, has averaged more than 4,600 pounds of ear corn per acre in Indiana station tests and is in great demand for confections. Seed of this and other superior Purdue hybrids is being grown under contract for the Agricultural Alumni Seed Improvement Association, La Fayette, Ind. This seed improvement association produced about 150,000 pounds of hybrid popcorn seed in 1944, and the Kansas station about 10,000 pounds.

Blackhawk, a new, soft or semisoft, red winter wheat developed by the Wisconsin station and the Department, has high resistance to leaf rust and good resistance to bunt and is especially hardy for a wheat of this type. It has yielded about 10 percent more than the next best winter wheat in 5-year trials at Madison. The new variety should enlarge the area in which soft winter wheat can be grown.

Mida, a new variety of spring wheat developed by the North Dakota station and the Department and released in 1944, was distributed to some 6,000 North Dakota farmers in 1945 from a stock of 250,000 bushels, with large unfilled demands from other States. The popularity of the new wheat is based on high yields, high resistance to leaf and stem rusts and bunt, and good milling and baking qualities.

Wasatch, a new winter wheat variety of the Turkey type, resistant to covered smut and stiff-strawed, bred and released by the Utah station in cooperation with the Department, is becoming the most popular of varieties in northern Utah and adjoining States where soil-borne smut still threatens. Wasatch is rapidly replacing Cache and Relief over the region because of its additional resistance to smut, coupled with much better straw strength.

A new barley variety named Mars, released by the Minnesota station, has outyielded the standard variety Wisconsin Barbless by 35 percent in southern Minnesota as an average of 1942-44. Mars should prove a valuable contribution to agriculture in Minnesota because of its earliness, high-yielding ability, stem rust resistance, high weight per bushel, and its very stiff straw.

Sunrise barley, a product of the breeding program of the North Carolina station, has in 7 years' tests produced 11 percent more grain than the next highest variety and 50 percent more than Tennessee No. 6, the old standard. It has resistance to mildew, covered smut, and aphids. A complete shift on North Carolina farms from hooded varieties to Sunrise would make possible an increase of 4 to 5 bushels per acre, or over 200,000 bushels for the State.

Winter barley has attained rapid popularity in southeastern Pennsylvania counties, yields having been far superior to those obtained with spring-seeded types. Tests of varieties conducted by the Pennsylvania station have again proved Wong, Kentucky No. 1, and Poland to be outstanding. Wong has produced phenomenal yields in favorable seasons up to 80 bushels per acre. It has stiff straw and stands up on highly fertile soil where winter killing is not a factor. Poland and Kentucky No. 1 are good varieties for soils of medium fertility.

Traveler, a new hardy winter oats, developed from a cross of the

Victoria and Curtis varieties by the Arkansas station and tested extensively in cooperation with the Department, has been outstanding in grain production and for winter pasture, and has resistance to crown rust, smut, and lodging.

A new oats variety, Clinton, to be distributed to farmers in 1946, was developed jointly by the Iowa station and the Department from a cross between D-69 and Bond. Clinton combines resistance to stem rust, crown rust, smuts, and halo blight with exceptionally good lodging resistance, plant height, grain quality, and high yield. In tests conducted in Iowa it has outyielded Tama, Boone, and other varieties of similar type by 16 bushels per acre. Final seed increase before distribution also was made in 1945 in Illinois and Indiana to provide seed stocks for these States. Approximately 20,000 bushels of seed will be made available in Iowa.

The Camellia oats, developed by the Louisiana station and the Department and released to farmers in 1942, continued to prove promising and is expected to make possible the production of oats in south Louisiana and to improve oats growing elsewhere. Enough Camellia seed was produced in 1944 to seed 100,000 acres. The new oats has complete resistance to leaf rust, has a plump kernel, and yields well. Its large dark leaves supply a dependable winter pasture.

A new early white potato, Marygold, developed by the Maryland station and the Department, outyields in spring and fall planting other varieties commonly grown in the State. Tubers are smooth and round with shallow purple eyes and have a rich cream colored flesh. Two crops can be grown without using seed stored from the previous year for the late crop. Seed harvested in July from the spring crop is treated with a chemical to break dormancy and is planted at once.

Warming seed potatoes before shipping them South for midwinter planting had definite advantages in experiments by the Nebraska station and the Department, cooperating with the Alabama and Texas stations. The warmed potatoes sprouted more quickly, emerged more uniformly, and produced 25- to 30-percent increases in yield. That these responses were very profitable in the production of the early crop is evident. Temperatures in storage cellars and bins were controlled by various devices, including false floors, vertical flues, and fans. Growers and sales services are recognizing the value of warmed seed potatoes and the importance of avoiding stocks stored at temperatures too low for best results.

Considerable losses occur in potatoes in common storage from sprouting as temperatures rise in the spring; also in stocks held in cold storage for making potato chips, which must be kept for several weeks above 70° F. to eliminate reducing sugars developed at temperatures below 45°. The Wisconsin station has found a way to prevent sprout development by treating potatoes stored above 70° with a plant hormone, the methylester of alpha-naphthaleneacetic acid. About 0.04 ounce of this chemical per bushel applied as a dust or spray or with shredded paper avoided losses due to sprouting and also reduced the accompanying decay of the tubers.

A new sweetpotato variety, Puerto Rico No. 3, developed at the Puerto Rico University station by inbreeding the native Mameya variety, is a very high yielder and has a high carotene content. Some samples have analyzed as much as 474 micrograms of carotene per gram of dry matter. This variety is a result of the emphasis given by the station in recent years to the development of new varieties having both high-yielding ability and high nutritive value.

A new sugarcane variety, Puerto Rico–903 developed at the Puerto Rico University station, is an excellent sugar yielder and resistant to the mosaic disease. It proved to be superior in yield of sugar to several standard varieties grown in the island.

CEREALS

Use of hybrid seed corn in the United States has expanded to the extent that now about two-thirds of the corn acreage and three-fourths of the corn produced is from hybrid seed, a noteworthy accomplishment of the research of the stations and the Department. The volume of the 1944 corn crop of 3,228,361,000 bushels from 97,235,000 acres, the largest on record, was largely due to the rapid increase of hybrid seed. Surveys by the Department reveal an increase of hybrid corn from 143,000 acres in 1933—0.1 percent of the total corn acreage in the United States —to 60,347,000 acres, or 64.1 percent, in 1945. Of the 1945 crop, close to 54 million acres, or nine-tenths of the hybrid corn, were grown in the North Central States. Half or more of this acreage in 23 States was planted to hybrids.

Pioneer efforts and greatest achievement in developing adapted hybrids have naturally taken place in the Corn Belt; the hybrid-corn enterprise, however, has been spreading rapidly to other areas, particularly in the South. Breeders at five southern stations have developed hybrids now in commercial production. The Tennessee, Louisiana, and North Carolina stations each have made available productive hybrids with definite adaptations for commercial planting. Hybrid corns, as shown in Kentucky station State-wide tests, have outyielded open-pollinated varieties by more than 35 percent, resulting in a yield increase of nearly 12 million bushels. Kentucky hybrids are planted on most of the 1,697,000 acres of hybrid corn in the State.

Productive corn hybrid combinations developed and released by the Texas station have yielded 20 percent more than open-pollinated varieties and can withstand adverse climatic conditions better. As examples of regional adaptation, Texas hybrids Nos. 7–W and 12 have given better results on fertile bottom soils and in east Texas, while Nos. 8 and 18 excelled in central and west Texas. A new yellow hybrid, No. 20, is more resistant to corn earworm than the yellow hybrids now grown. An important factor in the food and feed program, the 500,000 acres planted to hybrids in 1945 in Texas should result in 2,500,000 more bushels of corn over open-pollinated seed.

For the southern region, the corn hybrids developed at each station are made available for tests in the other States. Each station

and the Department shares its accomplishments with others to shorten as far as possible the time needed to provide the most productive material for the areas of different production conditions and needs. With similar objectives the Northeastern Corn Improvement Conference, organized during the year among station and Department workers of 15 States in the northeastern area and 2 Canadian provinces, has developed a coordinated program of research to promote the production of hybrid corn varieties with as wide use as possible in this region.

Practically all of the stations in States where corn is grown are now conducting comparative tests of commercial and experimental hybrids on either outlying fields or substations or in cooperation with farmers. The relative performance of the various hybrids, as published by the stations, enables the farmers to buy hybrid seed with reasonable assurance of a profitable crop.

Westar wheat, a new hard red winter variety developed by the Texas station and the Department for the Panhandle Plains region of Texas, is characterized by high yield, high test weight, good milling and baking characteristics, and very high resistance to leaf rust. Resembling Tenmarq and Comanche in general appearance, Westar has a strong straw and stands well for combine harvesting. In winter hardiness, it has ranked with Comanche and Wichita, considered hardy enough for the southern part of the Great Plains.

Sanford, a rust-resistant wheat developed by the Georgia station and the Department and made available to Georgia farmers several years ago, accounted for about 58 percent of the 1945 harvested wheat acreage of the State. The increase in value of the Georgia wheat crop, attributed to this variety, is estimated at about $400,000 annually.

Good crops of quality wheat require adequate supplies of plant food. The Oklahoma station reports that a mixture of three-fourths superphosphate and one-fourth sodium nitrate, which gave higher yields than superphosphate alone, has been the best combination tested, considering both yield and protein. Wheat from this treatment made a superior loaf having slightly greater volume than loaves from unfertilized wheat. All fertilizers containing phosphorus have resulted in higher grain yields than other combinations. Phosphorus fertilization also has given much greater fall growth, and phosphated areas would furnish considerable fall pasture.

Beneficial effects of superphosphate applications for wheat were also observed at the Kansas station, where the treatments resulted in increased yields of grain and straw, higher test weight, greater percentage of yellow berry grains, reduced protein content of grain, and hastened maturity. Varieties of similar adaptation tended to respond in similar manner to applications of phosphates.

That the stage of maturity at which wheat is harvested has significant effects upon starch properties was determined by the North Dakota station. As the grain ripens, swelling power of starch decreases, while viscosity and gel strength tend to increase. These changes are related with increases in test weight per

bushel and percentage of vitreous kernels and decreased wheat moisture. Wheat starch containing the "amylodextrin" component contains more nitrogen, but is lower in pH than corresponding starches with this substance removed. Gel strength and swelling power are lowered by "amylodextrin," but viscosity is raised.

About 93 percent of the barley grown in Montana in 1944 was of the Compana and Glacier varieties released by the Montana station, and Trebi and Horsford which it also recommended. The station estimated that yields were at least 15 to 20 percent larger than from the varieties replaced.

Osage and Neosho oats, two new spring-sown red varieties developed by the Kansas station and the Department and distributed to Kansas farmers in 1945 for increase, make high yields, have good test weights and stiff straw, and are resistant to the major oats diseases in the State.

Mission oats, derived by the Montana station and the Department, is a medium-tall, early to midseason variety with plump white kernels, is highly resistant to races of loose and covered smuts found in Montana, and is being increased for distribution to farmers for growing mainly on dry land.

Florilee oats, distributed by the Florida station, is highly resistant to crown rust and immune to smut. It represents a substantial contribution to grain crop and livestock production in northwestern Florida since it is excellent for grazing and is more prolific than varieties distributed earlier from that station.

POTATOES

The score of new varieties of potatoes developed and introduced through the National Potato Breeding Program, in which 32 stations and the Department cooperate, accounted for nearly 30 percent of the 1944 supply of U. S. certified potato seed. Katahdin, introduced about 12 years ago as the first of these varieties is currently the late variety grown most widely in the United States. It supplied about 4½ million bushels of certified seed in 1944, and Sebago and Chippewa, released later, each furnished nearly 2 million bushels of seed. Several varieties released within the last few years, as Sequoia, Pontiac, Warba and Red Warba, Mohawk, and Potomac, have continued to gain in popularity as their adaptations and other merits are established in different producing centers. The success of the several new varieties is attributed variously to wide adaptation, desirable shape, shallow eyes, high productiveness, high specific gravity, dryness of flesh, and resistance to or immunity from one or more of 16 diseases and forms of insect injury. Additional strains with special qualities were brought forward during the year.

Empire, a new potato variety immune to late blight, bred by the New York (Cornell) station and proving satisfactory in tests in New York and Florida, has good culinary qualities and yields well above the average.

Erie, the medium late, high-yielding potato from the Ohio station, thrives better than other varieties under the unfavorable conditions common to mineral soils in Ohio and cooks well.

The Michigan station has found Menominee to be highly re-

sistant to scab and moderately so to late blight. This late-maturing variety, if planted early, will produce relatively high yields of tubers of good cooking quality.

A new potato selection of the Minnesota station, which is moderately resistant to scab, early maturing, and high yielding, was distributed to farmers in sections of Minnesota where scab is a serious problem.

The Indiana station has developed a seedling potato which has produced a higher yield of marketable tubers in scab-infested muck soils of Indiana than any other variety yet available.

Cropping experiments of the Nebraska station in dry-land rotations showed that the most important factor for consistent production of satisfactory yields of marketable potatoes is the amount of moisture in the soil at planting. Potatoes should be planted on soil moist to a depth of at least 3 feet, with summer fallowing practiced 1 year ahead to insure adequate soil moisture. They should never be planted after small grain or other crops except when rainfall before planting time is unusually heavy.

Potatoes on heavy soils in the Red River Valley in Minnesota station studies have returned greatest yield increases with either phosphorus fertilizer alone or with a phosphorus-potassium mixture. On light soils the best response has been to a phosphorus-potassium mixture, which indicated the importance of potassium on these soils. Fertilizers have tended to improve cooking quality, particularly on the light soils. Appropriate formulas were devised for the two soil groups.

Yield and quality can be improved by application of minor elements in various combinations to potatoes, according to the Colorado station. When they are added to commercial fertilizers, very pronounced increases have been obtained. Bliss Triumph was affected more by combinations of fertilizers and minor elements than was the late Red McClure variety. Cobalt and nickel in combination gave increased yields. Addition of sulfur with commercial fertilizers also resulted in higher yields.

The New Hampshire station found that the presence of a winter rye cover crop cut runoff losses in half. Plowing under rye as a green manure for continuous potatoes boosted the yields of No. 1 tubers an average of 17 percent.

Airplane application of sprays and dusts to hasten tuber maturity, the Idaho station reports, makes possible early digging of some fields of potatoes to take advantage of early-market prices, spreads the harvesting season by prematurely ripening part of the acreage, and artificially ripens the tubers for digging in years when killing frosts come too late to insure completion of harvest before danger of loss from severe freezing. Flying barely above the tops of the vines, an airplane duster can cover 10 acres in about 6 minutes. The best material appears to be Sinox dust 15 at a rate of 30 to 40 pounds per acre. Promise was shown also by liquid sprays of Sinox and ammonium sulfate and by certain other dinitro compounds in solution in stove oil. Results on ground level indicate that an effective kill may be obtained by a 1-percent solution of Sinox plus 5 pounds of ammonium sulfate at a rate of 100 gallons per acre.

The New Hampshire station determined that, by maintaining about 10 percent of carbon dioxide in the storage-house air after potatoes just start to break dormancy, the tubers may be kept from sprouting when held at about 50° F. for around 40 days. This aids in prolonging the market for old table potatoes and helps to keep seed potatoes in good condition for late planting.

Moisture and temperature conditions prevalent in straw-loft storages that are satisfactory for potatoes promote decay of wood, according to Pennsylvania station investigations. Storages of this type are satisfactory, however, when plenty of ventilation over the straw layer is provided the year around. There must be enough straw for insulation to prevent condensation on the wood supporting the straw layer.

SWEETPOTATOES

Better sweetpotato varieties were being developed by the stations and the Department for human food, for manufacture of starch or other products, and for livestock feed, where highest total yield per acre and high content of starch and other solids are major objectives. Recent examples include Ranger, a new sweetpotato developed by the Louisiana station, which has a flesh-colored skin and bright rich orange flesh and is highly promising for northern Louisiana. The Porto Rico-Nancy Hall crosses have produced the highest proportion of desirable seedlings with high carotene content in the station improvement studies.

Total acre yields of sweetpotatoes, starch percentages, and commercial grades of roots were affected markedly by location and seasonal conditions at any one place in uniform tests involving 38 varieties by the Georgia and Georgia Coastal Plain, Louisiana, Mississippi, South Carolina, Texas, and Virginia Truck experiment stations and the Department. Drought serious enough to greatly reduce sweetpotato yields resulted in marked reductions in percentages of starch and of total dry matter in the roots. Starch content tended markedly to vary inversely with the degrees of latitude of the localities where grown, but this tendency does not appear to be related with rainfall, temperature, or length of growing season to which the crops were exposed for the last 4 months of the season. No clear association between soil fertility and starch content was noted. Marked and consistent differences among varieties were evident in starch content and in yield, and among varieties relative starch content varied somewhat from year to year and from place to place. Several seedlings such as B196 and B219 and the introductions Wenholz 1, Wenholz 2, Director, and Wannop surpassed varieties commonly grown in the United States in starch content and yields of roots and starch per acre. Many varieties did better in some places than in others, although a few excelled in all tests. It appeared feasible to obtain superior new varieties of such wide adaptability that a multiplicity of kinds will not be needed to meet regional or local requirement.

Appropriate production methods are required for maximum yields of high-quality sweetpotatoes. Sweetpotato yields decreased markedly with any delay beyond the earliest practicable frost-free

planting date in studies by the Georgia, Mississippi, South Carolina, and Texas stations cooperating with the Department. Late planting also lowered the starch and carotene content of No. 1 sweetpotatoes and resulted in longer and slenderer roots, as compared with shorter and chunkier roots from early plantings. Close spacing reduced the size of the roots without markedly affecting the shape, starch content, or total yields. Close spacing thus did not compensate for the reduced yields of late plants, and the influence of time of planting on yields was far greater than that of spacing.

That the average southern farmer can have a continuous supply of fresh sweetpotatoes for table use throughout the year was shown by the Alabama station. The program developed from the experiments calls for planting early, harvesting small quantities of the largest roots for current use in summer and early fall, and harvesting in fall before frost and storing just after harvest in ventilated or sheltered banks with enough earth or other cover to avoid chilling during the coldest weather. This will provide sweetpotatoes for fall, winter, and early spring. The sweetpotatoes are removed from the bank when dormancy is over in late winter or early spring, put in a dry place, and protected from chilling on cold nights. Those that remain sound provide a supply from late winter or early spring until the new crop is ready for use in midsummer.

BEANS

Scottsbluff Pinto, a bean produced by the Nebraska station by crossing the common pinto with the Great Northern bean, is considered a valuable early pinto for both dry land and irrigation in western Nebraska. Its earliness, vigor, yield, and quality commend this variety to growers, although it has no notable disease resistance.

FORAGE, PASTURE, AND RANGE

EXAMPLES OF RESEARCH RESULTS

Ladino clover has gained rapid popularity in the United States, with a resulting great demand for seed. The New York (Cornell) station finds that seed of excellent quality can be produced in the Northeastern States. Yields of cleaned seed ranging from 50 to 110 pounds per acre have been obtained under experimental conditions, the wide range in yield being due chiefly to different methods of harvesting.

A new pasture and hay grass, introduced by the Department from Russia and released by the South Dakota station as Ree wheatgrass after intensive study, has many good qualities commending it for trial by South Dakota farmers. Noteworthy are the facts that it withstands more heat and drought than bromegrass, is exceptionally cold resistant, can live through the rigors of South Dakota winters, and tolerates a higher salt concentration in the soil than crested wheatgrass. The grass is highly nutritious and palatable to all classes of livestock.

The annual bromegrasses (*Bromus tectorum* and *B. rubens*),

formerly considered as weeds of little value for grazing, have been shown in studies of the Nevada station to be as nutritious as perennial grasses when in comparable stages of maturity. While young and succulent, these grasses are an excellent feed for both cattle and sheep. Early spring grazing results in new growth and thus keeps the nutritive content at a high level for a longer period. Former attempts at eradicating or preventing spread by restricted grazing having proved fruitless, this research by the station on how to make the best use of these grasses should prove of considerable practical value to Nevada ranchmen.

Rancher, a new early sorgo with a low content of hydrocyanic acid, developed by the South Dakota station, provides farmers a forage crop which can be fed to cattle and sheep without danger of losses from hydrocyanic poisoning. It has the lowest hydrocyanic content of any named forage sorghum in production—about one-tenth as much as commercial varieties. Maturing in about 90 days, Rancher is adapted to all parts of South Dakota and to a wide range of soils.

Cody grain sorghum, a new variety with waxy starch, developed by the Kansas station in cooperation with the Department, was grown in 1944 on some 20,000 acres in Kansas and Texas, with production estimated at 535,000 bushels of grain. As compared with ordinary grain sorghum, the Cody variety sold on local markets at a premium of 28 cents a bushel, and the farmers who grew it had an increased income of about $150,000. In addition, the war effort was benefited through the availability of a type of starch needed for industrial uses in place of root starches formerly imported.

Pasture rejuvenation has been demonstrated by the West Virginia station to bring marked results quickly. Shallow tillage accompanied by reseeding and fertilizer and lime applications has given decided increase in both quantity and quality of forage. For the first 2 years this method gives returns considerably in excess of the more common surface treatment with lime and superphosphate. By the third year results under both systems are about equal. Reseeding has been shown to be of greatest advantage where high-quality forage is needed urgently and without delay.

Continuous and rotational systems of grazing have been studied further by the experiment stations as to comparative advantages. At the Indiana station greater returns were secured with ewes and lambs from the continuous grazing of Ladino clover-grass and alfalfa-grass mixtures than by rotational grazing of such pastures. Similarly, little advantage was obtained over rotational grazing of pastures for dairy cows over a system of continuous grazing at the Michigan station. Because of the higher cost involved, rotational grazing appears to be a questionable practice.

ALFALFA

New varieties of alfalfa, developed in the national breeding program in which the stations and the Department are cooperating, are demonstrating their superiority in regional tests where their adaptations and merits are carefully appraised, and are

being rapidly increased for commercial use. Outstanding examples include Ranger by the Nebraska station and Buffalo by the Kansas station, both wilt resistant; and Nemastan by the Nevada and Utah stations, resistant to nematodes and somewhat resistant to wilt. Atlantic, developed by the New Jersey station, is vigorous, high yielding, and adapted to areas in the Eastern States where wilt is not a factor.

Productive and profitable seedbed, planting, management, and harvesting methods have been developed, adapted varieties indicated, and other useful practices established by the Arkansas, Georgia, New Jersey, New Mexico, and other stations.

To produce good yields of alfalfa consistently, the Arkansas station finds that a soil must contain plenty of calcium, phosphorus, and potassium, and the crop must not be cut too often or too late in the fall if stands are to be maintained. Other factors apparently detrimental to stands have included a crown rot, anthracnose, and leaf spot; white grubs and grasshoppers; and climatic variations, especially periods of drought.

Alfalfa stands were rejuvenated and yields increased greatly in Georgia station experiments by applications of potassium chloride. Failure of stands is attributed in large measure to lack of potassium. Other treatments including superphosphate, manure, limestone, and borax, as well as definite cultural practices, have been indicated as productive by the station's research.

The alfalfa crop has responded in New Jersey station experiments to heavy application of phosphorus and potassium and early growth has been stimulated by a small amount of nitrogen at seeding. Since alfalfa thrives at pH 6 or higher, application of from 1 to 5 tons of limestone per acre is indicated on most New Jersey soils before seeding. Boron deficiency, common in some areas, may be corrected by 10 pounds of borax per acre on light soils and 20 pounds on heavy soils.

In farm practice, the Minnesota station determined, phosphorus fertilizers on markedly phosphorus-deficient soils may be expected usually to cause an appreciable increase in the protein content of alfalfa hay.

Alfalfa seed yields were increased in Kansas station and Department studies an average of 21.6 pounds of seed per acre by building up food reserves in the roots for the seed crop; that is, by letting the preceding crop go to full bloom before cutting. Moderate air temperature, low humidity, and soil moisture below optimum have produced the type of vegetative growth of alfalfa plants conducive to storage of high organic reserves, resulting in a physiological condition favorable to setting of alfalfa seed. The best temperature for setting of seed pods was 80° F., and the highest percentage of flowers setting pods was at 10 percent relative humidity.

Since alfalfa flowers must be tripped for a good seed set and tripping agents found in Utah alfalfa by the Utah station and the Department are honeybees and wild bees, which nest in or on the ground, seed growers are encouraged to keep honeybees near alfalfa fields and to protect nesting places of wild bees and apply insecticides carefully. Cutting weeds lessens the competition for

pollen-collecting insects. Regulation of irrigation practices to avoid rank growing succulent alfalfa may reduce injury from Lygus bugs.

Allowing alfalfa hay to wilt in the swath for 2 to 4 hours and then raking into a small windrow was found by the Kansas station and the Department to be the best practice in regard to rapid curing and carotene preservation. Swath-cured hay cured as rapidly as did windrowed hay raked after wilting in the swath for 2 to 4 hours, but contained much less carotene. Windrowing just after mowing preserved the carotene but prolonged the curing time. Temperature was the main atmospheric condition causing variations in loss of carotene from alfalfa during curing. Relative humidity had no effect other than prolonging or shortening the curing period.

Stacking hay with careful handling appeared to be at least as economical as barn storage in West Virginia station experiments. Stack and mow hay were of about the same feeding value when fed to wintering lambs.

CLOVERS AND OTHER LEGUMES

Ladino clover continued to gain in popularity in the Northeastern States. Its combination with orchard grass has proved outstanding for pasture in New Hampshire station tests, where smooth bromegrass and reed canary grass also did well in single mixtures with Ladino. The station is developing a leafier, more productive strain of Ladino that will endure grazing better.

Kaimi Spanish clover (*Desmodium canum*), native of West Indies, was found by the Hawaii station to be a good pasture plant for humid lowland regions of the Tropics, having appropriate palatability, persistence, growth habit, recovery, and seed production. It is best adapted to zones below 1,000 feet with 50 inches or more of rainfall a year. The plant, which resembles common Spanish clover (*D. uncinatum*), endures grazing remarkably well and flourishes in association with sod-forming perennial grasses, and its feeding value compares favorably with that of alfalfa and koa haole.

White sweetclover (standard, medium-late), the Ohio station finds, should be used whenever it is desired to cut for hay in the seeding year or for pasture use, because of its later maturity and later yield. Either white or yellow sweetclover may be used satisfactorily for soil improvement as a catch crop in a 2-year corn-small grain rotation. Yellow sweetclover has proved much superior for any summer seeding and for establishing itself in dry seasons or climates. Madrid (yellow) and Evergreen (white) sweetclover have been outstanding varieties.

Hairy vetch yields in Mississippi station experiments on several soils were usually greater in the last 2 years than in the first 2 years. Phosphorus was indicated as the nutrient most needed for maximum vetch production. Removal of the first crops of vetch as hay did not materially reduce the yield of following crops of cotton when compared with cotton receiving commercial nitrogen. Continued removal of vetch, however, did result in lower yields of subsequent cotton.

Vetches, winter peas, and other winter legumes usually emerged best from a 2-inch planting depth, the Louisiana station reports, although differences were not great between 1, 2, and 4 inches. Bur-clover and *Melilotus indica* seeds germinated best from surface planting. In south Louisiana seeding with a grain drill on ridges made by the middlebuster usually gave the greatest tonnage of green matter. This method provides for more uniform seeding and coverage and better drainage than other methods. Broadcasting vetch or Austrian winter peas in the old middles or drilling in bar furrow on each side of the old ridge and in either case covering with the middlebuster have given satisfactory results in north Louisiana.

GRASSES

Kentucky 31 fescue or Suiter grass, a bunch grass resembling orchard grass in growth habits, the Kentucky station reports, thrives under a wide range of conditions, is persistent in sod, makes a fair winter cover crop when seeded in late summer, and provides considerable pasture and some seed in the following spring. It has made satisfactory growth in outlying tests, and at the Robinson Substation in the mountains, the grass has been in a pasture mixture for 7 years and relished by cattle.

Martin bromegrass, a new selection, and Itasca timothy, a new variety produced from a combination of inbred lines, were placed on the recommended list by the Minnesota station and were being increased for distribution to farmers of Minnesota.

Bromegrass, grown in association with alfalfa or other legumes, was found by the Iowa station to be valuable for pasture and hay and also to rank high in erosion control, particularly for grassed waterways and terrace outlet channels. Productive seeding, management, and harvesting methods have been established.

Irrigation of buffalo grass by the Oklahoma station and the Department resulted in forage which had more protein and carotene in early fall than dryland grass, and lignification was postponed. Buffalo grass, making remarkable increase under irrigation, more than tripled in density in 5 months. Indications were that the irrigated grass would yield 2.5 to 4 times more than dryland grass. In one year irrigated buffalo grass produced 161.2 pounds of beef per acre, and native dry-land pasture 39.4 pounds.

Turf was established successfully on sandy and gravelly hydraulic-fill soils along airport runways by the Rhode Island station and the Navy Department in spite of the sand-blast effects of persistent winds and propeller blasts. The station found that lime and fertilizer, and organic matter such as cover crops of rye and millet or native peat or straw, were necessary in establishing turf under such conditions. Creeping red fescue, planted alone, was more aggressive in the dry sandy areas than other grasses tested. Grimm alfalfa, red clover, smooth bromegrass, and meadow fescue gave good results in rough-border plantings. The cover was enough to abate sandblows. It also accounted for a very definite reduction in airplane losses by cutting down the amount of silica which got into the motors and which had very materially curtailed their number of hours in the air.

SORGHUMS

Productive new forage and grain sorghums are being introduced by stations in the Great Plains and Western States.

Idaho Amber sorgo, an Idaho station selection from Early Amber, is characterized by high yields of quality forage and rather compact heads, uniformity, and sturdy leafy stems resistant to lodging, and is early enough for any of the areas in Idaho adapted to sorghum production.

Sweet Sudan, distributed by the Texas station in small amounts during 1943 and 1944, was increased further on several hundred acres by growers, and estimates were that in 1945 from 15 to 20 million pounds of seed would be produced and soon thereafter the seed supply should meet the demand and the variety become firmly established. About 6 million pounds of seed were produced of the new dwarf combine varieties Plainsman, Bonita, and Caprock, developed and distributed earlier by the station. Half of the grain sorghum acreage in Texas in 1945 probably was planted to these varieties which have already saved growers much in the cost of grain production and have been responsible for a large increase in the acreage and yields of grain sorghums in Texas.

PASTURE

Highly productive pasturage has been established on old worn-out creek bottom in the east Texas timber country by the Texas station by clearing, drainage, application of superphosphate, and seeding of suitable legumes and grasses. Application of about 200 pounds of phosphoric acid per acre enabled establishment of adapted clover and grasses and increased both yield and quality of pasturage. Carpet, Dallis, and Bermuda grasses, and white, hop, and Persian clovers have persisted throughout the years. Common lespedeza also contributed extensively to the grazing. Such pastures have provided more and better feed for a longer period than native pastures. They can provide good grazing for 250 to 280 days and may also furnish hay for winter feed and seed for improvement of other pastures. Excellent cattle have been produced on the station pastures.

Alta fescue and perennial ryegrass have shown greater persistence than other grasses tested in irrigated pastures of the New Mexico station, and the stand of Alta fescue has increased. Ladino clover has been promising for permanent pastures in southern New Mexico when grown on a fairly heavy adobe soil. Throughout 5 months of the pasture season, both alfalfa and Ladino clover (and also clover with grasses) have afforded good pasture, with a carrying capacity equivalent to about 1.5 cows per acre and, in addition, the clover has provided a small amount of pasture for two to four yearling heifers during winter. The clover started growth early in the spring, allowing very light grazing in March and April before the other areas could be pastured.

For dairy pasture, the Illinois station observed that bluegrass usually has not been satisfactory in central Illinois for use as the only pasture plant because of low yields and low feeding value in midsummer, faults which could be overcome in measure by good management practices. More and better forage could be obtained

from the same area by rotational grazing with several pasture crops, as winter rye, bluegrass, alfalfa, a Sudan grass-soybean mixture, bromegrass, and sweetclover, along with good management. The Sudan-soybean mixture has made high-yielding and drought-enduring midsummer pasture. Winter rye has been ready for grazing 1 to 2 weeks earlier than bluegrass, and bromegrass several days earlier. In seasons of low rainfall, the rotational system provides pasture longer than bluegrass.

Results at Winterhaven by the Texas station indicated that part of the small grain pasture area had better be planted to an early variety of oats as Vicland, Boone, or Tama for grazing until March and the remainder in a later variety as DeSoto, Victorgrain, Florilee, or Letoria for grazing until May. The acreage devoted to the early oats could be planted to Sudan grass in March and be ready for grazing in May.

Balbo rye and Kawvale and Pawnee wheats yielded highest among the cereals tested for pasture by the Kansas station.

Striking increases in forage production followed addition of phosphorus and potassium and preseason applications of nitrogen to Indiana station pastures. The importance of a proper balance between legumes and grasses in pasture vegetation was emphasized by the results.

Limestone alone was effective in increasing yields of a pasture mixture of Kentucky bluegrass, redtop, orchard grass, and Korean lespedeza at the Illinois (Dixon Springs) station, although addition of phosphorus either as rock or superphosphate to the limestone gave best results. Nitrogen carriers stimulated growth during the forepart of the season but did not increase the total seasonal yield beyond that provided by the minerals. They encourage grass growth but usually suppressed the lespedeza, which is commonly a factor in higher yields.

Permanent pastures of Alabama as a rule, respond well to lime, phosphorus, and potassium according to findings by the Alabama station. On the Black Belt lime-containing soils, phosphate and potash were sufficient. Analyses of grasses and legumes from the fertilized pastures showed very definite improvement in the quality of grazing, whereas plants from unfertilized pastures often contained less than the minimum nutritive requirements for maintenance of healthy livestock.

Pasture fertilized by the Louisiana station regularly over 8 years produced 42 percent more milk than one treated similarly for 4 years. Manure gave especially good results on clover and Dallis grass. Lime, phosphorus, and potassium also resulted in good increases. Native grasses, as carpet grass, have not equaled improved grasses, even when fertilized.

Permanent pastures in the Mountain area returned substantial increases to limestone, especially in combination with phosphates, in North Carolina station experiments. Calcium metaphosphate and fused rock were as satisfactory as triple superphosphate. Where lime was applied, potassium metaphosphate equaled 16 percent superphosphate and potassium as a source of phosphorus and potassium. Its additional calcium seemed to give superphosphate a slight advantage on unlimed soils. Lespedeza, white clover,

and bluegrass were increased by both phosphate and lime, and their resulting competition reduced the proportion of weeds and broomsedge.

An annual application of 500 pounds of an 0–6–12 mixture per acre or equivalent, the Florida station reports, is needed to maintain optimum growth and mineral content of a well-grazed grass growing in Everglades peat.

Alternate grazing appeared preferable to continuous grazing in Illinois station pasture studies. A system in which the number of animals is carefully adjusted to the amount of forage and which includes rest periods has given best results. Permanent pasture grazed rotationally and renovated at intervals with alfalfa and red clover by the Wisconsin station produced 118.5 percent more forage and 170.8 percent more grazing days in 1944 than continuously grazed pasture.

Rotation pastures at the Montrose field of the Pennsylvania station have consistently produced one and one-half to two times as much feed as adjoining improved permanent pastures. During dry years, when permanent pastures were at their worst, these rotation pastures produced from two to three times as much grazing as the permanent pastures after July, a time when the extra feed was needed most. Grass harvested from crop rotation pastures contained 13.5 to 17 percent of crude protein, and from improved permanent pastures only 11 to 13 percent.

Deferred grazing has increased animal gains and the carrying capacity of native bluestem pastures, as compared with season-long grazing, in Kansas station experiments in cooperation with the Department. Burning has been followed by reduced forage yields, with the greater reduction from early burnings, because moisture losses through runoff and evaporation are greater. Deferred grazing followed by heavy stocking evidently would reduce the need for burning.

Young bluegrass or bluegrass clipped frequently, which prevents the fruiting stage, the Kentucky station determined, provides grazing livestock a more proteinaceous feed and they get more protein per acre than if they eat the grass after it has matured. In Korean lespedeza clipped repeatedly, the percentage of protein was higher than in that grown continuously, but not to the extent as in blugrass.

RANGE

Effective management, conservative utilization, and conservation and improvement of range resources are major objectives in the range research program of the Western States.

Appraisal of the range resources of Cochise County by the Arizona station revealed a need for balanced livestock and forage production. The forage inventory showed that the current forage productivity of most vegetational types is considerably below potential capacity through past overutilization by livestock. Measures to obtain increased forage production, outlined for each type, comprise desirable species and methods for artificial revegetation, control of noxious shrubs, and improved management practices.

Utilization by livestock must be less severe, if ranges are to be

maintained at a level of maximum production, the Montana station and the Department report from studies with bluestem wheatgrass and blue grama. Under proper grazing a certain percentage of plants evidently should remain unused each year, so that the vigor may be rebuilt in plants closely grazed in previous years.

That a range with a good mixture of palatable perennial grasses, weeds, and browse provides a better balanced ration, which in turn assures more consistent livestock production, was determined by the Colorado station and the Department. Young growth of grasses and weeds in spring and early summer have ranked comparatively high in protein but have declined rapidly as the forage matures. Winter fat, an excellent shrub, however, has retained a high protein level throughout the fall and winter and where it occurs abundantly in ranges should be reserved for fall and winter grazing. All forage species are deficient in phosphorus from late summer throughout the winter and decline to a deficiency level coinciding with time of seedstalk heading. Although calcium is adequate in all forage plants throughout the year, weeds and palatable shrubs are sigificantly higher in calcium than the grasses.

Forage available from most shrub species in Wyoming station range studies showed a decrease in volume from spring to fall. The grasses generally remained about constant or increased slightly in volume from June 1 to September 1. With development of stock water, the arid lands in Wyoming could be grazed into spring and summer, thus utilizing a part of the forage lost under the current system of winter grazing only. When the short grasses were grazed to within ½ inch of the ground, about 65 percent of the total weight was used, and about 30 percent when grazed to 1 inch from the ground.

Native range grasses after eradication of sagebrush showed increased growth in height and better vigor than on land with sagebrush, according to the Colorado station and the Department. Standard crested wheatgrass made excellent growth under all conditions, whereas bromegrass, slender wheatgrass, and erect brome preferred cooler situations, indicating the need for selection of grasses for different soils and site exposure. As to grazing preference in late September, animals made full use of nursery seeded bromegrass, Russian wild-rye, erect brome, Mecca rye, and beardless blue bunch while crested wheatgrass was practically ungrazed. Condition of the cattle throughout the season indicated that substantial gains in weight can be made on sagebrush-grass ranges. There are 7 million acres of sagebrush lands in Colorado alone.

The Utah station in cooperation with the Department also found it possible and profitable to rebuild range lands by eliminating sagebrush and planting grass, especially crested wheatgrass along with other grasses of different growth habits.

Dormancy of range grass seeds is a cause of poor germination and a major problem in use of many desirable species for reseeding range. The Hawaii station, studying 10 range grasses, found dormancy due to one or more conditions, including presence of enclosing structures that hinder maximun expansion of the seed or of structures that interfere with exchange of gases, dormancy of the embryo, need within the seed for stimulators of respiratory and

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nutritive activities, and presence of inhibitors produced by seed hulls. Dormant seed could be made to germinate by soaking in water, cutting the seed coats, acid and mechanical scarification, alternating temperatures, removal of hulls, soaking in potassium nitrate and in ammonium thiocyanate, and afterripening at warm temperatures. Practical methods were developed for seed of each grass.

FRUIT PRODUCTION

EXAMPLES OF RESEARCH RESULTS

The Halehaven peach developed by the Michigan station and introduced in 1932 has come to be a leading variety in Michigan as well as in many Eastern States. The higher prices for which this variety sells as compared with other varieties of its same season resulted in an estimated added income to Michigan peach growers in 1945 of $500,000.

Two new apples, Payette and Idagold, desirable products of the apple breeding studies of the Idaho station, were offered to the fruit growers of the State. Payette, obtained from a cross between Wagener and Ben Davis, is a red winter apple, and Idagold, a cross between Wagener and Esopus Spitzenburg, is a winter apple of rich golden color.

Interest in blueberry production has created a great demand for blueberry plants than nurserymen can fill. The Masschusetts station has developed an easy and quick method for propagating blueberries. Highbush blueberry cuttings rooted well if taken 2 or 3 weeks before the fruit ripened and treated with indolepropionic acid, a growth-promoting chemical.

Nitrogen has been shown by the Arizona station in several years of study to be a limiting plant food element affecting yield and quality of citrus fruits in the State. The station finds that high yields of good quality fruits are obtained when there is a high level of nitrogen in the leaves of the citrus trees during winter and spring, with gradual decline to a low level during growth and maturity of the fruit in summer and fall. Growers are aided in regulating nitrogen at desired levels through a nitrogen control service, which now includes 28 orchards totaling about 500 acres.

A suction-type mechanical harvester developed by the Oregon station gathers, cleans, and sacks filberts with a two-man crew at the rate of one-half acre or more per hour. One farmer harvested 70,000 pounds of nuts successfully. With modifications the same type of machine solved the difficult problem of harvesting seed of subterranean clover and recovered 200 pounds of cleaned seed from a 12-acre field, where 150 pounds had been obtained in the first harvest. Development of this method of harvesting has led to a material increase in the acreage of subterranean clover in Oregon.

Macadamia nut varieties selected and propagated by the Hawaii station are far superior to seedling trees and are attracting wide attention for commercial planting. They are adapted to high-cost sugar lands and to the better pasture lands. Macadamia culture would not compete with labor needed for sugar or pineapple harvest since the nuts mature in the winter months.

Of the many phases of agricultural production, fruit growing is among the most precarious. Most species have only one crop a year, and a heavy frost or cold wet weather at time of bloom can destroy the season's prospects almost overnight. Insects and diseases constitute a menace every year, and not until the crops are harvested and marketed are the growers actually safe. New developments such as freezing storage, and an increased appreciation of nutritive values such as vitamin C, help to keep fruit production from becoming static. Shortage of labor in the war years has stimulated interest in labor-saving operations, for example, in thinning fruits by the use of moderately caustic sprays applied at the time of bloom and in the use of improved spraying and dusting equipment, notably the new speed sprayers and spray dusters which apply at a rapid rate large or small quantities of material dispersed in finely divided particles. As fruit growing approaches its northern limits, an ever increasing interest in hardier varieties possessing desirable market qualities is evident. Better-shipping varieties are needed to reach more distant markets. There is an increasing demand by the consumer for well-ripened good-quality fruits free from insect and disease blemishes. This demand has created an unusual interest in new varieties to meet specialized needs, such as adaptability to quick-freezing preservation.

Better varieties of strawberries are appearing in quantity. The California station distributed five new strawberries adapted to the northern part of the State. All five produce fruit in the fall in the central coast region and one, Sierra, does well in the foothill and interior valley districts. Four varieties, Shasta, Lassen, Sierra, and Tahoe, possess varying degrees of resistance to yellows. Of these, Shasta and Tahoe resist verticillium wilt, and Shasta and Donner are resistant to powdery mildew.

Evermore, a new creation by the Minnesota station from a cross between Duluth, an everbearer, and Senator Dunlap, a June bearer, is a desirable new everbearing variety, possessing a capacity to form runners freely and it has considerable resistance to winter cold.

Willamette, a new red raspberry, obtained by the Oregon station and the Department from a cross of Newburgh, a New York State station production, and Lloyd George, an English variety, is more productive, firmer, and larger than Cuthbert, a standard variety of many years. At Corvallis, Oreg., Willamette outyielded 79 other red raspberries and in frozen-pack tests proved one of the best.

Fruit thinning by hand is slow and costly. Recent research of the Department and several State stations offers promise of quick and economical method through the use of caustic chemicals. These chemicals destroy excess blossoms and thus reduce the set of fruit. There is, however, a narrow margin between sufficient thinning and too much injury to flowers and young leaves that requires much research as to correct dosage for different varieties and the effects of seasonal conditions.

Elgetol, found promising elsewhere, was used in Missouri station tests for thinning apple and peach flowers with little injury to foliage. The variety of tree and its vigor were factors in determining effective and safe concentrations of the spray material.

Elgetol sprays were used also by the Virginia station with success. York Imperial apple flowers were thinned satisfactorily, and the fruits which developed were larger than those of unsprayed trees. A 0.2-percent spray proved economical and lessened the chance of foliage injury.

Naphthalene acetic acid and borax solutions in concentrations of 0.003 percent and 0.5 percent, respectively, were found promising at the New Mexico station as sprays for reducing the set of apples without causing any visible injury to the leaves.

Hormone sprays for delaying fruit drop are now used by many fruit growers following earlier research by the Department and the State experiment stations. Certain varieties of apple, particularly the McIntosh, have an inherent tendency to drop freely before they are ready to harvest.

Early dropping of McIntosh is a serious problem in New York and New England, where this variety is important commercially. Much progress has been accomplished with sprays, and now the Massachusetts station reports that appropriate dusts applied early in the morning when dew is on the foliage and fruit are also effective in decreasing early dropping of this variety. Dusting has the advantage of requiring lighter machinery and less labor than spraying.

Rootstocks may exert a profound influence on the growth and fruiting of the tree, a fact long recognized by horticulturists. The importance of rootstocks is indicated by the fact that practically all woody fruit plants, except most varieties of grapes, currants, raspberries, and other bush fruits are propagated customarily by grafting or budding on rootstocks, usually seedlings of vigorous rooting habits. Rootstocks of moderate to low vigor are employed in the production of dwarf and semistandard trees. An interest has developed in recent years on the effect of the rootstock on the composition and quality of the fruit produced by the scion top.

The composition of the fruits of Valencia and Washington navel oranges and Marsh grapefruit was found by the California station to be influenced by the type of rootstock upon which the trees were growing. In all three varieties the highest amount of chemical substances in the peel, pulp, and juice was found in fruits from trees on Morton and Savage citranges and trifoliate orange rootstocks. Markedly lower contents were found in fruits from trees on rough lemon roots.

Marked differences were observed by the Indiana station in the capacity of different varieties of apple to grow on Virginia Crab, a highly desirable understock with regard to cold and disease resistance. Stayman Winesap failed to make satisfactory growth on Virginia Crab, whereas certain of its red-fruited mutations grew well. This points to the need of thorough tests before formulating general recommendations.

Limitations in the usefulness of the vegetatively propagated apple understock Spy 227, a vigorous selection by the Department from among a group of Northern Spy seedlings, were observed by the Massachusetts and New York State stations. At the Massachusetts station many varieties and strains of apple failed to grow satisfactorily on Spy 227, and at the New York State station it

was observed that the rootstock would unite well with one strain of McIntosh apple and give poor results with another.

Vegetatively propagated or clonal rootstocks did not, according to the West Virginia station, give greater uniformity in fruit production than was obtained in the same varieties on French Crab seedlings. Causes other than rootstock variation are believed to account for most of the yield differences observed in apple orchards.

Orchard soil management and fertilization have been important in the horticulturists' research program for many years, and yet many problems remain unsolved. The long-continued use of land for the growing of fruit trees has gradually exhausted the inherent fertility represented by organic matter and other fertility components. Certain deficiencies are coming into the picture that were formerly not recognized, or did not exist because of the original fertility of the soil.

Potassium was found lacking in certain peach and cherry orchards in Niagara County, N. Y., by the New York (Cornell) station. On one of these fruit farms Elberta peaches and Montmorency cherries responded markedly to applications of muriate of potash. This was particularly true with peaches where an application in October and in the following April produced striking improvement in growth.

Phosphate fertilizers proved valuable for grapevines growing in north Texas, according to work of the Texas station. Carman vines supplied phosphorus were more vigorous and fruitful than those without added phosphorus.

Tillage of the soil at intervals of about 2 weeks from April to September followed by a cover crop of winter rye or winter barley was found by the Missouri station to be a favorable soil management procedure for the young peach orchard. A permanent lespedeza sod gave the poorest growth of any system studied. Winter legumes as a group gave better results than did summer legumes.

Fruit-bud formation was greater in the unfavorable dry summer of 1944, according to the Indiana station, in apple trees growing in bluegrass sod or mulched with strawy manure than in trees in cultivation or in legumes and weeds.

Ladino clover, according to the West Virginia station, continued to be outstanding as a legume cover crop for apple orchards in the Cumberland-Shenandoah Valley. Ladino clover, the Cumberland red clover mixture, and dwarf biennial sweetclover are all considered worthy of use in West Virginia orchards as alternatives to bluegrass sod.

The use of 3 pounds of ammonium sulfate and 3 pounds of treble superphosphate per tree increased production of Elberta peach trees from 308 to 509 bushels per acre according to the Utah station. Translated in terms of total yield in the State, this nitrogen-phosphorus treatment, if applied universally, could boost yields from 510,000 to 816,000 bushels, an increase of 60 percent.

Mulching of red raspberry plants was shown by the North Carolina station to be a simple and effective means of preserving the plants and increasing their growth and yield. As compared with clean cultivation rated as 100, the total cane growth in the

pine straw, strawy manure, and legume hay mulched plots rated 218, 248, and 256, respectively. In view of the desirability of red raspberries and the difficulty in maintaining plantings in warmer areas of North Carolina, the results are highly promising.

Two or more warm days followed by a drop toward 0° F. may cause serious damage to mature and hardened red raspberry canes according to the Minnesota station. Injury began at the tip of the canes and progressed downward with greater exposures. Cane injury, commonly believed a result of immaturity, is due apparently to fluctuating temperatures during the dormant season.

Quality of fruit as it reaches the consumer is determined by various factors, such as proper stage of harvest, promptness in storing, prestorage treatments, correct storage temperatures, etc. Considerable attention has been directed in recent years toward research pointing to the better handling of fruit from tree to consumer.

Maturity at time of harvest was found by the Illinois station to have a profound influence on the final quality of peaches. Fruits harvested green never did attain a quality suitable for eating or preserving. Fruits harvested in the hard medium mature stage attained fair quality for canning. Those harvested in a firm mature state became suitable for all purposes. Studies of the composition of peaches harvested at the various stages showed a rapid increase in sugars in the final days on the tree. An appreciable increase was observed also in size of fruits as long as they remained attached to the trees.

The waxy coating on the surface of apples was observed by the Rhode Island station to play an important role in regulating water loss in storage and its consequent effect on the shriveling of the fruit. Golden Delicious, with a notable tendency to shrivel badly in storage, has an insignificant wax coating. Wiping fruits with a cloth tended to accelerate water loss by removing some of the surface wax.

The structure of the skin of Golden Delicious, particularly unhealed cracks in the cuticle layer, was found by the Tennessee station to be associated with the excessive shriveling of this variety in storage. The skin of Golden Delicious developed much the same as that of any other variety of apple up to the time the young fruits were a little over one-half inch in diameter. From this size on the Golden Delicious skin developed abnormally, and, by the time the fruits were 2 inches in diameter, cracks became evident and these continued to enlarge as the apples increased in size.

Waxing Stayman Winesap apples prolonged their storage life and edible quality, according to the results of studies by the Maryland station. Holding the fruit for a period of 5 days between harvest and waxing and storage did not materially influence storage life or edible quality. A delay of 10 days proved, however, somewhat harmful. The red color sports of Stayman Winesap retained their firmness fully as well as the parent variety provided they were not allowed to become overmature on the tree.

An initial treatment of Rhode Island Greening apples with high concentrations (30 to 60 percent) of carbon dioxide for as brief

a period as 3 days when the fruits were first placed in storage at 32° F. was found by the Rhode Island station to give 100-percent control of the surface injury known as scald. Untreated fruits had 78-percent injury. The treatment increased the storage life of the apples and had no harmful effect on flavor.

VEGETABLE PRODUCTION

EXAMPLES OF RESEARCH RESULTS

Hybrid tomatoes have produced outstanding yields in experiments by several stations. The Minnesota station, for example, crossed Pritchard and Earliana and obtained 9.61 tons of fruit per acre from the hybrid as compared with 7.26 tons for Earliana, the highest-yielding parent. A solution for the high labor costs involved in producing hybrid seed may lie in the discovery by this station of tomato plants that produced 80 percent crosses when cross-pollinated without emasculation. This was due to an abnormality of the flowers that partly prevented self-pollination.

Hybrid sweet corn varieties are being developed by the Maine station for home gardens and commercial canning. Northland, an early garden hybrid released by the station in 1943, has brought especially favorable reports from gardeners throughout the State. Five other good yellow hybrids are in limited seed production. New combinations under test show promise of even greater superiority.

Onion seed production has become an important source of income to farmers in the irrigated valleys of New Mexico. From numerous trials the New Mexico station determined that onion seed should be planted before September 15 for maximum amount of bolting and highest seed yields. Later plantings result in a low percentage of bolted plants and smaller seed heads with low yields. By using a high ridge method of culture for bulb planted onions, the station has also found a promising practical way to reduce the amount of bulb rot in onions, a disease of increasing importance in the State.

Onion bulbs set upright rather than sown at random as commonly done increased seed production 40 percent in Idaho station experiments. The increased return over the extra labor cost amounted to $25 to $35 per acre.

A new cantaloup, Texas Resistant No. 1, developed by the Texas station, is resistant to downy mildew and melon aphid. Under downy mildew attack it produced a good crop where the common Hale Best variety grown in adjoining rows produced hardly any commercial melons. Resistance to aphids is even more outstanding, and in a number of trials the vines seldom had more than a few aphids, these being confined to the youngest leaves. The new cantaloup is expected to replace other varieties in areas of Texas where mildew and aphids are serious problems.

The Blacklee watermelon, developed at the Florida station, tops the list of satisfactory commercial varieties resistant to fusarium wilt. It is impractical to grow popular varieties such as Cannon Ball and Tom Watson because of their susceptibility to the disease. The quality of the Blacklee is as good or better than that of

these other varieties. This melon is dark green and has a thin but tough rind and solid, sweet, bright-red flesh with intensely black seeds. It matures as early as Tom Watson and, by pruning, produces melons of satisfactory size. Strain and commercial trials last season on old and new land again demonstrated its resistance to *Fusarium,* while the popular but susceptible varieties on old land were practically destroyed. This is of great value as *Fusarium* is known to persist in the soil for 15 to 18 years.

Virginia Victory beans, described by a farm journal as the most promising bean of this generation, were under trial in 1945 by more than 9,000 gardeners, commercial growers, and seedsmen in 39 States, Hawaii, and Australia. The Virginia station developed them over the years by crossing the Kentucky Wonder bean with rust-resistant varieties.

Alabama No. 1, a pole snap bean developed by the Alabama station, is filling an important need in several Southern States for a bean which possesses resistance to nematode and rust disease. It is high in quality and a heavy yielder and fruits better under adverse weather conditions than standard varieties. It is desirable for use fresh, for canning, and for sale on markets where its qualities are known. The mature beans may be used for boiling, baking, or for making black soup. Two national seed companies have been producing commercial quantities of the seed, but demand has exceeded the supply in recent years. The variety transmits its nematode resistance when crossed with Kentucky Wonder; for this reason, it is important as a source of breeding material.

Every State or Territory in the Union produces vegetables at least in home gardens, and a great majority grows them on a commercial basis. The war period, with its Victory garden campaign, helped to widen popular interest in vegetable growing and make people more conscious of the role that vegetables play in the human diet. Incidentally people became more conscious of the difference in varieties and more alert to various problems in vegetable production, such as insect and disease control, and to cultural problems such as adequate preparation of the soil and weed control.

New varieties of vegetables have played an important part in maintaining vegetable production in the emergency period and promise much for the future. Increased resistance to plant diseases has been a major accomplishment, accompanied usually by improvement in yield and in uniformity and quality product.

The Penn State Ballhead cabbage developed some years ago by the Pennsylvania station has been constantly improved by intensive selection of the better plants. In 1944, 73 percent of the retail seedsmen selling vegetable seed in Pennsylvania offered Penn State Ballhead cabbage seed at prices often considerably higher than for usual varieties. This new cabbage has greatly increased the income of Pennsylvania cabbage growers.

Purdue 44, a new muskmelon developed by the Indiana station,

possesses marked resistance to alternaria leaf spot, a most destructive disease in southern Indiana, where large quantities of melons are produced. Purdue 44 resembles Hale Best in type and is equal in quality to the best varieties in this group. Unfortunately the new variety is not resistant to bacterial wilt.

Michigan 55, a new melon of the Honey Rock type, was distributed to the growers by the Michigan station because of its resistance to fusarium wilt combined with good quality. In addition to fusarium resistance the outstanding distinctions of the new melon are firm flesh, small seed cavity, uniform shape and a firm and well netted rind.

The USDA–34 variety of sweet corn, developed some years ago by the Puerto Rico Federal station, is now grown not only in Puerto Rico but throughout tropical areas of the world. This variety thrives in regions of short day lengths where the usual Temperate Zone sweet corn varieties fail often to grow properly. In addition USDA–34 is resistant to certain diseases occurring in mild tropical climates. The variety has done well in the Hawaiian Islands and is being used by the Hawaiian station as a source of inbred lines in the development of hybrid sweet corns adapted to the Hawaiian climate. The Hawaiian station supplied a considerable quantity of USDA–34 seed to Government agencies for use in various Pacific areas under control of the United States or its allies.

Promising new sweet corns possessing resistance to bacterial wilt and smut are being developed by the New Jersey station. Of the new combinations under trial, eight appeared so worthy that the early release of the best is expected.

Iogreen 56, Iogreen 16, and Iogent 11, three new hybrid white sweet corn varieties developed by the Iowa station, are designed especially for canning. In 1943, Iowa devoted 57,700 acres to sweet corn for canning, being surpassed by three States only, namely, Minnesota, Illinois, and Wisconsin.

Tomatoes are one of the most important of the vegetables grown in the United States because of their varied uses in the fresh and preserved state. Furthermore because of their high content of nutritive properties, such as vitamin C, tomatoes offer a satisfactory substitute for several of the more costly fruits. No vegetable was more generally grown in the Victory gardens of the war era. Yet the tomato is beset with many disease enemies affecting the plant, the leaves, and the fruit. Hence, there has been and is underway a rather extensive number of breeding projects in the development of varieties of tomatoes suited to specific environments where various diseases prevail.

The Pearl Harbor tomato, a new variety bred by the Hawaii station for resistance to a destructive virus disease known as spotted wilt, is now planted widely on the islands. The new variety is proving valuable as one parent of hybrid tomatoes, one of which known as C–1 is soon to be distributed for commercial use. HES 929, a Bounty hybrid developed by the Hawaii station, produces more abundantly than Bounty because of the longer life of the plants. Tomato-breeding investigations are being actively continued by the Hawaii station in an effort to combine in a single

variety good quality, good size of fruit, and resistance to several diseases and nematodes.

The Rutgers tomato developed some years ago by the New Jersey station continues to gain in popularity throughout the tomato-producing areas of the United States. Indicative of the extent of its use is the fact that in 1943 of the 167,462 pounds of certified tomato seed produced in New Jersey 113,396 pounds were of the Rutgers variety.

The Sioux tomato distributed a year ago by the Nebraska station proved to be an acceptable variety throughout most of Nebraska as well as in nearby States. Sioux produces consistently an unusually high percentage of vitamin C.

Hybrid tomatoes like hybrid corn offer great possibilities to American gardeners because of their consistently higher yields and greater uniformity in size and shape than the usual commercial varieties. Seed of hybrid tomatoes is costly to produce, a fact which has retarded the general use of hybrids despite the recognition of their potential value.

Progress toward the solution of the problem of producing hybrid tomato seed on an economical basis reported by the Minnesota station is cited under the examples. Certain tomato plants were found in a seedling group which were partially self-sterile because of unusually long styles which extended beyond the pollen-bearing anthers prior to the ripening of the pollen. By dusting the protruding stigmas with a desired variety of pollen, good crops of seed were obtained. Since the long-style character is inherited as a simple factor, it may be transferred to any desired parental variety and thus do away with the laborious task of removing the anthers from the flowers.

As grown by the Rhode Island station, hybrid tomatoes outyielded regular horticultural varieties to the extent that, on the basis of existing prices, the hybrids brought $77 to $249 more per acre than the highest commercial variety. Some evidence was obtained that it may be advisable to develop hybrid varieties for different soil types.

Improved cultural operations that lead to higher and more profitable yields of vegetables are often the result of painstaking research.

Increased set of greenhouse tomatoes was obtained by the Ohio station by treatment of the blooms with a combination of two growth-promoting chemicals, indolebutyric and beta-naphthoxyacetic acids. The mixture proved more effective than did indolebutyric acid alone. Not only was the number of fruits increased greatly but the size was larger and the quality as measured by development of the pulp was improved. The Ohio Hothouse Growers Cooperative adopted the exact formula developed by the station and distributed enough material for the 1945 spring greenhouse crop to treat some 200 acres of plants. Yield records indicated that treatments may increase yields threefold.

Beneficial effects from treating the flowers of winter-grown tomatoes were obtained also by the Wisconsin station, using water solutions of beta-naphthoxyacetic or dichlorophenoxypropionic

acid. One spraying of clusters of well-advanced blooms resulted in five to seven tomatoes of relatively uniform size.

The topping of young tomato plants at the height of about 9 inches was found by the New York State station to result in the early development of strong shoots at the base of each leaf and in stocky plants that were easier to handle in transplanting to the field. The pruned plants were more productive than the untreated, which at the time of setting were leggy and difficult to handle by machinery.

Rapid increase of selected carrot plants was obtained by the Idaho station by a simple method of cutting a single root lengthwise into four sections, with some of the crown attached to each piece. When potted and placed in a warm greenhouse, each of the segments developed into an individual plant. The method has particular significance to the plant breeder.

Successful storage of carrots designed for home use was reported by the Minnesota station by placing the roots in paper-lined containers held at low temperature and high relative humidity. Carrots held at 36°, 43°, and 53° F. lost 27, 48, and 98 percent of their weights, respectively, by decay and shriveling during 137 days of storage. Storage in moist sand or soil was beneficial at all three of the temperatures employed.

Low viability of Michigan-grown radish seed was found by the Michigan station to be associated with inadequate drying before placement in the seed sack. When radish seed was dried and cleaned thoroughly immediately after threshing, good-quality seed was obtained. Seed-borne organisms were not found an important cause of low-quality seed.

Heavy fertilizing of vegetable crops is an accepted practice. Yet many facts are regularly coming to light to show growers how to use fertilizers more effectively. Most vegetables are relatively short-lived and need available fertilizer to promote the vigorous growth that means large yields of good quality.

Poor development of tomato plants in the seedbed is often due, according to the New York (Cornell) station, to an excess rather than a deficiency of soluble fertilizers. In general the average field soil composted with a small quantity of stable manure should not receive more than 4 to 5 pounds of a 5–10–5 fertilizer or its equivalent per cubic yard. With soils of greater fertility, this amount should be reduced or even dispensed with altogether.

A combination of fall plowing, adequate fertilizer, and application of a copper fungicide for control of foliage diseases resulted in yields of tomatoes of over 10 tons per acre, as compared with an Ohio average of about 6 tons, according to the Ohio station.

Splitting the application of superphosphate so that part was applied at the time of setting the plants and part at the time of fruit setting gave good results at the Kentucky station with both tomatoes and lima beans. With tomatoes, a division of the application of nitrogen was not so important as that of phosphorus. In some instances, nitrogen applied just prior to fruit setting caused some decrease in yield.

A starter solution consisting of 1 pound of a 4–12–4 fertilizer in 10 gallons of water applied at the rate of 1 pint per plant at the

time of transplanting was found more effective by the Colorado station for stimulating onion growth than was any one of four hormone treatments. Of all treatments tested, the fertilizer was the only one to increase yields significantly over those of the control plots.

Lime was highly beneficial to snap beans growing on a fine sandy loam soil, according to results of experiments conducted by the South Carolina station near Charleston. The average yield of the limed plots was 102 percent greater than that of the unlimed plots receiving otherwise the same treatment.

Applications of calcium limestone increased the yield of spinach grown by the New Jersey station on an acid Sassafras loam soil so low in natural fertility as to support little growth except poverty oatgrass. The lime released apparently sufficient phosphorus from the soil to permit the spinach seedlings to reach the fertilizer which had been placed in bands below the soil surface.

High nitrogen fertilization during the cool weather of autumn was observed by the Arizona station to retard the tendency of lettuce heads to form seedstalks. On the other hand, under conditions of high temperature the nitrogen had no such beneficial effect. The findings have real practical value in Arizona, where the production of head lettuce is an important industry.

Ammonium sulfate proved a better source of nitrogen for asparagus than did either alfalfa hay or horse manure containing equivalent amounts of actual nitrogen, according to studies conducted by the Washington station at its Prosser branch. There was indicated, however, that with the passing of time production on the organic nitrogen plots was increasing while that on the ammonium sulfate plots was leveling off.

Control of weeds has always been a costly operation in vegetable fields and gardens because of the large amount of hand labor involved. Hence it is not surprising that the stations have given considerable attention to the development of sprays such as caustic materials and oils that would eradicate weeds without causing material injury to the crop plants. The work of the California station on the use of oils as weedicides created wide interest in the subject, and certain other States have explored the possibilities in their own regions.

Promising results were reported by the Massachusetts station in the control of weeds in young carrot and parsnip plantings by the use of certain proprietary oils properly diluted and properly applied. When mixed with white kerosene the oils destroyed most of the pernicious weeds without apparent injury to carrots or parsnips. The limitations in the general use of oils were shown in trials with other vegetables where much injury and frequent complete destruction was encountered.

Good results in weed control were reported also by the New York (Cornell) station in experiments with oil sprays with carrots, celery, and parsley, again all members of the same family of plants. There was observed a marked difference in the response of the weeds as well as vegetables to oils. Among weeds that were readily destroyed were dandelion, lambsquarters, and purslane. Ragweed, poison-ivy, and wild carrot, on the other hand, were

resistant. It was observed that carrot seedlings must have two or more true leaves developed before oil sprays can be applied with safety.

SPECIAL CROPS

EXAMPLES OF RESEARCH RESULTS

Empire cotton seed developed by the Georgia station in cooperation with the Department is now available in quantity. A one-variety gin at Haralson, Ga., will have about 400 tons of breeders' seed for distribution. Seed of a wilt-resistant strain will be available in 1947. Empire cotton has been the leading variety in tests in the Piedmont and has given large increases in yield and money value under practical farm conditions. It has a big boll, a high lint percentage, and a staple length of 1 to $1\frac{1}{16}$ inches and is very early and resistant to thrips. The large boll should decrease the time of picking cotton about 12 percent in comparison with varieties now grown.

Sheyenne, a new early variety of flax developed by the North Dakota station and the Department, is immune to races of rust known to exist in this country, is highly wilt resistant, and has about the same degree of tolerance to pasmo disease as Bison, Buda, and Koto. The new variety should fit particularly well in the southeastern sections of North Dakota, where earliness is desirable to escape high summer temperatures or late droughts.

Arrow flax, developed by the Montana station and the Department from a cross of Renew with Bison, has proved satisfactory for seed yield and in quantity and quality of oil. It has been found highly resistant to North American races of flax rust and as resistant to flax wilt and pasmo as the Bison parent. It is recommended for growing on both irrigated and nonirrigated land in Montana.

The peanut breeding program of the Georgia station, cooperating with the Georgia Coastal Plain station and the Department, has resulted in a late-maturing variety, 207–3, which has averaged more than 100 pounds of shelled seed per acre above that of the Spanish peanut in tests over a 5-year period. It is especially adapted to the lower Coastal Plain and is expected to replace the North Carolina Runner variety in this area. Another introduction has a white seed coat and is desirable for commercial uses.

Nitrogen fertilizers measurably and profitably increase the production of Spanish peanuts in Alabama, according to results of tests by the Alabama station. Marked increases were obtained with sodium nitrate, up to 500 pounds per acre, on Spanish but not on Runner peanuts. Years ago the station found that Runners develop root nodules for obtaining nitrogen from the air more rapidly than Spanish.

The farm unit rice drier developed by the Arkansas station has gained popularity in four rice-producing States, and inquiries have been received from distant countries, such as China and India. Use of the combine-drier method of harvesting prevents serious losses due to unfavorable weather at the time of rice maturity. A commercial company was interested in obtaining the

rights to manufacture rice driers using the principles developed by the station.

Shortage of charcoal for local use due to the demands of war industries prompted the development by the Connecticut (State) station of an inexpensive charcoal kiln made of cinder concrete blocks, which requires little attention and no experience for successful operation. Tests show an average yield of 45 bushels of charcoal from each cord of seasoned oak or maple. The station had already designed a steel panel kiln, but wartime restrictions created a need for a kiln that required no strategic materials.

Growing timber on farm woodlots under scientific management and marketing practices for sustained yield and income has been demonstrated as economically feasible on several thousand acres of farm woodland in West Virginia. Costs of expert management and marketing services have been carefully recorded and are found to represent only a small percentage of total returns. The demand for such management services and cooperative contracts far exceeds the capacity of the West Virginia station to extend them.

COTTON

Yields of cotton for the period 1942–44 have averaged more than 270 pounds per acre, as compared with less than 170 pounds for the predrought period 1923-32. This increase is due in large part to improved varieties of cotton, better use of fertilizers, soil conservation practices, and better handling of the crop. Research of the experiment stations and the Department is responsible in large measure for these improvements in cotton production.

Delfos 444, a very prolific early strain of long-staple cotton of the Louisiana station, has dwarfish-type plants well adapted to highly fertile soils and suitable for mechanical harvesting. It yielded at the rate of 2.5 bales per acre on 4 acres of alluvial soil. A newer strain, Delfos 9169, is an excellent producer, has a larger boll and higher lint percentage than most strains of Delfos, and has good staple length and uniformity.

The great increase of verticillium wilt in recent years is a serious problem affecting cotton growing in New Mexico. To meet this problem, the New Mexico station and the Department have selected a cotton strain, wilt-resistant Acala 1517, for increase in 1945. Foundation seed will be available for distribution in 1946. This strain, while not highly resistant, has significantly outyielded the regular Acala 1517 under severe wilt conditions. Spinning tests of 13 advanced strains of cotton, with staple lengths of $1\frac{1}{8}$ and $1\frac{5}{32}$ inches selected by these cooperators, showed that all 13 could be spun into yarns as fine as 100's count without difficulty. Since cottons of these lengths are not ordinarily spun into such fine yarns, this is an excellent indication of the superior quality of these New Mexico strains.

Marked success has resulted in the cotton-breeding activities of the Oklahoma station. In cooperative variety tests in western, central, and eastern Oklahoma, 5 of the 10 most productive varieties in each instance have been station products.

Data by the New Mexico station have shown that, after 1 year of alfalfa, cotton yields were increased by 23 percent; after 2 years of alfalfa, 32 percent; after 3 years, 39 percent; and after 4 years, 45 percent. Such increases were not possible by any system of commercial fertilizer treatments employed.

That fall-seeded green manures, especially adapted legumes, turned under in the spring, have increased yields of following crops of cotton and also corn was determined by the Arkansas station. Hairy vetch and crimson clover gave the most consistent production of organic matter and added large amounts of nitrogen to the soil. Austrian winter peas did not produce as consistently, yet made large average crops of organic matter. Bur-clover and red clover also yielded large average amounts of organic matter, but fluctuated greatly from year to year. Average increase in yield of seed cotton after winter oats turned under has been only about one-third of that after adapted legumes.

Defoliation of cotton varieties by calcium cyanamide dust to facilitate mechanical harvesting was studied in the plains area by the Texas station. Excellent defoliation resulted from the use of 30 to 35 pounds per acre, especially where dew remained on the leaves as long as 3 hours after treatment. Rains following the day of application interfered with defoliation. Some varieties made a rapid second growth of leaves while others did not, and large-leafed cotton did not defoliate as well as those with normal leaves.

FLAX

Redson, a new flax developed by the Minnesota station and the Department from a cross of Redwing and Bison and released by the Wisconsin station, is recommended for Wisconsin because of its strong straw, early maturity, resistance to wilt, and content of high-quality oil. Sheyenne and Arrow flax, developed by the North Dakota and Montana stations, respectively, and the Department, are cited under the examples.

PEANUTS

Holland Jumbo and Holland Virginia Runner, new strains of Virginia type peanuts, developed by the Virginia station are adapted to different requirements of the trade and meet varying farm conditions. Holland Virginia Runner, having short and thick kernels, supplies the need for a strain with exceptionally high meat content without special regard to size of pods and kernels, chiefly for use in making peanut butter and is also valuable for oil. It is more suitable for growing on the darker, heavier soils not adapted for varieties with large bright-colored pods. Holland Jumbo provides a peanut with a high percentage of extra large kernels, chiefly for high-grade salted nuts and for general confectionery purposes, and with a high content of large, bright-colored pods to be hand-picked and sold unhulled. It is best adapted to production on the light-colored, sandy soils with a relatively high calcium content.

Dixie Runner peanut, a new variety for late hog feed, developed by the Florida station from a cross between Florida Span-

ish and Dixie Giant, is a vigorous grower with more prostrate branches, more fruiting nodes per branch, and more nuts per node than the popular Florida Runner, which it has outyielded by 53 percent over 4 years and has equaled or surpassed in percentage of sound and mature seed and in oil percentage. Dixie Runner also remains dormant long after maturity, thus providing a long period for hogging off.

A main reason for low yields of peanuts in many fields in Georgia is an inadequate stand of plants, according to results of cooperative experiments by the Georgia and the Georgia Coastal Plain stations and the Department. Maximum yields of Small Spanish were obtained from plants spaced about 3 inches apart in the row at digging time, whereas Carolina Runner, Carolina Bunch, Virginia Runner, and Virginia Bunch yielded highest with an average of 6 to 8 inches spacing. Width of row down to 24 inches had slight effect on the spacing of plants within the row.

Highest yields from Valencia peanuts in tests at the Arkansas station were obtained from 30- by 8-inch spacing, and from Spanish strains from the 36- by 8-inch spacing. The narrower spacing produced higher hay yields with both varieties. These and other stations have outlined effective production methods.

Striking responses to calcium by Virginia Bunch peanuts were observed by the North Carolina station in experiments at two different locations. Calcium was concerned with the filling of the nuts, and in soil containing appreciable amounts of organic matter there was a higher calcium requirement than in soil essentially mineral.

At the Arkansas station on soil with pH 5.42 to 5.65 crushed limestone (1,056 pounds per acre) in the rows resulted in acre gains of 890 pounds of peanuts and 1.03 tons of hay.

SOYBEANS

The quest for better varieties of soybeans, adapted to special conditions and possessing superior qualities, and improved production and harvesting methods has been continued by the stations. Varieties recently released were being tested extensively for adaptation, and intensive seed increase programs were under way. Several stations, aiming at increased acre yields and efficiency of production, published from their research and experience appropriate information on growing, cultivation, harvesting, and storage practices.

In Ohio station experiments soybeans were defoliated completely in a week by dusting in September with 75 to 100 pounds of cyanamide dust per acre, thus making earlier harvest by combining possible. Defoliation did not impair germination, although it tended to reduce the ash content of the seed and at immature stages to lower the oil content slightly. Cyanamide dust killed most weeds common in soybean fields, smart weed being affected least.

TOBACCO

Oxford 26, a strain of flue-cured tobacco resistant to Granville wilt, developed by the North Carolina station and the Department, was released to growers for use in 1945. A supply of seed for

40,000 acres was produced under supervision of the North Carolina Crop Improvement Association. In some years Granville wilt has caused losses to North Carolina growers totaling from 12 to 15 million dollars. Although highly resistant to the disease, Oxford 26 is recommended only for fields contaminated with Granville wilt and should be rotated with other crops to help control other diseases.

Havana 142, a cigar leaf tobacco resistant to black root, developed by the Wisconsin station and the Department, is now the most popular variety in Wisconsin. Certified seed of this and a few other varieties grown under inspection from foundation seed provided by the station is used to plant some 85 percent of the State's tobacco acreage.

Breeding of a high-nicotine strain of dark tobacco by the Kentucky station appeared promising in that 15 selections grown at Princeton ranged from 4.9 to 6.2 percent of nicotine in the leaf and from 4.4 to 5.9 percent in the lugs. Brasilia and Olson, high-nicotine varieties of *Nicotiana rustica*, grown in the station greenhouse, produced tobacco of a nicotine content from 6.6 to 8.8 percent, but their nicotine content in the field was only 1.54 to 2.64 percent in leaves of topped plants and 0.65 to 2.20 percent in plants gone to seed. The station is also endeavoring to combine superior aroma and mildness with resistance to mosaic, root rot, and fusarium wilt in high-yielding strains of all Kentucky types of tobacco to eliminate losses with these diseases and to increase quality in the State crop as a whole.

Turkish tobacco thrives and produces best quality on comparatively poor soil and does not overlap areas devoted to the growing of domestic leaf, according to experiments in the Piedmont area by the Virginia station cooperating with the North and South Carolina stations, the Department, and Duke University. Plants of Turkish are spaced 5 to 6 inches apart in 20-inch rows and under such crowded conditions produce many small leaves one-tenth as large as leaves of domestic tobacco. Although the labor of planting and other handling operations is greater, the growing crop needs little weeding or cultivation. The crop was being grown under station supervision in 1945 on 55 small farms to determine if a high-quality product can be grown with profit to the farmers.

Cash returns from Burley tobacco, the Kentucky station found, were affected by soil fertilizer treatment and the relative humidity during curing. Unfertilized tobacco, properly cured at 68 percent relative humidity yielded 1,350 pounds worth $648 per acre; at 78 percent it yielded the same but the value fell to $629; and with a relative humidity of 88 percent the yield dropped to 1,230 pounds and the value to $492 per acre. A highly fertilized crop cured at 68 percent yielded 2,500 pounds worth $1,250 per acre; yielded the same when cured at 78 percent, but the relative decrease in value to $1,175 was greater than in the smaller crop of unfertilized tobacco. Cured at 88 percent, the yield was decreased to 2,180 pounds and the value to $415 per acre—less than that of the unfertilized tobacco.

Cigar-leaf tobacco of black root rot-resistant varieties was

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grown by the Wisconsin station in the northern Wisconsin tobacco district on heavy Tama silt loam variously fertilized. Yields and quality over 4 years at average prices for cigar-binder tobacco showed that profitable returns may be expected from as much as 1,000 pounds per acre of high potash commercial fertilizers alone or in conjunction with manure. Because of the general need for phosphates on newer tobacco fields and difficulties in applying potassium sulfate alone, a 3–9–19S formula is generally recommended for Wisconsin.

Improvement of the leaf burn of Wisconsin-grown cigar tobacco, a major problem confronting growers as well as local leaf dealers supplying manufacturers of cigars, involves a number of factors and has been the objective of prolonged research by the Wisconsin station. Much of the poor leaf burn of tobacco in the State appears to be associated with high chlorine content of farm manures and with high calcium and magnesium content in the more alkaline soils. Suggestions for soil treatments to help overcome the difficulty have been developed by the station.

OTHER CROPS

Safflower, an oil seed plant adapted to areas with relatively low humidity, and 3,000-foot elevation or higher, the Nebraska station reports from extensive experiments, may provide an additional cash crop for semiarid regions in western Nebraska and a protein concentrate for adjacent range territory. The crop yields best when the air is hot and dry during flowering, in conjunction with a favorable supply of subsoil moisture throughout growth. Its extensive root system and branching habit enable safflower to adapt itself to a wide range of plant and row spacing, although planting in cultivated rows in preferable.

Moisture content is an important factor in relation to quality of vanilla beans, according to the results of studies conducted by the Puerto Rico University station. Curing of vanilla beans was accompanied by a loss of moisture, which begins during the sweating process and continues throughout drying and conditioning. Beans with a moisture content of 31 to 34 percent had a well-developed and satisfactory aroma and desirable flexibility. A higher moisture content resulted in a fermented aroma and a lower moisture content in a loss of flexibility.

Applications of potash and phosphate may increase the quantity and quality of derris roots, an important source of the insecticide rotenone, according to studies by the Puerto Rico Federal station. Sand culture studies showed the most severe checking of shoot growth from deficiencies of potash, phosphorus, or calcium. Provided the proper nodule-forming bacteria are present in the soil and environmental conditions are favorable, the inclusion of nitrogen in the fertilizer had no material value, derris being a legume.

Important differences in the sugar content of sap from different maple trees were recorded by the New Hampshire station in a State-wide study. With 80 percent of the trees in the 3.0 to 5.9 percent class, one tree ranged above 9 percent. Attempts were made to propagate the high tree by cuttings to determine whether

its high sugar content is heritable or due simply to some favorable environmental factor or factors.

The tannin content of canaigre (*Rumex hymenosepalus*), according to studies by the Department and the Texas and other stations with the progeny of wild plants, has averaged from 21 to 26 percent on a moisture-free basis. The content varies with strain and with soil and climatic conditions. Canaigre roots were shredded at the rate of 1 ton per hour with a shredder of the type devised by the Alabama station for sweetpotatoes and were dried in the sun on asphalt and concrete floors in 24 hours when spread at the rate of 1.25 pounds per square foot. The Department has made progress in processing canaigre for production of extracts suitable for tanning heavy leather.

CONTROL OF INSECTS

EXAMPLES OF RESEARCH RESULTS

Southwestern corn borer is a pest of serious importance which has spread rapidly and in 1944 infested 63 Kansas counties. Probably 5 to 10 counties have since become infested. The Kansas station in studies to develop control methods finds that early planting of corn helps to reduce injury. Earlier planted corn had fewer borer holes and less girdling than corn planted later, and hibernating borers were not so abundant nor so large in early-maturing corn.

European corn borer damage may be reduced in Kentucky by late planting of corn. The Kentucky station found in test plots in 1944 that field corn planted after May 15 escaped attack by most first-generation worms, whereas that planted before or during the first 10 days of May was infested. In one test, Reid Yellow Dent planted May 10 averaged 0.9 first-generation worm per stalk, as compared with none in adjacent rows planted May 19.

Dinitro-o-cresol dust for chinch bug control was found by the Nebraska station a distinct improvement over creosote barriers, confirming earlier results by the Iowa station. The dinitro dust was easier to handle and to maintain as a continuous barrier. It killed all bugs that came in contact with it. Since Nebraska farmers must often practice chinch bug control, these results will find wide use in the State.

Asphalt saturated felt used as a lining for corncribs proved a cheap and practical method of protecting stored corn from rice weevils and other pests of stored grain in Mississippi station experiments. Cribs lined with this material gave good service for 3 years and promised several more years of service. The asphalt lining costs about $5 for a 300-bushel crib. Carbon bisulfide was the most satisfactory fumigant, but methylallyl chloride and chloropicrin also gave satisfactory control of the insect pests.

Alfalfa seed production in Utah, now less than 5 million pounds, could probably be restored to the 1925 level of about 22 million pounds through application of the discovery by the Utah station that seed yields may be increased greatly through the use of new insecticides, especially DDT, for controlling Lygus bugs and other insects that have been chiefly responsible for decline in seed

production. By the use of insecticides on experimental plots, insects such as *Lygus* that destroy or prevent seed development have been so well controlled that yields of alfalfa seed have been increased from less than 50 pounds to more than 300. Possible harmful effects on livestock of alfalfa forage treated with DDT is under investigation by the station. Results seem to indicate the possibility of reestablishing the alfalfa seed industry in Utah to its former high state of production.

The oriental fruit moth, a destructive peach pest, has not been effectively controlled with insecticides. Parasites have been used successfully, but the cost of rearing them has been high. The California station has solved this problem for the State and Nation by developing an "assembly line" method of rearing the parasites on the potato tuber moth at a cost of only 30 cents per thousand. Nearly 20 million parasites were produced and liberated in California in 1944, and a larger number were estimated for release in 1945.

Missouri farmers of the Ozark region are adopting a system of pasture management, worked out through research of the Missouri station, for getting rid of Lone Star ticks. Two pastures are needed. One is grazed until June 15, then kept free of stock by grazing the other pasture until the first killing frost. Repeating this practice the second year starves out the seed ticks. Then the pastures are reversed, and the second one largely freed of ticks by the same system of restricted grazing.

Medication of soil near growing bean plants with Dithane (disodium ethylene bisdithiocarbamate) was found by the Delaware station to be effective against the Mexican bean beetle. Previously such treatments with other materials have never given satisfactory results.

Spraying the ground cover in peach orchards as a substitute for late cultivation had the double advantage in Pennsylvania experiments of killing insects as well as weeds. Two materials, a dinitro and a pentachlorophenol compound, both used with oil and a spreader, killed grasshoppers and tarnished plant bugs and the top growth of all weeds, and cost about as much as a double disking. All bare ground was covered with new vegetation within 7 weeks after spraying. When these sprays were applied at half strength directly to insects they also killed Japanese beetles, buffalo treehoppers, and plum curculios.

DDT, according to results of Minnesota station tests of dusts and sprays for potatoes, may not only prove to be one of the most important insecticides against flea beetle, Colorado potato beetle, and several species of leafhoppers and sucking bugs, but also appears to have considerable effect on reduction of early blight infection in consequence of the destruction of flea beetles.

DDT has proved the most outstanding material used in 30 years of codling moth research at the Oregon station. Practically 100-percent control of this destructive insect pest was obtained on apples in experiments at Medford. Before recommending DDT for use by growers, the station is conducting further studies as to proper dosage, fruit and foliage injury, and effects on beneficial insects.

A promising new insecticide made from the finely ground wood of a tropical plant, *Ryania speciosa,* has given outstanding control of the European corn borer in New Jersey station experiments. Applied as a dust on sweet corn, this insecticide gave a control of European corn borer which was equal to or better than that with rotenone or nicotine compounds. Comparable results with the *Ryania* dust have been reported by the New York State station in parallel but independent experiments. From results of the past two seasons the New Jersey station is recommending the new insecticide for use by growers of sweet corn.

Codling moth, in its ability to damage apples, has kept pace with the development of spraying methods and spraying equipment, and in many orchards the standard lead arsenate program has failed to protect the fruit. The discovery by the Virginia station that adult codling moths can be killed by free nicotine has resulted in new control procedures. The shortage of nicotine has prevented its general adoption, but many growers have demonstrated that injuries to the fruit can be prevented by the use of several sprays containing nicotine. Orchard tests with DDT have shown that small amounts combined with nicotine or with arsenate of lead greatly aids in worm control. It now seems certain that this new insecticide will find a place in the regular spray program.

Any program of food and feed production to be successful must take into account possible outbreaks of insect pests and make proper provision for their control. During the war emergency period when increased production was the most important problem in American agriculture, station entomologists concentrated their efforts on substitutes for insecticides not then available or available in limited amounts, the development of new insecticides, the use of smaller quantities or combinations so as to stretch supplies, and better methods of application and improved cultural practices for insect control. Many of the findings and practices originating during the period will be continued and improved by research now under way at the several State stations. The following are selected examples of recent accomplishments of some of the research at the State stations in addition to those cited above.

INSECTS ATTACKING CROP PLANTS

Fall plowing reduces damage by the corn rootworm, according to recent results of the Nebraska station. Studies were made in a field that had been in corn continuously for several years where there was a heavy rootworm infestation. In spring-plowed plots 95 percent of the stalks were somewhat affected and 52 percent or more were severely affected. These observations indicate that wherever other conditions permit fall plowing might be profitably employed in conjunction with the recommended rotation.

Late corn was found by the Arkansas station to be the most important source of hibernating pupae of the cotton bollworm, which is described as the number one crop pest in Arkansas.

Early corn was not found to produce hibernating stages of the insect. The observations suggested that the recommendation for winter plowing should be limited to late corn.

A white grub (*Ochrosidia* spp.), known to feed upon young wheat plants, was observed by the Kansas station to damage growing wheat, a habit not reported previously. Normally, the insect feeds on decaying organic matter and usually is most abundant in soils high in such material. It overwinters in the larva stage and pupates in the spring, and the beetles emerge in June. This is the first report of any extensive damage to growing wheat. The station is studying this insect further to ascertain its habits and the soil conditions and farm practices which favor increase of population of the species.

Important crop pests in Alaska, particularly those in the Matanuska Valley, have been investigated during the past 2 years by the Alaska station and the Department. Thus far, these investigations indicate that the most important insect damage to Alaskan crops is caused by the seed corn maggot. The important cutworms, which also cause serious damage in the Matanuska Valley, were found to be the red-backed cutworm, the glassy cutworm, and the spotted cutworm. Studies on root maggots indicate that DDT may have distinct possibilities for control of these insects under Alaska conditions.

Methyl bromide fumigation of sacks to kill walnut husk fly pupae has been further studied by the California station. As in earlier results, all pupae were killed in bales containing 500 sacks when fumigated with methyl bromide at the rate of 1 pound per 100 cubic feet for 12 hours at atmospheric temperature and pressure, provided a 28-inch vacuum was drawn on the fumigator initially for injection of the methyl bromide.

Biological control of insects and weeds by the use of other insects or diseases has been helpful in control practices on numerous occasions. Important advances in this direction have been made this year by station entomologists cooperating with the Department. An example from the California station has been cited.

In large-scale tests the New Jersey station liberated approximately 45,000 adult *Macrocentrus ancylivorus* in peach orchards on the first brood of the oriental fruit moth and about 20,000 on the second brood. Data on twig and fruit infestation in these and a number of "check" orchards indicated that the liberation of 200 parasites per acre on the first brood gave as good or better control than 500 parasites per acre on the second brood. Effective use has been made in New Jersey of the potato tuber moth technique for rearing the parasites as developed by the California station.

An attempt to control Klamath weed (*Hypericum perforatum*) by the use of insects was undertaken by the California station in cooperation with the Department. Breeding stock of three species of *Hypericum* insects, two leaf feeders and one root borer, was obtained from Australia, and one of these, *Chrysolina hyperici* Forest, was released in May 1945. It is hoped that this method may make the control of Klamath weed possible in areas

where its destruction by other methods is not economically practicable.

Collection of corn borers in 1944 from fields at different distances from the point where the parasite *Lydella* was liberated showed that the parasite had become successfully established, according to the Delaware station and the Department. Records were taken in the vicinity of two other liberation points, and two new release points were set up in each of the three counties of the State. About 45,000 parasites, representing four genera, were liberated. More borer collections were made in the current spring. A parasitism of 27 percent by *Lydella* was recorded at the liberation point in Sussex, with nearly 10 percent parasitism at a distance of 3 to 5 miles from this point.

Two bamboo scales, *Asterolecanium bambusae* Bvd. and *A. miliaris* Bvd., have proved serious pests on bamboo under Puerto Rico conditions. Because of the potential value of bamboo to the agricultural industry of the island, the Puerto Rico Federal station introduced two predatory beetles to combat these scales. As a result, 1- and 2-year-old culms of bamboo have become almost entirely free of scale infestation, whereas previously more than 50 percent of the culms and foliage of this age were heavily infested with scales. Field observations indicated that the most effective predator introduced against the bamboo scale is *Egius platycephalus* Muls. One of the reasons for the effectiveness of this species is the fact that it is able to maintain itself under conditions of extremely light scale infestation.

Italian pear scale (*Epidiaspis leperii* (Del Guer.)) populations decline to a low level when the lichens with which they are associated are destroyed, according to studies by the California station. On previously established plots of walnuts in Tulare County, Calif., the station discovered that the lichens could be eliminated by a thorough spraying during the dormant season with hydrated lime at a dosage of 10 pounds plus 2 gallons of dormant oil spray per 100 gallons of water.

Pea aphid was found by the North Carolina station to winter over to such an extent in Austrian winter peas, vetch, and alfalfa that it has become economically impossible to grow garden peas in the same vicinity. When garden peas were grown in isolation from the above legumes one dusting with rotenone or nicotine materials gave adequate protection from aphids. In several instances good crops were obtained without any dusting.

Aphid yellows of celery, formerly thought to be caused by a virus, has been shown by the Colorado station to result from the secretion of a toxic substance by aphids. Affected celery plants recovered when the aphids were destroyed. This aphid (*Aphis helianthi* Mondell) overwinters on dogwood and feeds during summer on many plants, but those infesting celery came largely from sunflowers.

OTHER INSECTS

Treatment of feeder cattle for cattle grub control did not result in improved rate of gain over untreated calves and heifers in feeding tests at the Nebraska station, although about 95-percent

control of grubs was obtained. Examination of hides at time of slaughter, 96 days after treatment, showed that grubs had emerged from untreated cattle and the openings had healed faster than in treated animals. These findings with information obtained earlier indicate that the most important avenue for attacking the cattle grub control problem is through treatment of breeding herds and stock cattle.

Resistance of honeybees to foulbrood has been studied by the Department and several State stations. During the year tests for resistance to American foulbrood were completed on 59 colonies of bees from three distinct breeding lines which have a known history for resistance at the Iowa station. For the second consecutive season positive evidence of American foulbrood was found in 100 percent of the colonies inoculated. As compared with results for the preceding year the percentage of recoveries in one line increased from 82 to 88, in another 67 to 100, and in the third 82 to 100. It is of considerable interest that only one of the 59 colonies tested failed to recover completely by the close of the season and it showed only a light case of the disease. These results have a great deal of potential interest to Iowa beekeepers.

Royal jelly influences sexual development, maturity, size, coloring, shape, length of life, and instincts of bees. Results from the Florida station show that it is a bitter, milk-gray jelly, containing protein, fat, carbohydrates, and minerals, with a composition approximating that of evaporated milk. Proteins were separated into two fractions, one a globulin and the other an albumin present in the proportion of 2 : 1. The carbohydrate was found to be largely invert sugar and the other extract largely composed of a hydroxy fatty acid not previously reported. Injection of the acid into rats caused an interruption of the estrous cycle. Royal jelly was found to have remarkable keeping qualities with resistance to both molds and bacteria. Concentration of the fatty acid in concentrations of 1 : 10,000 have a marked stimulating effect on the growth of both *Staphylococcus* and *Streptococcus,* but at 1 : 1,000 the influence is lethal.

ADVANCES WITH INSECTICIDES

The increasing consumer demand for quality food products in the postwar period should intensify entomological problems, since the control of insects and diseases is an important factor in improving quality. The use of proper insecticides in minimum amounts applied at the correct time helps to insure sound unmarred products as well as larger crops. With this point in mind station entomologists are moving forward on the improvement of insect control practices. Below are a few examples of some of the results obtained in addition to those cited under examples.

The relative efficiency of dust and spray applications was studied by the Connecticut (State) station using dosage series of cryolite on beans for the control of the Mexican bean beetle. Results show that in general a pound of cryolite applied in the dust form was more effective than the same amount of material applied as a spray. This interesting finding is contrary to the gen-

eral experience that sprays are more efficient than dusts in terms of material used.

Adaptation to deciduous fruit orchards of the spray-duster, a machine developed with the help of the California citrus station for applying fungicides and insecticides in citrus orchards, is the objective of experimental work by the New York (Cornell) station. When the original type proved inadequate for apple orchards the outlet was redesigned to streamline the airflow so that it can now cover trees 25 to 30 feet tall with fair success. Further improvement work is being done because the results already show important advantages in this type of pest-control equipment. A large fan delivers 20,000 cubic feet of air per minute while nozzles atomize liquids into the air stream at the rate of 15 gallons per minute. With larger volume of air and low velocity for carrying chemical dusts, better pest control appears possible with less injury to leaves than in the conventional duster or sprayer. The use of a liquid mist seems to pull the dust out of the air and make a heavier and more adhesive deposit on the tree. This principle is also being used in the Florida "Speed-Sprayer" type of equipment.

Two new basic copper arsenical products, copper hydroarsenate and copper hydroarsenate-arsenite, were compared toxicologically at the Iowa station with certain arsenical compounds, and the relative toxicities were determined on several economic insects. The greatest susceptibility was shown by grasshoppers, followed by potato beetle larvae, cabbageworms, and corn earworms. The hydroarsenate was more toxic than the hydroarsenate-arsenite to potato beetles but was less effective against cabbageworms and spotted cucumber beetles, whereas there was no significant difference in the action of these materials on grasshoppers. Both had a definite repellent effect on potato beetle larvae and corn earworms, the hydroarsenate-arsenite apparently having the greater repelling property. They were less injurious to bean foliage than commonly used arsenicals and show promise of becoming useful, economical poisons.

Sulfur, properly used, has been found effective against mites which are found on most vegetables and fruits grown in Hawaii. Among these are the russet mite, found by the Hawaii station in 1941 and now considered a major tomato pest at low elevations; the broad mite on tomato, pepper, eggplant, green bean, chard, beet, papaya, and Irish potato; the privet mite on papaya; and the erinose mite on litchi. In addition to the mites, sulfur is equally effective against leafhoppers on green and lima beans, chard, beet, and Irish potato, and the station has also secured evidence that sulfur is rather effective as a stomach poison for cutworms, beet armyworm, and green garden looper.

Bordeaux is the standard insecticide-fungicide used on potatoes in New York, but a low lime formula commonly recommended has not proved entirely satisfactory in areas where flea beetles and leafhoppers are important pests. Tests by the New York (Cornell) station showed that hydrated lime is not so repellent to flea beetles as bordeaux but that successive increments of lime from 2 to 8 pounds in 50 gallons of water progressively increased the

repellency of the mixture. The rise in effectiveness was most pronounced at a low level (2 pounds in 50 gallons) of sulfur sulfate. At the highest sulfur sulfate concentration used (8 pounds in 50 gallons) the low lime spray was only slightly inferior to the one containing a maximum of hydrated lime. Considering the various dilutions of copper sulfate similar trends were noted when the amounts of copper were varied within the limits of 2 to 8 pounds per 50 gallons of bordeaux. Information from field tests in western New York indicated further that the protection against flea beetles and leafhoppers afforded by bordeaux was better with a high than with a low lime formula. Tuber yields were also increased with successive increments of lime, but the most pronounced increase occurred between the 2– and 4–pound levels of lime. The concentration of copper sulfate greater than 4 pounds did not appear necessary during the years the tests were conducted.

Residual effects of insecticides are important in the control of cotton leafworm. In field plots in Texas treated by the Department cooperating with the Texas station, lead arsenate or basic copper arsenate dusts gave protection against the cotton leafworm for 2 months following the last application and heavy rainfall, whereas cotton dusted with calcium arsenate or cryolite was defoliated by leafworm feeding. In cage tests in fields, cotton dusted twice and exposed to 7 inches of rainfall after the second application showed the following percentage reductions of leafworms 5 days after this treatment: With basic copper arsenate-sulfur, 82; with lead arsenate, 79; with calcium arsenate, 51; and with cryolite, 38.

Cryolite has been recommended for Mexican bean beetle control on numerous occasions. In experiments conducted by the New York (Cornell) station against the larvae of the Mexican bean beetle, cryolite sprays appeared highly toxic though slow acting and repellent. First to third instar larvae were more susceptible than fourth instar larvae, and to obtain high kills with the latter 3 to 4 days of feeding on heavy deposits seemed necessary. Two days were sufficient for the younger stages.

The influence of insecticides on plant growth is an important factor to be considered before they can be recommended for insect control on specific plants. Various insecticide dusts have been studied by the South Carolina station to determine their value against the cowpea curculio, a serious pest of cowpeas in South Carolina, and their influence on plant growth and yield. Results showed sodium fluosilicate decidedly undesirable for use on cowpeas, since the yield from plots treated with this dust was less than half that of nontreated plots. This reduction in yield is apparently due to the prevention of pod formation and the serious shortening or stunting of pods that form. South Carolina investigators have concluded that since the yield is so drastically reduced the use of sodium fluosilicate at full strength is precluded on cowpeas regardless of control obtained.

Dithane, a new organic chemical, when used by the Connecticut (State) station with spreader, killed adults and nymphs of red spiders at all concentrations above 0.125 percent, and most of

those in the egg stage were killed by a spray of 0.6 percent. A spray of 0.15 percent plus the spreader repeated after 10 days controlled red spiders on strawberries and carnations. Spray injury was not severe, in fact less than 0.5 percent on strawberries and peaches, but some discoloration of carnation foliage occurred at a concentration of 0.15 percent. Experiments in which the spreader was omitted consistently showed less injury to the plants and a lower kill of the mite population. The spruce mite was controlled by immersing the cut ends of spruce twigs in a 0.6-percent solution, indicating that control of this species was effected by the absorption of the chemical by the twigs. No population reduction was observed on check twigs immersed in water. The common red mite was not controlled when cut petioles of strawberries were immersed in various concentrations or when the solutions were added to the soil.

A new polychlor compound was discovered by the New Hampshire station which gives 100-percent kill of houseflies, mosquitoes, and other insects when incorporated in kerosene at 0.8 percent. This concentration did not appear hazardous to animals when atomized in a closed space. The station also discovered a new pyrimidine compound which has exceedingly prolonged repellency against flies and may become useful for reducing fly population in barns and milk rooms.

A new tenacity agent for insecticides superior to any other material tried has been studied by the New Hampshire station. This compound is water-soluble but sensitive to light and on exposure to a moderate amount of daylight becomes completely insoluble in water. Addition of this material to a typical insecticide dust at the rate of 4 percent or less by weight renders the dust highly resistant to subsequent rain, provided the application is made when the plants are wet with dew. This compound also has an important relation to fungicides which are not tenacious on foliage. A material such as copper sulfate, which has little tenacity, adheres strongly to foliage when the new compound is added to the spray tank in proportions as low as 2 pounds per 100 gallons of water.

RESEARCH WITH DDT

DDT, a synthetic organic compound initially developed before the war and used in Switzerland about 1939 for protecting fabrics against clothes moths and then to control Colorado potato beetles and houseflies, has received more attention by the State stations during the past 2 years than any other insecticide. Even though about 17 manufacturers were producing more than 2 million pounds per month by the end of 1944, because of military needs, only enough DDT above these requirements was available for research investigations by the Department, State stations, and other research institutions.

Station and Department research under varied conditions throughout the country has shown that this insecticide has considerable promise for field crop pests, such as sugarcane borer, sugarcane aphid, and grasshoppers, and for *Lygus* on alfalfa seed; for control of several important fruit insects, especially codling

moth, leafhoppers, oriental fruit moth, grape berry moth, and Japanese beetle, and for several common pests of garden crops; for insects injurious to wood and wood products; for insects which defoliate trees and shrubs; for insects attacking man and animals; and for a few cotton pest insects. Because of the possibility of harmful residues, DDT must be used with care for treating grain or forage crops to be used for animal feed and the residue problem on fruits and vegetables is receiving serious consideration.

Although promising for general use, DDT does show some selectivity, there being some important insect pests, such a screwworm, cattle grub, chigger, poultry mite, plum curculio, Mexican bean beetle, tobacco hornworm, turnip aphid, melon aphid, cabbage seedpod weevil, red spider, tomato russet mite, boll weevil, and cotton leafworm, which are controlled more effectively by the standard insecticides now being used. In fact, the use of DDT may result in increased number of certain serious pests such as mites and aphids. Furthermore, a drawback for its widespread use may be that it is not selective enough, since in some cases beneficial parasites may be killed which have taken years to establish.

Truck crop insects have been successfully controlled by DDT in many instances. Station work has shown that one of the most valuable features for potato insects is its pronounced and prolonged residual effects. For example, the Minnesota station found it highly toxic to flea beetles, leafhoppers, and tarnished plant bugs and its tenacity after application a useful attribute when heavy and persistent migrations occur from field to field.

The New York (Cornell) station found DDT to be highly effective for leafhoppers and to compare favorably with standard arsenical treatments and 0.75 percent rotenone for Colorado potato beetle and for reducing the number of aphids and flea beetles. At the same time, this station showed it to be compatible with the most common fixed coppers, bordeaux mixture, and at least two organic fungicides. Although used in concentrations as high as 10 percent in dusts and 5 pounds in 100 gallons of spray, no plant injury from DDT was evident in field-grown potatoes.

A 3-percent DDT dust used by the North Carolina station proved successful in controlling adults and larvae of Colorado potato beetle, as well as leafhoppers and the flea beetles. Nebraska station tests showed it more effective against the major potato pests than any material yet tested, and the Ohio station showed spray containing 1 pound per 100 gallons of water effective in controlling leafhoppers and increasing yields. The Texas station controlled potato beetle larvae and adults with a 3-percent dust, and an application on June 15 gave a 78.5-percent control of psyllids. In North Dakota, where leafhopper, Colorado potato beetle, and flea beetles are major pests, plots treated with a 5-percent DDT copper dust yielded 174.4 bushels per acre, as compared with 160 bushels for the check plots. The Louisiana station obtained promising results against tomato fruitworm with a 3-percent dust in combination with an insoluble copper.

When dusted on the heads of onions being grown for seed and heavily infested with a small plant bug (*Psallus ancorifer*

(Rieber)) a good seed yield resulted, as compared with a 50-percent loss in the nontreated portion of the field, according to results from the Oregon station.

The Texas station, using a 3-percent dust of DDT at a rate of 20 pounds per acre for onion thrips on cantaloup, found an average of 0.9 thrip per leafs, as compared with 24.6 thrips per leaf in the nontreated plots.

Under Oregon conditions the Oregon station found a 3-percent DDT dust, applied at the rate of 8 ounces per 300 foot of row when carrots were a half inch high and rust flies were active, resulted in only 12 percent wormy carrots, as compared with 56 percent for nontreated checks.

Evidence from the Hawaii station indicates that greenhouse whitefly and Chineses rose beetle, the two most important insects of green beans in the Hawaiian Islands and not previously satisfactorily controlled, can be controlled by a 2-percent DDT dust. Under some conditions dusts containing higher percentages of DDT were detrimental to bean plants, and further studies are under way on this point. A 1-percent DDT dust controlled cabbage webworm as effectively as a 50-percent cryolite dust.

For imported cabbageworm and cabbage looper the Wisconsin station found a 3-percent DDT dust superior or equal to rotenone and arsenicals in the control of both these insects when applied to cabbage either as a dust or spray. Yields of cabbage by average weight in pounds per head were considerably greater in the DDT-dusted plots.

The Virginia station obtained 100-pound kills of garden flea hopper with 0.4-percent DDT dust.

For control of cucumber beetles the Nebraska station treated cucumbers, squash, and pumpkins with 3-percent DDT dust and found it about equal to cryolite. A 3-percent dust with an insoluble copper and free nicotine appeared highly toxic against pickleworm, according to the Louisiana station.

The South Carolina station dusted sweet corn with 3-percent DDT dust and found the treated plots had 33 percent of the ears injured by corn earworm whereas 86 percent were injured in the nontreated plots. The Kansas station found that one application of the 3-percent dust gave approximately 75-percent control of the corn earworm; nearly 100-percent control was acquired, however, when the constriction method by twine was used on other plots.

Five applications of 3-percent DDT dust were made by the Indiana station during June to Golden Cross Bantam sweet corn, with the result that only 9 percent of the treated stalks were infested with European corn borer, whereas 62 percent were infested in the untreated areas.

Delaware station results showed that 4-percent DDT dust resulted in only 1.0 European corn borer per stalk, with 2.8 as the average for the control.

Orchard insects have been controlled effectively with DDT. Used in oil emulsions both as a ground and tree spray, it gave excellent results for the control of pear thrips in Oregon station experiments. Emergence on plots was reduced almost 100 percent

with some treatments and in heavily infested plots the thrips population was reduced to a point where it was no longer a commercial factor. From these results the station anticipates that DDT will probably replace nicotine sulfate, formerly the standard control for pear thrips.

Used at the rate of 0.8 pound per 100 gallons of spray, DDT gave codling moth control equal to that produced with 3 pounds of lead arsenate on apples in western New York in experiments by the New York State station. No apparent injury resulted to the trees or the fruit, and no visible residue was present on the fruit at harvest following five cover sprays.

The Oklahoma station found that 2 pounds of DDT per 100 gallons of water reduced the pecan casebearer infestation to 40 percent, as compared with 60 percent in the checks.

Under field conditions the Pennsylvania station found that one application of a DDT spray gave satisfactory control of the grape leafhopper, this spray appearing toxic to both adults and nymphs and leaving a residual effect for several weeks. Early season applications appeared more satisfactory than later sprays.

Dusting with 10 percent DDT in pyrophyllite by the North Dakota station of a limited area of shrubbery where large numbers of mosquitoes were harboring resulted in an abrupt decrease, but the area was soon invaded by mosquitoes from outer areas. Evergreens which had been dusted soon became heavily infested with mites, and dusting with sulfur to destroy the mites became necessary to save the trees. This indicated that DDT had destroyed natural enemies of the mites, thus aiding their unusual increase in numbers.

Effectiveness of DDT for killing chicken lice was tested by the Kansas station, with special attention to its residual or persistent influence when applied to the plumage as a dust. Concentrations of 3, 5, and 10 percent were not superior to the standard sodium fluoride treatment in immediate or retentive killing power.

A single application of a 1-percent suspension spray of DDT controlled stable and other flies in farm buildings for 6 months, according to results from the Idaho station. The station also found that a dust or spray application to cattle controlled lice effectively for the season.

DDT aerosols for field use were tested by the Maryland station and Department and proved effective on 31 species of insects attacking vegetable crops. For the control of onion thrips, aster leafhopper, egg plant lacebug, and potato aphid this method seems outstanding since the nature of the aerosol is such that it gives maximum contact and apparently, in addition, leaves a toxic residue on the plant foliage sufficient to repel or kill migrant leafhoppers. Some of the more resistant species were harlequin cabbage bug, squash bug, and Mexican bean beetle. For pea aphid DDT applied by the aerosol method was highly effective, rapid in action, and gave a kill equal or superior to standard sprays of derris or suspensions of DDT. A new type machine was designed for application of DDT by this method whereby

the spray material was released under a metal hood confining the insecticide near the aphids.

The Arizona station successfully controlled several insect pests by means of DDT in a fog which was generated by a device similar to military smoke-screen apparatus.

INSECTICIDES FROM PLANTS

During the year several plant species were studied as possible sources of satisfactory economic poisons and outstanding advances were made. An example resulting from cooperative research between the New Jersey and New York State stations of outstanding control of the European corn borer obtained with a hitherto unreported insecticide of plant origin is cited at the beginning of this section.

Kerosene extracts of sabadilla, a widely distributed plant and known for sometime to possess certain insecticidal properties, were found highly toxic to houseflies by the Wisconsin station, the kill and knock-down comparing favorably with other kerosene types of sprays, such as pyrethrum. Considerable variation in toxicity to flies existed, however, among different sabadilla samples. Of 25 studied about 30 percent proved toxic, and these were the ones obtained in a powdered condition. At room temperature samples of freshly powdered seeds were not effective, but, by raising the temperature of the extractive, all inactive samples became potentially toxic. The initial increase in toxicity occurred at temperatures above 75° C., the optimum being 150°. Heating powdered seed and treatment with soda ash prior to extraction also considerably increased the toxicity of inactive samples. Toxicity of powdered seed increased with age, and kerosene extracts of seed retained their toxicity in brown glass containers for 2 years. Seeds from two species of sabadilla from the United States were found to possess properties highly toxic to flies and comparable with those of species from the Tropics.

Mature mamey seeds in kerosene extracts proved toxic to roaches, flies, ants, and mosquitoes in tests by the Puerto Rico Federal station. The active principle, found to be a pyrethrum-like substance, is ether-soluble and appears to act as a contact insecticide. This plant may offer a cheap, local source of an insecticidal material.

Rotenone has become an important insecticide for control of pea aphids. Because of a shortage the use of minimum amounts is essential. According to results of tests by the Wisconsin station and the Department with an oil-conditioned rotenone-bearing dust mixture, the quantity of rotenone applied per acre governs, within limits, the resulting kill. When as much as 0.3 pound of rotenone is applied per acre it makes little difference whether a dust mixture of high rotenone content is used at a low rate or one with a lower content at a higher rate. If only half that amount or less is used, a high rotenone content dust applied at a low rate is preferable to one of low content at a high rate. A marked decrease in pea aphid kill occurs when the

rotenone content is decreased from 0.375 to 0.25 percent or lower.

An investigation of dispersants for rotenone and other insecticidal dusts by the Wisconsin station showed that success against the pea aphid depended largely on the dispersant used and the most important factors related to particle size, shape, and hardness. In these studies 15 different clays, 3 claylike materials, and a plant material were tested with dusts containing four different percentages of rotenone. Effectiveness was correlated with even dispersion and good coverage, and, with two exceptions, best coverage was obtained with dusts giving the lightest clouds, settling quickly, and becoming more evenly dispersed on plants and aphids. Dispersants with large particles up to 40 microns gave better coverage and more even dispersion than those 2 microns or less in diameter. The electrostatic charge effects produced by different dusts indicated a relationship between size of charge and effectiveness of the dust and usually the higher the charge the better the dispersion and coverage.

Nicotine sprays applied weekly at the rate of 1 : 800 of 40 percent nicotine sulfate in water controlled two injurious thrips (*Scirtothrips longipennis* Bagn. and *Anaphothrips orchidii* (Moulton)) causing severe damage to *Cinchona* seedlings in Puerto Rico. According to the Puerto Rico Federal station, the first species was more abundant but both caused damage by rasping the upper surface of the leaves causing them to curl and die. In open beds under palm leaf shade, damage was slight on plants 6 to 15 months old, but severe on 70 to 80 percent of the plants the same age in beds more protected from rains. Growth of the more protected plants was considerably checked, resulting in some dying, and even though leaves outgrew injury much tissue along the midribs was killed. These results should have application to the growing of better plants of *Cinchona* for planting in tropical areas.

PLANT DISEASE CONTROL

EXAMPLES OF RESEARCH RESULTS

Dithane-zinc sulfate-lime spray has proved to be the most effective fungicide yet known for controlling late blight of potatoes under south Florida conditions. It was exceedingly effective in tests by the Florida station at Homestead in 1944. In 1945 it was used on 95 percent of the 6,000 acres in the area planted to this crop. Very favorable weather early in the growing season resulted in a heavy set of tubers. Then, the almost universal use of this spray prevented late blight from becoming epidemic. In spite of fogginess, showers, and cool weather, the disease made little headway where the plants were sprayed weekly with Dithane, but was rampant where copper sprays or no sprays were used. The life of the plants was extended several weeks by its use, and killing the tops with herbicides was necessary to begin harvesting on time. It was estimated that the use of Dithane netted the potato growers in this area at least 1½ million dollars.

Leaf spot is the most destructive disease of currants, often causing complete loss of leaves, stunting plants, and ruining yields. Experiments over 6 years by the New York State station have

greatly simplified and reduced the costs of control. The best protection was secured with bordeaux 3–3–100 with 1 pint of a self-emulsifying cottonseed oil preparation applied about June 1 and again immediately after fruit harvest early in July. Formerly five sprays were applied by growers.

Two new fungicides developed by the Rhode Island station have shown excellent control of apple scab in Rhode Island trials and in other States, including New York and Massachusetts. They are effective in high dilution, stick well, largely avoid leaf and fruit injury, and have the double advantage of killing some infections already started and preventing new infections. Although still in the developmental stage, one of them, Isothan Q–15, was scheduled for production of over 100,000 pounds in 1945. The other, Puratized N5E, because it contains mercury is for use on nonedible plant parts.

Ring rot of potatoes, a destructive bacterial disease of widespread importance, may soon be brought under effective control through the breeding of resistant varieties at the Wyoming station. Beginning with more than 2,000 potato seedlings the station obtained 13 that have shown no infection in 5 years of testing. One of these, Wyoming 27, a white-skinned, medium-late variety, yielding, storing, and cooking well, was increased to 2,000 bushels in 1944 and is now under trial in Wyoming, other States, and Canada, before release for general use.

New chemicals are replacing old materials for controlling insects and diseases through extensive investigations by the experiment stations. Based on Illinois station studies two new organic dusts, Arasan and Thiosan, are replacing formaldehyde for onion smut control in the Chicago area, where 80 percent of the onion sets produced in the United States are grown. The formaldehyde treatment used there for the past 25 years is slow and laborious; the new treatment is two or three times faster and equally effective.

Penicillin, in tests by the Arizona station, destroyed crown galls on plants of bryophyllum. Cotton soaked in crude penicillin was wrapped around the galls after they had been pricked with a needle. This procedure is suggested for trial on nursery stock, trees, and other plants that are seriously injured by the crown gall disease.

Potato scab is a difficult disease to control on Indiana muck soils. During 3 years of experimental work by the Indiana station wettable sulfur proved the most effective seed treatment. It is much cheaper than the commonly used formaldehyde or mercury treatments and is easily applied. By using wettable sulfur in these experiments, Indiana-grown seed produced crops as free from scab as northern-grown seed.

A new strain of the tomato-wilt fungus has been discovered in Ohio which, if widely disseminated, might become a serious threat to tomato production. In studies at the Ohio and Missouri stations this new strain of *Fusarium* attacked varieties of tomatoes that are resistant to ordinary strains of the fungus and even infected the cherry tomato used by plant breeders in developing wilt-resistant varieties. Evidence of the existence of factors for

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resistance to the new strain were found which may prove valuable in breeding to meet this new hazard.

Late blight rot of potatoes in storage, which destroyed 4 million bushels of the Aroostook County crop in 1943, can be prevented by killing the vines with chemical sprays before harvest. In cooperative tests by the Maine station and the Department, tubers harvested before the vines were all dead showed 53 percent rot after 6 to 8 weeks in storage, whereas those dug 10 days after the tops had been killed by spraying showed less than 1 percent rot. Although this rot can also be largely avoided by delaying digging until after killing frosts, early harvesting is an effective way of reducing virus infection.

Potato dump piles having been proved by studies of the Maine station and the Department to be the worst source of the late blight infection in potato fields, the next step in the station program was to devise ways of avoiding the dump-pile hazard. Any method that prevents sprouting or kills the early sprouts was found effective, such as natural freezing through early dumping out of storage houses, treatment with salt brine, burning with straw, deep burying, or spraying the sprouts with chemicals.

Scientists of the Connecticut (State) station in the past few years have tested some 6,000 chemical compounds for possible usefulness in plant disease control. From this testing came two new fungicides: Spergon for seed treatment and Dithane for a foliage spray. Dithane has proved outstanding against potato late blight, as noted in the results reported by the Florida station, and controls apple scab well.

Tomato fruit rot caused by *Phytophthora capsici* and responsible this year for a 25-percent loss in the Arkansas valley of Colorado can be controlled effectively by field ridging or the use of fungicides, according to Colorado station experiments.

LOWERING PRODUCTION COSTS BY CUTTING CROP LOSSES

Increasing efficiency in the protection of American crops against plant disease losses is assured by the continued progress which the State agricultural experiment stations are making. Their plant pathologists are digging into unsolved crop-disease problems. They are devising and testing out superior materials, methods, and machinery for use in fighting plant diseases. They are working with plant breeders to develop disease-resistant, high-yielding varieties of crops, suited to all parts of the country. American farmers are applying the results on farms in every State. This will help in a very substantial way to meet the expected postwar return to lower price levels. Farmers will be able to produce more economically because they can more effectively prevent the damage caused by diseases that are always cutting down crop yields and crop quality and thus raising the unit costs of production.

In cooperative research among scientists, America probably leads the world. This is certainly true in the field of plant pathology. During the year a large amount of research relating to plant-disease control was continued on a cooperative basis be-

tween the Department and the State stations or among the different stations. In some instances cooperative programs have included Canadian experiment stations. It is not too much to hope that, with encouragement from the United Nations Food and Agriculture Organization, a world-wide cooperation in the investigation of plant diseases may eventually become greatly expanded. Such a course would insure more rapid progress in reducing the plant-disease hazards that hinder agriculture on every continent.

In addition to the examples given above, the following items disclose some of the progress reported by State experiment stations in the plant-disease field. The work referred to was done for the most part during the 1944 growing season. A brief survey like this, although necessarily far from complete, will reveal the major trends in current research work leading to better crop protection. For further details, readers are referred to the experiment stations concerned.

DISEASES OF TOMATOES, POTATOES, AND OTHER VEGETABLES

New synthetic chemicals for plant protection have recently been developed by the stations working with the chemical industry, as was brought out in last year's report. Because of the superiority shown by some of these materials in preliminary trials, experiment station workers in all parts of the country set out energetically during the year to learn more with respect to the different crops and diseases on which they could be used with economy, effectiveness, and safety under the diverse climatic and soil conditions prevailing in the various agricultural areas.

Fermate (ferric dimethyldithiocarbamate) has continued to surpass copper fungicides for anthracnose control on tomato, according to the Ohio station, which found the dust better than the spray. At 2–100, Fermate spray alone never caused more than minor injury. It could not be combined with copper-containing materials without injury, but excellent control of both anthracnose and alternaria blight was secured by using Fermate and a fixed copper in alternating sprays. The best protection and highest fruit and foliage quality were given by Fermate combined with Puratized N5D, another new synthetic fungicide.

The West Virginia and New Hampshire stations report excellent control of alternaria blight on tomato with Fermate, and the Hawaii station found it effective for both alternaria and stemphylium blights. Fermate is not equally effective, however, for all tomato diseases. The South Dakota station found that it gave little or no foliage protection in that area against bacterial speck, bacterial spot, and septoria spot.

For potato early blight the Hawaii station found Fermate good. In Ohio station tests, Fermate combined with DDT for controlling flea beetles and leafhopper gave a higher tuber yield than all other sprays used in one set of tests at McGuffey. On celery for early blight the Ohio station reported better control by a spray of Fermate and sulfur than by a fixed copper-sulfur spray, and with no injury. The Ohio station also showed that for cercospora and macrosporium blights of carrot Fermate was equal to copper fungicides, though a slight yellowing and lowering of the yield

followed its use in one of two seasons. In tests with cucumbers, however, using 15 materials or combinations, the Ohio workers got foliage injury that reduced the yields in the Fermate plots below any of the others.

Dithane (disodium ethylene bisdithiocarbamate), first developed at the Connecticut (State) station, has continued to show much promise. Already noted at the head of this section is the Florida station work that led to wholesale grower adoption of Dithane plus zinc sulfate and lime for potato late blight control. Unfortunately, not all experimental results in the 1944 season indicate the true potency of Dithane. Some samples low in effective constituent, reputedly because of undetected errors in pilot-plant handling, were accidentally sent out for experimental use. No such lowered potency has been reported for the commercial product now available. Ohio station results with Dithane alone in 1943 point to celery blight control about equal to that from copper sprays, to poorer control of cercospora and macrosporium blights of carrot than with bordeaux, to excellent control of alternaria blights of potato and tomato, and to only mediocre results against tomato anthracnose.

In addition to fungicidal properties, Dithane has shown certain insecticidal activities in Connecticut (State) and Delaware station tests. The Hawaii station found Dithane effective against alternaria blight of potato and tomato and against stemphylium blight of tomato. Delaware station work indicated that adding zinc sulfate and lime to Dithane increased its effectiveness against alternaria blight and reduced leafhopper damage. For sugar beet cercospora leaf spot, Dithane failed to give as good protection as fixed coppers in the Ohio station tests.

Zinc dimethyldithiocarbamate (Methasan, Zimate, Zerlate, etc.) has been studied as a fungicide by the Delaware station and the Department. The zinc salt appears to have certain advantages over the iron salt (Fermate) and other metallic salts of dithiocarbamic acid. In Delaware it controlled tomato anthracnose better than any other material and equaled bordeaux for alternaria blight on both tomato and potato, giving rise to the opinion that the zinc salts may prove better protectants for vegetables than any material previously available. They combine definite protection against certain insects like leafhoppers, as well as against diseases, with a high degree of safety for plants. DDT added for insecticidal purposes did not decrease the fungicidal potency of the zinc salt. Foliage conditions on potato were even improved. In 1945 Zerlate applied to potatoes for early blight in Delaware tests surpassed bordeaux, Dithane with zinc sulfate and lime, and copper oxychloride (Compound A) in plot yields. With the zinc salt, the Hawaii station obtained good control of potato early blight and of alternaria and stemphylium on tomato. The Ohio station using Methasan with calcium arsenate got better yields and control of early blight and insects on potatoes than with any other material tried, except that where DDT was used insect protection was better. Methasan proved better than Fermate for tomato alternaria and better than nickel or copper dithiocarbamates for tomato anthracnose. Methasan with sulfur

also proved better than Fermate or copper oxychloride sulfate with sulfur for cercospora blight of celery in the Ohio station experiments.

Puratized (phenylmercuri triethanol ammonium lactate) represents a different group of synthetic chemicals, the quaternary ammonium compounds, some of which have shown high potency against certain fungi at dilutions so great that the residue is practically invisible and highly safe for plant tissues. Few experiments have been reported with this material on vegetables, but the Ohio station tested Puratized N5D on tomatoes and found it very effective against anthracnose and early blight. Combined with Fermate in one test, it surpassed all other sprays in anthracnose control and in preventing defoliation. Its eradicant power and other properties appear to warrant further exploration of its usefulness, especially on plants where the foliage or fruit is not eaten, since a tolerance for mercury in residues has not yet been established.

U.S.R. 604 (2,3-dichloro-1,4-naphthoquinone), recently named Phygon, has excellent fungicidal properties and has been tried out on tomatoes and potatoes by the Florida station. Although at 1 pound per 100 gallons, it provided excellent protection against late blight (*Phytophthora*), it affected the foliage and reduced yields considerably, as compared with plots sprayed with other materials. The Rhode Island station tried five chemical dips for carrots before placing them in storage. All reduced decay, but U.S.R. 604 was one of the two best. In tests on tomato foliage against bacterial speck, bacterial spot, and septoria spot, the South Dakota station found that 1.5–100 U.S.R. 604 surpassed all other materials tested and caused little or no leaf injury. The Ohio station reports fair control of tomato early blight and good control of anthracnose at 4–100, although some superficial spotting of fruits was noted in two experiments.

Newer seed treatments for vegetables have been actively experimented with during the year. In 1944, workers in 29 States and 2 Canadian Provinces conducted 236 uniform tests continuing a program referred to in earlier reports. Much independent research was also done on seed and soil treatments. The object was to find the best means to protect germinating plants from the soil-borne and seed-borne organisms that cause extensive losses from seed decay, damping-off, and seedling blights.

The cooperative tomato seed treatment tests in 10 States resulted in improved stands in some 42 percent of the cases. Arasan showed general superiority, but dusting the seed with Semesan, Yellow Cuprocide, and New Improved Ceresan also yielded good results. The last was equally good when used as a dip.

Uniform sweet corn seed dust treatments in 19 States and 1 Province resulted in generally improved stands from all materials with Arasan in the lead, Spergon next, then Semesan Jr. and Barbak C.

Pea seed treatments in 22 States and 1 Province showed all three materials used to be in most cases beneficial. Spergon was best; red copper oxide and Arasan were also protective.

Spinach seed treatments were made in 25 States and 1 Province.

In the majority of tests significant increases in stand resulted with all three materials, but zinc oxide showed consistently better results than Arasan or Fermate.

Carrot seed treatments were studied cooperatively for the first time. In 15 States and 1 Province all treatments gave better stands, but Arasan slightly excelled Spergon, Semesan, red copper oxide, and zinc oxide.

Lettuce seed was treated cooperatively in eight States. In general all materials gave stands better than untreated seed. They included red copper oxide, zinc oxide, Semesan, Arasan, and Spergon, the latter giving the most marked benefits.

With dusted onion seed in the tests conducted in eight States, less damping-off was reported in only about one-third of the cases. Arasan, Fermate, and Semesan gave benefit. No consistent improvement was obtained with Spergon, red copper oxide, or zinc oxide (Vasco 4). Moistening the onion seed with Methocel as a "sticker" resulted in good control of smut with Arasan, Fermate, or Thiosan dusts.

Soybean seed treatment for garden varieties has been a problem. About one-third of the tests in 14 States with Banzei soybeans disclosed some value from use of Arasan, Fermate, or Spergon, the last giving the most consistent increases in emergence. What benefits were noted occurred in Atlantic Seaboard States and indicated that treatment could be expected to help under conditions unfavorable to vigorous germination.

Table beet seed was treated in coordinated tests in 20 States and 1 Province, Arasan, Ceresan, and Yellow Cuprocide being compared. Striking results were obtained in 1944 where in the preceding year the benefits had been limited. It appears that less vigorous strains or lots of seeds may show greater response to treatment. Arasan gave the best results.

Cucumber seed treatment proved beneficial in only about one-fourth of the tests in 12 States, whereas in 1943 practically all cases showed improvement under field conditions more favorable to seed decay and damping-off. Semesan and Spergon rated higher than Arasan in 1944, although in 1943 the latter surpassed the others. There is evident need for studies of the factors influencing the performance of the different chemicals in order to learn how and when to use each for the best results.

Lima bean seed treatment proved advantageous in tests conducted by the New York State station on Long Island over several years, but only when the soil was low in moisture before the plants came up. Yields were hardly improved enough to recommend treatment for general adoption except in unusally dry seasons. Where treatment was beneficial, Spergon showed the most promise and Semesan Jr. was next best. Red and Yellow Cuprocides and COCS stunted the seedlings. The Delaware station reported injury to lima bean seed also from U.S.R. A03 and 604.

The Oregon station cooperating with the Department has found many advantages in applying vapor heat in place of hot water for seed disinfection. Seeds of peas, beets, cabbage, and several grasses withstood temperatures of 140° to 150° F. for more than 30 minutes without damage to germination, although this tem-

perature and time were more than enough to kill such fungi as *Macrosporium, Fusarium,* and *Sclerotinia* carried with the seed. Grass nematodes were completely killed. In beet seed, *Phoma* was usually killed and bacteria were greatly reduced in numbers. Chemical dusting after such treatment will aid in protecting against soil-borne infection.

For bean seed the Western Washington station got the best improvement in stands with Spergon and the next best with Semesan, and squash seed treatment with Cuprocide and U.S.R. 604 was found effective.

Sweetpotato sprout treatment with Spergon before transplanting decreased the amount of fusarium wilt (stem rot) in experimental plots at the Maryland station and increased the yield from 258 pounds for untreated sprouts to 436 pounds for those treated with this material. Fermate gave very similar results. When sweetpotatoes used for seedbed propagation were dipped in Spergon (4 ounces per gallon) before curing and storing, they sprouted several days earlier, when bedded, and showed less rot and loss of weight, although rot control was far from satisfactory. The New Jersey station found Thiosan effective against the same disease and also against scurf when used as a sprout treatment. Both stations report injury from Semesan Bel.

Treatment of white potatoes used for seed has become quite general, but evidences of some injury have led to tests with different varieties. The Maine station found that standard mercuric chloride markedly reduced the yields of Katahdin and somewhat injured Sebago, whereas this treatment gave slight increase in yields with Green Mountain, Chippewa, and Cobbler. The use of acetic or hydrochloric acids with this chemical resulted in maintaining the strength of the dip through 25 successive treatments. The Minnesota station found Semesan Bel most effective in reducing seed-piece decay, although Spergon, mercuric oxide, Fermate, and acid mercuric chloride helped to some extent. Wettable sulfur dust and DDT dip increased the decay. The New York State station reports losses from seed-piece rot amounting to 10 to 100 percent on at least 2,000 acres of Long Island potato land, necessitating replanting in most cases. Three species of the *Fusarium* fungus were found to be involved. Their attack was favored by warm moist air, usually considered as ideal for quick curing of the cut surfaces of the seed pieces. Experiments revealed that chemical seed treatment could entirely prevent seed-piece infection. The New York (Cornell) station found that, although mercuric chloride dips were most effective in preventing spread of the bacterial ring rot infection when cutting the seed, better results in yields were obtained when the seed tubers were cut into pieces by a rotary cutting knife running in boiling water to kill the germs. The Colorado station confirmed this experience.

Soil treatments that aim to lessen attacks on vegetable crops by soil-borne fungi, bacteria, and nematodes are being investigated with increased vigor since for many diseases they appear to afford the greatest hope of reducing losses from these pests until resistant varieties can be developed.

Tomatoes are troubled greatly by the root knot nematode in

warm open soils or in greenhouses. The South Carolina station reports that in tests where soil was fumigated by the two chemicals, DD mixture and chloropicrin, the latter was most effective, giving tomato yields 340 percent over the crop grown on untreated soil. It was, however, much too expensive for wholesale field use and also was disagreeable to handle. DD, on the other hand, although somewhat less effective under the test conditions, gave a marked increase in yield and was enough cheaper and pleasanter to handle to warrant further experimental trials. The New York (Cornell) station found a number of chemicals effective against root knot nematode in greenhouse tomato culture. In one set of experiments a combination of methyl bromide, ethylene dichloride, and carbon tetrachloride (Dowfume Br. 10) appeared very promising from the standpoints of cost, effect on the operator, ease of handling, and speed with which the chemical disappears from the soil so that plants will not be injured.

Onions are subject to several soil-borne diseases. The fungus infection resulting in so-called pink root was reduced in New Mexico station experiments by the use of chloropicrin as a soil fumigant. Where soil was not treated the yield was only 61 pounds of onions, all diseased; where treated, the yield was 137 pounds, of which only 31 pounds were diseased. In Massachusetts where onion "sets" are planted, pink root was reduced by treating the sets with Spergon before planting. It was also reduced when untreated sets were planted in soil to which 70 pounds of Fermate or 400 pounds of sodium nitrite were added per acre, the latter treatment increasing the yields by some 150 percent. Where Fermate was applied in commercial fertilizer (58 pounds in 1,500 pounds) onion smut was well controlled in these Massachusetts station experiments.

Where potato land needs calcium, the Rhode Island station found that the use of gypsum as a source resulted in less scab on the tubers than where ordinary limestone was applied. The North Carolina station in experiments over two years obtained almost complete control of southern bacterial wilt of potatoes in loam high in organic matter by a heavy application of sulfur followed later by one of lime. Urea was also helpful where lime was applied to the soil, and ammonium thiocyanate gave promising results but reduced the stands unless planting was delayed until several months after application. In tests by the Florida station with the Department, Cyanamid, 1,000 pounds per acre, disked into the soil, effectively destroyed the hard black kernels by which the watery soft rot fungus (*Sclerotinia*) lives in the soil from one season to the next. Beans, which are very susceptible to it, were grown successfully if planting was delayed until the injurious effect of the chemical disappeared. Urea was also effective, but practical methods of application remain to be worked out.

The Massachusetts station announces the control of club root of cabbage by soil treatment with Fermate or calomel before planting the seed. It also reports great reduction in damping-off of vegetable seedlings in greenhouse flats where watering was postponed 4 to 6 days after planting in fairly dry soil.

New developments in disease resistance in vegetables are being

reported in increasing numbers. Every successful addition contributes more permanent and less costly safeguards against disease hazards than any other methods of control. No scientific effort is more worth while, although the work is long and tedious, the difficulties often great, and the progress at times discouragingly slow. The advances actually made, however, are very encouraging. Much of the work is cooperative between different State and Federal workers.

During the year substantial progress was reported in developing potato varieties resistant to scab, late blight, early blight, leaf roll and net necrosis, spindle tuber, mosaics, wart, bacterial ring rot, bacterial brown rot wilt, fusarium wilt, and southern (sclerotium) blight, as specified in more detail elsewhere in this report.

The Hawaii station has developed hybrid (F_1) tomato seed, with C_1 as code number, carrying high resistance to spotted wilt, and rust-resistant pole beans were soon to be released. Resistance to all existing strains of leaf mold has been achieved by the Massachusetts station in strains of tomato that show high commercial qualities. Several hybrid lines of tomatoes from the U. S. Vegetable Breeding Laboratory showed encouraging resistance to southern (sclerotium) stem blight in tests at the Mississippi station. The New Hampshire station found no true resistance to early blight in a large number of tomato varieties and lines under test.

The Georgia station has released the Georgia Wilt Resistant watermelon and also a home-garden strain, No. 2, resistant to both wilt and anthracnose. The scab-resistant Highmoor cucumber was released by the Maine station, and Maine No. 2, maintaining its high scab resistance, gave favorable results in limited commercial pickle tests.

Complete resistance to fusarium near-wilt found in a breeding line of peas is being used by the Wisconsin station in crosses with fusarium wilt-resistant lines to get combined resistance to both diseases. The Texas station developed a blackeye pea (No. 8152) showing considerable tolerance to root knot nematode and high resistance to southern ashy stem blight.

The Wisconsin station has discovered amounts of vitamin C as high as 60 milligrams per 100 grams in seedlings of Wisconsin All Seasons cabbage selected as completely resistant to fusarium yellows and highly resistant to two mosaic viruses. None of 39 commercial lines of cabbage tested by the Mississippi station exhibited resistance to rust or mildew and all tested varieties of cauliflower, kohlrabi, broccoli, or brussels sprouts proved highly susceptible. High resistance was discovered, however, in Chinese cabbage and radish, with some rust resistance noted in one kind of kale and two kinds of rutabaga, thus providing a starting point for a program of breeding to transfer resistance to the present susceptible types.

New disease discoveries are constantly appearing. These show that agriculture still has new problems to face which the experiment stations must help solve. The Wisconsin station reports a new virus disease, a strain of the potato latent ring spot, which readily attacked all plants tested in the family to which the

potato belongs. One potato seedling was found immune to this virus. The same station reported an apparently new and striking potato disease causing wiltlike symptoms and death, the cause of which is being investigated. The Louisiana station attributes to a soil-borne fungus, *Pythium debaryanum,* a sudden wilting of potato plants and rot of tubers, the insides of which turn a smoky gray. The Nebraska station found a pythiaceous fungus associated with a tuber rot apparently new to science which produces symptoms resembling the "leak" type of decay but distinct from it in certain respects. Affected tubers were sometimes completely rotted when dug. A leak disease of potato tubers investigated by the Colorado station was found due to two species of the fungus *Phytophthora,* most troublesome in wet soils; while the Idaho station determined *Pythium debaryanum* to be responsible for a type of tuber rot widespread in potato storages of the State in which injured tubers developed a soft wet decay followed by drying of the insides, generally forming a cavity surrounded by a firm shell—hence the common designation "shell rot."

The California station announces the presence of a serious tomato fruit rot and stem canker in the central California canning-crop area; the common black mold, *Rhizopus,* was found to be the cause. A new type of disfiguring spot of wrapped tomato fruit in cold storage was discovered by the West Virginia station to be due to a fungus, *Pullularia pullulans,* never before reported on tomato. The Oregon station found a fungus, *Cercosporella,* spreading from the wild turnip—which it commonly attacks—to the leaves of cabbage grown for seed. The Louisiana station determined that *Phoma terrestris,* a fungus associated with pink root of onions, is capable of attacking the roots of other crops like sugarcane, sweetclover, and corn. The Delaware station in 1943 and 1944 discovered a disease of sweet corn and field corn the cause of which has not yet been determined. The foliage becomes a brilliant red turning to purplish red over the whole plant, which produces no mature kernels though ears may be formed. In one sweet corn planting 37 percent of the plants were affected.

DISEASES OF GRAIN CROPS

Seed treatment of cereals has been practiced for years to prevent smut infections. Experiment stations have recently been active in determining the value of some of the newer synthetic chemicals for grain treatment, not only to control the smuts and other seed-borne diseases, but also to protect the germinating seed from soil-borne organisms that rot the seed or blight the emerging plants. The Kansas station reports that covered kernel smut of sorghums was well controlled and stands were about doubled by dusting the seed with Spergon, Arasan, New Improved Ceresan, and DuBay 1452–C. The Nebraska station reports somewhat similar findings, adding to the list of effective materials: U.S.R. 604, Fermate, Zimate, and basic copper sulfate. During one season New Improved Ceresan, DuBay 1452–C, Merc-o-dust, and sulfur caused some injury to germination in Leoti sorgo. Where sorghum seed is covered with persistent glumes, the volatile mer-

cury dusts DuBay 1452–F and New Improved Ceresan were the only materials that afforded good control of heavy smut infection.

The Washington station reported good control of seedling flax diseases—especially where the seed was injured in threshing and subject to attack by *Fusarium*—when the seed was treated with Spergon, Arasan, Semesan, or New Improved Semesan.

The Southern Cooperative Corn Disease Research Committee sponsored 14 coordinated tests in seven Southern States in 1944 on the value of dust treatments for seed corn. Semesan Jr., Spergon, Barbak C, and DuBay 1452–F were used. In the majority of the tests all were effective in improving the stands. The average increase in emergence due to treatment, for all tests, ranged between 5 and 6 percent. Barbak C averaged a little better, but in some locations one or more of the others slightly surpassed it.

Disease resistant varieties provide the best answer to the problem of controlling cereal diseases. Most stations are helping to develop resistant types adapted to local conditions, usually in cooperation with the Department in the Nation-wide cereal improvement program. The Texas station reports that its rust-resistant Rustler oats, Austin wheat, and Tunis barley are finding favor with farmers in the Gulf coast area where leaf rusts have been a serious obstacle to the growing of small grains. The Minnesota station has discovered facts which the plant breeders must use to safeguard the future success of new disease-resistant types, namely, that many wheat varieties resistant to certain races of stem rust at ordinary temperatures may become more susceptible when subjected to unusually warm conditions.

The Iowa station has presented evidence of variations in susceptibility of the seedlings of several inbred lines and single crosses of dent corn to charcoal rot, *Macrophomina*, a serious soil-borne disease of many crops in hot, dry soils. Corn breeders will, therefore, find seedling tests useful in searching for resistance to this disease.

The Arkansas station, noting heavy damage to Bond oats and its hybrids from Race 45 of the crown rust fungus, has crossed a foreign variety of little value but almost immune to this race with commercial oats varieties resistant to other races of the fungus. The result is a hybrid spring oats (674 (2)–39f) of promising qualities, which is resistant to smut and was the only one of 23 varieties and selections to escape severe rust attack in 1944.

New disease discoveries are being made in the cereal field. The discovery by the Delaware station of the so-called red leaf disease, which destroys the productive capacity of affected field corn or sweet corn plants, has already been referred to. The Texas station reports a corn disease, new to the State and found in the lower Rio Grande Valley, which may be of virus nature. Plants attacked while immature become bushy and stunted, with pale green and white striped leaves that show broad reddish or bronze bands extending the length of the leaf and with poorly developed ears. Race 45 of the crown rust of oats, first detected in Arkansas in 1937, has increased enough in abundance to cause heavy damage. The Minnesota station reports that wheat stem rust, Race

15B, although hitherto not one of the most prevalent races, is present in various parts of the country and has shown the ability to attack many new winter wheat hybrids, commercial spring wheat varieties, most newer developments in hard red spring wheat types, and the new durums in spite of any resistance among them to other races of the fungus. This potential menace can be overcome only by incorporating resistance to Race 15B into desirable adapted types of wheat—a long job ahead for the plant breeder. The sooty stripe disease of sorghum (*Titaeospora*), first recorded in 1942 as occurring in the United States, is reported by the Louisiana station to be apparently spreading in Louisiana and Mississippi. The disease is serious on kaoliang in China and Manchuria, whence it may have come to the United States. It occurs in this country on several varieties of sorghum and on Johnson grass. In a cooperative study with the Washington and Idaho stations, the Department has identified 15 races of rough-spored and 16 of smooth-spored stinking smut. Several races of both were found capable of attacking some of the newer wheat varieties developed primarily for smut resistance. It is evident that more work is needed to incorporate resistance to all important smut races in the varieties developed for different parts of the country.

DISEASES OF OTHER FIELD AND FORAGE CROPS

Control of foliage diseases by chemicals is not yet standard procedure with many field and pasture crops because of the expense involved and general lack of information as to the economic benefits. Wartime peanut production, however, has greatly benefited by the use of sulfur dust or sulfur copper dust for the prevention of peanut leaf spot, according to methods developed by the Georgia, North Carolina, and Virginia stations, where dusting the fields was unknown a few years ago. The method is now in general use over wide areas in the eastern peanut-growing States, and the Texas station reports marked increases in that part of the country from peanut dusting, not only from control of the leaf spot but also through protection against peanut rust.

The Ohio station announces that sugar beet yield increases of 3 to 6 tons per acre were obtained from dusting and spraying wherever leaf spot was severe. The cost of the treatment developed in experiments over a 6-year period was not over $15 per acre; it added to the value of the crop about $50 per acre. A number of fixed copper sprays and dusts were found more to be recommended than bordeaux because of their greater convenience, although disease protection was somewhat less effective. Best results were obtained with copper Compound A and COCS, using about 35 pounds of dust containing 7 percent copper per acre. The new synthetic sprays, Fermate and Dithane, failed to provide as good protection or yields in a 1943 experiment.

The South Carolina station reports that marked reduction of infection of soybeans by the pustule bacteria was afforded by copper dust with 6 percent copper plus talc or sulfur as diluting material. Sulfur dust has no retarding effect.

The Rhode Island station has developed a spray in which the

active principle is phenylmercuri triethanol ammonium lactate. This material, now named Puraturf, gave almost perfect control of diseases of velvet, colonial, and creeping bent grasses at the low dilution of 1 part of the chemical to 17,000 parts of water. No injury was caused to the grass. Other materials were effective but caused injury.

Seed treatments developed by experiment station scientists are being increasingly depended on by growers to lessen the damage to field crops from seed- and soil-borne parasites, rots, and molds. Cotton growers generally have taken up seed treatment as a regular practice during the last decade. In North Carolina an estimated benefit of nearly 6 million dollars was reported from chemical treatment of cottonseed used for planting some 600,000 acres. New treating materials are constantly being tested out in comparison with the older standard preparations.

The South Carolina station reports that New Improved Ceresan, DuBay 1452-F, and Mersolite 5 percent gave excellent germination of cottonseed and nearly complete control of the anthracnose fungus, which, in this test, killed nearly half the seedlings from untreated seed. Dow 9A was nearly as good, Dow 9B not as effective, and Isothan Q4, Q48, and Q84 gave very poor anthracnose control at the strengths used and Q4 apparently injured the sprouts. The North Carolina station also reports New Improved Ceresan still highly satisfactory for cottonseed treatment, although the more costly 2 percent Ceresan was likewise effective.

Six States cooperated under a special coordinating committee in testing peanut seed treatments. The results from the North and South Carolina and the Virginia stations indicated Arasan and Ceresan to be more effective than Yellow Cuprocide and Spergon on machine-shelled seed, although all improved the stand. The Arkansas station reported about equal benefit from Arasan, Ceresan, Yellow Cuprocide, and Spergon with stands about double those from untreated seed. The California station found Semesan, Ceresan, and Yellow Cuprocide much more effective against pythium rot of peanut seed than Arasan or Spergon, although these greatly improved the stand. The Florida station reported Arasan, Ceresan, and Spergon about equally effective, but, held 60 days in storage after treatment, Arasan-treated seed surpassed that treated with Spergon. From North Carolina comes the report that one farmer in 1944 spent about 10 cents an acre for material to treat his peanut seed and for each penny spent in this way got a return of $2.77.

Experiments in treating seeds of alfalfa, white sweetclover, medium red clover, alsike clover, strawberry clover, and Ladino clover, conducted cooperatively by the Wisconsin station and the Department, showed germination of strawberry and Ladino clovers to be retarded by Spergon, although stands were improved by this material as well as by New Improved Ceresan and Arasan, in greenhouse trials with infested compost. In field tests, however, none of these preparations showed significant benefit and general seed treatment for these forage crops hardly appeared justified from the evidence obtained.

Soil treatments against fungi attacking crops from the soil are

being given increased attention. Tobacco growers, whose small seedling beds are estimated to add up to some 21,000 acres each year, will benefit greatly from fall treatment of beds in sandy soils with urea and cyanamide together, as developed by cooperative work between the Department and the experiment stations in Georgia, North Carolina, and South Carolina. Excellent results against weeds, black root rot, and root knot nematode have been obtained by this means in tests conducted over a number of years. The Wisconsin station obtained best control of bacterial wildfire and damping-off in tobacco beds by applying home-made bordeaux weekly, beginning before the plants came up. Yellow Cuprocide also controlled damping-off when applied weekly as a liquid or mixed with dry sand and spread over the soil. Copper dusts or Fermate dust mixed with the soil before seeding proved unsatisfactory, and Fermate applied before emergence reduced the stands. The Virginia station found that adding 2 pounds of peanut-hull meal to each square yard of tobacco bed previously treated with urea and Cyanamid quickly brought the soil back to a productive state and produced more vigorous growth and more usable plants than in beds where this amendment had been omitted. For controlling weeds and seedbed diseases of tobacco, the Massachusetts station found no soil-disinfecting treatment equal to steam sterilization except soil fumigation with chloropicrin, which appeared to contribute superior vigor to the seedlings in addition to its control of weeds and diseases.

The Mississippi station reported that fusarium wilt and root rot nematode attacks may be greatly reduced in cotton land where 8 or 10 tons per acre of stable manure are drilled in the cotton row. The Texas station found that growing Hubam clover a year ahead of cotton gave marked increases in cotton yield, particularly by delaying the attack of phymatotrichum root rot. High phosphate fertilizers used in the row at planting time in Ohio station tests reduced sugar beet seedling diseases on well-manured soil where the major loss in stands is usually from the soil-borne fungus *Aphanomyces cochlioides*. Dithane applied at the rate of 100 pounds per acre in the row at planting time in Delaware station experiments resulted in serious injury to soybean seed.

New developments in disease-resistant crop varieties are continuing to solve plant-disease problems. Among 300 selections and varieties of peanuts tested by the Texas station, marked differences in susceptibility to the destructive southern (sclerotium) blight were shown. A basis is thus given for a breeding program against this pest. The California station is attempting to solve the problem of sugar beet downy mildew infection by breeding methods in which an effiort is being made to increase the resistance to this disease found to a limited degree in a very few out of many varieties tested. Promising improvement in resistance has already appeared in some of the progeny. This mildew had been found capable of reducing sugar production by as much as 30 to 40 percent. The Wisconsin station reports finding strains of smooth brome grass resistant to the pyrenophora leaf spot which severely attacks it in that State. The Kentucky station has detected great variations in susceptibility to powdery mildew among

different plants of individual grass or cereal species. This provides the opportunity for plant breeders to develop strains of important grasses and grains for mildew resistance. Definite evidence of resistance to sweetclover stem blackening due to *Cercospora* was discovered by the Wisconsin station.

New diseases of field and forage crops reported during the year include a severe blighting of purple vetch and Canadian field peas determined by the California station to be due to the species of bacterium responsible for common bacterial blight of garden peas.

Danger of spread to other parts of the country of the alfalfa witches'-broom virus, a dwarfing disease present in the far West, is evident from the discovery by the Washington station that the virus may be transmitted from diseased to healthy alfalfa by a leafhopper, *Platymoideus acutus,* which occurs widely over the United States and Canada. The Oregon and Washington stations, in cooperation with the Department, have identified a disease causing low germination of perennial ryegrass in the Pacific Northwest as due to the fungus responsible for blind seed disease. This fungus, *Phialea temulenta,* was found attacking 14 other grasses. The Rhode Island station observed the copper spot turf disease (*Gloeocercospora*) occurring for the first time in that State in 1944.

A killing virus disease apparently new to science has been described by the Oklahoma station. This disease caused about 75 percent loss in an experimental field of guar, *Cyamopsis psoralioides,* a green manure cover crop, of which some 1,500 acres is devoted to seed production. A small number of scattered infections may spread in a few weeks to every plant in the field.

The Alabama station has tracked down the probable cause of a troublesome decay of peanut seed called "concealed damage" because it starts on the inside surface of the peanut halves so that in the early stages diseased seeds cannot be detected. In examining more than 1,200 seeds from 12 widely separated fields, a fungus, *Diplodia,* was found almost 20 times as often as any other fungi. Knowing the major cause of the trouble, research workers can now start to devise methods of preventing the damage.

DISEASES OF FRUITS

New **synthetic organic chemicals,** developed for the most part by American chemical concerns with the help of station plant pathologists, are now being subjected to intensive, critical study by experiment stations in all parts of the country. Those that survive give promise of replacing the older standard fungicides because they have special properties that afford them distinct advantages as protectants or eradicants against particular diseases.

Results of recent experiments with apples at the stations in Illinois, Kansas, Maine, Missouri, New Jersey, New York, both State and Cornell, Ohio, Pennsylvania, and Virginia agree generally in rating Fermate (ferric dimethyldithio carbamate) as an excellent substitute for wettable sulfur sprays, which it usually equals for scab control and surpasses for cedar-apple rust prevention. Although standard liquid lime-sulfur is found to surpass Fermate in scab control, Fermate causes far less injury and

is compatible with sulfur, lead arsenate, Black Leaf 155, zinc-lime safener, and the summer oil sprays sometimes needed for insect control. When Fermate is combined with lime or with a copper spray like bordeaux, injury may result and, although exceptions have been noted by the Illinois station, such combinations may be considered unsafe. The New York State station reports that 4-percent Fermate dust gave better control of cedar rusts on apples than 1.5–100 Fermate spray. The Ohio station found Fermate 2–100 as effective as bordeaux for bitter rot control, and without injury. The Ohio and Pennsylvania stations report better fruit size on Fermate-sprayed trees. DDT was more effective against codling moth when combined with Fermate in Virginia station experiments, as compared with its action when used with bordeaux or a so-called fixed copper.

The Virginia, West Virginia, and Pennsylvania stations have cooperated for some years in experiments with fruit sprays. In the results on sour cherry with leaf spot control, Fermate gave rather unsatisfactory control and in one year some fruit dwarfing was noted. On sweet cherry the New York State station found 1–100 Fermate with self-emulsifying cottonseed oil effective for brown rot control without giving an objectionable appearance to dark red fruits. The Missouri station reported that on sour cherries Fermate gave complete protection from brown rot, which took 42 percent of the fruit on unsprayed trees. In protecting against defoliation from leaf spot, Fermate was nearly equal to bordeaux and better than lime-sulfur under Missouri conditions. Foliage was excellent, and the fruit was large and of lively red color.

On Anjou pears, which are sensitive to wettable sulfur, the Oregon station cooperating with the Department found that Fermate 1.5-100 controlled pear scab better than either wettable sulfur or copper phosphate and caused less russeting of the fruit. Added lime markedly decreased the control of scab and resulted in a peculiar ring spot of young leaves.

Fermate has been found superior to bordeaux against cranberry fruit rots in New Jersey and Massachusetts station work cooperative with the Department, both dust and spray proving effective. The New York State station found 2–100 Fermate superior to any other material tested for raspberry cane blight control. The Indiana station found it as effective as bordeaux against black rot of grapes. The Florida station using Fermate against anthracnose rot of mangoes determined that on sprayed trees the fruit had about 26 percent more vitamin C than on unsprayed trees.

Puratized (N5 series = phenylmercuri triethanol ammonium lactate), developed at the Rhode Island station, has shown remarkable potency in controlling apple scab, having eradicant as well as protectant power. In Maine station tests it reduced infection better than Fermate or wettable sulfur. The New York State station reported it highly effective against scab and without causing visible injury when used at 0.5 pint to 100 gallons, but against rust it proved relatively inferior. Since mercury is present in minute amounts in the spray residue and no legal tolerance for this metal on fruits has yet been established, there is some hesitancy in rec-

ommending this spray. The Ohio station likewise found Puratized more effective against apple scab and bitter rot than all other sprays tested. No injury was noted, and the fruit was better in size than where bordeaux was used. On York apples, when combined with summer oil in Virginia station tests, Puratized N5X produced a light but characteristic injury.

When used on sour cherry in joint tests by the Virginia and Pennsylvania stations, Puratized furnished good leaf spot control until late in the season and had no marked effect on the fruit.

Isothan Q15 (lauryl isoquinolinium bromide) has come into commercial use as a fruit spray where eradicant as well as protective power, lack of injury, and compatibility with summer oils are needed. The Rhode Island station, which developed this material, reports that, when used at the rate of 1–20,000, it controlled scab on apple foliage as effectively as wettable sulfur and, when used as a spreader with lead arsenate, reduced arsenical injury and improved the fruit color. The New York State station reports that Isothan Q15 controlled apple scab better than Fermate and much better than micronized sulfur, although control of cedar-apple rust was inadequate. The New Jersey station secured good results with Isothan Q15 at 1–1,000 for apple scab control but got slightly better control with Fermate. Excellent control of brown rot in sweet cherries was reported by the New York State station, and good control of sour cherry leaf spot until late in the season was reported from the Virginia-Pennsylvania cooperative tests in 1944. Tenacity here may have been an influencing factor. Among other materials undergoing experimental tests may be mentioned Compound 341, which in several years of cooperative experiments by the Virginia, West Virginia, and Pennsylvania stations has proved to be the most effective of many materials tried out against sour cherry leaf spot. Little or no leaf injury was produced and no fruit dwarfing, although the fruit color tended to be lighter red than usual. In trials on apple in Virginia, no injury resulted from its use in combination with summer oil. Isothan Q4 (lauryl pyridinium bromide) gave good control of cherry leaf spot until late in the season with no marked effect on the fruit in cooperative tests by the Virginia and Pennsylvania stations.

Dithane (disodium ethylene bisdithiocarbamate) caused moderate injury on apple when used by the Virginia station in combination with summer oil. Used alone by the New York State station on apple, it gave control of cedar rust and scab comparable to Fermate. Dithane proved incompatible with lead arsenate and nicotine sulfate, but when added to zinc-sulfate-lime mixture, it was found compatible with lead arsenate and more effective than when used alone. Experiments by the Missouri station indicated that control of apple scab was inadequate with Dithane, but on cherry it proved effective against both leaf spot and brown rot. The New York State station reports that Dithane produced injury leading to defoliation of cherries when lead arsenate was added. It failed to control cherry brown rot or peach leaf curl without added zinc and lime. Where combined with zinc sulfate and lime, the results indicated that Dithane will control cherry leaf spot. The New Jersey station and the Department cooperating in cran-

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berry experiments found that Dithane A-10 controlled fruit rots better than bordeaux but not as well as Fermate or 604. Thiosan (tetramethylthiuram disulfide) was shown to be effective throughout the season for apple scab control. Its efficiency was increased by lead arsenate.

U.S.R. 604 (2,3–dichloro–1,4–naphthoquinone), now called Phygon, has also given evidence of effectiveness on fruits. On sour cherry the Virginia and Pennsylvania stations found this material effective until late in the season for leaf spot control and with no deterimental effects on the fruits. The New York State station in preliminary tests on raspberry obtained good control of spur blight with U.S.R. 604. When combined with summer oil in Virginia station tests, severe injury resulted on apple, although it showed promise against bitter rot and blotch. The Rhode Island station found that it gave a high degree of scab protection on apple but produced a mottled yellowing of McIntosh foliage.

The Connecticut station in preliminary experiments has found five materials successful in rendering peach trees immune to the X-disease virue; one of these, *p*-aminobenzenesulfanilamide, when injected into seedling trees previously inoculated, completely prevented the disease from attacking, whereas 85 percent of the inoculated but untreated trees came down with the disease. Injury from this drug was reduced by adding maltose or dextrose to the injected chemical. Such artificial immunization is still in the experimental stage, practical possibilities, if any, remaining to be worked out.

WEED CONTROL

EXAMPLES OF RESEARCH RESULTS

2,4–D (dichlorophenoxyacetic acid), a growth-regulating chemical, killed noxious weeds without injury to grass in experiments of the New York State station. Among the weeds killed were bindweed, sowthistle, narrow-leaved plantain, dandelion, lambsquarter, round-leaved mallow, and ragweed. The new weed killer stimulates growth to such a degree as to eventually cause death of the plants, in contrast to chemicals commonly used which produce defoliation and starvation by caustic action.

Two weeds, *Spiraea tomentosa* and *Potentilla fruticosa*, are to be found on approximately 500,000 acres of Vermont permanent pasture lands. Of this 500,000 acres, probably 200,000 acres could profitably be rid of these weeds through the use of various control measures. The Vermont station has found that 1 pound of ammonium sulfamate to 1 gallon of water sprayed on the plants just before or during early bloom resulted in the highest percentage of kill. Use of lime and fertilizer on treated areas brought about the quickest establishment of grass.

Perennial buttercup is one of the most serious weeds in New Hampshire pastures. Cattle will not eat it, and after a few years invaded pastures are worthless for grazing unless completely renovated. In two-season tests the New Hampshire station destroyed nearly all buttercups and certain other weeds by spraying with ammoniun sulfamate, using 3 ounces per gallon of water. The grasses were improved and relished more by cattle, whereas clovers came

back well the next season. Granular borax also gave good results. Further tests are under way to determine the economic value of these methods of weed control in the State pasture improvement program.

Weed control by chemical sprays for crops that require much hand labor is receiving increasing attention by experiment stations. The Michigan station found a 2-percent sulfuric acid spray best for weed control in onions. It saved three-fourths of the weeding costs in onions grown on muck soils of the State. Adoption of the procedure would mean a saving of $250,000 to $500,000 per year in labor costs. Special equipment for applying this spray is required because of the corrosive effect of the acid.

Results of spraying for weed control with solutions of 2,4–dichlorophenoxyacetic acid by the New York State station have been cited above. Other stations throughout the country, many cooperating with the Department, are testing this type of herbicide. Noting adverse effects on cotton when hormone weed killer reached the plants in very dilute quantities in irrigation water, the New Mexico station has notified reclamation and extension workers and others of the possible hazard involved.

Ammonium sulfamate, the Texas station reports, proved effective in eradicating broomweed (*Gutierrezia sp.*), which occupies a large acreage in many native grass pastures, especially on many farms where the small pasture area is subject to overgrazing. One-half pound of the chemical per gallon of water sprayed on broomweeds when about 8 inches high with a pressure pump was the most economical rate of application. A second spraying 2 to 3 weeks after the first might be advantageous. Spraying will be necessary for several years to eradicate completely the weeds which come from dormant seed or from reinfestation.

Northern nutgrass (*Cyperus esculentus*) and woundwort (*Stachys palustris*), serious weeds in northern New England, were controlled by the Maine station by spot treatment with ammonium thiocyanate and ammonium sulfamate sprays.

The most practicable method for eradicating the most serious weeds of the Yakima Valley, the whitetops—lens-podded whitetop (*Cardaria draba repens*), Siberian mustard, and hoary cress—and Russian knapweed, from many areas, determined by the Washington station, was continuous clean cultivation (two seasons) with duckfoot sweeps at 3-week intervals. Irrigation during the cultivation period aided in the mechanics of cultivation. Fall-seeded rye for pasture or grain was more successful than row crops the year after cultivation. Where the extent of the infested area makes cultivation impracticable, certain crops may be grown successfully. Alfalfa, in particular, corn, sugar beets, and millet or Sudan grass yielded well on land infested with lens-podded whitetop and held it in check, and millet and Sudan grass were excellent one-season competitors. A whitetop control program, based on results of cropping treatment of infested areas, has also been outlined by the Utah station.

Lens-podded hoary cress (whitetop) on subirrigated land was controlled cheaper by spraying with a 30-percent solution of so-

dium dinitrocresylate in California experiments, although more applications (6) were needed than with oil sprays (5). Searing with weed burners was most expensive (13 operations) and resembled cultivation in the number of operations needed and in the best interval between operations.

Carbon disulfide was the only chemical successfully eradicating all perennial weeds on which it was tested by the Washington station in the Yakima Valley, including lens-podded whitetop, Russian knapweed, camelthorn, slender perennial peppergrass, Canada thistle, and bindweed. Sodium chlorate eradicated bindweed, Russian knapweed, and Canada thistle, but like other chemicals tested did not eradicate lens-podded whitetop or Siberian mustard.

Recent studies by the California station indicate that dinitro compounds of the substituted phenols may furnish new herbicide chemicals with properties more desirable than those of most weed killers now in common use. Experiments with some 50 compounds suggested that toxicity to plants increases through the series of benzenes, phenols, and substituted phenol. It was found that dinitro compounds are more toxic than nitro, chloro, or nitro-chloro compounds and that ortho-substituted salts are more toxic than the meta or para salts. Its high toxicity renders 2,4–dinitro–6–secondary-butyl-phenol more effective than dinitro-*o*-cresol, and its relatively greater solubility in oil enhances its value. Mixing it in Diesel oil around 5 to 10 percent and adding emulsifiers provide a general contact weed killer that would need only 3 to 6 percent oil, a saving of over 90 percent of the oil previously used in weed control. This material is said to kill oil-tolerant weeds not ordinarily susceptible. The mixture is not highly flammable; the poison hazard is also much less than with arsenic, for livestock are not attracted by the taste as they are by sodium arsenite.

Weeds in carrots and certain other truck crops were controlled at a fraction of cost of hand weeding by spraying with stove oil and other types of oil in experiments of the Idaho, Massachusetts, New York (Cornell), and Washington stations following earlier results by the California station. The Washington station estimates the cost of weeding by oil spray to be $8 to $10 per acre, as compared with hand-weeding costs of $80 to $100 at 1944 prices. Onion growing on muck infested with weed seeds at the Michigan station made much higher yields when the soil had been treated with sulfuric acid.

White horsenettle is a most troublesome weed in the cottonfields of southern Arizona, and any successful method of eradication is of immediate practical importance. The Arizona station found that white horsenettle may be eradicated in 3 years by any of three systems of cropping: Growing winter grain during the dormant period of the weed followed by clean cultivation during the summer growth period; or growing cotton, with hoeing each month or when the weed appears; or clean cultivation in early summer, followed later by sorghum. Shade from sorghum or cotton apparently is a main factor in eradicating the weed but is not effective without cultivation and hoeing. Small patches were eradicated by two annual injections of 2 ounces of carbon disulfide into the soil 18 inches apart or at the base of each plant.

Weeds in tobacco plant beds were controlled effectively in Virginia station experiments by applying calcium cyanamide or urea in October at the rate of 1 pound per square yard of soil. The material is worked into the top 4 inches of soil, and the bed covered with straw until planting time. Treated beds have commonly produced three times as many plants as untreated beds, even though weeds were removed from the latter as they developed. Virginia growers who have needed a practical treatment for controlling weeds and diseases in tobacco plant bed soil are using the new method with good results.

That alfalfa cropping may be used as a control measure for bindweed was determined by the Idaho and Washington stations and the Department cooperating. Three or four years of alfalfa has reduced cultivation required for eradication by about one-third with better methods used. Satisfactory methods developed for bindweed eradication following 3 or 4 years of alfalfa cropping are (1) plowing in late fall followed by cultivation the next year and then two successive crops of winter wheat or winter barley; (2) plowing after the first hay crop followed by three successive crops of winter barley; and (3) plowing after the first hay crop followed by winter wheat or winter barley and then cultivation the next year. Use of alfalfa as a control measure where adapted increases production of forage for livestock and will increase production of grain in later years. Alfalfa also reduces by about one-third the amount of cultivation needed to eradicate the bindweed. Presence in the soil of a high content of bindweed seed which may produce seedlings during several years is an additional problem. Competition from good fall grain generally has sufficed to control seedlings emerging in that crop, provided the stubble is plowed just after harvest. Where summer fallow is practiced, monthly cultivation controls seedlings coming up in the fallow year. Cultivation, smother crops, and other cropping practices and chemicals, especially sodium chlorate, have been used with some success by these and other stations to control bindweed.

Fall plowing controlled wild buckwheat at the North Dakota station. The seed as a result, germinate early in the spring, and the seedlings may be killed by frost or cultivation.

BETTER FEEDING PRACTICES FOR LIVESTOCK

EXAMPLES OF RESEARCH RESULTS

Grass-fed steers, averaging 1,100 pounds, were finished for market at 28 months of age in Tennessee station trials. All of the steers were fed hay and crimson clover pasture during the winter and carried on good pasture during the summer. Less than 5 percent of the market value of grain was realized when fed to steers on good bluegrass-white clover-hop clover pasture.

Feeding one-half feed of grain (an average of 7.4 pounds daily of a mixture of 80 percent barley and 20 percent beet pulp) throughout the pasture season to steers on alfalfa-crested wheatgrass pasture lengthened the grazing season 44 days and resulted in an increased production of 128 pounds of beef per acre over

similar pasture without feeding of grain. In the Washington station experiments with this speed-up system of feeding, the steers were finished for market at approximately 18 months of age, a saving of 6 months from the time normally required to get range steers to market.

Protein and phosphorus in range grasses, according to analyses by the New Mexico station of 96 consecutive monthly samples, are much below usual levels in some winter and spring months, generally from January to May, due largely to leaching caused by abnormally heavy winter rains. The duration and severity of these periods of low values and the presence or absence of early spring plants and browse are important factors in determining the amount of supplemental feeding needed for range cattle.

Shortages of protein concentrates to meet the requirements of a larger livestock population prompted study by a number of experiment stations of new or unusual feed supplements. Last year's report on the experiment stations gave details of trials of urea, a simple nitrogen compound, in rations for dairy cows, heifers, and calves by the Massachusetts, New York (Cornell), Wisconsin, Hawaii, Mississippi, Florida, and South Carolina stations. The Mississippi station, continuing its research, found in 1945 that 10 pounds of urea added to a ton of sweet sorghum silage was equal in value to 90 pounds of cottonseed meal for feeding to yearling heifers and mature cows.

Pineapple tops, now a waste product left in the field at harvest, were found by the Hawaii station to be a good, palatable feed for dairy cows. In a feeding trial, 100 pounds of green tops, chopped in an ensilage cutter, produced as much live-weight gain in heifers as 135 pounds of Napier grass, the chief forage for dairy cattle in the islands. Following these results, one company plans to salvage the tops for dairy feed on a trial basis by bringing the pineapple fruits to the cannery with the tops on.

Hay cut and windrowed in June or July and left in the windrows for fall and winter feed in range areas of South Dakota lost practically no nitrogen or phosphorus even though it remained on the ground until the last of December. Retention of carotene also appeared to be satisfactory. These findings of the South Dakota station are proving helpful in reducing labor requirements and haying costs in range areas.

Peanut hay of good color and quality was found by the Oklahoma station to be fully equal pound for pound to alfalfa hay of similar quality for the feeding of dairy cows. The omission of cottonseed meal from the ration did not appear to lower the value in any way and suggested that high protein feeds are not needed in the concentrate mixture when good legume hay is used with such feeds as corn, oats, and wheat bran. Since from ½ to 1 ton of peanut hay can be harvested per acre it becomes a valuable byproduct of peanut production.

Ground alfalfa hay fed to lambs in Nevada station tests did not produce significant gains over the feeding of long hay, a conclusion contrary to ideas held by some farmers. When fed long hay, lambs select and eat the choicest and most nutritious parts first and satisfy their hunger by eating the less palatable forage last.

When hay is chopped or ground all parts are intermingled, and selective eating is thus largely prevented.

Ground corncobs have one-half the feeding value of corn grain for fattening steers according to several years of digestion experiments and feed-lot trials by the Ohio station. Digestion trials showed that the corncobs were equal to alfalfa in energy and fattening value.

Potatoes produced good beef in Colorado station experiments wherein lots of both heifers and steers were fed rations containing potatoes, as compared with standard fattening rations. Raw potatoes chopped and combined with dry corn fodder or alfalfa hay made high-quality silage that compared favorably with corn silage. Heifers fed cooked potato silage also made good gains. Potatoes showed a feed replacement value ranging up to about 55 cents per bushel. Dehydrated potato pulp compared favorably with ground corn in these fattening rations. Such use would furnish an outlet for surplus potatoes.

Blackstrap molasses is available in quantity as a feed for farm animals in Puerto Rico, but only limited amounts could be used because of unpalatability or extreme laxative effect on the animals. The Puerto Rico University station found that the crude molasses contains certain gums or minerals that cause the trouble, and solved the problem by devising a simple process for removing these impurities.

A **monograph** in preparation by the West Virginia station, sponsored by the National Research Council, will represent an accumulation of a greater body of data on the digestibility of feeds than has ever been assembled before. Data from a total of 22,000 digestion trials have thus far been tabulated. An analytic bibliography of all references on composition and digestibility of individual feeds for five species of farm animals is now ready for publication.

Grains containing ergot should not be fed to pregnant sows, according to findings of the Montana station. Two primary effects in feeding barley ergot were observed: Lactation was completely inhibited, and the vitality of the newborn pig was markedly reduced. Sows receiving the ergot during the early stages of gestation but later changed to regular feed did not exhibit these symptoms.

Dehydrated potatoes fed to pigs in equal amounts with shelled corn plus a supplemental mixture made gains nearly equal to those receiving shelled corn and the supplement in North Dakota station trials. The corn-potato lot required about 14 percent more feed to produce 100 pounds of gain. The dehydrated potatoes were worth about 2 cents per pound in terms of replacement value of the other feeds used. This information will be valuable as a guide in using low-grade potatoes for livestock feed.

Findings of North Carolina station research explain why soybeans or other oily feeds that promote soft pork can be fed safely to hogs up to about 100 pounds weight, if from them on to full maturity corn or other hard fat-promoting foods are fed. Using a unique technical approach in which pigs were fed a dye material during different stages of growth in addition to their normal rations, the station found that only a small amount of the fat depos-

ited in the early fattening stages remains with the hog when it reaches slaughtering age.

Dehydrated vegetable wastes prepared by the Eastern Regional Research Laboratory of the Department and tested for the second season in broiler feeding trials by the Delaware station showed high growth values when incorporated in poultry feed. One percent of broccoli leaf meal supplemented by crystalline riboflavin produced better broiler growth than either 5 percent alfalfa leaf meal or 1 percent broccoli leaf meal when added to the basal mash. Dehydrated kale, spinach, and beet leaf meal also produced excellent growth. Pea vines and lima bean vines were slightly less efficient. In many truck crop areas large amounts of vegetable waste are available which, as these experiments have shown, can be converted into materials of high nutritive value for the benefit of local poultry production.

Increased hatchability of eggs was obtained by the Rhode Island station when small amounts of distillers' soluble byproducts were added to the standard New England College Conference ration. Adding 1½ pounds of the supplement daily to the ration for 100 hens increased hatchability nearly 3 percent, and with 3 pounds added daily, hatchability increased more than 4 percent. Feed costs per dozen eggs were only slightly affected.

Rations for laying and fattening hens should contain at least 1.5 percent, probably somewhat more, of fat for maximum performance, according to results of the Illinois station. If thoroughly fat-extracted ingredients make up a high proportion of poultry rations, the addition of fat or of fat-rich feeds may be necessary in order to obtain full value from the ration.

Vitamin A in milk varies within wide limits according to quality of pasture and abundance of rainfall, as determined by the Ohio station. During the 1943 pasture season, when rainfall was adequate and well distributed, vitamin A values of milk ranged between 2,600 and 1,700 U. S. P. units per quart, whereas in 1944, a dry year, they ranged from 2,200 units in early spring to as low as 1,100 units during the dry summer. Following fall rains, with resulting improvement in pastures, the values in October were almost as high as in May.

Death losses of baby pigs, a major problem in the Corn Belt, may be largely avoided, according to Illinois station research, by supplying water-soluble vitamins to the sows in the form of alfalfa meal. Sows fed a basal diet of ground yellow corn, soybean meal, tankage, fish meal, cod-liver oil, and minerals during the gestation and lactation period weaned only 7 to 13 percent of their pigs. From 41 to 50 percent were weaned when dried corn, distillers' solubles, or a mixture of six synthetic B vitamins were added to this diet. More than 82 percent lived to weaning age when the basal diet was supplemented with 10 to 12 percent alfalfa meal.

High-grade alfalfa meal has come into general use in poultry rations as a well-established practice of proved merit. The Kansas station finds that a low-grade meal made from sun-cured alfalfa hay or one composed of bagasse and soybean meal are effective substitutes in rations for growing chicks when supplemented with

vitamins A and G. Thus it appears that the main value of high-grade artificially dehydrated alfalfa meal for growing chicks lies in its content of these two vitamins.

Kudzu leaf meal or whole kudzu meal proved pratically equal to alfalfa meal in rations for growing chicks at the Mississippi station. Carefully dried kudzu leaf meal was rich in both carotene and riboflavin.

Fundamental studies of the Wisconsin station have shed additional light on the important and indispensable role of biotin in the nutrition of poultry. A deficiency of biotin in the ration of laying hens caused death of embryos during incubation, especially during the first week and the last 3 days of the incubation period. The addition of 150 micrograms of biotin per kilogram of ration proved adequate in preventing death of the embryos.

Supplying adequate phosphorus to farm animals at the Utah station has prevented or aided in the recovery from parturient hemoglobinemia, a prevalent disease which decreases milk production and often causes acute illness and death of high-producing dairy cows in the intermountain area. Phosphorus feeding also increased weight gains of beef cattle and improved the spring lamb crop from ewes maintained on winter range. It may be supplied as bonemeal or other phosphate supplements or by increasing the phosphorus content of feed crops by applying manure or superphosphate to phosphorus-deficient soils.

The advantages of adequate minerals for the range beef cattle breeding herd were clearly shown in experiments at the New Mexico station in which range cows fed a mineral supplement in the form of bonemeal continuously throughout the year produced an average of 46 pounds more calf weight per cow than those that received the supplement during the winter period only. This difference was due to the greater number of calves raised by the cows receiving the bonemeal the year round.

Experiment stations have continued to make substantial advances in research in the field of animal production. They have made noteworthy contributions to fundamental scientific knowledge concerning the genetics, physiology, nutrition, and diseases of farm animals on which to base better practices in the breeding, feeding, and management of livestock.

Ways of attaining maximum returns of consumable animal products from all available sources of feed have been a primary objective of research in this field in view of the continuing high demand for meat, milk, and eggs to meet military and civilian needs. Typical examples of experiment station work in this field, in addition to those shown above, as reported during the year, are cited in the following paragraphs.

GREATER RETURNS FROM PASTURES AND RANGE

Grazing crops have assumed an increasingly important role as a means of attaining high per acre returns of animal products with a minimum of labor.

The once-prevalent idea that only poor land that will not grow other crops should be used for pasture has been clearly disproved

in trials at the Utah station. Good irrigated land, fertilized with manure and phosphate and seeded to pasture, when used to supply feed for a herd of dairy cows, returned over $5 for each $1 cost of pasture production. Over a 3-year period, these pastures, grazed an average of 253 days per year, provided over two-thirds of the total nutrients required by the milking herd with a net return of 206 pounds of butterfat per acre of pasture per year, exclusive of returns from supplementary feeding.

Two-year-old steers of good quality can be made to produce carcasses that will grade "good" with around 20 bushels of corn and 125 pounds of protein supplement if extensive and judicious use is made of good pasture and good roughage, as determined by the Missouri station. One lot of steers was marketed off of Korean lespedeza pasture without grain feeding other than the grain in the corn silage fed during two winters. Steers grazing on good wheat-lespedeza pasture until early fall produced carcasses that graded "good" in a month less time and with around 20 percent (5 bushels) less corn than steers grazed during early summer and then full-fed. Steers making large winter gains and hence in higher conditions in spring made correspondingly smaller summer gains on pasture. Wheat-lespedeza pasture produced more gain on steers than mixed grass-lespedeza pasture during the first half of the grazing season.

How to produce the most edible beef with the least corn during periods of feed-grain scarcity has been shown by Illinois station experiments. Recommendations are: Keep cattle largely on pasture and roughage until they have most of their growth, or until they are about 2 years old; feed common 2-year-old feeder cattle a minimum amount of corn until they have no more than a medium finish, thus producing Commercial or B carcasses; feed medium 2-year-old cattle a minimum amount of corn to a medium finish, producing Commercial or B carcasses, or short-feed them a full feed of corn to a Good finish, producing Good or A carcasses depending on the spread in price between feeder and finished cattle; short-feed Good and Choice 2-year-old feeders a full feed of corn suitably supplemented to a Good finish, thus producing Good or A carcasses. If these practices are followed beef supplies will be distributed rather uniformly throughout the year.

Economy in the total amount of feed required for finishing beef steers resulted from the feeding of sufficient supplement during periods of dry, short range to maintain continuous growth and development in trials at the California station. When no supplement was fed yearling steers generally lost weight during the dry range period from July to December. Steers fed supplement at a rate to keep them gaining about 1 pound per day during this period consistently maintained a weight advantage over the unsupplemented animals to the end of the feeding period, which included a subsequent period (January to June) on good green range followed by a finishing period of full feeding on dry range. At time of slaughter they yielded 108 pounds more live weight and 52 pounds greater carcass weight with only 70 pounds higher consumption of concentrates per head than the unsupplemented group of steers.

The Washington station found that turkeys on a good green pasture will consume less mash or concentrated feed and more of the cheaper whole-grain feeds, with no difference in the mature weights. Although there is no marked saving in the cost of feed consumed, mortality is lower and the quality and finish is better when turkeys are provided with green pasture.

Forage from more than 20 varieties of native and imported grasses was analyzed at monthly intervals over a period of 3 years by the Oklahoma station in cooperation with the Department to give a picture of the relative feeding value of each grass by months. Results are already being used at Woodward and Stillwater in grass breeding and in determining the most nutritive sequence of grasses for year-round grazing. Variations between varieties were as high as 300 percent in calcium, 250 percent in protein, and 100 percent in ash and fiber.

BETTER USE OF SILAGE AND HAY

Silage studies involving new advances in preparation and the use of new crops have extended the usefulness of this method of feeding preservation.

Studies by the Ohio station on 67 separate ensilings of meadow crops with and without various popular preservatives indicated that all silages in the highest dry-matter group (30–38 percent) were of high quality, whereas of those below 25 percent dry matter only half were so classified. The proportion of poor silages was no greater in untreated lots than in the whole group. Dry-matter control was clearly more important than the treatment studied. In general, dry silages are inclined to be of high pH and to have an odor and taste more suggestive of hay than of silage. The dry-matter content may be increased by waiting for greater maturity of the crop and better weather conditions or by field wilting. Dry materials, such as ground grains, may be added to increase the dry-matter content of the silage and also to improve its nutritive value.

Oat silage as compared with silage made of a grass-legume mixture at the West Virginia station showed that excellent silage could be produced from both crops without the use of a preservative. Steers fed oat silage for a 70-day period made an average daily gain of 2.82 pounds and steers fed grass-legume silage made an average daily gain of 2.75 pounds on rations which were identical in other respects. As a result of this work a number of West Virginia farmers either started making grass or legume silages or increased their acreages. This type of silage is of special importance to farmers who have land too steep for corn production yet can produce oats and hay crops without serious soil erosion.

Timothy, the old stand-by of Pennsylvania farmers for hay production, makes as good silage as corn for dairy cows if 200 pounds of hominy feed per ton of green material is added when the grass goes into the silo, according to Pennsylvania station studies.

A good silage can be made from sweetpotato vines pulled by hand and chopped in an ensilage cutter as demonstrated by the North Carolina station. Three methods of ensiling were studied: (1) With vines alone, (2) with a mixture of vines and roots, and

(3) with vines and molasses at the rate of 60 pounds of molasses per ton of vines. Each process resulted in satisfactory silage. The vines must be harvested before frost. The good silage had a mild aroma similar to sauerkraut. In tests during three consecutive years sweetpotato vine silage has been found as good as corn silage in the dairy ration for maintaining body weight and milk production. It provides carotene in the winter feed, which is ordinarily deficient.

Second-crop Ladino clover put up as silage by the Maine station in 1944 was relished as feed by hens and, at the end of 16 weeks' feeding, egg hatchability was highest for Ladino-fed hens, as compared with those on the basal ration or basal ration with alfalfa leaf meal. Egg production and body weight were as good in the Ladino silage-fed group as in the others. This silage provided as much carotene as good alfalfa leaf meal.

Hay harvesting methods and supplements for hay have been studied, and new findings have increased the usefulness of cured forages in livestock production.

Sulfur-dusted and undusted peanut-vine and alfalfa hays were compared at the Virginia station. Practically the same digestibility of the dusted and undusted peanut-vine hay was obtained. The peanut hay resulted in at least as high milk production as high-grade alfalfa. Evidently alfalfa hay may be satisfactorily replaced by sulfur-dusted or undusted peanut-vine hay if the protein content of the grain mixture is adequate.

Sudan grass cut when immature and dried artificially was found by the Nebraska station to be a very satisfactory substitute for alfalfa meal in rations of growing pigs fed in dry lot. Sudan grass hay, field-cured, has not been entirely satisfactory because of difficulties in producing a clean, bright, unbleached hay by field curing.

When large quantities of alfalfa hay are fed with limited amounts of concentrates to growing dairy heifers, phosphorus is more likely to be deficient than when timothy hay is fed with a high protein concentrate supplement, according to findings of the West Virginia station. The feeding of large quantities of alfalfa hay therefore should be supplemented by some feed high in phosphorus or a phosphorus supplement.

Many experiments have demonstrated that high-yielding dairy cows fed solely on alfalfa hay will produce only two-thirds to three-fourths as much milk as when a concentrate mixture is used to supplement the alfalfa ration even though the intake of digestible nutrients from alfalfa is high enough to support higher production. In experiments at the Michigan station, Ladino clover hay proved to be superior to alfalfa hay in milk-producing power. Cornstarch and corn sugar added to an alfalfa hay ration were of little value in improving milk production. When these carbohydrates were replaced by either corn or wheat, milk production increased. Distillers' grain solubles also contain the factor stimulating milk production. When cows depleted on alfalfa hay alone had part of the hay replaced by corn silage milk production increased, indicating that the corn in corn silage exerts a marked lactogenic effect. Apparently, the first reason for feeding grain

to dairy cattle is not for calories but as a source of this unknown lactogenic factor.

In similar experiments the Oregon station tested the supplementary value of a wide range of feedstuffs for improving an alfalfa hay ration for milking cows. The results indicated that good producing cows do not utilize a ration of alfalfa hay supplemented only with minerals as well as when part of the alfalfa hay is replaced by calculated equal amounts of total digestible nutrients in the various concentrates. There was no indication of improvement in quality of protein in the ration, but the best results were obtained with ground soybeans followed in turn by medium and high protein feeds from plant sources, dried molasses beet pulp, animal protein feeds, dehydrated molasses, and sugar. The total digestible nutrient system of feed evaluation overrates the production value of good alfalfa hay when fed only with minerals to good cows.

MORE EFFICIENT USE OF CONCENTRATED FEEDS

Concentrates, including both the feed grains and protein-rich feeds, have been a severe limiting factor in livestock production throughout the war, with indications midway in 1945 that the same condition will extend into the postwar period. New research findings have continued to point the way to more effective uses of the limited supply of such feedstuffs.

Dried sweetpotatoes are a promising source of food for overwintering beef cattle, according to results reported by the Oklahoma station. However, higher yields per acre and the development of efficient methods of harvesting and drying must precede the general use of this material as livestock feed. In steer fattening trials dried sweetpotatoes proved about 82 percent as valuable as ground corn and the steers fed sweetpotatoes gained almost as rapidly, sold at the same price, and produced carcasses of the same grade as those fed corn.

Sweetpotato vines with cull potatoes attached may be readily dried into a palatable livestock feed by procedures developed by the Texas station. A specially designed digger cuts the vines on each side of the row, lifts the entire row, and leaves the plants on top of the row with the soil loosened about the roots. If a grower wished to convert his vines and culls into livestock feed, the persons employed to pick up sweetpotatoes can remove the marketable roots and pile the vines with culls attached about as fast as they could remove all roots and drop the vine back into the middles. The vines and cull potatoes, when run through a slicing machine and spread on a prepared drying surface at the rate of 1 pound per square foot, dried satisfactorily in about 48 hours. With the aid of this inexpensive equipment a sweetpotato grower can salvage enough feed per acre practically to offset the expenses of cultivation and harvesting and the marketable crop would represent the profits from his operations.

A mixture of cull peas, barley, and oats, of which 20 to 40 percent consisted of the cull peas, proved approximately equal to a mixture of 80 percent of barley and 20 percent of oats for the promotion of gain in baby beef steers over 150 days in trials at

the Washington station. The average daily gain on all rations was slightly better than 2 pounds. No digestible disturbances or bloat occurred when 20 to 40 percent of cull peas was included in the grain mixtures fed with chopped first-year sweetclover, but when more than 40 percent of peas was included bloat hazard was serious. This finding offers a profitable outlet for cull stock from the extensive production of dried peas in the area.

Distillery slops were found to give good results for fattening steers in experiments by the Kentucky station in cooperation with the Department. Mashes made from granular wheat, whole wheat, and equal parts of corn and wheat were each fed with about 5 pounds of lespedeza-grass hay per head daily. During 224 days the average daily gains on these rations were, respectively, 1.50, 1.70, and 1.45 pounds. No signs of night blindness, an early indication of vitamin A deficiency, were observed in any of the lots. All three lots produced carcasses that averaged between U. S. Good and U. S. Good Plus in grade, with lot 2 averaging slightly the best and lot 1 slightly the poorest. In cattle-feeding areas adjacent to distilleries, distillery slop may contribute materially to the potential beef supply.

When Holstein-Friesian cows in three experiments at the New York (Cornell) station were fed less than 5 pounds of hay and sufficient grain mixture to satisfy their energy requirements the fat content of the milk and milk yield were reduced as compared with similar cows fed normal rations of hay, corn silage, and a grain mixture. The results clearly demonstrate that there is an optimum intake of coarse bulky material for the most favorable production of milk and milk fat. The important role of roughage in the nutrition of ruminants may be explained on the basis that it provides a more favorable environment for the micro-organisms of the digestive tract.

In each of five 90-day reversal-type experiments at the Texas station, in which citrus peel and pulp were compared with corn-and-cob meal for milking cows, the differences in milk production and live-weight increases were small, but in all except one of the experiments the cows fed the ground corn ration produced slightly more milk. The calculated productive energy of citrus peel and pulp was practically the same as that for corn-and-cob meal. The citrus feed seemed to have some beneficial effect on appetite in extremely hot weather. No effect was detected on the flavor of the milk. Apparently in localities where the price relationship favors the citrus byproduct feed it may successfully displace most of the corn in the dairy ration.

A home-mixed calf starter ration developed by the New Mexico station has proved capable of developing dairy calves at approximately a normal rate. Concentrates generally available in that area were used in the mixture, the ingredients consisting of ground threshed kafir, wheat bran, cottonseed meal, alfalfa leaf meal, dried brewers' yeast, and minerals. Calves given a good start on whole milk to about 1 month of age, then fed only the calf starter ration and high-quality alfalfa hay from 1 to 4 months, and a simple grain mixture with good-quality hay thereafter, were approximately normal in size at 6 months of age with

a marked saving in milk, as compared to the conventional method of raising calves.

Raising dairy calves for dairy herd replacement under Alaska conditions was found to be both practical and economical by the Alaska station. Many dairymen in Alaska discard the heifer calves from high-producing cows because of the prohibitive cost of raising them with fresh whole milk. From a study of various methods of raising calves the station developed a satisfactory and economical calf ration made from Alaska-grown grains and commercial protein supplements, using a minimum of whole milk. Feeding the calf starter as a gruel to the young calf showed some advantage over the use of the dry meal in the ration.

Lamb and wool production was not increased by use of a fattening ration, as compared with a ration that merely kept ewes in good breeding condition, according to results from the New Mexico station. A bare maintenance winter ration resulted in lowered birth and weaning weight of lambs, whereas wool production was equal to that of ewes kept in good condition. A submaintenance ration caused still further reduction in lamb production and reduced wool production. These results are providing a basis for determining the need and influence of supplemental feeding on New Mexico range sheep.

In experiments to determine the extent to which urea might be successfully used as a source of nitrogen for lambs the New York (Cornell) station previously found that urea nitrogen has a much lower value than when nearly all the nitrogen was furnished by linseed meal, dried skim milk, or casein. In recent experiments addition of the amino acid methionine was found to increase materially the value of urea for lambs, this combination being nearly as efficient as linseed meal. Nitrogen-balance data were in line with observations on growth. Thus it appears that growing lambs have a specific requirement for methionine.

Waxy corn was found equal to nonwaxy corn in feeding value for growing fattening pigs fed in dry lots in Nebraska station tests. The waxy corn used contained more crude protein, fat, fiber, and ash, and less N-free extract than the nonwaxy corn. Pigs given a choice of both types preferred nonwaxy to waxy corn. Yet those fed only one kind responded very similarly irrespective of the type of corn fed. These findings are important in view of the increasing production of waxy corn previously for industrial use and the possibility of a surplus of this product for feeding purposes.

Soft, moldy corn can be fed successfully and profitably to fattening cattle, hogs, and sheep. Three out of the last corn crops in South Dakota and in many parts of the Corn Belt have been seriously damaged by frosts. In two years feeding trials by the South Dakota station soft, moldy corn had the following values in terms of hard corn, when fed to the following classes of livestock during the winter: 82 percent to yearling steers, 78 percent to lambs, and 76 percent to hogs and calves. When the soft corn was left in outdoor piles during the entire cattle feeding period, it deteriorated during the warmer seasons to the extent that its feeding value for the entire period for yearling steers was only

73 percent of that of hard corn. Likewise, when fed to calves its value dropped to 57 percent of that of hard corn.

The relative value of rations containing a single grain and combinations of grains for fattening pigs has been investigated further by the Michigan station. When pigs were fed rations consisting largely of corn or barley or one-half corn and one-half barley the rates of daily gain were about equal. The barley pigs were about 10 percent leaner than the corn pigs. Eye muscles and muscles in the face of the ham were noticeably thicker in the barley-fed pigs. Cooking tests showed that meat from barley-fed pigs shrinks less and that the meat from the corn-fed pigs is browner when cooked than from the barley-fed pigs.

Wheat showing appreciable damage as indicated by moisture content, reduced germination, and rancidity of oil was found by the North Dakota station to be practically equal to undamaged wheat as a feed for fattening pigs.

In tests at the Montana station comparing the feeding value of ergotized barley with clean barley, the ergotized barley proved to be poor feed and also much more tankage was consumed by pigs fed the infected grain. Actually, 412 pounds of the infected grain plus 75 pounds of tankage as against 342 pounds of sound grain plus 43 pounds of tankage were consumed per 100 pounds of gain.

The Colorado station found that pinto beans when cooked were palatable to fattening pigs and produced good gains, and carcasses obtained from pigs fed pinto beans compared favorably to those fed corn. Raw pinto bean meal was not palatable. A considerable amount of cull and split pinto beans is available for feed each year in Colorado, and the test gives indications of their value as a feed for fattening pigs.

Weanling pigs of about 30 pounds weight effectively utilized rations containing up to 20 percent cane molasses as a supplement to a basal diet of rolled barley, wheat middlings, meat meal, soybean meal, and salt in a series of experiments at the Hawaii station. The average daily gain and the total digestible nutrients required per unit of gain were similar when 10 percent raw sugar, 10 percent molasses, or 20 percent molasses were added to the basal ration. No appreciable diarrhea resulted from the feeding of molasses at either level. The abundance of molasses as compared with other carbohydrate feeds in the Territory makes this finding highly significant.

Pigs on pasture require less protein feeding, according to results from the Pennsylvania station. The results indicate that a 12–15 percent protein ration is more economical than an 18 percent protein ration for growing pigs on legume pasture and that there is little difference between a 12 or a 15 percent protein ration for pigs up to 120 pounds in weight. On the basis of these results, legume pasture can probably furnish at least 30 percent of the protein required by growing pigs.

The Hawaii station found it possible to grow ducklings economically on raw garbage supplemented by a vitamin concentrate mash. At current feed prices it cost 18.5 cents to produce a pound of duck up to 8 weeks of age on commercial mash alone, while it

cost only 6.3 cents per pound to produce ducks by feeding raw garbage plus a vitamin concentrate mash although the rate of gain was lower.

The influence of ground oat groats, oat hulls, ground wheat, wheat bran, and wheat shorts in chick rations on feathering development in New Hampshire Red chicks was studied by the Iowa station. Untreated oat hulls and wheat bran produced dark uniform color and smooth, glossy, complete feathering. Oat groats produced feathers which were brittle, frayed, and ruffled. Ground wheat produced feathers which were soft, downy, and silky over the back, thighs, and fluff. Ground wheat and wheat shorts produced the greatest number of chicks with abnormal types of plumage. Autoclaving the oat hulls destroyed the ability of this ingredient to produce normal pigmentation so that the feathers were light in color and lacking in uniformity. Thus, it is apparent that composition of the ration materially influences feather development in growing chickens.

With ground whole grains as a basal ration the addition of meat scrap had no appreciable effect on protein utilization or growth above that obtained when soybean meal was used alone, according to West Virginia station findings. Results indicate that meat scrap may be replaced by soybean meal when ground whole grains are used as a basal ration, provided that alfalfa leaf meal, cod-liver oil, and riboflavin are fed as vitamin supplements.

Experiments on the use of soybean meal for growing broilers at the Texas station gave evidence that when a shortage of animal protein prevails and when a fair quantity of soybean meal is available the animal protein should be used to the limit of its requirement or availability in the starter mixture fed during the first 6 weeks, and after that time soybean meal should be used to the exclusion of animal protein feeds. As little as 21 percent soybean meal as the sole protein supplement supplied sufficient protein of adequate quality to meet the requirements of chickens from 6 weeks up to broiler age. This method will give better results than stretching the same amount of animal protein over a 12-week or longer period. Such procedure would deprive the starter chicks of half or more of their much needed high-quality animal protein.

Important differences were observed by the Indiana station in the growth-promoting values of different soybean meals and oils made by both the expeller process and the solvent process in different plants. Additions of choline to rations containing soybean meal of inferior growth-promoting properties increased growth to a level equal to that obtained with superior soybean meal. A ration of ground yellow corn, soybean meal, distillers' dried solubles, alfalfa leaf meal, and vitamin and mineral supplements produced growth equal to that obtained with rations containing meat and bone scrap and dried skim milk, indicating that animal proteins per se are not essential for good growth in young chicks.

Tests on the ultilization of various native feedstuffs, including algarroba bean meal, processed garbage meal, and pigeon pea meal in the poultry laying mash, by the Hawaii station gave evidence that large quantities (20 percent or more) of algarroba bean meal

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or processed garbage meal can be used to supplement imported feeds and thus help to maintain the poultry industry during the period of feed shortage. The inclusion of pigeon pea meal in the ration significantly reduced feed consumption, possibly because of the bitter taste of this product.

Mung beans have satisfactorily replaced two-thirds of the cottonseed meal and soybean meal, commonly used in turkey starting rations, in Oklahoma station tests. The beans were found to contain protein of high quality for turkey poults. Cooked beans gave only slightly better growth than uncooked beans, not enough to make cooking worth while.

Feeding experiments in which normal proteins in the chick ration were entirely replaced by mixtures of pure amino acids have been carried out successfully by the California station, permitting the determination of the amino acids which are indispensable in the nutrition of this species. Of the amino acids used, alanine, aspartic acid, hydroxyproline, proline, norleucine, and serine were found to be dispensable. Glycine proved to be essential for promoting the best growth and glutamic acid had a similar action. Tyrosine was required when only moderate levels of phenylalanine were used, but was dispensable with higher levels of this product. To prevent weight loss, leucine, phenylalanine, threonine, and valine were found to be necessary dietary components, and the similar status of histidine and isoleucine was confirmed. Earlier studies have established the essentiality of the sulfur amino acids cystine and methionine.

The insufficiency of a ration composed of cereal products, soybean meal, alfalfa meal, vitamins, and minerals in meeting the optimum methionine requirements of growing chickens has been confirmed in trials at the Maryland station. The addition of 0.2 percent *dl*-methionine to such a ration materially enhanced its growth-promoting properties, the growth stimulus due to the methionine exceeding that obtained by supplementation with 4 percent fish meal.

PROVIDING NECESSARY VITAMINS AND MINERALS

No phase of animal nutrition research has been more productive than that directed to the establishment of the vitamin and mineral requirements of the different species and the determination of ways of providing these essential nutritive factors in adequate amounts.

Additional examples of recent findings in this field follow:

Dairy calves require considerably more vitamin A during the winter months than in summer, according to findings of the Maryland station. Using spinal fluid pressure as a delicate test of vitamin A sufficiency, it appeared that Holstein and Ayrshire calves required about 30 micrograms of vitamin A daily per pound of body weight during the winter months, whereas during the summer months the requirement was from 18 to 20 micrograms. Guernsey calves had a slightly higher requirement. Evidence of such seasonal variation in vitamin A requirements was reported earlier by the Pennsylvania station.

Studies by the Ohio station of a number of dairy calves born

in the fall and kept in the barn throughout the winter with heavy milk and grain feeding and consequent low hay consumption showed that under such a system of feeding and management rickets develop in most of the calves ranging from mild to severe cases. Affected calves responded promptly to vitamin D therapy, although severely affected animals remained permanently deformed. It is suggested that many calves born in the fall may suffer from subclinical vitamin D deficiency and that some minor change in feeding or management might easily bring on rickets in an active form. Some form of vitamin D supplement in the winter calf ration would provide effective protection against such a condition.

In a trial at the Alaska station comparing commercial laying mash with and without additional vitamin A and D supplements for laying hens, the group fed the mash fortified by additional vitamins laid 4,918 eggs during the 6 months of the trial at a cost of 30.2 cents per dozen. Those fed the regular mash laid 3,889 eggs at a cost of 42.3 cents per dozen. Quality and percentage of eggshell was also improved by the addition of vitamin. Eggs from the pen fed fortified mash showed a shell percentage of 10.06, whereas the other pen averaged 8.58.

Earlier results by the South Carolina station indicating the high biological value in terms of riboflavin in lespedeza have been verified. Feed costs may be reduced and farm income enhanced by the use of locally grown lespedeza as a substitute for alfalfa leaf meal in poultry rations.

More and more attention is being directed toward the retention of natural nutritional constituents in feeds as well as in foods. Blanching fresh alfalfa with steam prior to drying, the Kansas station determined furnished complete protection for the carotene and considerable protection was afforded when fresh ground alfalfa was treated with certain chemicals before it was dried. Diphenylamine and hydroquinone were the most effective of the antioxidants; thiourea and sodium cyanide were more effective than any other tested substances to inactivate enzymes. The carotene content of alfalfa meal decreased as the storage temperature rose, although essentially no change has been noted in the carotene content of alfalfa meals stored at 3° C.

Fish press water, dried cow manure, sheep manure, and a sewage product (milorganite) were found by the Wisconsin station to improve markedly rations high in vegetable protein and low in animal protein, indicating that these products contained essential nutritive factors normally provided by animal protein concentrates used in poultry rations. Breeding rations containing 2 percent alfalfa leaf meal with no milk products and minimum amounts of animal protein were found to give poor hatchability, whereas the addition of crystalline riboflavin resulted in a significant increase in hatchability—results equal to those on rations containing milk products and larger quantities of animal protein being obtained. Riboflavin additions to rations containing no alfalfa meal failed to support hatchability when fed to birds in batteries.

Fish press water at 2- to 4-percent levels proved to be a valu-

able supplement to simple chick-growing rations consisting mainly of ground yellow corn and soybean meal in trials at the Indiana station. The evidence indicated that the fish press water contained ample amounts of nicotinic acid, pantothenic acid, and choline but an inadequate supply of riboflavin for satisfactory chick growth. The riboflavin deficiency was corrected by adding 1 percent whey solubles to the ration.

Wheat distillers' dried grains with solubles could be used to advantage to the extent of 13.5 percent in laying mash formulas made up of common feedstuffs available on Great Plains farms, according to findings of the Nebraska station. Results compared favorably with those obtained on a control ration of high protein and vitamin quality as regards production, mortality, and hatchability. As long as industrial alcohol plants using grain continue in operation large amounts of such byproducts will be available for poultry feeding.

The evidence that vitamin D concentrates vary in their effectiveness for growing turkeys, previously reported by the Pennsylvania and California stations, has been confirmed by the Maryland station. Irradiated 7-dehydrocholesterol and irradiated animal provitamin were, respectively, 2.29 and 1.83 times as effective for poults as the same number of A.O.A.C. chick units from Reference cod-liver oil. Another sample of cod-liver oil was similar to the Reference oil in relative efficacy for poults and chicks.

The cereal grains are relatively rich in vitamin E and constitute the primary source of this nutritive factor in animal rations. Tests at the Iowa station show that whole cereal grains retain their vitamin E potency for long periods of time, whereas the same grains stored under similar conditions after finely grinding eventually lose most, if not all, of their vitamin E activity. The application of this finding to the handling of feed grains is obvious.

Chickens deficient in vitamin E in Kansas station studies had gonads that were smaller and showed less activity of the germinal epithelium than birds receiving an ample supply of vitamin E. Birds deficient in vitamin E also had pituitaries deficient in gonadotropic hormone, as compared to fowls that received adequate vitamin E. Vitamin E evidently may influence gonad development and activity indirectly by way of the pituitary gland.

Mineral content of soils and crops in various areas of the State, as determined by the Florida station, pointed to phosphorus deficiency in areas not previously recognized as problem areas. Both copper and phosphorus are proving to be primary factors limiting cattle development in the Everglades section. Further evidence of cobalt deficiency in certain areas also was obtained. It was evident that mineral deficiencies continue to be one of the chief drawbacks to a successful cattle industry in Florida. Unless these deficiencies, particularly phosphorus, are met cattle will fail to utilize adequately available feed.

From extensive data covering the growth and lactation periods for cattle, the Minnesota station has shown that the phosphorus requirements for growth increases at a gradually decreasing rate with advancing age, the requirement at a weight of 150 pounds being 6.02 grams daily and reaching 11.6 grams daily at 1,200

pounds live weight. Approximately 0.85 gram of phosphorus, beyond the quantity needed for growth or maintenance, seems to be needed per pound of milk produced. More complete information regarding the phosphorus requirements of cattle under various conditions will make it possible to feed more nearly according to their needs. It should result in higher and more economical production in herds where phosphorus is the only limiting factor.

Factors influencing the utilization of organic sources of phosphorus have been further explained by Wisconsin station studies. In the presence of an ample supply of vitamin D, phosphorus from wheat bran and from soybean meal is efficiently utilized by various species of animals. Enzymes capable of hydrolyzing phytin or phytic acid phosphorus were isolated from the intestinal walls of the porcine, bovine, and avian species, thus explaining the availability of organic phosphorus in these species.

Further evidence has been obtained to indicate a rather widespread cobalt deficiency in various sections of the country. Earlier reports have cited such evidence from the Florida, Michigan, and Wisconsin stations. Recent reports from the Florida and Michigan stations indicate that cobalt deficiency is more widespread than previously supposed.

Work by the New Hampshire station has disclosed the extensive occurrence of an unhealthy condition of cattle resulting from a deficiency of cobalt in the feed consumed in certain areas. Extreme emaciation is quickly overcome by administering cobalt to affected animals. Soil deficiency in cobalt resulting in plant deficiency brings about this condition in animals. The Department through its Plant, Soils, and Nutrition Laboratory at Cornell University is cooperating with the station in studies to determine the symptoms and effects by which this deficiency may be recognized in animals and in determining the tolerance of dairy animals of various ages to this deficiency.

Cattle grazing on forest areas in the Coastal Plains area frequently are anemic and have a poor record of breeding efficiency, according to findings of the North Carolina station. Such cattle have shown a remarkable response to cobalt supplements in their diet.

An interrelationship was observed by the Washington station between the levels of calcium, phosphorus, and vitamin D in the diet of turkey poults. The level of any one appeared to change the requirements of others for optimum growth and calcification. As little as 50 A.O.A.C. chick units of vitamin D per 100 grams of diet were sufficient for growth and calcification when the diet contained 2 to 3 percent calcium and 1 percent phosphorus. The levels of calcium and phosphorus in the diet appeared to have a greater influence than the calcium to phosphorus ratio.

Keel-bone deformity in young chicks was found to be closely related to vitamin D deficiency in the diet in trials at the Arkansas station. This vitamin had a uniform and highly significant effect on bone ash. The extent of crookedness of the keels was fairly closely related to bone ash deposition in individual trials. In all trials the extent of crookedness of keels was significantly reduced by adding vitamin D to the ration.

In further studies of the role of manganese in the nutrition of the chicken, the New York (Cornell) station has found that chicks hatched from eggs of hens on a manganese-deficient ration are commonly subject to tetanic spasms generally characterized by a backward bending of the head and feet. The abnormality occurred generally when the maternal diet contained approximately 6 parts per million of manganese but rarely occurred when 35 parts per million of manganese were supplied.

A series of experiments by the Utah station has shown that the natural deposits of limestone in the State can be used as a grit to replace the oystershell commonly used both in the mash and as a grit to supply the need of calcium in the ration of the laying hen. When this study started, oystershell, which must be shipped in from the coast at considerable expense, was selling from $1.40 to $1.75 per hundred. With an estimated 2¾ million chickens in the State and an annual consumption of about 11 million pounds of limestone at 55 cents per hundred, this finding of the station is saving poultry producers about $77,000 a year. In addition to these savings a new industry has been developed in the State in the mining, crushing, and grading of limestone for the poultry industry of Utah and nearby States.

A cooperative trial by the Maryland and West Virginia stations and the Department, testing the effectiveness of 10 different samples of phosphate materials as sources of phosphorus for bone formation of chicks during growth gave the following results: One sample of defluorinated superphosphate was almost completely unavailable, and its availability was not increased by finer grinding. The phosphate in the five other samples of defluorinated superphosphate was reasonably available but less so than in bonemeal and tricalcium phosphate. The availability of the phosphorus in defluorinate phosphate rock, phosphate slag, and vitreous calcium metaphosphate was intermediate between the phosphate in the superphosphates on the one hand and bonemeal and tricalcium phosphate on the other. Calcium pyrophosphate was totally unavailable or nearly so. The solubility in 0.25 percent hydrochloric acid at 38° C. was found to be a quick approximate measure of the phosphate availability.

INCREASING PRODUCTIVITY OF LIVESTOCK

EXAMPLES OF RESEARCH RESULTS

High resistance to disease, both fowl typhoid and leucosis, has been bred in strains of chickens by the Iowa station. Important findings in the long-time experiments are that resistance to both diseases is transmitted through the females more than the males, and that the progeny from resistant mothers is practically as good commercially as pure resistant lines.

Increased milk production in dairy cows was found by the Michigan station to be due to an unknown factor present in corn and wheat, which stimulates milk flow. The factor also occurred in distillers' grain solubles and in the corn in corn silage. According to the station, the first reason for feeding grain to dairy cattle is not for calories but as a source of this lactogenic factor.

Thyroid hormone has been fed to laying hens at the rate of 10

grams of synthetic thyroprotein per 100 pounds of complete ration for a period of 3 years by the Missouri station. Its effect has been to help maintain summer production and thus increase yearly egg production by about 10 percent. At this level of administration of the hormone no effect on the mortality rate has been observed.

Caponizing has usually been unprofitable under Oklahoma farm conditions but an alternative method may now find profitable use in poultry meat production. By adding a female sex hormone in minute amounts to the feed of cockerels, stags, and cocks, the Oklahoma station has produced market chickens of high quality, fully fattened, and with a milk-fed appearance. Cockerels 15-weeks-old and weighing 4½ to 5 pounds fried like 2-pound broilers. Flesh of old roosters was tenderized, and they assumed the appearance of prime fowl.

Twenty years of inbreeding Berkshire hogs inaugurated by the California station for the purpose of studying the effect of such a program, as well as the effect of outcrossing inbred strains, has yielded a byproduct in the discovery of a strain manifesting marked hereditary resistance to brucellosis infection.

Scientific principles of breeding which have been so widely and effectively applied in the plant field are constantly gaining wider application in the breeding of farm animals. The experiment stations are making noteworthy contributions in demonstrating the possibilities and limitations of various systems of breeding and in developing criteria for evaluating parent stock.

An analysis by the Minnesota station of the relative effects of age, weight at breeding, gains during pregnancy, and body length of dams on litter size in swine led to the conclusion that age and weight of sows at time of mating together account for 4 percent of the variance in size of first litters and provide the most reliable criteria for use in selection for fertility in young sows. Litter size decreased with an increase in the inbreeding of the dam, an increase of 10 percent in inbreeding resulting in a decrease of about 0.6 pig per litter.

Further study at the New Jersey station beyond that reported in 1944 gave evidence that Holstein-Friesian cattle may be inbred without necessarily causing a decrease in body weight or body size from birth to maturity, provided the intensity of inbreeding does not exceed 20 percent. Females which were more intensely inbred developed normally to about the first calving age, but thereafter they were considerably smaller than the outbred controls.

Volume of milk production, percentage of butterfat, and percentage of solids other than fat in the milk are inherited separately, according to an extensive analysis of dairy herd production records by the New Hampshire station. Thus, it appears feasible to breed for improvement in any of these characters independently of the others. In this study the ability of 19 sires to transmit these characteristics was proved.

Substantial progress was reported by the Oklahoma station in the improvement of Duroc-Jersey swine by the use of moderate inbreeding, selection, and outcrossing. Certain lines of swine

inbred between 30 and 40 percent when crossed with other inbred lines produced offspring that manifested marked hybrid vigor. Inbreeding was attained at the rate of 5 to 10 percent increment per generation without detriment. A three-way cross in which the hybrid sow between two lines is mated with a boar of a third line appeared to be an effective manner of utilizing inbred lines.

The Oklahoma station also has produced a strain of Barred Plymouth Rock chickens pure for the sex-linked early-feathering factor combined with excellent growth rate and egg production. The early-feathering habit reduces cannibalism and yields a more attractive dressed bird for market. Surplus cockerels were distributed to Oklahoma hatchery flock owners in order to improve privately owned flocks.

The Arkansas station, in experiments on growth of broilers involving 12 different breed crosses, found that early growth was not consistently increased by crossing and that greater early growth of crossbreds depended primarily on the inbreeding of the purebred parents to produce lines particularly adapted for making the cross. At 12 weeks of age, purebred Barred Plymouth Rocks averaged 2.3 pounds and required 4.4 pounds of feed per pound of gain, whereas hybrids between Barred Plymouth Rock males and New Hampshire females averaged 3 pounds and required only 4 pounds of feed per pound of gain.

Similarly, the Florida station in comparative growth studies with purebred chicks of the Light Sussex, Rhode Island Red, and Barred Plymouth Rock and with two- and three-way crosses between these breeds concluded that for these strains the two-way cross was in general superior, followed by the purebred and three-way crosses.

In a comparison of Barred Plymouth Rock-New Hampshire and Dark Cornish-New Hampshire crosses by the West Virginia station both crossbreds were heavier than the parental purebreds at market age. The Cornish-Hampshire crossbreds graded higher than the Rock-Hampshire crossbreds but no higher than the purebred Hampshires. The broader breast fleshing of the Cornish-Hampshire crossbreds was offset by the longer leg development and the slightly poorer feed efficiency, as compared with the other lots. The Rock-Hampshire crossbred appeared to be the most satisfactory for conditions in West Virginia.

The feasibility of breeding for good livability in chickens has been demonstrated both by the North Carolina and Wisconsin stations. After three generations of selective mating for high livability at the North Carolina station chicks hatched from selected matings had less than one-third the mortality to 3 months of age of chicks from unselected matings.

Comparative livability records between a low-mortality strain and a high-mortality strain of White Leghorn chickens over a 3-year period at the Wisconsin station showed approximately one-half as great death losses in the low-mortality strain during the first 20 weeks and significantly lower mortality in this strain from 20 to 75 weeks of age. In these same groups 2.99 and 9.06 per-

cent of pullets for the low- and high-mortality lines, respectively, died of some form of leucosis.

Artificial insemination as a means of extending the use of sires of proved merit has been greatly expanded in recent years but is limited by the relatively short period during which viability of the semen can be maintained.

Further study of semen diluents, with particular reference to the use of mixtures containing egg yolk, by the Missouri station has indicated that a factor highly effective in improving the resistance of spermatozoa to adverse conditions can be fractionated from egg yolk. After removal of an alcohol soluble fraction from the egg yolk a product is obtained which gives a water clear solution in phosphate buffer and which is much more useful than the original egg yolk-buffer mixture. On identification of the active principle contained in this new egg yolk fraction it should be possible to prepare diluents which will greatly extend the life and usefulness of stored semen.

INCREASING PRODUCTION THROUGH USE OF HORMONES

Following the announcement by the Missouri station that iodinated casein had been found to possess thyroidal activity, a number of stations have explored the possibilities of employing this product to increase the productive capacity of animals, particularly dairy cows and chickens.

As a result of 5 years of research, methods have been discovered by the Missouri station of increasing the potency of thyroprotein from a product about the equal of dried thyroid glands to one containing from 20 to 30 times the activity of the thyroid gland. When this type of thyroprotein is fed to dairy cows at the rate of about 10 grams per 1,000 pounds body weight per day, milk production increases from 10 to 30 percent within the course of a few days. Increased feed must be provided to provide the nutrients for manufacturing the extra milk, otherwise the loss in body weight may be large. There is no evidence that milk from cows receiving the thyroprotein contains detectable amounts of the thyroidal hormone.

Holstein cows fed synthetic thyroprotein continuously in experiments by the Massachusetts station showed a definite response in milk yield from greater persistency in milk flow. At the end of the fortieth week of lactation, after 21 weeks of continuous hormone feeding, milk production per cow averaged 227 pounds per week, as compared with 162 pounds based on previous performance. This increase in milk flow was usually accompanied by some loss in body weight since the grain ration had not been increased. Response to thyroprotein differed between breeds and between different animals within a given breed. Composition of milk was not significantly affected.

The stimulating effect of thyroprotein on milk and butterfat production has been confirmed by the New Jersey, West Virginia, and Michigan stations. In addition, the Michigan station has shown that it may have considerable value in maintaining or improving sexual activity in bulls.

The continuous feeding of thyroprotein to milking cows in a

relatively warm and humid climate by the Louisiana station indicated that both body temperature and pulse rate were significantly increased, loss of body weight occurred, and milk and butterfat production were increased for 5 or 6 weeks. However, following this period, the untreated or control cows average higher in production than the treated cows. Significant increases in milk yields and in percentage of butterfat resulted from feeding the iodinated casein in a reversal type of feeding experiment. Results from these two trials suggest that it is highly questionable whether the increased production obtained by feeding iodinated casein under Louisiana conditions would be great enough or would continue over a long enough period to justify possible injury to milk cows that might result from losses in body weight, increases in pulse rates, and higher body temperatures.

Marked increases in the fat content of the muscle tissue and the depot fat occurred in cockerels treated by implantation subcutaneously of pellets of diethylstilbestrol in trials at the California station. All treated birds had more fat than controls, and the fattening effect was increased with increased duration of the treatments. As much as 20 times the subcutaneous dose administered orally failed to produce fattening.

Similarly, the administration of substances reducing thyroid activity in fattening fowls appears to improve their fleshing quality. In trials with New Hampshire chicks at the Missouri station to determine the effect of a ration containing 0.2 percent thiouracil, this substance was found to improve the grade without deterioration in the rate of growth during a 16-day period with 10-week-old chicks.

MAINTAINING HEALTH OF FARM ANIMALS

EXAMPLES OF RESEARCH RESULTS

Penicillin is highly effective for the treatment of bovine mastitis, according to research of the New Hampshire station. Results obtained to date indicate that streptococcal mastitis may be cured by one injection of 100,000 Oxford units of penicillin administered in 100 milliliters of sterile saline or distilled water via the teat canal. However, in more acute cases or cases of long-standing chronic infection, one injection of 200,000 units may not be sufficient to effect a complete cure; such cases were cured by three injections at 24-hour intervals of 75,000 units of penicillin per injection. Staphylococcal mastitis is more difficult to cure than the streptococcal type.

Bovine mastitis has been controlled effectively by the Connecticut (Storrs) station by means of a program of periodic testing and segregation of infected cows developed through research of the station and carried out under a State mastitis control program in cooperation with the State Commissioner of Domestic Animals. Altogether some 36,000 samples from 350 herds were tested during the year. Complete segregation of infected cows has resulted in the elimination of the disease in many herds and in marked reduction in others. During the same period infection increased in the nonsegregated herds. The saving in milk yield alone for 206 herds where segregation has been practiced is estimated at $60,000.

Combating fowl leucosis through development of immunizing

agents is indicated as an encouraging possibility through the finding of the Massachusetts station that chickens inoculated with a suspension made from a lymphoid tumor became highly resistant to later inoculations of the same tumor. The resistance was well developed within 7 days after inoculation. These findings essentially confirm results at the United States Regional Poultry Laboratory.

Vaccination for the prevention of fowl leucosis as developed by the Virginia station has given promising results. Only a small percentage of vaccinated birds developed the disease when exposed to inoculation with potent virus. Young chicks instead of embryos are used for developing the vaccine which is prepared from ground desiccated blood and other tissues treated with formaldehyde. Successful extension and application of this vaccination method should be of great value to poultrymen.

Streptomycin, an antibiotic discovered and purified in highly active concentrated form by the New Jersey station, offers promise for the treatment of important diseases of man and animals caused by various bacteria that are resistant to penicillin or to sulfa drugs. The new antibiotic is formed by a certain strain of a soil-inhabiting organism, *Actinomyces griseus*. It is active against many gram-negative and gram-positive bacteria and has already been tested against a variety of diseases with remarkable success, including typhoid and paratyphoid, tularemia, cholera and influenza, tuberculosis and undulant fever, various gastrointestinal infections, fowl typhoid, and others. A great deal of research is under way by public-health agencies, industrial organizations, pharmaceutical houses, and others as to uses and manufacture of streptomycin.

Swollen joints, a serious malady of young calves under Florida range conditions, have been found by the Florida station to be generally due to a bacterial infection transmitted to the navel of young calves by the screwworm fly. The most practical means of control indicated is the prompt treatment of the unhealed navel of newborn calves with tincture of iodine and a reliable screwworm fly repellent and subsequent treatment until the navel is completely healed.

The stiff-lamb disease has been a baffling problem as to cause and control. Although nutritional deficiencies have been suggested among other possible causes, specific proof awaited experiments by the New York (Cornell) station whereby the disease was produced in a high percentage of lambs by feeding a ration of cull beans and alfalfa to the ewes during gestation and lactation. When vitamin E in the form of mixed tocopherols was administered to ewes, beginning 24 days before the first lamb was born, none of the lambs had the disease. Moreover, affected lambs were cured by subcutaneous injections of an alpha tocopherol compound. Supplementing the ration of breeding ewes with natural sources of vitamin E, such as wheat germ meal (unextracted), should prevent the trouble.

Phenothiazine, added to the salt at the rate of 10 percent, proved highly effective in preventing clinical nematode parasitism in lambs on pasture and also in reducing worm numbers in ewes at

the Montana station. Winter treatment of ewes with phenothiazine was of no value in preventing infection in their lambs with the intestinal nematode parasites found in western sheep, where the ewes and lambs had access to the phenothiazine-salt mixture throughout the summer. Therefore, the expense and labor of winter treatment appears to be unnecessary under these conditions.

Serious losses in sheep and goats during the winter months may result from grazing the ripe fruit of tarbush or blackbrush (*Flourensia cernua*), according to findings of the Texas station. Eating the fruit results in acute inflammation of the abomasum and upper part of the duodenum, frequently resulting in death within 18 hours. There appeared to be a very narrow margin between a slightly toxic and lethal dose of the material. Green leaves of the plant appeared to be harmless.

Discovery by the Nevada station several years ago of a new poisonous plant, Halogeton, responsible for severe losses in sheep, has been followed by intensive research as to ways of overcoming this hazard. The largest and most frequent losses were found to occur when sheep first encounter the plant as a sudden change of forage. Studies indicate that the more often the plant is subjected to snow and rain the less liable it is to cause poisoning, even if eaten frequently and in large amounts. At least two-thirds of the oxalate content may be lost during the melting of one snowstorm. This finding explains the marked variation that has been observed between sheep losses in different years.

When it is recognized that losses each year from animal diseases and parasites may approach 10 percent of the gross income which farmers obtain from the sale of livestock and animal products, the importance of constant research to find ways of reducing these losses becomes apparent.

Vaccinating cattle against Bang's disease with Strain 19 *Brucellus abortus* vaccine continues to be the most effective means yet developed for preventing this disease. The Maryland station in cooperation with the Department in a comparison of subcutaneous and intracutaneous vaccination of calves found that in calves treated between 4 and 8 months of age 11.4 percent of those receiving subcutaneous vaccination were still reactors to the agglutination test after 2 to 3 years, as compared with 5.3 percent of those intracutaneously vaccinated. However, animals treated between 9 and 16 months of age showed loss of titer to a greater extent among those vaccinated subcutaneously with 5 cubic centimeters of Strain 19 than among those vaccinated intracutaneously with 0.5 cubic centimeter of the same vaccine. The relative merits of these two methods of vaccination is still undecided. In a study of about 1,000 cows vaccinated as adults, it was found 2 years after vaccination that only about 10 percent of the cattle were negative and 60 percent were positive reactors. The intracutaneously vaccinated animals had a higher proportion of reactors. Animals vaccinated as calves and revaccinated as adults develop much lower titers than either calves or adults vaccinated for the first time. All attempts to isolate *B. abortus* Strain 19 from the

milk of animals vaccinated as adults gave negative results, indicating little danger of infective milk from such treatment.

Observations on the incidence of brucellosis as influenced by the use of Strain 19 vaccine in cattle of various ages by the California station indicated that the resistance produced by the vaccination was apparently greater in animals adolescent or mature at vaccination than in calves vaccinated when younger than 9 months. After the infection had become established there was very little difference between the calf crop of the group vaccinated as adults and that of the group vaccinated as calves. Abortion in rare instances followed the injection of pregnant cows with Strain 19 after the fourth month of lactation, and some loss of milk production has resulted in lactating cows. Nevertheless, Strain 19 is the only product at present that has been used on thousands of animals with any degree of satisfaction.

A new skin test, reported to be 25 percent more accurate than the agglutination test for detecting brucellosis infection in hogs, has been developed by the Michigan station. The need for a more sensitive test for detecting individual reactors in swine herds has long been recognized.

Mastitis control studies are particularly timely in view of the widespread ravages of this disease in dairy herds. Penicillin infused into the udders of cows with chronic streptococcic mastitis proved highly effective in curing this disorder in trials at the Michigan station. Dosages ranged from 5,000 to 12,500 units of penicillin per quarter. In a higher percentage of the cows treated one infusion freed the infected quarters from infection and in no cases were more than three treatments required. Massive doses up to 400,000 units of penicillin per quarter proved relatively nonirritating to mammary tissue.

Similar results on the value of penicillin in curing streptococcic mastitis was reported by the New Hampshire (see examples) and the New Jersey stations.

Bloat in cattle grazed on succulent herbage, particularly immature legumes, continues to be a serious problem. Following an earlier finding of the California station that bloat is largely due to the lack of coarse fibrous material in the rumen to induce belching, this station has found that bloating was most prevalent in cows receiving grain just before turning on pasture, and that lactating cows were more susceptible than dry cows. Bloat was generally produced in cows by feeding ground alfalfa hay and concentrates in a 60 : 40 ratio but rarely occurred when the ground alfalfa and concentrates were fed in equal parts. The consumption of alfalfa by the dry cow was markedly increased by feeding barley straw overnight before pasturing, but the effect on the milking cow was less conspicuous. Feeding concentrates just before pasturing decreased consumption of alfalfa of dry cows without effect on the incidence or severity of bloat. Bloat was not prevented by feeding barley straw at night to cows pastured on alfalfa during the day. Individual variations occurred in the susceptibility to bloat which could not be explained by the amount, kind, or character of the feed consumed. Physiological activity of the rumen seemed the most likely explanation. The feeding of Sudan hay

completely prevented bloat, provided cattle had access to all the hay they would consume overnight prior to pasturing on alfalfa.

Grazing trials of the Washington station showed that when grasses constitute 30 percent or more of the mixture in sweetclover-grass pastures the hazard of bloat is almost nonexistent.

Studies by the New Mexico station show that dairy animals have been pastured successfully on alfalfa over two seasons without the occurrence of bloat when the alfalfa was allowed to approach cutting stage before pasturing. Bloat was avoided also when dry hay was supplied with the alfalfa pasture.

New immunizing agents and more effective ways of administering them continues to be an important field of research.

Results of extensive experiments covering a wide range in the ratio of serum to virus in hog cholera vaccination at the Minnesota station lead to the conclusion that the ratio of serum to virus for the production of an adequate immunity should be about 0.3 : 0.06 cubic centimeter per 1 pound of body weight for swine weighing between 75 and 80 pounds. Ratios of 0.1 : 0.06 approach the critical minimum, and ratios of 3.0 : 0.06 are unnecessary and may even be unsatisfactory. It appeared, however, that excessive doses of antiserum do not interfere particularly with the development of an active immunity. Administering antiserum and virus by the intramuscular, subcutaneous, and intraperitoneal routes all proved highly satisfactory. Depositing the antiserum directly into the stomach while injecting the virus intramuscularly failed to give protection, indicating that none of the antibody was absorbed from the alimentary canal.

A vaccine recently developed by the New Hampshire station for the protection of poultry against what is known as contagious indigestion, blue comb, or pullet disease is produced by growing the virus on egg embryos. The station produced enough vaccine in 1944 to vaccinate some 44,000 birds in 12 flocks in the second year of a wholesale flock protection experiment. Apparently, favorable results were secured and further field testing has been undertaken with a view to establishing evidence of the effectiveness of the vaccine on such a scale as to warrant recommendation for commercial development and general use by farmers in the affected poultry areas of the United States. The disease causes next to the heaviest loss of adult birds in New Hampshire and is widespread in other areas.

The use of sulfa drugs to combat various animal diseases has received wide attention.

Sulfathalidine proved highly effective as a prophylactic agent against swine enteritis when administered to apparently healthy animals in affected herds in trials at the Illinois station. It also was quite effective in the treatment of the disease when uncomplicated with pneumonia. The drug had no apparent value in arresting pneumonia.

Of seven sulfonamides tested by the Illinois station with respect to ability to reduce mortality from pullorum disease, sulfadiazine and sulfamerizine were most effective as judged by mortality and rate of gain of the surviving chicks and also proved effective in preventing mortality, if administered after development of visible

symptoms of pullorum disease. A close agreement existed between amount of free sulfonamide found in the blood and the effectiveness of the drug. When 9 months old, female survivors treated when 1 day old with sulfadiazine and sulfamerizine gave negative reactions to pullorum agglutination tests.

Further studies have confirmed the earlier report of the South Carolina station that sulfaguanidine administered in proper dosage is effective both prophylactically and therapeutically against white scours in young calves. In view of the dangers from complications associated with diarrhea of the newborn calf it is recommended that prophylactic measures should be given precedence over therapeutic control except in herds where only sporadic cases occur.

Results obtained with 6 experimental groups of chicks at the Texas station show that sulfaquinozaline offers possibilities in the prevention of enzootic pasteurella infections of the respiratory tract of chickens. Further trials are in progress to establish the limitations of such treatment.

Experiments at the Wisconsin station gave evidence that sulfadiazine may be used to prevent an epidemic of coccidiosis in poultry by preventing the disease in those not infected and preventing the development of carriers.

As one phase of the extensive investigations on control of anaplasmosis in cattle, the Oklahoma station studied blood transfusions as a method of treatment. Intravenous injections of from 2,000 to 3,000 cubic centimeters of citrated blood obtained from healthy cattle resulted in the recovery from anaplasmosis of 15 out of 16 head of cattle deemed possible of salvage, indicating that this method of treatment is potentially valuable in counteracting this devastating disease.

In research at the Wyoming station, *Vibrio fetus* was isolated from aborted lambs from two flocks of sheep. It is concluded that this organism may be incriminated as a cause of abortion in ewes. Further studies are in progress to determine the common mode of infection and the general susceptibility of sheep to this type of infection.

Internal parasites in their attacks on farm animals with resultant losses in vitality and productive efficiency are one of the most insidious problems in animal health with which the farmer must deal.

The development of phenothiazine as an anthelmintic has proved to be of very great importance in the control of most of the parasites invading the gastrointestinal tract. Later the discovery that under some conditions this drug could be effectively administered simply by mixing it in the salt consumed by animals has led to considerable work on the adaptation of this method to various types of livestock management.

Under an intensive system of handling sheep it appears that reducing the parasite load in older animals and reducing pasture contamination is essential to effective control. Sheep on experiments at the Illinois station were markedly protected from excessive parasitism by a 1 : 14 phenothiazine-salt mixture when relatively free from internal parasites and kept from contacting other

sheep directly or indirectly. Tests to date indicate that sheep should have the mixture before them at all times on pasture and should also be treated with phenothiazine in fall and in winter.

Phenothiazine-salt mixture was found effective in sheep parasite control by the Pennsylvania station. No indication of toxicity was manifested in sheep receiving the 1 : 9 mixture for 3 years. However, a low residual infestation in the ewe produced a significant infestation in the lamb. The 1 : 9 phenothiazine-salt mixture was a satisfactory procedure when supplemented with the fall and spring drench.

Phenothiazine and salt in the proportion of 1 : 14 was found by the Michigan station to prevent serious infestation in sheep without any drenches of phenothiazine during the summer months. It was found too that mature sheep, rather than the pasture, are the carriers of roundworm infestations. Infection on the pasture died out in 2 or 3 months as far as the stomach worm, nodular worm, and trichostrongyles were concerned unless reinfestation occurred.

A severe outbreak of trichomoniasis, a protozoan disease, in a flock of young turkeys was promptly brought under control by the addition of 1 pint of cod-liver oil and 2 pounds of dry milk per 100 pounds of growing mash in a trial by the South Carolina station. This simple procedure appears to have great potential value in the rearing of turkeys.

Poisons from various sources annually take a heavy toll in livestock. Examples of results aiding in the solution of certain plant poisons are noted above; other examples follow:

In connection with extensive studies by the South Dakota station on the problem of nitrate poisoning of cattle, cattle losses on two farms in one area of the State were traced to the high nitrate content of well water. The finding that cattle losses may occur from nitrate accumulation in well water may help to account for losses which in the past have gone unexplained.

Several widely separated turkey flocks in Utah were afflicted with nitrite poisoning following a drought-breaking rainfall. In experiments by the Utah station approximately half the nitrate in dry oat hay moistened with water was reduced to nitrite and present as such after 20 hours, suggesting that poisoning associated with the ingestion of high-nitrate hays following rain may be caused by the nitrite produced in the hay.

Beef calves received lethal doses of lead by chewing wooden fences which had been painted 3 years previously with lead paint, according to observations of the Indiana station. The most consistent findings on autopsy were nephrosis and high amounts of lead in the liver. The symptoms could be reproduced in calves fed known amounts of lead.

MAINTAINING QUALITY OF ANIMAL PRODUCTS

EXAMPLES OF RESEARCH RESULTS

Rancidity in home-cured pork causes serious waste in North Carolina, where an estimated 75 million pounds are cured each year, sometimes by rather primitive methods. The North Carolina station, in attempts to avoid these losses, found that rancidity

in bacon could be prevented by treatment with hydrogenated oils to which gossypol had been added. Soft pork was more subject to rancidity than firm pork.

Milk loses little of its vitamin content during high-temperature, short-time pasteurization, now widely employed. Analyses by the Massachusetts station on 20 lots of milk pasteurized by this method over a period of 18 months showed no loss of ascorbic acid or riboflavin and only about 3-percent loss of thiamine.

Skunkweed defect in butter, an important source of loss to Oklahoma farmers, occurs when cows are on scrub oak pastures from about April 15 to July 1. The off-flavor is difficult to detect in milk and cream. Affected cream may now be detected by use of a test developed by the Oklahoma station whereby the addition of one part of concentrated nitric acid to five parts of cream reveals the presence of the defect. Farmers can avoid trouble by keeping cows in the dry lot or on seeded pastures during the critical period.

Cheddar cheese and other kinds had better flavor and ripened sooner in Iowa station experiments when rennet paste was used in making it. The result was due to a fat-splitting enzyme contained in the rennet. Lower manufacturing costs and a more uniform product should follow the application of this finding.

Sweetpotato flour from yellow Porto Rico potatoes was used in Louisiana station experiments to replace 3 percent of the nonfat milk solids in ice cream mix. It saved high-test gelatin and 6.7 percent of the sugar. The ice cream had good flavor, superior body, and texture, and melting properties were good.

Eggs stored in Colorado station experiments at 72° F. showed little loss of quality after 40 days. This was accomplished by devising an air- and moisture-tight package in which carbon dioxide gas is released slowly during storage. A mixture of a carbonate and an acid in solid form is placed in the egg carton as a capsule or pellet or impregnated into the wall of the carton, then the carton is heat-sealed with moisture-proof cellophane or waxed paper.

The search for new and better ways of producing, processing, and preserving perishable animal products in order to insure consumers of high-quality products has been continued.

Beef ripened in coolers for 14 to 21 days before freezing was held in frozen storage at 0° for 15 months with only slight deterioration in palatability in Indiana station trials. The muscle fibers and bundles in meat subjected to such frozen storage did not undergo appreciable histological changes, and the changes in chemical constituents in frozen beef were not sufficient to indicate spoilage. There was no relationship of the chemical composition, palatability, and histological changes resulting from frozen storage to the finish of the steers and the length of the ripening period.

Studies of the Washington station showed that thiamine deposition in pork is directly related to thiamine intake during growth and fattening. The thiamine content was found to be greatest in hams and loins, followed by shoulders, hearts, livers, and kidneys. Thiamine content of newborn pigs was relatively low and nearly

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doubled between birth and weaning, after which a gradual decrease occurred.

Similarly, Pennsylvania station trials showed that the thiamine content of pork could be more than doubled within a period of 35 days by adding 50 milligrams of thiamine per pig daily to a conventional-type ration of grain, protein supplement, and mineral. Thiamine was not further increased by extending the period of supplemental feeding, indicating that tissue saturation was reached. There was a relatively slow rate of loss of stored thiamine after extra thiamine was withdrawn from the ration.

The effect of production and processing methods on the vitamin content of milk and butter also has received attention.

Milk from Jersey cows was, on an average, 52 percent higher in riboflavin than milk from Holstein cows, with evidence of an inverse relationship between the milk yield and the riboflavin content of the milk, as determined by the Idaho station. A material increase in the riboflavin content of the milk was produced in about 2 days by supplementing a dry ration of concentrates, alfalfa hay, and dried beet pulp with sunflower silage, indicating the marked response to increased riboflavin intake. The riboflavin content of the milk was not influenced by pasteurization, homogenization, or storage for 24 hours at 40° F. in a dark refrigerator, but exposure to direct sunlight for 2 hours in clear bottles destroyed as much as 40 percent of the riboflavin.

As an outgrowth of a request from the National Research Council for a Nation-wide survey of the vitamin A content of butter, a cooperative project, involving State experiment stations in all sections of the country and the Department, was undertaken in the fall of 1941. After 1 year's work by a technical committee in perfecting analytical methods for determining both carotene and vitamin A in butter the survey was undertaken and extended over a 2-year period. Data were submitted by the Department and the following State experiment stations: Alabama, California, Idaho, Indiana, Iowa, Kansas, Louisiana, Maryland, Minnesota, Mississippi, Montana, Nebraska, New York, North Carolina, Ohio, Oregon, Pennsylvania, Washington, and Wisconsin. An analysis of all data led to the conclusion that on the average butter produced in the United States contains slightly over 15,000 International Units per pound. On the basis of prewar normal consumption of butter, about 14.8 percent of the recommended daily intake of vitamin A would thus be supplied. About 36 percent of all the creamery butter is "winter" butter, with an average vitamin A potency of 10,500 to 11,200 International Units per pound. About 64 percent is "summer" butter, averaging from 17,000 to 18,000 International Units per pound. No appreciable loss of vitamin A potency occurred during normal cold storage, according to reports from six stations. Studies in four States indicated that the consumer may expect to obtain butter from retail markets which compares favorably in its average vitamin A potency with the over-all average of all the creamery butter produced in this country.

The Maine station has developed a short-time, simple method by which a farm housewife may by the use of rennet paste quickly

turn surplus milk into small-sized cheeses that cure in 6 or 7 weeks at 50° to 70° F. to a good flavor level suitable for home consumption or sale at roadside stands. A 5-percent solution of sodium propionate (Mycoban) brushed over the fresh cheese surface for two successive days was effective in keeping molds from developing.

Kansas station trials indicated that the phosphatase test may be applied with confidence to Cheddar cheese as a means of determining whether cheese milk has been properly pasteurized. In no case did samples of Cheddar cheese, with an initial negative phosphatase reaction, become positive during storage periods of 3 and 6 months.

Improved keeping quality of whole-milk powder was obtained in Illinois station experiments by increasing total solids in condensing, incorporating the minimum of air, spraying with low pressure, and packing warm and immediately after drying. Noteworthy improvement in keeping quality over air packing was gained by efficient gas packing. CO_2 appeared to be a satisfactory gas for gas packing in amounts up to 70 percent, and there was some slight improvement by addition of antioxidants. All samples stored at 100° F. deteriorated faster than those stored at room temperature. Gas analysis of headspace gas indicated more rapid oxygen absorption when the samples were stored at the higher temperature.

Tests at the Massachusetts station showed that, although the chloramine treatment given water supplies of cities and towns destroy certain harmful bacteria, others may be present that can survive the treatment and may impair the keeping quality of milk.

Continuing work on oil dipping as a means of improving keeping quality of eggs the Missouri station found that eggs processed in hot oil (30 seconds at 150° F.) kept better than those processed in cold oil and not a single mold spot was found in 1,007 eggs examined, contrary to the theory held in the trade that hot-oil processing results in mold spots.

An inexpensive, easy-to-use method of sealing fresh-laid quality into eggs on the farm has been developed at the Oklahoma station. The freshly gathered eggs are merely dipped into a sealing solution compound of paraffin, aerosol, diglycol laurate, a fungicide, and water. The protective film is so thin that the normal appearance of the egg is not changed. Sealed eggs may be immediately placed in clean cases and marketed. The sealer is of most value during the hot, dry summer months.

Olive-colored yolks are produced when cottonseed meal is included in the ration of hens. This is due to the gossypol contained in the cottonseed and has largely limited the use of this valuable protein source in poultry feeding. The addition of soluble iron salts to the ration containing cottonseed meal prevents the absorption of the gossypol by the hen and the formation of olive yolks in the stored eggs, according to findings of the Louisiana station.

FOOD AND NUTRITION INVESTIGATIONS

EXAMPLES OF RESEARCH RESULTS

Natural color in both frozen and dehydrated peaches and apples was preserved by treatment with sodium bisulfite in Tennessee station experiments. The bisulfite was added in minute amounts to the sugar sirup used for packing the frozen fruits. Dried fruits dipped for 2 minutes in a 2-percent solution had better color than by the old method of exposing them to sulfur dioxide for 30 minutes, and the stifling fumes of burning sulfur were avoided. Adding small amounts of citric or phosphoric acids to the sugar sirup helped to preserve both color and flavor in frozen peaches and apples.

The southern muscadine grape, unsuitable for shipping fresh because of the tendency to "leak" and for canning because of bitterness in the hulls, has been found to be excellent for freezing preservation by a process developed by the Georgia station. The method includes deseeding, removing the excess tartness of the hulls, tenderizing the hulls, mixing with sugar, packing in cartons, and freezing. Only the seed are removed. The product has an excellent bouquet; is suitable for pies, shortcake, cobbler, sherbet, ice cream, and sundaes; and may be cooked into jams and preserves. It is already being produced commercially.

Prevalence of dietary deficiencies, including pellagra, anemia, and calcium deficiency, associated with the large-scale consumption of corn meal and grits in the State, led the South Carolina station to research directed to the enrichment of these products with the deficient vitamins and minerals. Inexpensive automatic feeders developed by the station for attachment to corn mills have been installed by 67 mills, with resulting distribution and consumption of some 200,000 pounds of enriched corn meal. The station also developed a low-cost enrichment mixture containing niacin, iron, and calcium.

Discoloration in sweetpotatoes during processing had been shown in former work by the Maryland station to be caused by enzyme action. Since this discoloration appeared to be associated with lye peeling, research studies were conducted to eliminate discoloration under processing plant conditions. The station found that discoloration can be practically eliminated by preheating the sweetpotatoes for 30 minutes in water at 125° F., provided the initial temperature of the potatoes is at least 60°. If this treatment is used just prior to lye peeling, the temperature of the boiling lye then inactivates the enzyme. Application of the finding during processing for dehydration resulted in the saving of several million pounds of sweetpotatoes in the spring of 1945.

Wyoming housewives were helped through the sugar shortage by information from research of the Wyoming station on how to substitute honey and sirup. Honey was excellent in canning pears and apples, whereas dark corn sirup was best with blue plums. Crystal sirup was satisfactory with most fruits. Honey also proved excellent in cookies and fruit cake. It kept them moist in semiarid high altitudes.

Dates, recognized as rich in sugar and high in energy value,

were studied by the Arizona station as to their vitamin content. Chemical analyses showed them to contain no ascorbic acid and little carotene, but to furnish 0.10 milligram each of thiamine and riboflavin per 100 grams of date pulp. Thus servings of four to six dates would provide as much of these two vitamins as common servings of other fruits.

The high ascorbic acid content of papayas and guavas is attracting wide attention. Utilization of the vitamin from these common Hawaiian fruits in tests with 14 human subjects by the Hawaii station was found to be similar to their utilization of pure synthetic ascorbic acid. A single serving of either fruit, both inexpensive and abundant in the islands, could provide all the ascorbic acid needed by the body to meet a day's requirement.

Losses of vitamin C in fruit and vegetable juices were found by the New York State station to be dependent upon the temperature of storage. At 45° C. as high as 60 percent of the ascorbic acid in fortified apple, strawberry, raspberry, or sauerkraut juices is destroyed in a month. Losses at 37° and 32° are less, whereas juices stored at 1°, 10°, or 21° show very little loss. Undesirable changes in color, flavor, sugar, and pectin accompany losses of vitamin C at high temperatures.

Berries are grown in large quantities in Oregon for home consumption and commercial uses. Hence information on vitamin C is important. The Oregon station found wide variation among strawberry, raspberry, and blackberry varieties and selections in breeding experiments from a low of 50 to a high of 125 milligrams of ascorbic acid. Several strawberry selections had very high potency. Heredity rather than environment determined vitamin C content.

Kale, heavily frosted in the field, suffered serious losses of vitamin C, according to findings at the Delaware station. Whether the growing of kale under favorable climatic conditions can restore these losses should be given consideration if this commodity is to be grown as a late-season source of vitamin C in the diet.

Whole brown rice was found by the Arkansas station to be a much better source of the vitamins thiamine and riboflavin and a slightly better source of inositol and pyridoxine than white polished rice. Losses of nutritive properties in cooking were small in all types of rice when a double-boiler type of cooker was used. Large losses occurred in open vessels. There were no significant losses in food values after 2.5 years in cold storage.

Investigations dealing with the conservation of foods and with problems of insuring conservation of their nutritive values were well under way as a contribution to the war effort and have been continued within the year. Many, but not all, of these studies have been conducted as a part of a program of work carried out under the National Cooperative Project on Conservation of the Nutritive Values of Foods, first noted in the 1943 report. The studies on methods of food preservation and on factors affecting food values have constituted the major part of the food-research program of the stations. However, a number of studies have dealt with the relation of food intake to nutritional well-being and with

the associated problem of food habits. A few investigations have been concerned with the use and performance of household equipment utilized for food preparation.

The extent of these researches on foods and nutrition does not permit discussion of all the work that has been done in the year. The selected studies outlined briefly in the examples cited above and in the following pages will serve, however, to illustrate the nature and scope of the investigations and some of the results.

FOOD PRESERVATION

Freezing as a means of food preservation offers certain advantages which make this method very attractive. Chief among these is the fact that the palatability and nutritive value of the fresh food is more nearly retained by this method than by others. In trials at the Massachusetts station, in which snap beans, cabbage, carrots, and sweet corn were frozen, canned, dehydrated, and salted by home methods, freezing appeared to yield the most acceptable product from the standpoint of palatability, flavor, texture, and color. Retention of ascorbic acid on the basis of the cooked, ready-to-serve product was about the same for frozen and canned products.

Asparagus, carrots, peas, and spinach, precooked in steam, puréed, sieved, and preserved experimentally by canning, freezing, and dehydrating, were tested at the California station. The frozen products were the best from the standpoint of general palatability, appearance, and retention of ascorbic acid, thiamine, and riboflavin content. The canned products, lower in vitamin content than the frozen, were quite acceptable, and the dehydrated products were also good but tended to deteriorate more quickly during storage unless packed in a vacuum.

A circular prepared by the Kansas station as an aid to prospective buyers in the selection, use, and care of home frozen-food cabinets lists the disadvantages as well as the advantages of home food preservation and points out that superior quality will not be attained in the frozen product unless care is taken to use fresh material of prime maturity and quality and to prepare and package it properly. While different varieties of fruits and vegetables showed marked differences in the suitability for frozen storage in tests at the Minnesota station and the Kansas station, yet, the methods of handling and degree of maturity were more important. Methods of handling, of course, differ somewhat from product to product, and certain foods present special problems. To meet this situation, the Kansas circular, referred to above, includes instructions for preparing and packaging individual foods, including various fresh fruits and vegetables, meats, eggs, butter, and miscellaneous precooked foods.

One of the special problems in preparing frozen apples, peaches, and apricots is the prevention of brown discoloration. To inactivate the enzymes responsible for the darkening of frozen apples during storage and after thawing, the New York State station found cold immersion in a solution of sulfur dioxide or of sodium sulfite or steam blanching to be satisfactory treatments. Sodium bisulfite was found by the Minnesota station to be superior to

sodium sulfite in preparing pie apples for freezing, although this did not hold true for apples to be used for sauce. The Kansas station found thiocarbamide, one teaspoonful to a quart of water, or sodium sulfite, one-half teaspoonful per quart, to be effective in preventing browning of peaches if the prepared fruit was dipped into the solution and drained before packing in the sirup. Crystalline ascorbic acid, three teaspoonsful per gallon of sirup, improved the color and quality of frozen peaches and apricots, in tests at the Minnesota station.

Selecting a variety particularly adapted to freezing will help to insure quality in a frozen fruit or vegetable, or, on the other hand, it may be necessary to adapt the method to the variety. Thus, cultivated blueberries should not be blanched before freezing according to recommendations of the New Jersey station, since trials conducted there showed that blanching unfavorably affected the appearance and edible quality of the blueberries. On the other hand, wild blueberries and certain varieties grown at the Georgia station were improved by blanching before freezing, this treatment preventing the development of woody texture upon storage of the frozen berries.

Proper preparation of foods as to size and shape of package, choice of packing medium and amount of wrapping materials, and attention to location of the packages in the freezer and the amount of products being frozen at one time are factors that affect the freezing rate. These, the Pennsylvania station suggests, are points to be considered by the operator in the economical use of the freezing unit. The speed of quick freezing of vegetables has little or no effect on their quality, however, according to the New York State station, and the Iowa station found that the palatability of frozen broilers was not affected by the rate of freezing.

Once frozen, there is a constant turn-over of foods in the frozen storage cabinet. In preparing a schedule of changes of food in the home cabinet, the Kansas station considered the seasons when different foods are available for freezing and the storage life of the various products. Pork loin roasts, for example, kept well for only 16 to 22 weeks at temperatures from —9° to —18° C., in tests at the Minnesota station; after that period the fat developed an undesirable flavor and aroma, although the lean changed flavor at a slower rate and retained its tenderness and juiciness. Pork chops wrapped in two thicknesses of good locker paper and stored at 0° F. in trials at the Oregon station gradually decreased in desirability, but kept satisfactorily for 10 months.

The possibilities of the home freezer have not yet been fully explored, and new possibilities and new frozen products can be expected. Some of the new frozen products developed for home freezers in recent experimental work at the Minnesota station include unpeeled sliced eggplant frozen after dipping in water acidified with lemon juice and blanching; squash purée prepared from dry types of squash for use in pumpkin pies; sweetpotato slices prepared from baked, cooled sweetpotatoes peeled and treated with diluted lemon juice and a coating of sugar; and eggs, frozen separated or mixed, and treated with light-colored corn sirup to prevent undesirable coagulation of the yolk in freezing.

Interest in the freezing preservation of cooked foods led the Georgia station to study the suitability of fruits, vegetables, meats, and combination dishes for freezing after being cooked and to study the best methods of preparation, the most desirable types of containers, and the most satisfactory method of serving. The results of this study suggested that a wide variety of these foods could be satisfactorily cooked and frozen, but that it was much more difficult to hold the volatile flavors during preparation, packing, freezing, storing, thawing, and serving cooked foods than was the case with the frozen raw foods. The flavor of blueberries, raspberries, blackberries, apples, plums, and grape products was improved if the fruits were preheated and packaged as a "solid pack" before freezing. Precooked vegetables if packaged as "loose pack" lost fresh flavor and aroma and developed a "warmed over" flavor. This could be overcome, however, by packing them solid thereby eliminating air. Boiled, baked, or roasted meats, but not fried meats, could be satisfactorily frozen. The tests suggested further that a wide variety of combination dishes, sauces, bakery products, canned foods, preserves, pasteurized butter, pasteurized cheese, and precooked dehydrated products may be profitably and satisfactorily preserved by freezing.

Canning, which found wide application in wartime conservation of Victory garden crops and local market surpluses, will continue to be the method of choice in many homes. In the interest of safe home canning, the Massachusetts station has investigated the cause of spoilage observed in some home-canned foods and has made a study of processing times adequate to sterilize the packs without overcooking them. Preliminary to the study, an extensive review of the literature was made to obtain all the information available on botulism in relation to home canning. This type of food poisoning, although not very common, is by far the most spectacular (often fatal). The well-rounded review of the subject, presented in the Massachusetts station bulletin makes it clear in summary that botulinum organisms are widely distributed in nature and are not apparently confined to certain geographical areas, so that canning techniques employed in any region must be adequate to destroy chance spores of the organism. For nonacid foods, adequate sterilization is insured only by means of a pressure canner in good operation. Any nonacid foods canned without a pressure canner, or in a pressure canner incorrectly used, should never be tasted until they have been boiled for 10 to 20 minutes.

The Illinois station also mindful of this problem of botulism, made a survey of the soils of its own State to determine the incidence and distribution of *Clostridium botulinum,* the organism responsible for the development of the botulinum toxin. Examination of the soil samples resulted in obtaining toxic cultures from soils of about one-fourth of the counties in Illinois. These results emphasized anew the necessity of adequate processing of foods in home-canning operations.

The Massachusetts station continued its investigation by making a careful survey of 90 families to determine the spoilage in home-canned foods and found it to amount to about 2 percent.

Laboratory examination of samples, sound and spoiled, submitted by 300 families indicated that about three-quarters of the home-canning spoilage was due to understerilization and one-quarter to improper sealing; however, none of the samples contained any botulinum toxin. The study, continued further, utilized vegetables packed in home-canning jars and applied to them the exact methods long used by commercial canners to determine process times for their products. The results showed that water-bath processing, commonly used in the home, was not satisfactory for non-acid vegetables. By this method of sterilization packs of these vegetables inoculated with certain spoilage bacteria found in home-canned foods required from 5½ to 12 hours for adequate processing. In a pressure cooker at 240° F., these packs were found to be adequately sterilized well within the processing times recommended by the Department of Agriculture for home canning by this method.

Dehydration of fresh foods, as a means of greatly reducing their volume and converting them to products capable of being held for considerable periods, required research and development toward meeting the wartime food demands of the armed forces. One of the problems in the realm of food dehydration, that of preventing graying of potatoes, was investigated by workers at the New York (Cornell) station. They found that the chemical reactions which result in the darkening of boiled potatoes are the same as those causing graying of dehydrated potatoes; that whether a potato darkens during dehydration is a quality inherent in the potato itself; and that the actual drying process has little or nothing to do with the occurrence of this trouble. Observations as to the relation between the acidity acquired by the potato during storage and its graying tendency led to the development of a procedure for preventing graying during dehydration. The method, which worked well in commercial as well as in laboratory practice, involved slight acidification of the peeled whole or diced potatoes, either during or after blanching, with water acidified with orthophosphoric acid to a reaction of pH 4.0.

The ease of application, the short period of treatment required, the harmlessness of the dilute acid, low cost, lack of alteration of flavor, and production of a dehydrated product of uniform color with no darkening were the practical advantages of the process. Citric, acetic, lactic, or sulfurous acid or sodium dihydrogen phosphate could be satisfactorily substituted for the phosphoric acid.

An objectionable darkening of dehydrated sweetpotatoes which resulted in rejections by the Army was investigated by the Kansas station as to cause and prevention. Working with sweetpotatoes obtained from various farms in western Missouri and the Kaw River Valley of Kansas, the station obtained a satisfactory dried product with bright color by pretreatment of the sliced tissues with 0.5 percent sodium bisulfite solution followed by steam blanching and dehydration. By means of this treatment, the oxidizing enzyme responsible for the darkening was inactivated. Blanching in steam alone for 4 minutes at 200° F., although helpful, did not entirely prevent the defect.

Powdered, dehydrated tomatoes were prepared on an experi-

mental scale at the California station by dehydrating the halved or sliced tomatoes stepwise in a forced draft drier. At the temperatures that could be safely used, the moisture could not be reduced below 10 percent, and final drying to a satisfactory moisture content of 5 percent had to be accomplished in a laboratory vacuum oven. The dried brittle product, from both sulfured and unsulfured tomatoes, when ground, sieved, and packed varied in quality and vitamin retention when stored for various periods under different conditions. Sulfuring and vacuum packing, however, had a favorable influence on retention of color and flavor and vitamin values. The powdered dehydrated tomato and also blends of tomato with split peas, corn, or lima beans dried in an experimental-scale drum drier are considered promising for dehydrated soups.

Cold-mix dehydrated fruit spreads were developed for use in Army field rations through joint research of the Office of the Quartermaster General, U. S. Army, and the Delaware station. The study was designed to determine the thickening characteristics of various combinations of dehydrated fruits, sugars, and hydrocolloids in powdered mixtures which, when moistened with water would almost instantly and without application of heat, assume the character of a fruit jam. The basic flavor ingredient of the powdered mixes was dehydrated fruits, such as apples, apricots, cherries, cranberries, figs, pineapples, prunes, raspberries, or tomatoes; this was combined with (1) a sweetening agent, preferably lactose, mannitol, or dextrose since these sugars are less sweet than sucrose and did not mask the fruit flavor; (2) a thickening agent, such as pectinic acid, various commercial extractives of Irish moss, locust bean gum, and others; and (3) certain salts and acids. Tests to determine the behavior of the various thickening agents, the degree of sweetness desirable, and the resistance of the mixtures to caking as a result of moisture absorption under various conditions of packaging led to the development of several economical formulas which thickened rapidly to a desirable consistency when the proper amount of water was added.

The operational aspects of dehydration were the subject of a number of investigations. The Massachusetts station, for example, worked out a procedure for evaluating the operational efficiency of home dehydrators, based on the pounds of water evaporated and the kilowatt hours of electricity used. The best operating efficiency in home dehydrators was observed in those of the forced draft type since these required no rotation of the trays and showed the shortest drying time of the three methods used. Natural draft dehydrators, if properly designed, also yielded good results, but the drying time was prolonged, temperature control required watching, and trays had to be rotated at intervals. Oven drying proved least satisfactory because of the difficulty of controlling the temperature, variations of temperature in different parts of the oven, and the necessity of frequently shifting and rotating the trays.

Data obtained by California investigators in observations on products from commercially operated tunnel dehydrators led to the suggestion that the drying be started with high temperature

and high air velocity and that the partly dried product be placed in a second tunnel or other drier to be finished in air at lower temperature and velocity than in the primary tunnel. It was also suggested that trays of the partly dried product be doubled up, or trebled up in some cases, to permit one secondary tunnel to serve two or three primary tunnels.

Blanching by brief exposure to flowing steam or boiling water is an essential preliminary step to actual dehydration or freezing processes in order to inactivate enzymes which may cause deterioration of flavor and destruction of vitamins during storage of the product. These blanching treatments sometimes damage the texture of vegetables and leach out some of the water-soluble vitamins. Results obtained in laboratory scale tests at the New York State station indicated that electronic heat produced by a shot of high frequency electricity may be used in place of steam or hot water to inactivate the enzymes. By resorting to electronic blanching, the loss of ascorbic acid in the blanching of cabbage, for example, was reduced to 3 percent and handling of the material was greatly simplified.

Brining, pickling, and smoking are time-honored methods of food preservation that recommend themselves not only for the variety they offer in winter food but more especially because they require the minimum of equipment in their application. Sauerkraut, one of the most popular of the brined fermented products, was made at the North Carolina station from locally grown green-colored market-type cabbage. The product, whether manufactured on a large scale or made in quart-jar lots as for home use, was of very satisfactory quality; because it was made from green cabbage it had a yellowish color which was presumed to indicate a higher carotene content than that of the usual white cabbage product. The possibility of kraut manufacture from seasonal surpluses in market cabbage opens the way to a more profitable future for cabbage growers in the region and at the same time provides a palatable product for the consumer. For making kraut at home, the station in cooperation with the Department developed a procedure so simple that it can be used even in a kitchenette. The kraut thus prepared can be kept for a few weeks if sealed tight and kept in a cool place or it may be canned for longer storage.

Mindful of the nearly 5 million pounds of vegetables salted in Michigan in 1943, the still larger production in 1944, and the prospects of a very large crop of vegetables in 1945, the Michigan station investigated processes for salting beets, carrots, corn, green beans, and spinach as a method for preserving vegetables in large quantities for soup making and for institutions using considerable amounts of vegetables. Bacteriological tests, vitamin determinations, and observations on the influence of salting on the color, flavor, and appearance of the salted vegetables showed these products to compare very favorably with the canned products prepared from the same lots of the raw vegetables. Certain variations in procedure were tried, but the best products, as judged from their quality after cooking, were those put up in an 18-percent brine, the whole kernel corn, the snap beans, and the dried

carrots after preliminary blanching, the spinach and unpeeled beets without blanching. The use of 0.3-percent acetic acid in the brine improved the carrots, and the spinach was satisfactory with or without the addition of the acid. The brined beets were white on the outside to a depth of 2 or 3 millimeters.

As one way to conserve sugar in pickling, the New York State station suggests that the pickling solution or sirup from home-made or commercially processed sweet pickles be used again. This reuse of the pickling sirup always gave satisfactory results in the tests conducted, although the second batch of pickles was never as sweet as the first lot unless more sugar was added. It was found to be a good practice to make up about a third of the amount of pickles wanted, as sweet pickles, using the full amount of sugar called for in the recipe, the remainder of the pickles then to be packed in a solution having the same amount of vinegar, salt, and spices, but much less sugar. As the sweet pickles are consumed, the unsweetened pickles can be placed in the left-over solution and allowed to stand for a few days when they will absorb much of the sugar left in the original pickling solution.

Directions for the home preservation of fish by pickling and smoking and for preparing smoked-fish dishes are included with other fish recipes issued by the Michigan station and by the Iowa station. These tested recipes were assembled and developed in the interest of making greater use of an abundant but less generally used food supply. In connection with these studies on the locally available kinds of fish, information was obtained on weights and yields of refuse and dressed fish.

NUTRITIVE VALUE OF FOODS

A review of the year's reports indicates that many foods, probably some 75 particular commodities, including fruits, vegetables, meats and fish, cereals, eggs, and dairy products, have been concerned in the many investigations of the various experiment stations. Some of the studies were of the survey type to obtain information on the relative values of a large number of foods. Of this type were the Pennsylvania station study of the vitamin content of some tropical fruits, their juices, and nectars; the investigation by the Florida station of the vitamin A and C activity of Florida foods; the Nebraska station studies on the riboflavin content of cheese; the Wisconsin station experiments determining the choline and pyridoxine content of meats; and the California station analyses to determine the cholesterol content of foods. Most of the studies, however, were concerned with some special factors affecting food values, such, for example, as the effects of cooking, processing, storage, and natural variations on the vitamin content of foods.

The effect of natural variations on food values involves consideration of the various factors in operation as the plant, or animal, is growing. In this connection, the influence of variety, of stage of maturity, of the part eaten, of sprouting, and of feeding practices was investigated and are discussed briefly as follows:

Variety may or may not exert a pronounced effect on the nutritive value of fruits and vegetables, and its influence may be

masked by other factors. In trials at the Rhode Island station in which 11 varieties of snap beans, 9 green and 2 wax, all grown under identical conditions, were analyzed for their ascorbic acid and carotene contents, no variety appeared outstanding for ascorbic acid content. Moreover, although some varieties consistently ranked higher than others in carotene content, the differences between varieties were not marked. In general, the highest analyses for ascorbic acid in the green varieties were slightly higher than those for the 2 wax varieties, although some green varieties were lower than the wax. The wax beans had little more than one-third as much carotene as the green beans.

In tomatoes of 3 varieties, Marglobe, Rutgers, and Gulf State Market, grown from the same seed source at the Georgia station, Louisiana station, and Virginia Truck station in a cooperative study, no varietal differences in ascorbic acid could be shown. In the Rhode Island experiment in which 28 varieties and hybrids of tomatoes were compared for ascorbic acid content, there were large differences between the low and high results at each sampling, but many varieties were inconsistent in their relation to others at different sampling dates. Certain varieties, however, such as Comet, Vetomold, Pan American, and Marglobe, were consistently among the high-ranking varieties, with ascorbic acid values of from 19 to 24 milligrams per 100 grams, while other varieties were low (around 12 milligrams per 100 grams) or intermediate.

The Maine station on the basis of trials over several seasons with 29 varieties of tomatoes concluded that ordinarily a superior variety maintained its superiority even under unfavorable conditions. It was obvious from the data obtained that many of the varieties popular in home and commercial use were those on the lower level of ascorbic acid content. This fact together with the losses incurred in processing resulted in these tomatoes being less than a good source of this vitamin. The need for growing high-vitamin C varieties of tomatoes is emphasized.

In apples, ascorbic acid concentrations were related to varieties, according to the results of analyses of 13 varieties grown in the orchards of the West Virginia station and tested over a period of years. These apples ranged from 6.9 to 20.9 milligrams ascorbic acid per 100 grams. Ascorbic acid content as a varietal characteristic was also observed by the Iowa station in Iowa-grown apples. Willowtwig apples were surprisingly rich in this vitamin, about 25 milligrams per 100 grams, and retained it well over a 7-month storage period. This was in contrast to Jonathan apples, which contained about 9 milligrams of ascorbic acid per 100 grams when freshly picked and tended to lose about half of this amount in the first 3 months of storage. The Willowtwig apple may prove useful in an apple-breeding program from the standpoint of improving the average ascorbic acid content of apples.

The high ascorbic acid values of strawberries and the varietal differences in content of this vitamin were observed in trials at the Maine station, where six high-ranking varieties were found to contain 83 to 96 milligrams per 100 grams, five intermediate

varieties 65 to 76 milligrams, and three low varieties 46 to 61 milligrams per 100 grams.

The ascorbic acid content of 25 varieties of California-grown guavas as determined by the California station ranged from 55 milligrams per 100 grams in the Earle variety to a maximum of 529 milligrams per 100 grams in the Rolfs. Other varieties were intermediate usually with their own characteristic levels of the vitamin.

The part sampled must be considered in the laboratory in selecting a representative sample of the food for analysis. Such selection may also net returns in added nutritive value in preparing the food for table use. In the case of summer squash, for example, the Rhode Island station found that ascorbic acid was highest in the pith and seed portion, the seeds being about twice as high as the pith when analyzed separately. The rind was consistently and significantly highest in carotene in each of the three varieties tested. For maximum nutritive value, therefore, these summer squashes should be used in their entirety, texture permitting, in preparing them for table use.

In kale, as harvested for a study of vitamin C by the Maine station, the inner leaves were found to contain about 34 percent more ascorbic acid than the outer leaves. The leaves of celery, as another example, are far richer than the stalks in both carotene and ascorbic acid. Thus green (Pascal type) celery supplied to the Florida station by the Celery Investigations Laboratory contained 345 micrograms of carotene per 100 grams of outside stalks, 249 micrograms for the inside stalks, a trace in the hearts, and 4,508 micrograms per 100 grams of leaves; corresponding values for ascorbic acid in milligrams per 100 grams were 6, 9, 9, and 31. When bleached, the outside and inside stalks and heart contained only traces of carotene, while the leaves contained 4,500 micrograms per 100 grams of leaves; these four parts of the bleached celery contained, respectively, 10, 12, 20, and 37 milligrams ascorbic acid per 100 grams of fresh material.

Higher values for ascorbic acid in the heart portion were also observed by the Utah station in Utah-grown celery. The hearts and inner leaves of the fresh celery, Utah variety, contained 26.5 milligrams ascorbic acid per 100 grams, this being twice as much as was found in the outer stalks and about one-third to one-fourth as much as in the outer leaves. These same relationships but lower values were observed for celery of the Cornell variety. This difference in ascorbic acid content of leaves and stems was also observed in celtuce analyzed as freshly harvested at the Illinois station; the leaves, containing 41 and 55 milligrams ascorbic acid per 100 grams, were 10 times as rich in this vitamin as were the stems which contained only 4 to 6 milligrams per 100 grams.

Maturity and ripening conditions often exert a marked influence on the vitamin values of foods. Carrots, for example, were planted by the Arizona station at two locations in the State in October, November, December, February, and March and harvested from each planting beginning with pencil size and extending through a 240-day growing period. With both varieties (Imperator and Chantenay) and in all plots carotene increased with

the size of the carrots—and hence with age, maturity, and length of growing season—from 2 up to 20 milligrams per 100 grams fresh weight. Carrots from the south row of east-west beds always contained more carotene than those from the north row, indicating the influence of soil temperature on rate of growth. Also, carrots planted in October in the Salt River Valley at a higher elevation and, therefore, a cooler climate with longer chilling periods grew and increased in carotene content more slowly than those planted at the same time in Yuma. Carrots planted in the spring months, February and March, not only grew more rapidly, as expected, but carrots of the same marketable size were appreciably higher in carotene content. The New Mexico and Oregon stations also observed this increase in the carotene content of carrots with the growing season, the Chantenay carrots at the latter place synthesizing carotene most rapidly during the first 15 weeks of growth.

Potatoes harvested from green vines were observed by the Nebraska station to have exceptionally high ascorbic acid values. This was in line with the observation at the Idaho station that there was a distinct drop in ascorbic acid with maturity and subsequent storage.

Head lettuce (Boston), as analyzed by the Massachusetts station, proved to be a valuable source of carotene, riboflavin, calcium, phosphorus, magnesium, and iron and deserving of being classed as a protective food. Immature Boston lettuce, not yet starting to head, was found to have more riboflavin than the mature. The average of 0.124 milligram riboflavin per 100 grams of immature lettuce was over four-fifths as much as found in the same weight of milk from cows eating forage grown on similar soil.

The effect of sunshine on the vitamin storage in ripening oranges was observed at the Arizona station. Weight for weight, orange juice from navel and Valencia oranges picked from exposed sunny areas of trees in the experimental orchards contained more ascorbic acid than did juice from fruits picked from the shady areas of trees. In terms of total ascorbic acid per orange, however, this difference was materially offset by the fact that the oranges from the shady parts of the tree, the shaded center in particular, consistently attained greater size and weight and yielded more juice than the fruits exposed to the sun. These Arizona oranges, picked at marketable maturity, averaged, regardless of size, about 30 milligrams ascorbic acid per fruit for the navels and about 45 milligrams for the Valencias.

Sprouting cowpeas and mung beans was easily accomplished in experiments at the Oklahoma station by placing the seeds between wet pads in 8-inch flower pots at temperatures between 70° and 80° F. Sprouts 2 to 4 inches long developed in 96 hours. Comparison of the amount of ascorbic acid and protein in the dry seeds with that developed in the sprouts indicated that both of these substances were formed in the sprouting process. The cowpea and mung bean sprouts contained, respectively, 4.6 and 5.3 percent of protein and 19.6 and 19.2 milligrams of ascorbic acid per 100 grams of fresh sprouts.

Feeding practice can measurably affect the vitamin content of pork according to results obtained in three independent studies. Data obtained at the Pennsylvania station, discussed in the section on animal products, showed that thiamine can be stored at a rapid rate in pork muscle when the pigs are fed extra thiamine and that these tissues can be saturated within 35 days or less. Experiments conducted at the Hawaii station showed that cooked lean pork from grain-fed hogs contained 50 percent more thiamine than similar muscle from garbage-fed hogs. In agreement with results obtained in previous years, the North Dakota station found that the feeding of supplementary niacin increased the niacin of the rib and of loin and ham. Discontinuing the niacin 34 to 47 days before slaughtering gave lower niacin storage than the continuous feeding. Feeding the supplementary niacin only the last 33 to 64 and 22 to 33 days before slaughtering produced storage approaching or equaling that in the group fed niacin continuously.

The effect of storage or holding on food values is to be observed in many instances, as in winter storage of vegetables, in the marketing of produce and in the holding of foods for home use. Idaho-grown Russet Burbank and White Rose potatoes, for example, showed a distinct drop in ascorbic acid with maturity and storage in Idaho station tests, and the winter stored potatoes had only approximately one-third as much as the immature tuber. A low storage temperature is to be avoided except as needed to maintain dormancy, the Nebraska station experiments showed. The ascorbic acid content of the potatoes for late winter use could be doubled or tripled by storing at high temperatures (50° to 60° F.) until sprouting began and then lowering the temperature to 40° to maintain dormancy. With this method, potatoes retained more ascorbic acid till early March than was retained till November 10 when 40° storage was used from harvest time in mid-October.

In winter storage of beets, the North Dakota station found, there was little or no real destruction of the ascorbic acid present although an appreciable amount of it changed from reduced ascorbic acid, the form in which about half of it existed in the freshly harvested beets, to the dehydro form. Arizona-grown sweetpotatoes of the Porto Rico variety held in pit storage apparently lost no ascorbic acid in the first month of storage, but showed losses of 16, 21, and 37 percent after 2, 3, and 4 months, respectively, according to the Arizona station. In this interval there was very little change of ascorbic acid from the reduced to the dehydro form, and the three varieties tested averaged about 26 milligrams ascorbic acid per 100 grams after 4 months of pit storage. Carotene in these same sweetpotatoes showed no loss with storage and at the end of the 4 months averaged about 4 to 6 milligrams carotene per 100 grams in the Porto Rico variety grown in two different regions and about 2 milligrams per 100 grams in the Nancy Halls, which were from the beginning poorer sources of carotene than the Porto Rico sweetpotatoes.

Celery of two varieties received at the Utah station shortly after harvest was stored for 1, 2, and 3 weeks in a refrigerator at 40° F., being held wrapped in burlap which was moistened daily. Only

slight change in ascorbic acid occurred in the celery in 2 weeks of storage, but in the third week a marked decrease in vitamin content resulted, amounting to 34 and 50 percent in the two varieties, respectively. In trench storage, the celery remained crisp and retained its flavor for 2 months, but lost 50 percent of its ascorbic acid.

Holding vegetables on snow ice for market display greatly preserved their vitamin value as well as their appearance and quality in trials conducted by the Michigan station. In two displays of vegetables at the local retail grocery the leaf lettuce, green beans, and spinach displayed for 8 hours on a nonrefrigerated sheet-iron rack lost, respectively, 22, 11, and 45 percent of their ascorbic acid, while similar lots held on snow ice lost, respectively, only 0,3, and 4 percent of their ascorbic acid.

Storage tests with freshly harvested strawberries, raspberries, and loganberry and blackberry crosses grown at the Oregon station showed that these berries lost none of their ascorbic acid at refrigerator temperatures for a few days, and only slight losses when kept at room temperature as long as the berries remained in good condition. At 85° F., however, the berries did not stay in good condition for long and at the end of 2 days the strawberries tested had lost a considerable part of their ascorbic acid.

Sliced tomatoes permitted to stand in the refrigerator, as is sometimes done in holding them over from one meal to the next, were found to show no perceptible change in ascorbic acid content, as compared with freshly sliced tomatoes, in a cooperative study of the Georgia, Louisiana, and Virginia Truck stations. Similarly, cut sections of cantaloup held in the refrigerator for 2 to 4 hours lost no ascorbic acid, according to the findings of the New Mexico station, but after 18 to 21 hours the loss amounted to 13 percent.

Milk in commercial half-pint bottles exposed to sunshine for two 30-minute and two 60-minute intervals in experiments at the Massachusetts station was found to lose its ascorbic acid very rapidly, for little if any was present after 30 minutes' exposure. The riboflavin disappeared more slowly, there being a 10-percent loss during 60 minutes' exposure on a rainy day and about 85-percent loss during exposure in bright sunshine for 120 minutes. These results show that milk allowed to stand for more than a short period on the consumer's doorstep exposed to strong light or sunshine is likely to lose a large amount of its ascorbic acid and riboflavin.

Dried eggs stored either loose or compressed in wax cartons for 6 months at 20° C. or lower retained 62 percent or more of their initial vitamin A in tests conducted at the Indiana station. At 37° C. they retained only 30 percent. Compressing the dried egg powder prior to packaging failed to have any beneficial effect on the retention of vitamin A during storage. Eggs which had been sealed in tin cans retained about 75 percent of their potency regardless of storage temperatures.

Lists of foods suitable for storage in Hawaiian homes were prepared as an aid in meeting military and civilian food committee recommendations to Hawaiian families in 1940 and 1941. Pre-

cautions for storing the foods included instructions for fumigating brown rice, rolled oats, and whole wheat flour with carbon bisulfide by a household process to destroy insects. Tests at the Hawaii station showed that the cereals retained their original thiamine content after this treatment. The thiamine content of whole wheat flour treated with methyl bromide by a commercial process was likewise unaffected.

Samples of brown rice of five varieties obtained from two or more rice experiment stations (California, Texas, Louisiana, and Arkansas) and assayed at the California station when first received contained from 3 to 4 micrograms of thiamine per gram. After 6 months' storage at 68° F. under good conditions, the brown rice lost 0 to 30 percent of its thiamine. Rice bran and rice polishings lost 16 to 28 percent during this storage period and from 50 to 67 percent after an additional 24 months. Parboiled and undermilled samples apparently lost no thiamine in storage, but canned parboiled rice lost 20 to 30 percent of its thiamine in 3 months.

The effect of milling on food values was noted in Louisiana station analyses of rice and rice products for riboflavin and biotin. These analyses, together with those previously obtained on the same samples for thiamine, nicotinic acid, pantothenic acid, and pyridoxine, indicated that in general 66 to 75 percent of these B vitamins was removed in the milling process. Polished rice had only about 12 percent of the vitamin content of rice polish. This decrease in thiamine value was also observed at the California station where California-grown rice of the Caloro variety, subjected to rat-growth assay, was found to contain 3.8 micrograms of thiamine per gram of raw brown rice (only husk removed). The parboiled brown rice (prepared by preliminary soaking and steaming of the rough rice, followed by husking and drying) and the parboiled undermilled rice (prepared by a light milling of the parboiled dried rice) contained from 2.1 to 3.0 micrograms of thiamine per gram. The completely milled polished rice contained the least thiamine, namely, 0.9 microgram or less per gram.

Several varieties of Kansas-grown wheats, harvested over several crop years, and the flour experimentally milled from them were analyzed at the Kansas station for their thiamine and riboflavin content. The flours with thiamine contents of from 0.82 to 1.50 micrograms per gram retained from 12.4 to 24.5 percent of the thiamine of the wheats. The riboflavin content of the flours ranged from 0.65 to 0.96 microgram per gram, and they retained from 29.8 to 54.3 percent of the riboflavin of the wheats from which they were ground.

The effect of dehydration on food values was studied in five vegetables by the California station. The vitamin losses varied with the vitamin, being most pronounced for ascorbic acid; depended in some measure upon blanching treatment, subsequent storage, and reconstitution; and were not uniformly the same for all vegetables. For example, the dehydrated snap beans and spinach retained only 10 to 30 percent of the ascorbic acid originally present in the fresh vegetable, peas and carrots retained

about 50 percent, and broccoli as much as 80 percent if blanched before dehydration but only 36 percent if unblanched.

All of these dehydrated vegetables retained from 65 to 80 percent of the original thiamine of the fresh vegetable, but broccoli showed pronounced losses after storage for 3 months at 86° F.; the dehydrated spinach similarly stored showed negligible thiamine losses in storage. For riboflavin, the retention amounted to about 65 to 80 percent for broccoli and spinach, 75 percent for snap beans, and even better than this in carrots and peas; the two latter vegetables, however, contained but little riboflavin in the fresh state, and then lost about half of what was present after dehydration in subsequent reconstitution. Most of the pantothenic acid present in the fresh spinach, peas, and carrots was retained in dehydration; about 50 percent was retained in snap beans, and 40 to 60 percent in broccoli. The dehydrated reconstituted vegetables retained about 50 to 70 percent of their nicotinic acid. The study showed that, in general, losses of ascorbic acid and thiamine were somewhat greater in unblanched dehydrated vegetables than in blanched, particularly in storage, but that this is not true of riboflavin, pantothenic acid, and nicotinic acid. Only ascorbic acid and thiamine, and to a lesser degree pantothenic acid, were found to decrease in the stored dehydrated vegetables. From certain comparisons with the cooked fresh vegetables, it appeared that riboflavin, pantothenic acid, and nicotinic acid are likely to be retained during the process of blanching and dehydrating vegetables about as well as during ordinary cooking of the fresh vegetables.

A study on snap beans at the Virginia station bore out in general the results obtained in the California study of this vegetable. In the Virginia trials, the dehydrated beans were found, in general, to be as high in phosphorus as raw beans, and higher in calcium, the latter result apparently being due to the absorption of calcium from the water in the blanching process. However, the dehydrated beans were a poor source of ascorbic acid, since only about 7 percent of the amount in the raw beans remained in the blanched beans after dehydration and storage for 6 months.

Dried chard, obtained in the Michigan station experiments by home drying of the leaves in a homemade drier used on the gas stove retained from 70 to 82 percent of the carotene and about 66 percent of the riboflavin originally present in the fresh leaves. Storage for 6 to 7 months decreased the carotene retention to only 40 percent, and reconstituting and cooking caused further loss of riboflavin up to about 50 percent of that in the fresh leaves. However, the riboflavin content of the reconstituted cooked chard compared favorably with that of fresh chard cooked in a moderate quantity of boiling water.

Analyses of dehydrated vegetables at the Texas station to determine their content of B vitamins showed them to be good sources of riboflavin, nicotinic acid, and pantothenic acid. Dehydrated green leaf beet tops and spinach were particularly rich in riboflavin. Dehydrated root crops were relatively low in riboflavin but fairly good sources of nicotinic acid. In sweetpotatoes, the apparent loss during dehydration was about 12 percent for

riboflavin, none for nicotinic acid, and 28 percent for pantothenic acid.

The effect of freezing on food values was observed in a variety of vegetables studied by the Illinois station and the Rhode Island station for changes in ascorbic acid and by the Oregon station for changes in thiamine. The prepared vegetables were blanched preliminary to freezing, quick-frozen for the required length of time, held in frozen storage for periods of from 1 to 9 months, and then subjected to cooking as they would be in home utilization of the frozen product. Ascorbic acid changes followed in these steps showed that there was some loss in the blanching step, not more than 8 and 9 percent being leached out of soybeans (Illinois) and corn (Rhode Island), respectively, but as much as 35 or 46 percent (Rhode Island and Illinois, respectively) being lost by the spinach. Cauliflower and peas at this stage lost approximately 15 percent of the ascorbic acid originally present in the raw vegetable according to the Illinois findings. Analyses at both stations showed that cut snap beans lost about 15 percent of their ascorbic acid in the blanching operation. "Frenched" snap beans, also utilized in the Illinois tests, exposed a much greater surface and had about 44 percent of their ascorbic acid dissolved out in the blanching operation. The freezing process itself caused little further change in the ascorbic acid values, but as the vegetables were held in frozen storage there was a progressive loss of the vitamin and at the end of 3 months they had lost from 30 to 50 percent of it, except for the Frenched beans which had lost slightly more, the spinach which showed much greater losses, up to 64 and 73 percent (Illinois and Rhode Island, respectively), and the soybean which had lost only 10 percent of their original ascorbic acid.

Storage for as long as 9 months resulted in only an 18-percent loss for the soybeans, as much as an 80-percent loss for the spinach, and from 47- to 68-percent loss for the other vegetables tested at this period. With cooking of the frozen vegetables there were further losses of ascorbic acid (some of it to the cooking water), so that the cooked drained vegetables, using those that had been in frozen storage for 3 months, showed a loss of from 46 to 61 percent of the ascorbic acid originally present in the fresh raw vegetables, except that the Frenched beans lost more than the cut beans, the spinach lost as much as 87 percent, and the soybeans lost only 28 percent.

The study made by the Oregon station of thiamine losses during freezing and frozen storage and subsequent cooking showed that freezing plus storage caused losses of from 1 percent for Blue Lake snap beans to 48 percent for Pioneer snap beans and lima beans. Losses in other vegetables ranged from about 4 percent for asparagus to 33 to 39 percent for vegetables such as broccoli, brussels sprouts, corn, and Swiss chard. Cooking of the frozen products caused further losses, and a substantial part of the thiamine lost from the vegetables was found in the cooking water. Total losses in freezing, storage, and subsequent cooking amounted 25 percent for Swiss chard, 44 percent for asparagus, 32 to 56 percent for snap and lima beans, 53 to 56 percent for brussels sprouts and corn, and about 65 percent for broccoli. In all cases,

the cooked frozen vegetables contained considerably less thiamine than the cooked fresh.

In trials with berries at the New Hampshire station, four varieties of frozen raspberries held in frozen storage for 4 months lost from 9 to 49 percent of the ascorbic acid originally in the fresh berries before freezing. In four varieties of strawberries, these losses amounted to 16 to 37 percent in 2 months of frozen storage and increased to 54 to 99 percent after 6 months of frozen storage.

The effect of canning on food value in tomatoes is associated with the changes produced in the ascorbic acid content. A hundred samples of home-canned tomatoes collected, with their history, from housewives in Louisiana and analyzed for their ascorbic acid content at the Louisiana station laboratory showed no significant differences in the vitamin value of samples processed in the hot-water bath, those canned by the hot-pack method, and those processed under pressure. This finding was borne out by independent results at the Minnesota station, where tomatoes were canned experimentally by the open-kettle, cold-pack, and hot-pack procedures. The difference effected in ascorbic acid retention by these three methods was neither statistically nor practically significant. However, the total amount of ascorbic acid contained in the jar was higher for those samples processed by the open-kettle method than for either of the other two methods. In the Louisiana samples, tomatoes canned in tin cans had significantly higher ascorbic acid values than those canned in glass, whereas in a Maine station study experimental lots of tomato juice canned with a tin inset placed in the glass jar lost ascorbic acid less rapidly than juice similarly processed by the hot-pack method in glass jars without the tin.

The effect of the container on the retention of ascorbic acid during storage was investigated at the Massachusetts station, where the same lot of tomato juice was processed in a number of different types of containers. Of the commercial-type containers, plain tin cans and vacuum-sealed jars or bottles with tin vacuum-sealed caps or bottles with crown caps with tinfoil facing gave the best retention of ascorbic acid during processing and storage for 8 months. Of the home-canning types of glass containers, those with metal lids or with a minimum of head space were preferable for ascorbic acid retention. The difference in ascorbic acid retention between tomato juice packed in home-canning jars and that packed in tin cans was less than that reported in some previous investigations, apparently because the process time used was sufficiently long to permit much of the entrapped air to be exhausted from the jars.

In the Minnesota station study, the tomatoes canned by the three procedures (open-kettle, hot-pack, and cold-pack) lost ascorbic acid in storage but the greatest losses came in the first 3 months of storage, and again in the interval from the ninth to the twelfth month, with smaller losses at the sixth and ninth month. After 6 months of storage the ascorbic acid loss averaged 32 percent, and after 12 months 53 percent. At the North Dakota station, losses after 6 months' storage varied from 16 to 28 per-

cent. In experimental packs put up at the Maine station, similar trends were observed in storage losses in tomatoes canned by the hot-pack method and in juice from tomatoes sieved while hot. The tomatoes of both varieties tested (low-vitamin C and high-vitamin C varieties) lost 12 percent of their ascorbic acid in canning; the juices, 34 and 25 percent in the two varieties, respectively. In storage the greatest loss occurred in the first 30 days, but by the end of 9 months the tomatoes had lost, respectively, 60 and 48 percent and the juices 50 and 37 percent of the ascorbic acid they had when canned. Actual analyses of the canned tomatoes in these several experimental studies and also one at the North Dakota station showed the tomatoes as canned to contain 11 to 21 milligrams ascorbic acid per 100 grams; after 3 months' storage they contained 7 to 15 milligrams; after 6 months' 5 to 15 milligrams; after 9 months' 9 to 13 milligrams; and after 12 months' 6 to 10 milligrams per 100 grams.

Canning losses in Swiss chard and spinach, two varieties each, were also investigated at the Maine station. Both varieties of chard lost most of the ascorbic acid during the canning process. No additional loss occurred during storage. Both varieties of spinach lost about 40 percent of their ascorbic acid in canning, with no additional loss during storage.

A study of the effect of storage conditions and type of container on the stability of carotene in canned vegetables, as reported by the Massachusetts station, suggests that the original carotene content of fresh vegetables is stable during canning and storage.

The effect of cooking on food values has been studied in many foods—vegetables, meats, fish, and cereals in particular—and many stations have participated in these studies, some of which have dealt with large-scale cookery, some with cooking in small quantities as in the home. The results of these studies are detailed and variable, and for proper evaluation need to be summarized along with further data that will be available from studies now under way on the same commodities cooked by the various methods. A few examples will be of interest, however, to show the types of investigations involved.

Comparisons at the Hawaii station of cooking losses of thiamine from brown and partially polished rice showed that the cooked partially polished rice yielded much less thiamine than cooked brown rice. The latter lost about 12 percent of its thiamine in being washed and cooked, whereas 30 percent of its thiamine was lost in milling it to give partially polished rice and 20 percent of the remainder was lost in cooking the milled product, thus representing a total loss of a little less than half of the original thiamine content.

Packaged rolled oats of both the regular (large-flake) and the quick (small-flake) types cooked for various lengths of time were found in tests at the Wisconsin station to lose practically none of their thiamine, pantothenic acid, riboflavin, or niacin when cooked for 30 minutes or less according to normal kitchen practices.

Stewing is the basic cooking process for many meat dishes, and a desirable method for the less expensive cuts which have a high nutritive value. Preliminary results by the Texas station indicate

that if the stewing liquid is used there is little if any loss of riboflavin, pantothenic acid, or niacin but about 50 percent of the thiamine is lost. If the stewing liquid is discarded, approximately 50 percent of the riboflavin, pantothenic acid, and niacin are lost but only about one-sixth of the original thiamine content is discarded with the stewing liquid. Temperature of the stewing liquid apparently has little influence on the total thiamine retention.

Temperatures at which lamb and beef roasts were cooked had little effect on loss of thiamine during the cooking process, according to findings of the Minnesota station. Roasting legs of lamb to the rare stage (79° C.)) and to the well-done stage (82°) causes the same percentage loss of thiamine (about 30 percent). Standing roasts of beef may be cooked to the medium well-done stage (71°) at 177° rather than at 149° if desired, without fear of increasing the loss of thiamine. In planning dietaries, allowance should be made for a loss during cooking of about 30 percent of the thiamine content of leg of lamb roasts and about 45 percent of that of standing beef rib roasts. A small proportion of this thiamine is recovered if the drippings are used.

The effect of the process of roasting (and of canning and corning) on the nutritive value of the proteins of beef was investigated at the Montana station by determining their biological value for growth in the rat as the experimental animal. The data showed that the processes of roasting and corning do not significantly change the digestibility and biological value of the beef proteins, but that the process of canning does lower these values slightly.

The effect of institutional cooking methods on the vitamin content of potatoes, beans, and fish was investigated at the Massachusetts station. The potatoes, pared and soaked for 6 hours, lost 5 percent of their thiamine but none of their ascorbic acid in soaking; after cooking by steaming these losses amounted to 15 and 54 percent and were increased to an over-all total of about 20 and 64 percent, respectively, by the time the steamed potatoes had been kept warm for an hour and a half by holding on a steam table. Mashing the steamed potatoes did not appear to destroy any of the thiamine but did destroy ascorbic acid; with this loss and that occurring during holding for an hour and a half, the mashed steamed potatoes lost a total of 88 percent of the ascorbic acid originally present in the raw peeled potatoes. The dry beans that were soaked, parboiled, and then baked, following the addition of a molasses-tomato-brown sugar mixture, showed some loss of pantothenic acid and niacin in the soaking and further loss of niacin and large destruction of thiamine in the baking. Calculations of the amounts of these vitamins in a cup of baked beans showed that in terms of the daily vitamin requirements of a moderately active man, the baked beans would rate as only a fair source of thiamine and niacin and a very poor source of riboflavin.

In these Massachusetts station studies, the fish, prepared in large quantity by cutting into serving portions, rolling in crumbs, and baking 30 to 40 minutes at 450° F., lost about 44 percent of the thiamine, 28 percent of the riboflavin, 29 percent of the niacin, and 33 percent of the pantothenic acid originally present in the raw fish flesh. Lean fish such as cod, haddock, cusk, pollock, and

flounder were poor sources of these vitamins, but mackerel was a good source. It was estimated that a 4-ounce serving of cooked mackerel would furnish 10 percent of the daily thiamine requirements of an active man and 20 and 50 percent of his riboflavin and niacin requirements, respectively; such a serving would also furnish about 4.6 milligrams of pantothenic acid.

The nutritive value of cabbage as affected by quantity cooking procedures using various types of institution cookery equipment was given intensive study at the New York (Cornell) station. The results showed that the maximum retention of ascorbic acid in cooking would be attained by boiling the cabbage in salted water (1 quart of salted water per pound of cabbage) until just done. Steaming is also recommended for cooking cabbage, although green cabbage retained its color better by boiling. It was also shown that cooked cabbage should be served as soon as possible because ascorbic acid is lost rapidly on holding (15 percent in 15 minutes). Raw cabbage may be held without appreciable loss.

A study by the Tennessee station to determine the ascorbic acid retained by foods served student Army Air Corps units by the institution kitchens of the university gave interesting results on the ascorbic acid value of cooked frozen vegetables. The frozen green beans as received had a low ascorbic acid content and a retention of only about 9 percent in the cooked product. As a commodity they furnished a negligible quantity of the vitamin to the diet. Frozen green peas as received had quite a uniform ascorbic acid content and retained about 29 percent of the vitamin in cooking; however, the amount furnished the diet was small. Frozen Swiss chard had a low initial value and an average retention of only about 18 percent and so made an insignificant contribution of ascorbic acid to the diet. The frozen spinach retained on an average about 28 percent of its initial ascorbic acid value in cooking in the steam-jacketed kettle and made a uniform contribution to the diet amounting to 10 to 15 milligrams of ascorbic acid for each serving portion (130 grams cooked spinach).

Another study of cooking losses in an Army training camp was made at the Mississippi station. The results, obtained in some detail, suggested that when vegetables are cooked in quantity ascorbic acid losses are apt to be large, whereas carotene losses are much smaller. Fresh cabbage served as a salad contained the most ascorbic acid, boiled cabbage was next in order followed by potatoes, and reheated canned vegetables supplied the least amount of the vitamin. Losses of ascorbic acid during the serving period were found to be small in this study.

FOOD HABITS AND NUTRITIONAL STATUS

Unless people are nutrition conscious, they give little attention to food values and to selection of diets adequate to meet the body needs. How adequate or inadequate the food selection is depends then upon the availability of the food supply and upon the food habits of the people.

Food habits and physical condition of Maine grade-school children in four representative Maine communities were observed in a

4-year study by workers from the Maine station. The findings indicated that these children were not measuring up to the best nutritional standards in their diets and that this dietary inadequacy was reflected in their physical measurements and dental conditions. This led the investigators to conclude that efforts toward improving the nutritive condition of Maine people should be directed toward increasing food production and preservation and toward education in the choice of adequate diets. With the knowledge of food values in mind, it was further recommended, toward improving these diets, that special emphasis be given to the increased use of milk, fruits, and vegetables (especially those high in vitamin A and ascorbic acid), eggs, and whole-grain products. Emphasis was also given to the importance of vitamin D (and milk), especially for women during pregnancy and lactation, and for infants and children. The essential data from this technical report were utilized by the Maine State Nutrition Committee in the preparation of a summary for teachers, home demonstration agents, public health nurses, and nutritionists, showing practical applications of the findings to a complete program for the improvement of nutritional status.

A nutrition study by the West Virginia station of university students, selected at random as they passed through the examination line at the student health center, involved determinations of blood-iron content, hemoglobin values, red-blood-cell counts, and other values used as a measure of nutritional status. The values obtained for the majority of the students at the beginning of the fall term fell within normal range. However, from one-third to two-thirds showed improved values when tested again in the winter. This improvement, considered more significant than the average values found, suggested that eating habits had been improved, or that better balanced diets were being eaten. Food histories obtained from the students showed that of the iron-rich foods, which might have contributed to the improved hemoglobin values, liver was the most unpopular; 25 percent of the students expressed a dislike for it, whereas only 10 percent disliked spinach and prunes. Eggs were well eaten by men but were refused by 6 to 13 percent of the women. Bread, about one-third of which was whole wheat, was eaten in considerable quantity, and most of the men and more than half of the women drank two or more glasses of milk daily.

Freshman food likes at Nebraska, checked in a fall survey by the Nebraska station to determine dietary habits with respect to nutritionally important foods, indicated a tendency for the girls to prefer fruits and vegetables or foods high in cellulose, whereas the boys preferred the ones higher in energy; white potatoes, green peas, raw tomatoes, and leaf lettuce were liked best by boys and girls alike; all the boys were willing to drink whole milk often, but only 84 percent of the girls expressed such willingness; and only 4 percent of either boys or girls were unwilling to eat eggs.

Food habits of Mississippi children (white and Negro) were observed by the Mississippi station in surveys which yielded information that could be turned to practical use in formulating nutritional policies or food programs for low-income groups.

Information furnished by a large number of children indicated that they had very definite food preferences. Their selections suggested that serving but one type of vegetable at a meal, with rotation of the garden vegetables in the meals, would guarantee a better all-round consumption than if they were permitted to choose, meal after meal, only those they liked best. The survey indicated that a majority of white children preferred sweet milk. Negro children showed a preference for buttermilk.

A study by the Mississippi station, made during a period when there was a shortage of white corn meal in Mississippi, was aimed at determining the effect of this shortage on the consumption of other foods that "just naturally go with corn bread." Data were secured from questionnaires filled out by 1,404 white and Negro children in grades 7, 8, and 9 in 12 junior high schools. The story gathered from their answers was that they preferred corn bread made from white corn meal to that made from yellow corn meal; that corn bread was liked better than biscuits with certain foods; that Negro children liked corn bread itself better than did white children; that green vegetables, buttermilk, and beans and peas were the foods preferred with corn bread by the vast majority of the children; that the foods which would usually not be eaten in the absence of corn bread were the strong-flavored green leafy vegetables such as turnip greens, collards, and cabbage, with cowpeas, lima beans, and string beans next in order. A survey of actual consumption during the shortage of white corn meal showed that green vegetables were eaten in smaller quantities by the majority of white and Negro children, with the food intake of the latter group being more affected than that of the former by the absence of corn bread. All this suggested that when limited quantities of the favored kind of corn bread are available the consumption of other foods is affected. In the light of the observations in the course of this study, it is pointed out that a Government policy which might encourage more families to consume yellow corn meal because of its superior nutritive value might seem to be a good policy, but, that any policy must be examined for the harm it may do as well as the good. This, it is further suggested, is especially true of a policy which involves changing the food habits of a large group of low-income families, a group in which Negro families in the South would be included. For example, it is pointed out that the vitamin A in yellow corn meal will not make up for a reduced consumption of other foods such as vegetables and buttermilk.

Enriched corn meal and grits promoted in the nutrition program of South Carolina, were selected for enrichment because of the popularity of corn meal and grits in the diets of the population groups most needing the benefits of an enrichment program. Although enrichment was legalized in South Carolina, the idea of enrichment had to be "sold" to the people. Toward meeting this problem, the South Carolina station has issued a popular circular setting forth the nutritional advantages of enrichment and offering numerous recipes for the utilization of enriched corn meal or grits in a wide variety of ways.

The culinary preparation and use of soybeans and soybean flour

has likewise been the subject for presentation in a Missouri station bulletin designed to acquaint the people with the high nutritive value of soybeans and to aid in finding a place for the soybean in American diets. Suggestions, precautions, and tested recipes are presented for the use of soybeans and soybean products available on the retail market. The recipes and recommendations were developed in experimental work, and only the recipes for products rated as excellent are presented.

Blood regeneration in women blood donors was the subject of an investigation at the Nebraska station to determine the effect of generous amounts of meat and milk in the diet on the rate of blood regeneration following the donation of the usual 500 cubic centimeters of blood. Seventeen healthy young women served as blood donors and subjects on a controlled dietary regimen that furnished approximately 75 grams of protein daily following the first donation and 50 grams daily following the second donation 16 weeks later. Blood values determined at regular intervals following donation showed that regeneration, especially of hemoglobin, was significantly better on the higher protein intake but that the return to the blood values determined at the time of donation was not complete (except for serum protein) even at the end of 10 weeks. These results, it is emphasized, justify not only suggesting but urging the woman who is a blood donor (or who has hypochromic anemia and needs to build hemoglobin) to include in her diet additional quantities of meat and milk or other foods rich in animal protein and iron.

EQUIPMENT FOR HOME FOOD PREPARATION

The few equipment studies that have been reported within the year include one by the Maine station on the use of a wood cook stove converted for the use of kerosene, and studies by the Virginia station of coffee-making and electrical toast-making equipment.

The Maine investigation, undertaken to meet some of the problems of homemakers in the use of wood cook stoves equipped with oil burners, involved observations of the performance of such burners in home use and laboratory tests and measurements to determine the extent to which various conditions affected stove temperatures. The findings showed that a kitchen range can be made hotter with the use of wood than is possible with the oil burners now available on the market, but that suitable burners, properly installed, give enough heat for household cooking. Details of installation greatly affected the performance of these burners, and on the basis of these findings it was possible to suggest corrective measures for such difficulties as uneven flames, sooty flames, the spilling of kerosene over the burners when not lighted, too low a temperature on the top of the stove while the oven temperature is satisfactory, or too low an oven temperature while the top-stove temperature is satisfactory. Installation, operational, and performance details from these tests on kerosene-burning converted cook stoves are summarized in a Maine bulletin available for convenient reference.

The study of coffee-making equipment at the Virginia station

involved the use of 15 coffee makers of 3 different types and observations as to the factors concerned in the coffee-making process. The operational data obtained, together with beverage scores of a small panel of judges, indicated that high amounts of coffee with short, mild applications of water gave quality, whereas smaller amounts of coffee with longer and more vigorous action sometimes gave a strong beverage of low quality. Higher proportions of coffee (2 tablespoons per cup of water) gave best results in all cases except for percolators and appeared to be necessary with vacuum makers; with percolators 1 to 1½ tablespoons gave good results. Fine and extra-fine grinds scored high with vacuum makers, but much less so with dripolators and percolators because of the sediment. For general use in all equipment, the so-called "drip grind" was satisfactory. The vacuum makers scored the highest on the beverage produced, according to the tastes of this one small panel of judges, gave the highest yield, used the shortest contact time, handled the finest grinds of coffee, and produced acceptable temperatures, but required more coffee and were considered fragile to use and handle. Percolators worked best with medium and fine grinds, required less coffee, and gave the highest temperatures, but low yields. Dripolators took the most time, gave low yields, required higher proportions of coffee, and would not handle the finer grinds.

In the study of electrical toast making at the Virginia station, 18 household electric toasters of different makes and models, both automatic and hand-operated, were tested, using a total of 2,500 slices of standard, commercially baked bread. A combination of right temperature, time, and distance from heat was the secret of success in making good toast, the tests showed. The toasters tested varied in temperature from 253° to 547° F.; but 410° appeared to be about ideal. Too low heat made toasting slow and resulted in dry, tough toast. Too high heat caused scorching or sogginess, because it did not allow time for moisture to be driven from the surface of the bread. The time required by the different toasters varied from 50 to 96 seconds. The tests showed that successful toasting required from 1 to 1½ minutes. Because of the speed of the process, a few seconds more or less made a great difference in the quality of the toast. Some of the more expensive automatic models did not make as good toast as the cheaper, hand-operated toasters because their control devices—timers or thermostats—turned out toast either too rapidly or too slowly. In general, timers gave more accurate results than thermostats. The toaster which received the highest rating in the tests was a medium-priced automatic model, controlled by a timer. It held two slices upright in slots so that all four sides toasted evenly at the same time. It differed from the other models in that the heating wires ran vertically and the space which held the toast was larger, which apparently placed the slices at the right distance from the heat.

ECONOMIC AND SOCIAL ADJUSTMENTS

EXAMPLES OF RESEARCH RESULTS

A yearly mileage saving of 941,614 miles has been achieved in New Hampshire through cooperation of the New Hampshire station, local committees of eight milksheds involved, and the Office of Defense Transportation. Based on work by the station in mapping the sources of supply, channels of marketing, and routes for the entire State, programs were developed for nine market-shed areas. When the program for the ninth area is in operation the mileage saving for the entire State will be boosted to 1,150,000 miles. The station was formally commended by the Office of Defense Transportation for its service in helping to make these savings possible.

Optimum agricultural production as estimated by the agricultural experiment stations with cooperation by the Department served as a basis for planning wartime and postwar goals. Indiana station studies, for example, indicated slight increases in corn and soybeans at the expense of sod crops, increases in the ratio of wheat to oats, in the production of grass and legume seeds, and of several intensive crops used directly for food. Decreased numbers of livestock, particularly hogs, to bring livestock more nearly in line with feed supplies were indicated.

A survey of postwar needs by the Maryland station indicated that Maryland farmers plan to spend $72,560,000, or $1,990 per farm, on machinery and equipment in the first postwar years as follows: Farm machinery, $36,880,000, or $1,010 per farm; new construction and repair of buildings, $27,410,000, or $750 per farm; household equipment, $4,330,000, or $120 per farm; and for general service or miscellaneous equipment, $3,940,000, or $110 per farm.

Grazing and forage crop systems for the economical production of milk on the major soil regions of the State have been developed by the Alabama station. These systems provide for maximum soil cover and eliminate the necessity for expensive concentrate feeds. All the feed consumed by the cows (grazing and forage) is produced on 3½-4 acres of land per cow. The annual production averages 4,000 to 6,000 pounds of milk per cow, having a value of $120 to $180, with milk selling at $3 per 100 pounds wholesale. Additional income is provided by the sale of seeds produced as by-products. In one system, poor hill land that is unsuited for the production of row crops or permanent pastures is used. The maximum use of winter grazing in these systems results in the production of milk having a vitamin A value five times as high as winter milk produced by common methods of feeding in that area.

Surveys by the Missouri station show that the best one-third of Missouri pastures produced feed equivalent to 25.6 bushels of corn per acre. The pastures had a corn equivalent of 35 bushels per acre in northwest Missouri, 24 bushels in northeast Missouri, 25 bushels in west-central Missouri, and 16 bushels in south-central Missouri. The cost of the pasture equivalent of a bushel of corn was only 40 percent of the cost of the corn on the best land areas,

and the margin of difference was even greater on lands less well adapted to corn production.

Anticipating postwar demands, the Idaho station studied the refrigeration requirements of 2,000 Idaho farms. About one-fourth were interested in frozen storage with a combination storage and freezer compartment ranging from 75 to 100 cubic feet and costing $600 to $800. The others were about equally divided among reach-in units and lift-top cabinets of smaller sizes. Only 1 percent of the farms reporting now have frozen storage facilities on the farm, but many use locker-plant facilities available in the 130 plants located throughout the State.

New farmers in Washington, including veterans and ex-war workers, are finding information developed through research of the Washington station very useful. What prospective farmers may expect in good, fair, and poor farming districts is shown and the larger opportunities for success on good land are explained in Popular Bulletin 178, Suggestions to Prospective Farmers. Part-time farmers are cautioned not to select land too far from the job or land of poor quality. It is better to rent or work temporarily as a farm laborer in a good farming area than to buy a poor farm or try to develop one in a poor area. Good, fair, and poor farms in various districts of the State are illustrated, and a map is included showing the types of farming in Washington in 1944.

Population studies by the Kentucky station provided facts needed by 15 State and Federal agencies. Information as requested by the various agencies was obtained on population growth and migration, education, and age-group distribution; adjustments of rural migrants to urban residences and occupations; effects of war on farm population and farm labor supply; population aspects of land use; and population migration in relation to communication, income, and education.

As in all cases wherein the national interest is involved, such as the depression of the 1930's and World War II, the State stations have joined forces with the Department in broad research programs designed for the attainment of the Nation's economic and social objectives. Outstanding contributions of the stations in the war period included the assembling of available information helpful in the establishment and attainment of agricultural production goals.

A related activity has been the participation of the stations in the annual evaluation of the total productive capacity of United States farms and ranches, which helped the farmers of the Nation to meet the unprecedented demands for feed, foodstuffs, and fibers at home and on the battlefields.

A third activity, which helped bring forth the needed food supplies when so many of the men from the farms were serving in the armed forces has been the work simplification studies which made farm routine easier and the accomplishments larger than is normally the case.

Helpful also have been the studies of the problems affecting the movement of farm and ranch products to the markets. Confronted by serious restrictions, truckers of farm products were enabled to

save an enormous mileage and effect proportionate savings in trucks, tires, and gasoline.

Still other activities of moment in the war period have been the analyses made by the stations of available labor and of health facilities and services, yielding suggestions for their best distribution and utilization by rural people. Record volumes of crop and livestock production grown during the war years despite limited supplies of fertilizer, lime, labor, and farm machinery and implements constitute evidence of the success of this major undertaking on the part of the farmers and stockmen of the United States collaborating with their Government in wartime.

Cooperation in research of State and Federal agencies, as in the cases cited, is valuable not only in times of depression and war, but also in the transition from war to peace and peaceful years ahead.

Additional examples of these and related activities follow.

IMPROVING THE TYPE OF FARMING

As a result of a cooperative study participated in by specialists in many fields of agriculture, a reliable production pattern was established for 1945, and also a picture of agricultural possibilities of the State under certain basic assumptions for 1950, by the West Virginia station. The results formed not only the basis for setting production goals for the State for the current year, but also the basis for future agricultural planning and estimating. Revisions may be necessary to the extent that actual developments may not coincide with the assumptions used.

Results obtained by the Georgia station indicate that livestock numbers in the State are limited to an important extent by lack of proper and sufficient winter feed. The results of the study will enable farmers to obtain an abundance of nutritious winter grazing, which should result in increased livestock numbers, greater profits, and better quality of livestock products. This is important now when cotton, so long the chief money product of the South, is waning in importance.

In a study of 89 dairy farms the North Carolina station found that the average size of farms was 266 acres, with 89 acres in crops. The average number of milking cows was 24.5 per farm. The net cost of milk produced was $173.61 per cow, or $2.96 per 100 pounds of milk sold. Returns from milk sales were $183.22 per cow, leaving a net profit of $9.61 per cow, or 16 cents for each 100 pounds of milk sold. Many farmers overfed roughage and silage, so with a given level of grain feeding, there was not much increase in milk production when additional feed was fed. The cost of producing milk decreased as the size of herd increased. The larger herds were better fed and produced more milk than the smaller ones. Farmers who made efficient use of their labor produced milk at lowest cost and had the highest labor income.

In a study of problems brought about by war conditions and a preliminary project on anticipated postwar levels and patterns of production, the South Carolina station found that efficiency in production might be brought about by increased yields per acre, more efficient use of labor, increased mechanization, more careful selection of enterprises, and better land use. The results obtained

were used in establishing production goals and in making desirable adjustments.

An analysis of agricultural production trends and production capacity by the Maryland station gave evidence that agricultural production in the State is at or near the peak and further expansion will be controlled by the supply of labor and machinery. Some shifting from truck crops and dairying to broiler production is anticipated, hog production is declining, and dairy cow numbers are increasing but at a much slower rate than in previous years. The acreages of corn, wheat, and hay are expected to increase, but those of barley, soybeans for beans, and truck crops are expected to decrease. A material increase in the acreage of Maryland tobacco is needed, and research indicates that production could be increased materially, as land suited to the crop is not the limiting factor. The expansion in acreage is being retarded by the lack of curing space and the failure to develop machinery to reduce labor requirements.

In a study of farm adjustments and income of typical farms by size and types, the Wisconsin station found that the average net cash income on farms before the war was around $500 to $600, which, with the rental value of the house and the value of the farm products consumed in the home, gave the average farm family a total income of $900 to $1,100. In contrast, during the war years 1942 and 1943, the average family income from farming increased to $2,160 and $2,860.

In a study of the effect of the war on the organization and operation of farms, the Michigan station found that the farms included averaged 194 acres in 1943, as compared with 181 acres in 1940. Half of this addition was owned and the other half rented. There was a slight tendency to increase corn acreage and decrease small grains. Acreage devoted to hay and pasture increased slightly. Total amount of livestock kept increased more than 10 percent, particularly in dairy cattle. Labor efficiency increased from 259 work units per man in 1940 to 284 in 1943. This increase was in spite of a reduced labor force partially composed of old men and young people. Total expenses and net earnings in 1943 were about double those in 1940.

For several years the Texas station, in cooperation with the Department, has made appraisals of the agricultural resources in Texas in relation to national goals for farm products vital to the war purpose. The land resources were examined for their present and potential uses. Limiting factors such as the labor supply, machinery needs, and fertilizer supplies were also studied. The obstacles encountered in the expansion of production of a given product and the curtailment of another were analyzed and solutions suggested. A number of reports were issued, and the results were used in the establishment of State and national production goals for 1943 and 1944. The reports on the cost of producing and harvesting cotton were of especial interest and have been used at hearings concerning cotton policy and programs and by operators interested in increasing the efficiency of farm operation. The data gathered have been valuable contributions to the war purpose and

are now contributing to the development of postwar agricultural policy and plans.

Increased crop production in Ohio, as found by the Ohio station, could best be attained by increasing the yield per acre. The study showed that the wartime expansion of crop acres is decreasing the productivity of Ohio soils; that low yields per acre of feed crops in 1944 would necessitate a reduction in livestock numbers in 1945; and that in the postwar period it would be possible to reduce the acreage of cultivated crops and small grains and to increase the acreage of grass and soil conserving crops, thereby retaining the present high volume of agricultural output and at the same time building soil resources and yielding a satisfactory income. The results of this study were used by the War Food Administration in setting Ohio goals for crops and livestock for 1945. Results of this postwar crop- and livestock-pattern study have been widely used by the State Agricultural Extension Service and other agencies in discussions and plans for the postwar period.

Factors affecting efficient dairy management, according to Vermont station studies, included the following: A farm business of at least 650 man-work units, one such unit being equivalent to 10 hours' work of a man on a particular job in a given community; an annual production of 6,500 pounds of 4-percent milk or its equivalent per cow; at least 325 work units per man; a capital investment not exceeding $20 per man-work unit or $450 per cow on farms without important nondairy enterprises; and less than two-thirds of the capital in real estate.

Minnesota station investigations of farm organization and management in the southwestern part of the State reveal that the principal factors affecting returns of feed from beef cattle were found to be the cost of feeds per 100 pounds of gain in weight, the price of feeders, the proportion of protein in the rations, the rate of daily gains, and the percentage of death losses. For those lots of cattle which ranked below in all but one of these factors, return over feed was $1.52 per 100 pounds; for those lots above average in four or five of these factors, the return over feed was $5.05 per 100 pounds. The results were useful in planning production adjustments and setting up production goals.

A study by the Mississippi station of farm organization and operation in the Black Prairie belt of the State showed that the highest incomes were made on farms which derived a large part of their gross income from livestock and livestock products. Although the return per acre or per day of labor was lower for the livestock enterprises than for cotton, the increase in the number of acres utilized and the number of days worked increased the farm income over that obtained when livestock enterprises were neglected. The smaller farms gave dairying a prominent place, whereas the larger farms tended more toward general livestock farming.

That still better incomes were possible was indicated by the fact that the use of fertilizer and resultant yields were very low. Feeding rates on most farms were too low for normal maintenance, and grains and hay and pastures were inadequate to the needs of the livestock. Better feed supplies and feed practices, combined with better farm management, gave promise of better returns.

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Analyses of the Montana station of the factors affecting farm organization and management practices on Montana farms have been used by county agents and agricultural advisory committees in advising returning veterans and others regarding the purchasing, leasing, and financing of farms on a sound basis.

An investigation of the fiber-flax industry by the Oregon station disclosed the temporary character of the demand for Oregon flax-fiber under war conditions, and the extent of the possible postwar curtailment, unless special attention is given to developing standards that will assist Oregon growers to compete with foreign producers.

A 96-acre cotton-hog farm operated by the Alabama station from 1938 to 1943 gave a net return practically double that which would have resulted if only cotton had been grown under the Agricultural Adjustment Administration program. The average net return, exclusive of value of food supplied by the farm, was $569.81 for 1938 to 1940 and $3,169.08 for 1941 to 1943.

To test the soundness of the farm-ownership program in Puerto Rico as sponsored by the Farm Security Administration, the Agricultural Experiment Station of the University of Puerto Rico has completed the analysis of detailed farm-management records on 109 such farms, covering two different areas, during the past year. They averaged just over 30 acres per farm in size, of which an average of 60 percent was in crops. Despite an unfavorable crop year due to drought, the net cash income per farm averaged $1,176 and $679, respectively, in the two areas under study.

Studies conducted by the Arizona station cooperating with the Department contributed to agricultural adjustments needed in 1945. Suggestions included a fairly large production of grain sorghum, conservative plantings of American and Egyptian cotton, and a continuation of a rather large acreage of vegetables, to be modified, however, by the strength of the demand and price levels. No increase was recommended for alfalfa acreage. The findings, published in a bulletin entitled "Arizona Agriculture for 1945," were used by the War Food Administration in formulating recommendations for 1945 production and were also used individually by farmers in deciding upon production plans for the year.

HELPING VETERANS START RIGHT

Discharged veterans, men still in the armed forces, and war workers are becoming increasingly interested in farms and farming opportunities in New York State. Many veterans bought farms after World War I. Too many of the farms purchased were poor and overpriced, and the owners faced trouble, debt, and eventual failure. For the past 15 years, land-classification studies have been under way by the New York (Cornell) station. Such factors as usefulness for agriculture, soil type, climate, distance from markets, and condition of buildings have been considered. The land in many of the counties of the State has thus been classified according to how good a living a farmer can make if he depends wholly on the farm. With this research information available, it seems probable that many of the tragic mistakes such as followed the last war can be averted.

A study by the New Mexico station disclosed that an investment of $65,415 per ranch resulted in the production of an average of 4,077 pounds of lambs and 747 pounds of wool from the breeding stock per section of land grazed by sheep. At a normal price for lambs and wool, grazing land for sheep in southeastern New Mexico is worth about $1,112 per section for the land only, whereas improvements approximate $827 a section. From a budget analysis it was found that 1,700 head of sheep for a ranch of 20 sections, having a carrying capacity of 17 animal units per section, is the smallest family-sized unit that can be recommended for this area. These results have already been valuable in advising various agencies, State and Federal, concerning policies to be followed in helping veterans establish ranches.

CONSERVING FARM MANPOWER

Shortages of labor have been of serious concern to farmers in their efforts to increase food production. With farm wage rates at a record high level, work-simplification research by the New York (Cornell) station has been most timely in helping to increase labor efficiency. On dairy farms, labor can be saved by arranging the stable for maximum convenience in doing the work; by using equipment, such as food carts, to save time and trips; by training cows to milk out completely and rapidly; and by planning the chore routine to avoid back-tracking and other unnecessary trips. On poultry farms, work accomplishment can be increased by having large pens, combining jobs to save trips, having a convenient feed supply for each pen, placing nests near the door through which the operator enters the pen, and arranging for an automatic water supply and waste-disposal system that can be used during the winter as well as the summer season.

The South Carolina station found that farm-labor shortages increased in the State between 1942 and 1944, but farmers exercised greater skill in the use of both labor and equipment during the latter part of this period, and the effects were not particularly noticeable. More labor, however, would have made possible even greater production. Labor constitutes the largest item of expense on most farms, and the lack of it produces serious consequences. On a substantial proportion of South Carolina farms, labor is used very inefficiently.

Detailed work and observations on dairy farms cooperating with the New Hampshire station indicate that the adoption of practices to secure "let-down" of milk, the elimination of excessive hand stripping, and the rearrangement of the crews can result in large reduction in labor required. The adoption of practices to secure "let-down" results in immediate and substantial savings but the full advantage is not obtained on most farms without a complete reorganization of the crew and the method of milking. Several cooperators who have followed through on all these essential changes have been able to cut the milking time in half. One operator working alone milked 26 cows and carried the product to the milk room in 54 minutes. Detailed records indicate that 26 New Hampshire dairymen have reduced the average time required in milking to 2.5 man minutes or less per cow per milking.

Restrictions on supplies of critical materials for civilian use due to the demands for increased production of war materials created many equipment problems for farmers. The Oregon station, in keeping with the other State stations of the country, adjusted its research program to solve such problems by designing new equipment which permitted the use of noncritical materials needed by producers to increase the food production of the country. Oregon poultrymen were confronted, for example, with the problem of obtaining electric brooders. Plans and instructions for the construction of electric brooders were prepared and presented to producers to enable them to build electric brooders needed from materials that can be purchased without priority from local dealers. Instructions for the proper operation and care of equipment and the production of chicks were also included.

In a study of population in relation to resources and employment opportunities, the South Carolina station found that increased efficiency in the utilization of agricultural labor and high birth rates resulted in migration from the farms to the industrial areas of South Carolina. Approximately 500,000 people migrated from farms to nonfarm residences during the 20 years prior to 1940; about two-thirds of these found homes outside the State. At present rates of increase and employment, only 46 percent of the white farm boys and 35 percent of the Negro farm boys reaching maturity during the decade 1940-50 will be needed to replace South Carolina farm workers who die or retire during that period.

Rural-urban war migration as reported by the Washington station revealed that war workers, in spite of high wages, have been unable to save money because of the high cost of living, except in cases where more than one member of the family is working. Few had laid aside a secure economic foundation for the future shock of readjustment. The data indicated that the majority of rural workers now in metropolitan war industries have no definite plans for the future. About one-fourth think they will return to rural areas. Approximately 60 percent of workers of rural origin would like to stay in Spokane. This presents a challenge to the industrial ingenuity of Spokane and similar war-inflated communities.

Results of a study of adjustment of farm families and other rural groups and institutions to war conditions by the Michigan station showed that Michigan farm families were cooperating with the war effort. Forty-five percent of the 275 families interviewed spent an estimated 10 percent of their income for war bonds, while an equal number spent lesser amounts. All able-bodied persons in the farm families did more farm work than before the war began. Cooperation among neighbors increased, and while participating in war-related activities, they did not neglect their customary community responsibilities. The war situation during the first 2 years of World War II tended to strengthen rather than disrupt farm family life, despite the many adjustments necessary.

A study of farm-labor camps in New York State by the New York (Cornell) station disclosed that few boys above the years 14 to 16 were available; that girls make satisfactory workers, especially the older young women who are more serious, are less easily fatigued, and maintain better interest. Success depended upon the

facilities and services provided for living and recreation and the quality of the leadership. A camp council, composed of representatives of the youths, was the best device for handling camp social problems and relationships. Important benefits were the essential services rendered to farmers and an understanding on the part of city youth of farming and farm life. Thus rural-urban relationships were improved.

Labor-requirement studies by the Oregon station, including apples and pears in the Hood River Valley, potatoes in Klamath County, and cane fruits and tomatoes in the Willamette Valley, showed the total man-labor hours required per acre, as follows: Apples, 380.8; all pears 235.2; Bartlett pears 272.3; potatoes 129.2; cane fruits from 382.3 for black raspberries to 544 for red raspberries; and tomatoes 191.2 hours. The average pounds picked per picker in an 8-hour day were: Apples 1,386; all pears 1,606; cane fruits from 70.5 for red raspberries to 145.4 for Boysenberries and Youngberries; and tomatoes 1,528. These studies helped make maximum use of available labor in war-food production in the State.

Easier ways to do farm work have resulted from studies on work simplification conducted by the Kentucky station. Because of the high labor requirement of the Burley tobacco crop, work was concentrated on the various operations involved in its production. The steps in Burley tobacco production studied in detail included pulling plants; hand setting; machine setting; cutting and spearing; cutting and housing; stripping; and taking down, bulking, stripping, and pressing. As an example of the labor saved through these studies of 10 farms investigated in 1943, the time used in setting Burley tobacco ranged from 6 to 17 man-hours per acre. By using the best methods from the several farms surveyed, 2 men setting and 1 man driving should be expected to set 4 to 5 acres per day.

Studies of the Wisconsin station in cooperation with the Department in a township of Dodge County showed that the majority of farmers are highly efficient in use of their labor, there being 30 to 35 work units per man equivalent on many farms, 20 units or less on only 40 percent, and 16 units or less on only 19 percent of the farms. Only 12 percent of Wisconsin farmers now have regular hired men, and even on farms of 100 acres or more only 25 percent have hired men.

Losses from wartime labor shortages were at a minimum for Kentucky farmers because of the intensive studies by the Kentucky station of farm-labor supply and demand. Data on labor requirements were charted and made available early in the season and were used throughout the State to help farmers arrange their crop and livestock systems so as to avoid or minimize insofar as possible the pyramiding of labor peak periods, to forecast periods during which seasonal labor would have to be used, and to calculate the amount and arrange in advance to obtain the labor which would be required.

Improved celery harvesting methods resulted from studies by the Florida station as one of its contributions to the coordinated work simplification investigations involving many different farm

enterprises throughout the country. By a careful analysis of the prevailing methods of harvesting and packaging celery, numerous short cuts and labor-saving practices were inaugurated. Included was the development of a new type field box for celery and a celery crate-closing machine.

ANTICIPATING POSTWAR FARM PROBLEMS

A study by the Maine station in 1944-45 showed that potato acreage on individual farms had increased from 13 to 46 percent in the last 2 years. Part of this was due to abandoning rotation and growing potatoes after potatoes. Accompanying this was an increase of soil erosion on 32 percent of the farms with 80 or more acres in potatoes. The cost of production in 1944 was 54 percent higher than the 1926-30 average. The information will be of value in connection with postwar planning with reference to the optimum acreage that should be devoted to potatoes from a long-time point of view.

Producers of New Mexico are anticipating postwar cotton problems and are looking for alternative enterprises. Vegetable production is one alternative. Unfavorable freight rates are factors which discourage this enterprise. The request of vegetable growers for adjustments has been aided by the New Mexico station by assembling data on freight rates from New Mexico shipping points to central markets, in comparison with those from competing areas.

From a study of diversification in the Idaho Palouse wheat and pea area, the Idaho station concluded that farmers could diversify with livestock and make a living comparable to that on large grain and pea farms, and do this on about half the crop acres found in the straight grain and pea farms. Success on a diversified farm will call for the productive use of a large part of the leisure time found on the grain and pea farms. Diversification has resulted in more complete ownership of farms and higher net returns per acre. Farmers who diversify can pay enough for the land to compete successfully with grain farmers in acquiring a farm unit.

That profits of sheep ranching can be increased by increasing the percentage of the lamb crop, decreasing the death loss, increasing lamb weight at marketing, and increasing the value of the fleece was found in an economic analysis of the sheep industry by the Utah station.

Rural-housing facilities studied by the Pennsylvania station yielded information of value in after-the-war planning. Striking differences were observed. According to composite indices, dwellers in the open country have poorer facilities than dwellers in small boroughs or villages. Only rarely do farmers live in shacks; yet they seldom possess all the modern conveniences. Nonfarm rural families are more variable in their housing than any other class of families.

COSTS AND PRICES

Costs of producing farm products in New Jersey have increased generally during the year with labor the largest single factor in the increase. Labor costs are still rising, according to information obtained by the New Jersey station, and are now approximately

15 percent higher than a year ago. Since the labor item amounts to 50 percent or more of the cost of producing the perishable crops included in the study, its efficient use is especially indicated; also the need for price adjustments if the income of growers is to be maintained. Facts developed by the station were presented before various agencies seeking information on which to base ceiling prices.

The Washington station, in a study of the turkey enterprise in 1942, found the cost of production per pound averaged 27.2 cents in Clark County, 23.7 cents in Island County, and 24.5 cents in the Yakima Valley. Labor requirements per bird decreased from 2.41 hours for flocks of less than 500 poults to 0.72 hour with 2,750 or more poults. Grain consumed per pound of gain differed little with rations made up of less than 40, 40 to 59, or over 60 percent grain.

The effects of two world war periods on prices of the more important farm products of Maine were investigated by the State station, and a farm price index was computed for potato, apple, dairy, and poultry farming. These investigations provide an important basis for judging what the probable price situation may be following the war and may form a partial basis in assisting the Federal Government to establish satisfactory farm prices.

According to the Nebraska station, compared with 1912–14 values, Nebraska land is still cheap. If the average of these 3 years is used as a base of 100, the index of land prices on March 15, 1945, was 86. This is only 48 percent of the peak in 1920. Commodity prices have gone up more rapidly than have land values. In 1941 the land price index stood at 55 as compared with 77 in 1944. During the same period the index of Nebraska farm commodity prices advanced from 129 to 189.

BETTER FARM INCOMES

The Michigan station found that the livestock program, accounting for 60 to 80 percent of the farm income, is one of the major keys to better farm earnings in northeastern Michigan. Sheep and cattle ranches have not proved successful except when combined with trading in livestock. Sheep have declined because of competition from cattle and increasing difficulty with parasites. Medium-sized dairy farms of 90 to 150 acres of tillable land are the most successful. Next most successful are the small dairy farms, followed by dual-purpose cattle farms. Lowest in the category are the beef cattle farms.

Favorable farm incomes in 1944 were shown by a study of farming adjustments to meet war and postwar needs by the South Dakota station. Average operator's labor earnings were about $4,500 in the north-central area, and $5,100 in the southeastern area. However, earnings for the lower 20 percent were unsatisfactory. Low-profit farmers in the north-central area were operating too small a business. They kept less than half as much livestock per farm, and this livestock was 40 percent less efficient than that of the high-profit group in converting feed into livestock products. High-profit farmers accomplished a third more work per worker than did the low-profit farmers.

The inclusion of land in national forests in some of the counties

of Texas raised the question whether or not the counties lost revenue thereby. Studies by the Texas station showed that payments by national forests in lieu of taxes for the first few years after nationalization did not equal the amount of taxes lost. However, the revenue has gradually increased until it now about equals the amount of taxes lost. As far as ascertainable, the revenue lost is not reflected in the financial condition of the counties concerned.

Good crops have improved the financial position of Nebraska farmers materially in recent years. The farm-mortgage debt declined from $309,826,000 in 1940 to $232,921,000 in 1944. It was $691,732,000 in 1923. Forced sales and related defaults declined from 63.9 per 1,000 farms in 1933 to 7.6 per 1,000 in 1944. Debts have been paid and farmers have accumulated surplus funds. Caution should be exercised in investing these funds. Men who buy farms should avoid a heavy burden of debt.

MAKING BETTER USE OF LAND

Land use studies by the Nebraska station and the Department indicate that no drastic reduction in the cropland base is needed for Nebraska as a whole. Of nearly 20,950,000 acres in Nebraska physically suitable for cultivation, about 20,157,000 have been in crops, in tilled fallow, or idle. A decrease in the acreage of intertilled crops and a material increase in grasses and legumes are the principal changes that would result from the use of the cropping systems recommended. A regrassing program is needed in some crop adjustment sections and on many individual farms.

That soil conservation farming pays was determined by the Illinois station and the Department. For the period 1935 to 1943, 20 McLean County conservation farms showed a net average income of $3.23 per acre per year more than 20 otherwise comparable nonconservation farms. Contouring and other conservation practices, as compared with farming up-and-down the slope, increased average yields for the period 1939 to 1943 of corn 13 percent, soybeans 13, oats 20, and wheat 19 percent.

Land use studies by the Wyoming station and the Department show that wheatlands in the semiarid regions like Wyoming are in a much better condition than those further east. Soil erosion and some plant-food depletion were evident on the rolling lands of the older wheat areas of the region where the annual precipitation is above 20 inches. Several million acres of wheatlands in the northern Great Plains probably should be returned to grasses and legume crops. Because of improvements in tillage and harvesting implements and strip farming, summer fallow, and other improved methods of soil and water conservation, the wheat acreage of Wyoming may be increased. Shifts from sugar beets to beans on irrigated lands and from wheat to beans on dry lands have shown the undesirability of drastic changes in the farm economy. The State beet acreage should be brought back to prewar status. The most urgent need is for more efficient use of water resources on the proper lands. Abandoned farm lands in Wyoming have made a rapid recovery in the past few years due to above-normal precipitation, reseeding with tame grasses, and native revegetation.

Definite inflationary tendencies in farm real estate prices were revealed in a study of representative counties in the State by the Maryland station. Land values have risen materially in Maryland since the beginning of the war. The index of land values has increased 45 percent over the prewar level. The trend in volume of land transfers declined from 1936 to 1940. The volume of transfers in 1943 and 1944 was nearly 100 percent greater than in 1940. Another significant change in the farm real estate market is the present method by which land transfers are made, the most important method being voluntary trades and sales. In 1936 and 1937 forced sales, such as delinquent-tax and mortgage-foreclosure sales, were the second most important method of transferring land. However, by 1944, forced sales had become insignificant as a method of transferring land, whereas the number of voluntary sales in 1944 was nearly twice the number of transfers by this method in 1936.

An agricultural land use planning study by the South Dakota station showed an average rise in the price of land amounting to 34 percent in the index of land prices in four sample counties between 1941 and 1944. Foreclosures had reached a 24-year low. It was concluded that corn and soybean acreages should be continued at 1944 levels, while sugar beet, flax, sorghum, and tame hay acreages should be increased. A large feed supply suggested increased hog production. Cattle numbers should be reduced. Greater acreage of alfalfa and other tame hay and some shift from cropland to grazing land seemed desirable from the long-time viewpoint.

A study of the Montana station showed that in the immediate postwar period 8 percent of Montana farmers plan to retire, about 17 percent expect to build new houses, 25 percent are planning to build new barns, and 70 percent have to undertake major repairs to buildings, fences, and structures. The percentages of farmers planning to purchase different types of equipment are: 39 percent, cars; 42 percent, trucks; 39 percent, tractors; and 26 percent, combines. Approximately 60 percent reported they had the money needed or definite plans for financing the improvements and purchases.

The average price per acre, in the area studied by the Nevada station, for wholly irrigated land ran from $86 in 1941 to $226 in 1944; range and irrigated land combined rose from $11 an acre in 1941 to $22 in 1944; and range land alone from $2.78 in 1941 to $3.27 in 1944. Resales made within 2 years from time of purchase accounted for 20 transfers, or only 8 percent of the total transactions. Individual lenders, many of them sellers taking mortgages as security for payment, accounted for 67 percent of the farm mortgages in 1941; 100 percent in 1942; 52 percent in 1943; and 83 percent in 1944. Next, in descending order, came commercial bank, Federal land-bank, and insurance company loans. Buyers intending to operate the land themselves accounted for 83 percent of the sales.

A detailed study by the South Carolina station of the economic and social aspects of land use in a selected area in South Carolina provided data for appraising land use in other areas and for

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making future land use adjustments. A study of farmer attitudes toward farm practices and rural programs revealed a general lack of appreciation and understanding of economic and social problems affecting agriculture and focused attention upon "blind spots" in even the most elementary educational programs. Results of this study were used to test production adjustment potentialities in the State as a whole and to demonstrate locally the need for changes in land use.

IMPROVING FARM MARKETING FACILITIES

Important changes have occurred in the livestock-marketing system between farms and processors during the 30 years ended with 1940. According to Indiana station research, country buyers have been replaced largely by shipping associations, and these by local markets, as the country assembly points. Packer buying at country points and direct at plants increased rapidly from 1925 to 1940. The proportion of meat animals sold at competitive markets where several buyers operate decreased decidedly. Five posted stockyards in Indiana and 3 in adjoining States, 79 local dealer markets, and 31 packer markets handled 95 percent of the hogs, 93 percent of the sheep and lambs, 84 percent of the cattle, and 70 percent of the veal calves that farmers sold for slaughter during 1940. Approximately three-fifths of the hogs marketed during 1940 were reshipped to packers outside of the State; 43 percent of all hogs marketed were slaughtered by packers in the North Atlantic States region; about 30 percent of the hogs marketed were sold at average weights of about 200 pounds.

Low returns from the marketing of timber were found by the Ohio station associated with haphazard methods, indifference to wood-lot maintenance, and a progressive decline in the quality and quantity of the material produced. Approximately three-fifths of the woodland owners relied mainly on competition among buyers to insure a fair price for their timber. Many owners had little knowledge of the volume and quality of timber sold, accepting a lump sum price, the highest bid, for the total quantity marketed. In only one-third of the cases was the sale based on the more or less methodical cruise of the timber. The chief benefit of the study is to show how returns from woodlands can be sufficiently profitable to encourage farmers to consider the wood lot as another farm enterprise.

Studies of livestock trucking in Minnesota, made available to the Office of Defense Transportation and State and local war boards, helped to conserve trucks, tires, gasoline, and manpower during the war emergency and aided the Office of Price Administration and War Food Administration in determining equitable price ceilings and floors for slaughter animals and meat products. They also helped farmers to move farm products and farm organizations to understand price behavior and adjust operations to productive capacity.

In interviews with the truckers at the Kansas stockyards covering a 2-year period, the Kansas and Missouri stations found that the average age of the trucks was 3.2 years and mileage traveled 100,000 miles; about 90 percent of the trucks were in fair to

excellent condition. Ten to twenty miles of travel was necessary to assemble a truckload of animals, and the average haul to market was 100 miles. To deliver 1,000 pounds, 10 miles of travel was made with semitrailers, 12½ miles with standard trucks, and 29 miles with pick-up trucks.

ANALYZING THE FARM BUSINESS

Thorough statistical study by the Vermont station on reported losses due to farm fires in Vermont and on the major causes and types of risk involved are leading to important revisions in fire insurance underwriting and rating practices, which may be expected to reduce farm fire losses and to distribute the insurance burden more equitably.

Minnesota dry-milk industry has grown to enormous proportions since the prewar period. The State's output of dry milk reached an estimated total of 158 million pounds in 1944, as compared with 34.3 million pounds prior to the war. On the basis of existing capacity and further growth, the State's output of dry milk in 1945 may reach 200 to 210 million pounds, or about six times the prewar production. The information obtained by this study has been used by dairy-plant managers, dairy farmers, and others when considering the marketing of milk through drying plants. The results were also used by representatives of the War Food Administration, the State department of agriculture, the Office of Defense Transportation, and many other agencies.

The patronage dividend of cooperative cotton gin associations, according to Texas station studies, is equitable to a member provided he shares proportionately in the profits in all departments of the gin business in accordance with his contributions to those departments. A cooperative gin can pay a patronage dividend only as profits are realized on business operations. Experiences of many years have demonstrated the advisability of cooperatives charging the going rate or price for services offered or goods bought or sold. Under such circumstances a cooperative may assume its role as a competing agency in an economy of free enterprise. Such savings as are effected on volume of business and cost efficiency belong to the members as patrons. The payment of patronage dividends as a means of distributing profits has a pronounced stimulating effect on members.

RURAL HEALTH AND MEDICAL FACILITIES AND SERVICES

In a study of the operating experience of the Farm Security Administration prepayment medical care plans in five Ohio counties, the Ohio station found that the poorest families economically received more physicians' services than did the more advantaged families. Females received more services than males, adults more than children, tenants more than owners. Demand for medical services was greatest during the winter. Respiratory diseases and digestive disorders were the two most frequently treated. Annual prepayment of $23 per family was much too low to cover the costs of services demanded. The study points out both the strengths and the weaknesses of voluntary prepayment medical care plans for rural people. More important, it suggests guidelines

for establishing more adequate health programs for rural people. The results of the study have been used by the Ohio Rural Health Committee in its health-education program, by the Farm Security Administration in its planning and administration of medical-care plans, and by the United States Senate Subcommittee on Wartime Health and Education in its study of medical-care plans.

Health and nutrition studies by the Virginia station cooperating with State and Federal agencies have shown that the diets of approximately one-third of the school children in rural areas of the State are 50 percent or more below approved standards in milk and other foods. Many rural families go without medical care except in extreme emergencies and spend on an average only about $60 a year per family. Wartime scarcity of doctors has intensified the problem. The findings of the study have been given wide publicity and discussion, and a movement toward betterment has resulted in the appointment of a legislative committee with the aim of expanding public health services, establishing coordinated hospital-health centers, and adopting plans for spreading cost of hospital and medical-care insurance.

Diseases of the heart are far ahead of all the other causes of death in Louisiana, according to studies of the Louisiana station. Pneumonia and influenza, nephritis, cancer, diseases of the nervous system, tuberculosis, accidents other than those in which motor vehicles are involved, causes associated with premature birth, syphilis, and motor-vehicle accidents, in the order named, also are included among the 10 leading causes of death in the State. Louisiana's farms enjoy a definite advantage over its towns and cities from the standpoint of health and longevity. Louisiana Negroes have much higher mortality rates than their white fellows. Among both whites and Negroes, rural and urban, the death rates from most of the important diseases of this type are above those for the Nation. In 1940 the mortality rates from pneumonia and influenza, tuberculosis, typhoid fever, malaria, diphtheria, and most other contagious diseases were only fractions of what they were in 1920. The saving in life achieved during the period 1920-40 was much greater, relatively, among the Negro than among the white population of the State.

STATISTICS—PERSONNEL, PUBLICATIONS, INCOME, AND EXPENDITURES

PERSONNEL AND PUBLICATIONS

In 1945 the research personnel of the experiment stations included 2,163 full-time staff members and 2,207 staff members who divided time between research and teaching or extension work, or a total personnel, including both full-time and part-time research workers, of 4,370. In comparison with the fiscal year 1944 the 1945 personnel figures show a reduction of 63 full-time and 92 part-time research workers. Temporary assistants and nontechnical employees were not included in the tabulations.

Publications of the experiment stations in 1945 included 722 bulletins, circulars, and reports, 1,741 articles in scientific journals, and 457 miscellaneous publications. The comparable figures

in 1944 were 933, 1753, and 560. In addition to these printed publications the stations also issued a considerable number of progress reports and special articles in processed form which were not included in the figures cited above.

Details relating to personnel and publications by stations are shown in table 1.

INCOME

The income of the experiment stations from the Federal grants and from non-Federal sources for 1945 is shown in detail for each station in table 2. Appropriations of Federal-grant funds totaled $7,001,208 and the total from non-Federal sources, including State appropriations, research grants, and fellowships, and receipts from fees, sales, and miscellaneous sources was $21,080,879. The total from non-Federal sources approximated $3.01 to each $1 of Federal appropriations. Thus, the total funds available for research by the experiment stations in 1945 was $28,082,086—an increase of $1,139,424 over the total available in 1944. This increase was entirely from non-Federal sources as the amount of the Federal-grant appropriation was the same as in 1944.

The total of Federal-grant funds included $4,537,500 appropriated under the authorizations of the Hatch, Adams, and Purnell Acts, and the acts supplementary thereto, and $2,463,708 under the authorization of the Bankhead-Jones Act of June 29, 1935. Each State, Hawaii, and Puerto Rico received $90,000 under the Hatch, Adams, and Purnell Acts, while Alaska received $37,500. Allotments under the Bankhead-Jones Act are made mainly on the basis of the rural population of the States, Alaska, Hawaii, and Puerto Rico, and the amounts available for the individual stations are shown in table 2. Total disbursements from the United States Treasury for agricultural experiment stations under the Federal-grant acts through 1945 are shown in table 8.

EXPENDITURES

Classified expenditures are shown under the Hatch Act in table 3, the Adams Act in table 4, the Purnell Act in table 5, and the Bankhead-Jones Act in table 6. Non-Federal fund expenditures are shown in table 7.

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TABLE 1.—*Organization, personnel, and publications of the experiment stations for the year ended June 30, 1945*

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	42	22	1	----------	65	4	48	14	88	20	210
Alaska	May 2, 1929	May 1, 1931	6	1	1	----------	8	----------	----------	----------	----------	----------	----------
Arizona	Mar. 19, 1889	July 1, 1889	23	32	----------	----------	55	17	341	14	67	6	69
Arkansas	Mar. 7, 1889	Apr. 2, 1888	17	33	2	----------	52	5	241	7	55	----------	----------
California	Mar. 12, 1889	Mar. 13, 1888	67	188	----------	----------	255	13	527	----------	----------	----------	----------
Colorado	Mar. 25, 1889	Feb. 20, 1888	29	47	----------	5	81	20	400	19	76	18	32
Connecticut:													
State	May 18, 1887	May 18, 1887	54	----------	----------	----------	54	8	363	26	225	29	36
Storrs	do	Apr. 1, 1888	23	10	1	1	35	2	86	20	139	1	36
Delaware	Apr. 14, 1887	Feb. 2, 1888	10	12	3	3	28	14	335	23	56	9	22
Florida	June 7, 1887	Mar. 16, 1888	87	9	5	4	105	28	655	52	187	70	147
Georgia	Dec. 24, 1888	Feb. 18, 1888	35	----------	----------	----------	35	6	210	7	60	----------	----------
Hawaii	Mar. 31, 1911	July 1, 1929	23	15	----------	----------	38	2	29	----------	----------	----------	----------
Idaho	Jan. 23, 1891	Feb. 26, 1892	11	24	1	3	39	23	287	8	16	3	6
Illinois	May 11, 1887	Mar. 21, 1888	43	81	5	6	135	11	398	----------	----------	----------	----------
Indiana	Jan. 19, 1889	July 1, 1887	105	24	4	7	140	18	796	37	261	6	231
Iowa	Mar. 1, 1888	Feb. 17, 1888	83	110	20	6	219	16	922	55	573	16	260
Kansas	Mar. 3, 1887	Feb. 8, 1888	35	88	----------	----------	123	16	668	116	232	----------	----------
Kentucky	Feb. 20, 1888	Apr. 29, 1888	63	16	2	11	92	22	587	34	146	1	71
Louisiana	July 12, 1888	Apr. 5, 1887	68	28	----------	1	97	20	616	----------	----------	----------	----------
Maine	Mar. 16, 1887	Feb. 16, 1888	34	10	----------	1	45	17	957	6	50	9	129
Maryland	Mar. 6, 1888	Mar. 9, 1888	17	22	7	15	61	7	287	11	75	8	49
Massachusetts	Apr. 20, 1887	Mar. 2, 1888	60	18	----------	----------	78	26	431	40	218	----------	----------
Michigan	Apr. 12, 1889	Feb. 26, 1888	52	82	9	4	147	17	575	63	413	----------	----------
Minnesota	Feb. 4, 1889	Jan. 26, 1888	41	102	4	3	150	8	171	60	507	14	54
Mississippi	Jan. 31, 1888	Spring 1888	35	16	----------	3	54	20	150	15	60	106	129
Missouri	June 11, 1889	Jan. 31, 1888	8	77	----------	2	87	23	824	28	56	----------	----------
Montana	Feb. 16, 1893	July 1, 1893	28	15	1	9	53	13	243	2	19	----------	----------
Nebraska	Mar. 31, 1887	June 14, 1887	32	30	2	----------	64	26	667	24	48	----------	----------
Nevada	Feb. 8, 1889	Dec. 1887	15	1	----------	----------	16	2	61	----------	----------	----------	----------
New Hampshire	Aug. 4, 1887	Feb. 22, 1888	12	38	----------	7	57	14	246	----------	----------	----------	----------
New Jersey:													
College State	Mar. 16, 1887	Mar. 5, 1888	46	54	2	2	104	23	439	49	98	3	24

New Mexico	Feb. 28, 1889	Nov. 14, 1889	9	17	----------	2	28	7	216	2	11	3	10
New York:													
Cornell	Mar. 30, 1887	Apr. 30, 1888	25	140	2	16	183	22	950	407	2,295	----------	----------
State	(1)	----------	79	----------	----------	----------	79	14	411	50	50	5	10
North Carolina	Mar. 7, 1887	Dec. 5, 1889	68	42	----------	8	118	10	355	32	153	10	400
North Dakota	Mar. 8, 1890	Oct. 15, 1890	21	19	----------	2	42	11	305	14	78	4	11
Ohio	Mar. 16, 1887	Apr. 2, 1888	113	----------	----------	----------	113	13	459	25	50	2	129
Oklahoma	Oct. 27, 1890	Aug. 14, 1891	32	58	1	----------	91	17	413	57	246	----------	----------
Oregon	Feb. 25, 1889	July 2, 1888	58	44	----------	6	108	31	335	31	248	----------	----------
Pennsylvania	June 3, 1887	June 30, 1887	----------	144	----------	----------	144	14	421	38	224	10	144
Puerto Rico	Aug. 16, 1933	Nov. 14, 1935	50	----------	----------	----------	50	----------	----------	3	130	10	60
Rhode Island	Mar. 31, 1887	Nov. 3, 1881	17	9	2	4	32	6	206	14	83	5	70
South Carolina	Dec. 22, 1887	Jan. 1888	44	17	3	4	68	6	368	----------	----------	----------	----------
South Dakota	Mar. 11, 1887	Nov. 17, 1887	21	15	----------	1	37	14	292	12	34	----------	----------
Tennessee	Mar. 29, 1887	July 24, 1887	59	12	----------	3	74	20	714	15	85	----------	----------
Texas	Apr. 2, 1887	Jan. 25, 1888	144	2	----------	----------	146	32	1,389	23	133	52	206
Utah	Mar. 8, 1888	Nov. 6, 1889	14	43	----------	7	64	5	207	13	106	4	68
Vermont	Nov. 1888	Feb. 28, 1888	16	8	5	8	37	11	270	3	16	----------	----------
Virginia	Feb. 29, 1888	June 13, 1888	45	9	1	4	59	7	175	48	167	2	27
Washington	Mar. 9, 1891	May 1, 1891	69	34	----------	----------	103	17	558	32	251	10	93
West Virginia	Feb. 22, 1889	June 11, 1888	22	26	2	6	56	9	222	15	96	5	44
Wisconsin	(2)	July 1, 1887	38	71	4	14	127	7	321	176	352	----------	----------
Wyoming	Jan. 10, 1891	Mar. 27, 1891	15	24	----------	----------	39	8	224	1	2	16	158
Total	----------	----------	2,163	1,939	90	178	4,370	722	21,371	1,741	8,535	457	2,935

[1] First made eligible to receive part of the State allotment of Federal funds by legislative act approved May 12, 1894.
[2] Session of 1887.

TABLE 2.—*Income of the experiment stations for the year ended June 30, 1945*

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	Balance from previous year	Total	
Alabama	$90,000	$82,695.12	$172,695.12	$322,230.80	$6,904.65		$170,907.38	$1,010.36	4$75393.42	$548,446.61	$721,141.73
Alaska	37,500	2,252.44	39,752.44	7,500.00			25,414.69		15,550.98	48,465.67	88,318.11
Arizona	90,000	13,285.16	103,285.16	114,266.10			30,541.61		13,679.25	158,486.96	261,772.12
Arkansas	90,000	63,983.20	153,983.20	139,866.19			74,233.93		13,561.17	227,661.29	381,644.49
California	90,000	81,893.64	171,893.64	1,290,559.66	190,066.37		138,584.75		120,340.55	1,739,551.33	1,911,444.97
Colorado	90,000	22,430.96	112,430.96	114,922.20	31,530.00	$1,388.35	136,141.69		27,336.73	311,318.97	423,749.93
Connecticut:											
State	45,000	11,253.66	56,253.66	186,595.00	16,090.00					202,685.00	258,938.66
Storrs	45,000	11,253.66	56,253.66	56,028.42	7,160.08					63,188.50	119,442.16
Delaware	90,000	5,189.96	95,189.96	36,615.88			64,947.50	25,298.62	12,356.80	139,218.80	234,408.76
Florida	90,000	34,782.16	124,782.16	580,689.37			143,248.87		173,932.23	897,870.47	1,022,652.63
Georgia	90,000	87,522.92	177,522.92	82,613.86	34,081.78		87,033.61		57,896.66	261,625.91	439,148.83
Hawaii	90,000	9,186.40	99,186.40	161,603.61			36,783.87		3,181.27	201,568.75	300,755.15
Idaho	90,000	14,219.84	104,219.84	30,250.45			39,210.83		32,164.00	101,625.28	205,845.12
Illinois	90,000	86,736.52	176,736.52	443,385.53	71,814.40		169,041.99			684,241.92	860,978.44
Indiana	90,000	62,900.44	152,900.44	363,899.89	105,143.48	5,525.00	306,243.61	22,883.13	303,650.92	1,107,346.03	1,260,246.47
Iowa	90,000	64,854.64	154,854.64	357,569.40	85,056.70		144,805.57		167,388.20	754,819.87	909,674.51
Kansas	90,000	50,050.96	140,050.96	137,666.03		85,679.06	137,775.68	3,100.00	115,594.84	479,815.61	619,866.57
Kentucky	90,000	81,533.32	171,533.32	107,700.00		142,538.70	45,000.00			295,238.70	466,772.02
Louisiana	90,000	56,502.80	146,502.80	320,170.04	29,597.45					349,767.49	496,270.29
Maine	90,000	20,692.16	110,692.16	79,783.34	12,112.66		41,927.64	35,870.12	24,158.02	193,851.78	304,543.94
Maryland	90,000	30,259.72	120,259.72	116,119.56	8,327.50		60,937.36	5.00	49,880.43	235,269.85	355,529.57
Massachusetts	90,000	18,674.92	108,674.92	179,844.62	20,150.00				21,288.52	221,283.14	329,958.06
Michigan	90,000	73,566.60	163,566.60	251,591.98			38,108.52			289,700.50	453,267.10
Minnesota	90,000	57,269.04	147,269.04	364,250.36	92,820.45	2,991.33	87,451.81			547,513.95	694,782.99
Mississippi	90,000	72,651.40	162,651.40	222,500.00	21,156.11		133,870.86	19,766.25	153,417.43	550,710.65	713,362.05
Missouri	90,000	76,967.80	166,967.80	105,176.98	9,500.00	47,973.26	74,253.43		95,391.49	332,295.16	499,262.96
Montana	90,000	15,503.16	105,503.16	94,789.00			126,381.99		68,655.72	289,826.71	395,329.87
Nebraska	90,000	38,776.60	128,776.60	132,500.00			132,087.60			264,587.60	393,364.20
Nevada	90,000	2,734.64	92,734.64	2,734.64			15,456.10		17,019.32	35,210.06	127,944.70
N											
New Hampshire	90,000	8,507.40	98,507.40	8,507.40			11,066.90		18,793.43	38,367.73	136,875.13
ew Jersey	90,000	31,260.32	121,260.32	449,116.04	139,166.97					588,283.01	709,543.33

New Mexico	90,000	14,516.00	104,516.00	18,016.00			41,172.56		65,550.65	124,739.21	229,255.21
New York:												
Cornell	81,000	85,030.40	166,030.40	893,522.25				2,542.50		896,064.75	1,062,095.15
State	9,000	9,447.84	18,447.84	451,606.49			8,463.58			460,070.07	478,517.91
North Carolina	90,000	106,085.56	196,085.56	178,626.25			44,496.40	20,114.62	16,170.22	259,407.49	455,493.05
North Dakota	90,000	24,675.76	114,675.76	152,513.57	12,138.74		37,642.84		20,990.76	223,285.91	337,961.67
Ohio	90,000	93,717.64	183,717.64	316,711.32			223,542.07	39,664.52	741,387.71	1,321,305.62	1,505,023.26
Oklahoma	90,000	68,450.84	158,450.84	201,190.00	21,047.00	43,521.85	135,689.10		97,150.74	498,598.69	657,049.53
Oregon	90,000	22,790.32	112,790.32	255,359.26	22,689.64	114,192.56	80,196.84			472,438.30	585,228.62
Pennsylvania	90,000	135,322.64	225,322.64	238,666.01	36,146.77		89,054.01		20,784.70	384,651.49	609,974.13
Puerto Rico	90,000	53,213.24	143,213.24	201,000.00			22,372.09			223,372.09	366,585.33
Rhode Island	90,000	2,449.04	92,449.04	5,000.00	7,300.00		14,898.59		6,452.42	33,651.01	126,100.05
South Carolina	90,000	59,464.96	149,464.96	173,000.00			311,433.54		118,621.46	603,055.00	752,519.96
South Dakota	90,000	24,432.44	114,432.44	50,333.00	4,138.95		40,253.84		43,280.46	138,006.25	252,438.69
Tennessee	90,000	77,136.04	167,136.04	87,138.73			97,193.38			184,332.11	351,468.15
Texas	90,000	149,364.76	239,364.76	423,345.62	12,999.16		371,277.43	78,923.15	336,694.23	1,223,239.59	1,462,604.35
Utah	90,000	10,503.68	100,503.68	88,747.00	21,738.00		25,345.30		23,934.54	159,764.84	260,268.52
Vermont	90,000	10,471.60	100,471.60	8,000.00		10,471.60	5,461.59	500.00	7,608.83	32,042.02	132,513.62
Virginia	90,000	71,144.56	161,144.56	205,672.35			10,000.00			215,672.35	376,816.91
Washington	90,000	33,254.64	123,254.64	261,908.46	17,641.86		134,582.45			414,132.77	537,387.41
West Virginia	90,000	55,859.16	145,859.16	61,050.00			73,651.06		34,835.82	169,536.88	315,396.04
Wisconsin	90,000	60,224.88	150,224.88	401,722.00	198,653.00		150,973.00			751,348.00	901,572.88
Wyoming	90,000	6,759.52	96,759.52	23,046.23			59,639.87		49,634.83	132,320.93	229,080.45
Total	4,537,500	2,463,707.08	7,001,207.08	11,557,220.89	1,235,171.72	454,281.71	4,448,797.33	249,678.27	3,135,728.75	21,080,878.67	28,082,085.75

[1] Includes unexpended balances from the previous year as follows:
Hatch—Connecticut Storrs, $829.39; Illinois, $2,810.12; New York Cornell, $24.20; Rhode Island, $13.01.
Adams—Alabama, $1,092.30; Delaware, $1,252.78; Hawaii, $779.07; Illinois, $170.02; New York Cornell, $47.72; Puerto Rico, $47.49; Rhode Island, $13.73.
Purnell—Arkansas, $775.50; Connecticut Storrs, $1,935.95; Hawaii, $938.59; Illinois, $1,939.79; Indiana, $3,992.74; Maryland, $703.02; Massachusetts, $1,665.04; Michigan, $803.41; New York Cornell, $705.76; Ohio, $1,490.76; Oklahoma, $20.02; Puerto Rico, $2,488.36; Rhode Island, $50.41.
Bankhead-Jones—Arkansas, $1,482.72; Connecticut State, $62.25; Connecticut Storrs, $255.50; Illinois, $150.12; New York Cornell, $85.47; Ohio, $847.33; Puerto Rico, $1,221.55; Vermont, $165.21.

[2] Hatch, $15,000 for each State, Alaska, Hawaii, and Puerto Rico.
Adams, $15,000 for each State, Hawaii, and Puerto Rico; $7,500 for Alaska.
Purnell, $60,000 for each State, Hawaii, and Puerto Rico; $15,000 for Alaska.

TABLE 3.—*Expenditures and appropriations under the Hatch Act (Mar. 2, 1887)[1] for the year ended June 30, 1945*

Station	Expenditures												Unexpended	Appropriation
	Personal services	Travel	Transportation of things	Communication service	Rents and utility services	Printing and binding	Other contractual services	Supplies and materials	Equipment	Lands and structures (contractual)	Contributions to retirement	Total expenditures		
Alabama	$13,879.42		$6.49	$76.36	$85.00	$126.33	$12.84	$395.56	$418.00			$15,000.00		$15,000
Alaska	11,915.08	$957.09	442.23	39.08	103.63		43.22	1,410.23	89.44			15,000.00		15,000
Arizona	13,668.78	181.71		1.61		73.10	705.03	139.25	230.52			15,000.00		15,000
Arkansas	9,012.98	412.17	32.66	80.76		2,160.06	10.81	3,046.87	7.00		$236.69	15,000.00		15,000
California	15,000.00											15,000.00		15,000
Colorado	14,388.56	289.42			8.78						313.24	15,000.00		15,000
Connecticut:														
State	7,209.42							290.58				7,500.00		7,500
Storrs	3,116.10	355.73	11.84	77.02		390.97	39.38	843.95	2,211.44			7,046.43	$453.57	7,500
Delaware	10,645.01	384.04	24.55	813.32	105.33	1,497.95	329.97	826.46	373.37			15,000.00		15,000
Florida	14,997.26			2.74								15,000.00		15,000
Georgia	12,152.81	383.17				151.52	146.06	1,392.31	774.13			15,000.00		15,000
Hawaii	14,867.76							112.06	20.18			15,000.00		15,000
Idaho	6,483.67	1,128.33	23.77	115.00		2,800.14	234.73	3,523.16	691.20			15,000.00		15,000
Illinois	13,634.96										426.11	14,061.07	938.93	15,000
Indiana	15,000.00											15,000.00		15,000
Iowa	14,840.74	2.36		2.40				154.50				15,000.00		15,000
Kansas	14,150.57	446.05		96.53	8.50	57.63	7.09	185.30	48.33			15,000.00		15,000
Kentucky	14,080.00	162.52	20.61	67.87		387.00		282.00				15,000.00		15,000
Louisiana	14,009.15	312.02	.53	51.55			372.28	150.23	95.53	$8.71		15,000.00		15,000
Maine	10,519.54	916.15	79.32	504.58	676.83	590.33	209.70	984.25	519.30			15,000.00		15,000
Maryland	12,456.62	193.66	2.92	44.16			3.15	1,391.21	333.59	574.69		15,000.00		15,000
Massachusetts	11,613.33	218.63		15.70		222.32	816.69	687.61	1,425.72			15,000.00		15,000
Michigan	15,000.00											15,000.00		15,000
Minnesota	11,089.11	205.27	.98	.94			65.46	1,185.33	2,163.91		289.00	15,000.00		15,000
Mississippi	11,066.06	652.23	27.37	336.60		1,960.18	94.61	840.73	22.22			15,000.00		15,000
Missouri	14,591.37										408.63	15,000.00		15,000
Montana	10,363.98	354.36	7.00	386.18	524.06	943.56	15.00	1,835.67	372.19	198.00		15,000.00		15,000
Nebraska	15,000.00											15,000.00		15,000
Nevada	11,925.62		31.51	379.25	152.35	1,473.10	45.05	526.03	58.09		409.00	15,000.00		15,000
New Hampshire	10,159.16	647.31	315.61	479.04	700.00	765.96	607.63	704.42	620.87			15,000.00		15,000
New Jersey	13,746.00	268.31	2.45	2.30		35.00	94.47	545.28	306.19			15,000.00		15,000

New Mexico	12,822.84	150.73		13.70	563.86	567.35	95.72	361.18	424.62			15,000.00		15,000
New York:														
Cornell	9,705.34	128.78	12.00	103.87	403.50		776.35	1,249.48	1,117.80			13,497.12	2.88	13,500
State	1,500.00											1,500.00		1,500
North Carolina	12,714.48	636.24	8.74	76.09	9.50	450.00	173.95	737.92	193.08			15,000.00		15,000
North Dakota	13,022.52	10.39	.63	4.04	9.64	360.28	1.50	279.83	1,001.17		310.00	15,000.00		15,000
Ohio	7,330.00	577.78	139.59				159.06	5,401.92	1,391.65			15,000.00		15,000
Oklahoma	6,724.21	1,630.53	34.59	53.84		378.61	228.04	4,415.90	1,534.28			15,000.00		15,000
Oregon	13,253.37	705.98	1.11	1.64		654.97	33.43	251.79	97.71			15,000.00		15,000
Pennsylvania	11,822.77	229.76				2,687.02		80.45	180.00			15,000.00		15,000
Puerto Rico	10,878.76	622.37	3.30	46.80		13.36	4.00	2,166.62	1,264.79			15,000.00		15,000
Rhode Island	10,350.92	30.83	6.51	378.08		891.48	274.95	2,813.50	253.73			15,000.00		15,000
South Carolina	11,309.78	167.05	2.98	219.06		1,058.53	97.36	1,520.52	551.91		72.81	15,000.00		15,000
South Dakota	10,469.14	609.97	61.82	139.46	8.00	538.98	143.66	2,274.37	754.60			15,000.00		15,000
Tennessee	11,736.20	92.41	115.85	679.21	17.21	655.16	110.99	1,233.13	359.84			15,000.00		15,000
Texas	11,157.57	1,101.55		159.09		88.88	58.21	595.20	1,839.50			15,000.00		15,000
Utah	13,578.48	311.78	19.65	74.03		14.50	9.80	970.31	21.45			15,000.00		15,000
Vermont	9,761.09	98.73		357.18	1,519.48	1,057.57	490.96	1,498.96	27.70		188.33	15,000.00		15,000
Virginia	14,015.74			40.00	30.62	3.10	178.22	732.32				15,000.00		15,000
Washington	12,959.73	264.61	14.13	2.84		1,379.81	7.15	127.60	18.13		226.00	15,000.00		15,000
West Virginia	11,520.32	352.94	2.98	255.27	7.44	197.23	369.49	2,089.65	204.68			15,000.00		15,000
Wisconsin	12,684.00	68.58				1,237.15		1,010.27				15,000.00		15,000
Wyoming	12,180.69	416.07	88.27	78.14	261.95	329.40	158.25	1,205.24	281.99			15,000.00		15,000
Total	622,081.01	16,677.61	1,541.99	6,255.33	5,195.68	26,198.53	7,224.26	52,469.15	22,299.85	781.40	2,879.81	763,604.62	1,395.38	765,000

[1] Extended to Hawaii by act of May 16, 1928; to Alaska by act of Feb. 23, 1929; and to Puerto Rico by act of Mar. 4, 1931.

TABLE 4.—*Expenditures and appropriations under the Adams Act (Mar. 16, 1906)[1] for the year ended June 30, 1945*

Station	Expenditures											Unexpended	Appropriation
	Personal services	Travel	Transportation of things	Communication service	Rents and utility services	Other contractual services	Supplies and materials	Equipment	Lands and structures (contractual)	Contributions to retirement	Total expenditures		
Alabama	$12,685.01	$35.02	$50.12	$2.87	$659.06	$169.24	$1,183.60	$215.08			$15,000.00		$15,000
Alaska	7,381.15	19.15					99.70				7,500.00		7,500
Arizona	12,044.44	1,394.03	10.18	34.41		589.66	641.97	285.31			15,000.00		15,000
Arkansas	13,130.42	144.09	10.55	.36		19.60	868.68	306.36		$519.94	15,000.00		15,000
California	15,000.00										15,000.00		15,000
Colorado	12,003.28	225.72		5.82	98.14	118.66	859.82	1,463.26		225.30	15,000.00		15,000
Connecticut:													
State	7,500.00										7,500.00		7,500
Storrs	7,500.00										7,500.00		7,500
Delaware	11,185.12	469.33	29.25	.35	369.64	111.25	1,563.65	796.41	$369.98		14,894.98	$105.02	15,000
Florida	15,000.00										15,000.00		15,000
Georgia	10,715.51	5.20	1.92	1.61		25.00	4,250.76				15,000.00		15,000
Hawaii	13,863.57		8.48				172.56	955.39			15,000.00		15,000
Idaho	11,965.81	477.38	20.63	13.90	45.00	315.60	1,233.14	375.80	552.74		15,000.00		15,000
Illinois	14,566.25									433.75	15,000.00		15,000
Indiana	12,706.18	46.70			20.00		1,608.37	3.20			14,384.45	615.55	15,000
Iowa	15,000.00										15,000.00		15,000
Kansas	13,949.08					241.50	699.73	109.69			15,000.00		15,000
Kentucky	14,329.22		10.88			10.00	614.90	35.00			15,000.00		15,000
Louisiana	13,932.22	308.57	4.04	3.04		14.19	420.94	317.00			15,000,00		15,000
Maine	14,191.99	153.80	1.20	.10		103.38	508.99	40.54			15,000.00		15,000
Maryland	12,283.29	425.22	.58	.34	8.40	51.31	2,032.26	198.60			15,000.00		15,000
Massachusetts	15,000.00										15,000.00		15,000
Michigan	15,000.00										15,000.00		15,000
Minnesota	13,510.34	61.35					298.26	768.64		361.41	15,000.00		15,000
Mississippi	13,437.41	212.81	39.23	1.58	179.57	197.91	341.02	581.89	8.58		15,000.00		15,000
Missouri	10,094.16	4.65	248.23	25.14	12.25	225.84	3,384.03	711.20	114.80	179.70	15,000.00		15,000
Montana	13,140.89	456.61	4.18	2.02		78.01	601.25	654.49	62.55		15,000.00		15,000
Nebraska	15,000.00										15,000.00		15,000
Nevada	12,073.77	270.65	34.97	65.20	15.30	26.84	649.30	1,248.26	281.21	334.50	15,000.00		15,000
New Hampshire	14,038.36	114.52	22.78	7.46	130.00	109.59	416.34	160.95			15,000.00		15,000
New Jersey	13,731.85	45.83				25.55	1,051.04	145.73			15,000.00		15,000
New Mexico	12,079.70	216.53	57.26	52.60	258.34	18.70	1,518.64	798.23			15,000.00		15,000

New York:													
Cornell	11,701.97				64.50	135.28	834.18	764.07			13,500.00		13,500
State	1,344.33						90.67	65.00			1,500.00		1,500
North Carolina	12,803.24	392.23	11.42	8.26		352.49	847.72	584.64			15,000.00		15,000
North Dakota	14,062.30	14.81	5.20	15.41		130.29	150.22	312.02		309.75	15,000.00		15,000
Ohio	12,228.86	8.75	25.09				1,530.79	1,206.51			15,000.00		15,000
Oklahoma	10,609.18	78.73	4.65			27.76	1,724.77	2,554.91			15,000.00		15,000
Oregon	13,194.53	486.79	9.43	7.08	8.00	38.83	1,177.49	77.85			15,000.00		15,000
Pennsylvania	15,000.00										15,000.00		15,000
Puerto Rico	13,022.67	165.30	8.00	15.00		69.68	1,215.50	503.85			15,000.00		15,000
Rhode Island	13,570.00	130.27	211.32			8.80	871.78	207.43			14,999.60	.40	15,000
South Carolina	12,713.94	142.02	59.71	131.91	43.00	109.10	525.29	1,154.95		120.08	15,000.00		15,000
South Dakota	13,046.60	466.23	42.20	38.20		54.34	1,146.29	206.14			15,000.00		15,000
Tennessee	12,346.55	65.74	45.77	13.60	18.69	154.07	919.66	1,435.92			15,000.00		15,000
Texas	14,717.91			.68		16.00	262.01		3.40		15,000.00		15,000
Utah	12,841.28	623.82	27.39			7.62	687.34	812.55			15,000.00		15,000
Vermont	10,525.99	69.41	14.60	11.15	4.00	905.15	994.51	1,100.45	550.00	207.49	14,382.75	617.25	15,000
Virginia	13,172.32	297.66			15.00	57.56	1,300.63	156.83			15,000.00		15,000
Washington	12,861.40	647.99		5.31			716.45	437.85		331.00	15,000.00		15,000
West Virginia	13,243.00	114.39	5.90			81.90	1,073.68	481.13			15,000.00		15,000
Wisconsin	13,686.00						1,314.00				15,000.00		15,000
Wyoming	13,185.73	124.44	12.76	25.18		17.58	1,588.87	45.44			15,000.00		15,000
Total	667,916.82	8,915.74	1,037.92	488.58	1,948.89	4,618.28	43,990.80	22,278.57	1,943.26	3,022.92	756,161.78	1,338.22	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, 1945*

Station	Expenditures												Unexpended	Appropriation
	Personal services	Travel	Transportation of things	Communication service	Rents and utility services	Printing and binding	Other contractual services	Supplies and materials	Equipment	Lands and structures (contractual)	Contributions to retirement	Total expenditures		
Alabama	$51,162.17	$1,460.47	$172.48	$65.72	$1,919.64	$150.05	$354.71	$3,286.29	$1,428.47			$60,000.00		$60,000
Alaska	13,232.27	386.01	275.02	24.76				573.84	508.10			15,000.00		15,000
Arizona	43,802.72	1,891.98	64.31	81.45	20.00	1,044.48	1,516.47	5,805.83	1,063.76	$4,709.00		60,000.00		60,000
Arkansas	44,886.00	971.13	53.69	40.20	1,400.13		618.83	6,183.29	1,134.74	4,000.00	$711.99	60,000.00		60,000
California	60,000.00											60,000.00		60,000
Colorado	46,218.79	1,860.93	33.84	147.71	1,735.01	14.37	1,318.47	5,974.89	1,938.23		757.76	60,000.00		60,000
Connecticut:														
State	25,905.43	53.78	5.25		24.67		397.31	1,098.11	2,494.35			29,978.90	$21.10	30,000
Storrs	21,596.85	254.16	21.72			25.91	108.53	3,144.09	2,288.65			27,439.91	2,560.09	30,000
Delaware	43,135.03	2,732.46	52.77	5.41	351.40	1,278.30	695.82	8,346.33	1,797.48	1,605.00		60,000.00		60,000
Florida	52,122.22	2,025.35	3.41	3.51	300.12		267.35	2,417.98	2,860.06			60,000.00		60,000
Georgia	38,040.92	1,362.90	32.58	4.75	150.00	1,027.80	375.71	14,487.34	4,518.00			60,000.00		60,000
Hawaii	57,534.62	53.35	4.77					855.51	1,263.15	288.60		60,000.00		60,000
Idaho	47,923.88	1,327.99	99.17	126.99	371.35	243.05	807.25	4,382.25	3,793.33	924.74		60,000.00		60,000
Illinois	51,015.00	1,865.64	.35	36.50		651.55	1,786.92	774.56	2,787.20		910.66	59,828.38	171.62	60,000
Indiana	52,532.28	1,061.91	73.63	37.07	220.00		1,168.52	2,646.37	2,260.22			60,000.00		60,000
Iowa	60,000.00											60,000.00		60,000
Kansas	55,811.70	201.61	15.00		9.00	34.04	221.64	2,377.70	1,329.31			60,000.00		60,000
Kentucky	55,624.64	1,780.20	13.60	38.48		754.25	581.20	787.51	420.12			60,000.00		60,000
Louisiana	49,258.28	2,151.77	78.61	59.42		748.31	1,099.50	5,153.33	1,450.78			60,000.00		60,000
Maine	47,731.04	1,505.58	17.56	200.88	895.60	1,071.34	573.00	7,621.65	383.35			60,000.00		60,000
Maryland	48,852.30	2,280.76	28.36	5.82		440.03	505.14	5,531.43	2,221.94	134.22		60,000.00		60,000
Massachusetts	51,118.89	1,855.55		31.28			1,000.89	2,940.07	3,051.52			59,998.20	1.80	60,000
Michigan	53,179.12	1,057.49	17.55		100.00	5.62	482.69	1,957.51	3,200.02			60,000.00		60,000
Minnesota	51,317.23	761.13	208.56	61.43	23.46	670.84	546.76	2,434.41	3,123.42		852.76	60,000.00		60,000
Mississippi	43,228.00	1,585.23	209.45	317.39	377.26	489.71	683.19	10,342.25	2,761.22	6.30		60,000.00		60,000
Missouri	45,465.47	850.58	175.14	78.58	421.88	263.65	418.76	10,576.02	1,328.57	10.92	410.43	60,000.00		60,000
Montana	43,711.13	969.75	38.64	75.94	243.30	819.89	420.48	11,010.30	2,143.79	566.78		60,000.00		60,000
Nebraska	50,049.03	747.30	60.70	73.75	10.00	384.49	673.00	5,381.82	2,619.91			60,000.00		60,000
Nevada	49,344.17	1,238.01	125.42	488.08	360.86	247.50	1,223.73	4,468.55	1,602.85		900.83	60,000.00		60,000
New Hampshire	51,486.37	1,552.49	155.44	54.85	284.10	702.35	1,160.54	3,196.34	1,407.52			60,000.00		60,000
New Jersey	53,497.83	955.41	4.58	20.00	76.00	11.50	620.09	3,307.29	1,507.30			60,000.00		60,000

New Mexico	49,079.68	1,213.33	57.00	91.29	1,652.10	533.29	1,220.99	5,815.67	336.65			60,000.00		60,000
New York:														
Cornell	45,190.16	1,084.82	16.92	.30	1,507.20		1,473.57	2,190.70	2,143.27			53,606.94	393.06	54,000
State	5,322.33							131.01	546.67			5,999.94	.06	6,000
North Carolina	46,109.65	3,144.80	18.32	315.05	1,013.20	487.06	723.49	5,801.02	2,387.41			60,000.00		60,000
North Dakota	49,835.01	575.19	46.22	23.37	57.91	28.41	939.73	4,231.51	3,118.30		1,141.12	59,996.77	3.23	60,000
Ohio	50,217.89	772.64	5.53				6.00	6,078.02	1,046.91			58,126.99	1,873.01	60,000
Oklahoma	43,175.40	566.39	221.65	5.00	908.25	127.07	1,598.78	10,173.46	2,361.94	862.06		60,000.00		60,000
Oregon	50,793.81	1,289.81	49.88	524.92	210.86	965.02	2,919.32	1,433.53	1,812.85			60,000.00		60,000
Pennsylvania	53,363.99	627.05	1.35	49.92	.70		172.45	5,194.47	590.07			60,000.00		60,000
Puerto Rico	47,342.54	3,538.22	85.45	240.71	28.00	239.30	452.41	3,635.18	4,438.19			60,000.00		60,000
Rhode Island	51,219.61	376.08	23.42	3.05	5.74	1,147.55	89.45	4,987.03	2,146.72			59,998.65	1.35	60,000
South Carolina	42,499.09	1,005.07	236.63	459.96	1,102.91	1,831.09	2,561.44	5,844.86	1,776.84	2,354.00	328.11	60,000.00		60,000
South Dakota	43,545.44	2,517.31	63.06	613.41	336.80	2,360.42	1,196.39	3,677.36	5,689.81			60,000.00		60,000
Tennessee	54,405.45	714.33	75.89	48.77	97.96	267.13	321.13	2,381.50	1,431.99	255.85		60,000.00		60,000
Texas	54,396.61	1,367.42	42.16	260.38	24.44	78.05	455.63	2,658.47	716.84			60,000.00		60,000
Utah	46,353.59	2,614.98	40,90	16,00	52.10	670.50	571.67	3,757.53	5,413.25	509.48		60,000.00		60,000
Vermont	49,372.36	877.34	53.37	66.71	151.14	667.51	954.75	3,878.50	1,058.57	1,722.42	1,197.33	60,000.00		60,000
Virginia	53,398.42	466.65	14.70	2.00	724.52	949.06	319.40	1,803.87	2,321.38			60,000.00		60,000
Washington	51,776.38	1,637.40	54.82	95.72		1,260.66	469.00	2,878.69	1,222.33		605.00	60,000.00		60,000
West Virginia	50,286.39	801.14	6.90		1,453.60	227.66	110.63	4,125.39	2,988.29			60,000.00		60,000
Wisconsin	55,927.34	472.73		1.92	31.58	369.47	50.50	3,146.46				60,000.00		60,000
Wyoming	48,323.56	2,179.27	165.79	31.71	77.31	546.43	193.38	4,832.08	3,650.47			60,000.00		60,000
Total	2,500,718.08	64,642.89	3,321.56	4,930.16	18,730.10	23,834.71	36,426.61	225,719.17	105,886.04	17,949.37	7,815.99	3,009,974.68	5,025.32	3,015,000

[1] Extended to Hawaii by act of May 16, 1928; to Alaska by act of Feb. 23, 1929; and to Puerto Rico by act of Mar. 4, 1931.

TABLE 6.—*Expenditures and appropriations under the Bankhead-Jones Act (June 29, 1935) for the year ended June 30, 1945*

Station	Expenditures												Unexpended	Appropriation
	Personal services	Travel	Transportation of things	Communication service	Rents and utility services	Printing and binding	Other contractural services	Supplies and materials	Equipment	Lands and structures (contractural)	Contributions to retirement	Total expenditures		
Alabama	$54,266.43	$1,507.39	$202.58	$178.16	$1,489.94	$137.77	$2,558.20	$19,876.49	$2,395.67	$82.49		$82,695.12		$82,695.12
Alaska	2,060.33							192.11				2,252.44		2,252.44
Arizona	8,566.96	836.87	30.82	108.03		348.55	160.30	2,776.54	457.09			13,285.16		13,285.16
Arkansas	45,956.65	1,466.74	81.55	10.00	1,176.21	24.69	655.35	4,620.40	2,657.40	6,718.75	$615.46	63,983.20		63,983.20
California	81,876.71							16.93				81,893.64		81,893.64
Colorado	16,917.38	608.29	18.00	61.19	391.32	163.36	726.77	2,694.90	631.06		218.69	22,430.96		22,430.96
Connecticut:														
State	8,790.00				22.10	35.97	130.94	1,039.31	1,025.24			11,043.56	$210.10	11,253.66
Storrs	7,432.43	138.65	15.38		1.84	3.00	60.83	2,740.71	422.44			10,815.28	438.38	11,253.66
Delaware	3,862.07						8.39	1,319.50				5,189.96		5,189.96
Florida	25,867.89	780.25	36.87				405.84	4,412.50	3,278.81			34,782.16		34,782.16
Georgia	59,037.46	1,733.87	54.90	1.81	94.00	1,116.14	1,366.65	15,841.99	8,276.10			87,522.92		87,522.92
Hawaii	7,048.54					12.00		829.25	1,102.05			8,991.84	194.56	9,186.40
Idaho	9,829.55	568.32	15.52	3.73	240.00	12.75	366.76	1,622.21	866.07	694.93		14,219.84		14,219.84
Illinois	67,921.43	2,758.26	121.01	69.32		120.31	2,949.16	7,849.40	3,338.61	27.50	1,495.17	86,650.17	86.35	86,736.52
Indiana	51,998.50	950.72	110.47	14.44	379.20		473.25	4,436.26	3,971.37	566.23		62,900.44		62,900.44
Iowa	64,854.64											64,854.64		64,854.64
Kansas	45,387.02	116.42	8.34			41.74	332.11	2,996.55	1,143.78	25.00		50,050.96		50,050.96
Kentucky	75,358.00	469.38	24.12	2.22		1,391.88	188.98	3,253.53	845.21			81,533.32		81,533.32
Louisiana	45,073.39	2,252.06	124.21	25.47		691.59	632.67	5,002.27	2,701.14			56,502.80		56,502.80
Maine	16,700.28	1,434.47	.50	14.67	130.40	114.69	30.65	1,303.47	963.03			20,692.16		20,692.16
Maryland	23,238.65	1,016.66	20.33	4.26	9.08		633.32	4,593.26	744.13			30,259.69	.03	30,259.72
Massachusetts	18,666.23							8.69				18,674.92		18,674.92
Michigan	68,108.64	136.88	17.37				4.95	1,416.74	3,882.02			73,566.60		73,566.60
Minnesota	42,413.59	1,675.00	198.72	74.98	355.49	637.53	795.47	6,540.07	3,852.25	45.00	680.94	57,269.04		57,269.04
Mississippi	54,401.12	1,740.77	564.01	419.46	1,699.51	1,380.43	1,522.50	8,514.71	2,255.54	153.35		72,651.40		72,651.40
Missouri	51,443.39	1,138.79	271.76	260.07	646.98	196.10	754.96	18,299.62	2,214.47	795.28	946.38	76,967.80		76,967.80
Montana	13,561.40	13.71	67.81	1.25			38.83	1,768.36	51.80			15,503.16		15,503.16
Nebraska	29,884.75	691.13	49.36	28.22	317.50		23.64	6,673.04	1,108.96			38,776.60		38,776.60
Nevada	1,961.59	172.15		.45				314.41	229.79		56.25	2,734.64		2,734.64
New Hampshire	7,047.25	677.03	3.02	14.49	136.70	35.87	56.24	526.85	9.95			8,507.40		8,507.40

New Jersey	25,379.40	406.46	1.28		123.85		112.54	4,539.60	662.77	34.42		31,260.32		31,260.32
New Mexico	11,678.26		117.52	6.35	176.53		234.14	2,292.70	10.50			14,516.00		14,516.00
New York:														
Cornell	59,885.89	954.28	37.24	13.43	1,776.25	103.02	1,332.51	9,641.63	11,003.33	282.82		85,030.40		85,030.40
State	4,655.09	23.90				5.01		1,921.15	2,842.69			9,447.84		9,447.84
North Carolina	86,287.32	3,670.80	155.29	280.68	808.38	227.11	1,962.54	9,245.59	3,197.85	250.00		106,085.56		106,085.56
North Dakota	18,891.24	1,877.71	39.46	27.67	28.88	101.35	46.38	2,235.67	861.80	86.50	478.85	24,675.51	.25	24,675.76
Ohio	73,903.64	767.54	36.21		63.96		924.25	11,710.47	3,920.71			91,326.78	2,390.86	93,717.64
Oklahoma	42,233.19	508.39	300.11	12.30	118.65	106.20	1,285.75	17,789.12	5,375.26	721.87		68,450.84		68,450.84
Oregon	18,940.68	798.06	36.59	22.35	252.55	14.00	242.37	1,840.36	643.36			22,790.32		22,790.32
Pennsylvania	121,878.37	2,000.97	47.11		72.65	222.53	241.08	8,768.40	2,091.53			135,322.64		135,322.64
Puerto Rico	33,147.31	787.08			704.68	308.65	275.00	15,549.59	2,440.93			53,213.24		53,213.24
Rhode Island	2,089.42	23.58				336.00						2,449.00	.04	2,449.04
South Carolina	34,926.10	674.31	454.12	259.70	186.27	21.35	1,928.46	9,140.78	1,690.41	10,000.00	183.46	59,464.96		59,464.96
South Dakota	18,222.95	524.19	63.93	56.98	96.00	355.12	121.01	2,192.07	2,800.19			24,432.44		24,432.44
Tennessee	61,601.60	1,597.51	1,038.62	37.07	287.85	44.88	723.19	9,832.77	1,109.79	862.76		77,136.04		77,136.04
Texas	129,556.97	2,361.86	48.05	26.09	41.22	67.01	1,142.45	11,712.19	3,495.90	913.02		149,364.76		149,364.76
Utah	9,394.51	245.58	.45	67.08		11.89	182.14	218.06	383.97			10,503.68		10,503.68
Vermont	8,062.94	204.37	7.50	2.89	107.61		258.00	1,431.93	94.92		301.44	10,471.60		10,471.60
Virginia	60,902.25	788.47	26.05	59.85	372.32	197.50	874.76	5,726.52	2,196.84			71,144.56		71,144.56
Washington	27,160.81	749.26	23.45	6.67			176.26	3,693.54	1,033.65		411.00	33,254.64		33,254.64
West Virginia	46,576.72	2,668.04	65.92		24.34	537.54	83.39	3,773.37	2,129.84			55,859.16		55,859.16
Wisconsin	57,680.32	109.10	96.54					2,338.92				60,224.88		60,224.88
Wyoming	6,125.69	281.90	17.76				122.37	174.92	36.88			6,759.52		6,759.52
Total	1,968,712.94	44,907.17	4,649.85	2,171.33	12,332.26	9,123.53	27,145.35	267,249.42	96,447.10	22,259.92	5,387.64	2,460,386.51	3,320.57	2,463,707.08

TABLE 7.—*Expenditures from non-Federal funds for the year ended June 30, 1945*

Station	Personal services	Travel	Transportation of things	Communication service	Rents and utility services	Printing and binding	Other contractural services	Supplies and materials	Equipment	Lands and structures (contractural)	Contributions to retirement	Total	Unexpended balances
Alabama	$183,780.91	$9,509.02	$2,068.83	$2,011.76	$5,753.85	$781.30	$21,116.45	$77,506.54	$28,939.75	$52,287.69		$383,756.10	$164,690.51
Alaska	15,060.54	389.12	2,300.19	382.26	1,298.76	185.77	1,713.53	4,183.29	5,265.52	2,749.86		33,528.84	15,036.83
Arizona	96,128.99	3,270.62	434.27	1,611.37	3,329.36	2,289.06	6,328.46	15,331.67	16,083.91			144,807.71	13,679.25
Arkansas	115,577.38	12,855.82	147.54	1,398.66	3,600.70		3,302.12	29,394.19	13,939.12	143.25	$972.55	181,331.33	46,329.96
California	1,166,602.47	45,213.84	5,437.90	22,226.53	43,240.45	31,449.14	48,194.66	142,411.57	36,990.51			1,541,767.07	197,784.26
Colorado	113,462.94	3,851.70	1,622.37	1,948.09	8,914.46	2,031.15	10,216.36	73,925.63	6,880.95	1,069.14	1,136.01	225,058.80	86,260.17
Connecticut:													
State	137,993.90	948.29	148.29	1,443.49	3,839.77	158.62	5,615.02	12,699.85	5,116.32			167,963.55	34,721.45
Storrs	52,047.08	713.42	112.37	62.50			1,305.92	8,123.80	823.41			63,188.50	
Delaware	48,276.91	2,229.90	417.05	430.89	3,465.03	278.20	11,125.91	40,794.63	5,159.57	2,980.37		115,158.46	24,060.34
Florida	488,993.02	20,085.20	3,364.51	4,046.93	12,169.71	8,194.52	39,300.93	122,963.05	51,097.57	5,250.00		755,465.44	142,405.03
Georgia	108,774.95	3,806.13	447.30	1,552.45	5,699.57	2,934.94	10,370.77	58,128.32	17,306.21	500.00		209,520.64	52,105.27
Hawaii	150,380.28	2,125.70	339.70	1,211.81	4,188.27	230.60	3,214.03	28,407.39	8,853.93			198,951.71	2,617.04
Idaho	35,348.74	6,200.00	1,400.00	1,000.00	2,800.00	2,300.00	3,000.00	23,500.00	3,500.00	6,300.00		85,348.74	16,276.54
Illinois	448,996.51	36,000.00		13,000.00		25,000.00		147,894.25	13,351.16			684,241.92	
Indiana	347,416.89	14,075.74	3,786.89	6,405.38	6,266.88	7,143.78	49,188.73	176,483.70	52,445.93	841.27	3,100.00	667,155.19	440,190.84
Iowa	308,706.94	14,646.64	1,480.56	3,252.18	1,529.61	14,239.49	20,922.41	181,367.01	28,055.37			574,200.21	180,619.66
Kansas	189,762.02	4,326.28	3,173.30	2,591.40	7,219.95	921.26	6,939.35	53,773.38	23,320.04	1,178.50		293,205.48	186,610.13
Kentucky	184,895.78	7,250.97	981.68	1,700.82	10,765.40	2,452.58	20,157.31	48,465.21	10,392.03	8,176.92		295,238.70	
Louisiana	236,233.70	16,539.29	1,064.70	2,608.51	5,895.91	2,454.90	10,051.06	47,990.22	24,712.02	2,217.18		349,767.49	
Maine	100,322.56	8,397.16	2,956.11	985.25	14,616.64	4,443.93	3,962.43	20,716.00	4,924.29	2,333.18		163,657.55	30,194.23
Maryland	78,061.95	2,916.82	259.63	1,012.50	1,529.76	666.80	10,932.68	57,151.11	13,548.21	4,196.04	9,594.20	179,869.70	55,400.15
Massachusetts	161,297.84	3,438.84	591.38	2,383.34	1,657.99	2,850.06	1,566.25	15,240.46	5,760.58	305.20		195,091.94	26,191.20
Michigan	194,261.02	14,650.37	619.98	954.24	2,529.23	17,543.26	10,244.63	38,667.90	9,678.42	551.45		289,700.50	
Minnesota	367,411.28	15,481.16	2,197.90	4,250.29	7,357.52	8,928.40	45,826.83	73,263.59	21,151.95	1,645.03		547,513.95	
Mississippi	202,344.55	5,500.34	2,326.20	1,656.20	6,188.46	5,553.73	17,353.20	31,097.36	39,504.22	19,193.30		330,717.56	219,993.09
Missouri	99,575.19	5,698.64	1,298.29	2,741.22	3,853.59	6,260.76	7,575.32	62,499.60	17,887.87	2,015.30		209,405.78	122,889.38
Montana	123,454.86	3,231.38	1,901.06	1,105.71	3,431.89	866.69	8,716.87	36,352.20	18,300.42	5,882.90		203,243.98	86,582.73
Nebraska	58,040.81	6,448.75	3,780.52	2,555.38	10,297.67	4,564.82	13,019.85	131,776.88	32,846.36	1,256.56		264,587.60	
Nevada	2,587.47	723.19	77.42	282.82	2,284.17	62.39	3,494.90	3,323.97	2,388.79	3,295.30	16.67	18,537.09	16,672.97
New Hampshire	7,612.27	181.65	22.92	28.96		100.00	33.24	1,033.03	261.29			9,273.36	29,094.37
New Jersey	436,645.02	7,658.22	359.20		20,796.16	7,876.66	15,680.75	82,929.33	910.43		746.01	573,601.78	14,681.23
New Mexico	26,406.81	639.96	377.07	325.29	2,594.92	576.43	7,080.82	11,095.85	1,618.68			50,715.83	74,023.38

New York:														
Cornell	639,537.25	16,406.31	2,153.31	7,441.42	66,382.71	2,396.72	15,735.44	111,557.16	33,151.22	1,303.21	----------	896,064.75	----------
State	352,274.55	8,308.19	722.29	3,607.85	10,256.69	4,284.67	20,220.75	45,940.37	14,454.71	----------	----------	460,070.07	----------
North Carolina	152,727.24	8,945.84	625.20	2,526.15	3,691.64	3,771.50	9,601.60	40,064.71	17,180.70	1,953.90	----------	241,088.48	18,319.01
North Dakota	62,068.19	3,294.04	543.60	783.84	20,967.71	2,620.89	5,698.28	23,075.16	17,607.94	49,808.28	870.43	187,338.36	35,947.55
Ohio	537,178.00	14,021.90	4,701.41	4,273.15	3,629.24	41,540.79	20,993.25	134,811.40	29,789.98	----------	----------	790,939.12	530,366.50
Oklahoma	233,022.09	8,011.96	5,171.53	1,982.98	7,541.90	2,115.66	10,460.24	82,458.74	21,789.78	9,796.85	----------	382,351.73	116,246.96
Oregon	321,085.22	14,852.50	2,336.42	4,269.41	10,874.13	2,582.61	19,116.83	61,397.84	26,028.49	9,890.68	4.17	472,438.30	----------
Pennsylvania	239,481.21	10,238.53	----------	1,477.19	2,657.33	2,830.61	4,888.01	69,866.67	18,564.91	5,627.33	----------	355,631.79	29,019.70
Puerto Rico	167,873.77	4,548.10	643.58	1,405.06	6,519.93	3,270.09	143.93	27,699.98	10,321.22	----------	----------	222,425.66	946.43
Rhode Island	8,385.11	1,300.08	41.09	184.11	441.12	171.23	1,129.44	8,482.23	3,219.24	----------	----------	23,353.65	10,297.36
South Carolina	171,607.15	3,937.46	6,580.69	2,057.68	5,823.30	695.40	25,036.60	145,662.96	32,281.14	63,365.26	2,724.37	459,772.01	143,282.99
South Dakota	50,955.74	2,574.31	538.93	149.03	851.94	540.02	1,043.58	32,707.33	5,492.83	----------	----------	94,853.71	43,152.54
Tennessee	89,646.56	1,219.48	1,967.25	1,141.09	2,276.54	2,925.66	14,077.96	44,769.08	16,591.75	9,716.74	----------	184,332.11	----------
Texas	456,209.87	7,407.91	1,408.97	3,377.86	15,180.96	4,419.69	53,202.25	117,504.93	85,447.99	37,580.03	5,319.55	787,060.01	436,179.58
Utah	59,415.12	3,851.34	380.43	1,361.00	5,026.95	3,494.54	2,899.01	15,099.50	10,583.35	27,096.40	1,532.92	130,740.56	29,024.28
Vermont	17,176.51	1,380.11	29.91	357.18	490.76	110.02	2,453.45	3,362.24	1,465.49	415.78	281.93	27,523.38	4,518.64
Virginia	140,749.66	14,817.49	855.57	1,993.99	5,811.70	3,191.56	5,671.49	19,298.41	11,717.24	11,565.24	----------	215,672.35	----------
Washington	266,575.78	13,173.11	4,806.79	2,568.91	7,110.57	6,065.78	11,242.31	79,503.65	18,937.87	1,097.20	3,050.80	414,132.77	----------
West Virginia	66,384.87	2,020.13	627.94	876.47	4,859.72	1,602.06	10,299.21	38,875.78	10,170.63	2,967.70	----------	138,684.51	30,852.37
Wisconsin	569,594.00	13,626.00	1,206.00	1,013.00	6,616.00	4,312.00	10,498.00	130,233.00	14,250.00	----------	----------	751,348.00	----------
Wyoming	38,517.97	1,846.63	825.99	743.40	----------	249.97	4,479.30	39,470.53	15,221.63	----------	----------	101,355.42	30,965.51
Total	10,926,927.44	434,785.58	81,662.03	130,757.00	394,126.52	256,530.71	666,441.72	3,130,332.65	935,282.94	356,553.04	29,349.61	17,342,749.24	3,738,129.43

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 1888–1945	Adams Act 1906–45	Purnell Act 1926–45	Bankhead-Jones Act 1936–45
Alabama	$869,199.34	$564,966.80	$1,099,903.19	$692,571.63
Alaska	210,000.00	60,000.00	40,000.00	18,641.50
Arizona	834,467.73	569,995.61	1,099,986.80	107,489.34
Arkansas	868,127.12	569,900.00	1,098,772.76	534,376.58
California	870,000.00	569,926.84	1,100,000.00	616,070.63
Colorado	869,718.82	568,638.93	1,100.000,00	187,859.29
Connecticut	868,478.53	570,000.00	1,095,791.38	179.051.26
Dakota Territory	56,250.00			
Delaware	868,258.28	563,809.32	1,093,139.91	42,620.85
Florida	869,966.06	569,996.06	1,096,523.74	273,885.81
Georgia	865,593.43	557,092.87	1,100,000.00	733,004.46
Hawaii	239,919.17	191,940.95	326,561.41	76,936.10
Idaho	794,824.13	565,842.22	1,100,000.00	116,898.06
Illinois	864,374.44	569,545.99	1,091,646.05	720,854.42
Indiana	869,901.19	565,000.00	1,096,007.26	523,775.67
Iowa	870,000.00	570,000.00	1,097,965.17	543,157.61
Kansas	869,995.00	570,000.00	1,100,000.00	419,176.79
Kentucky	869,996.57	570,000.00	1,100,000.00	671,487.20
Louisiana	870,000.00	570,000.00	1,100,000.00	467,220.00
Maine	869,999.62	570,000.00	1,100,000.00	173,296.84
Maryland	869,967.40	569,236.48	1,099,296.98	245,947.23
Massachusetts	869,617.70	570,000.00	1,097,691.78	154,246.81
Michigan	869,676.10	566,341.60	1,098,393.18	587,250.70
Minnesota	869,917.78	569,345.74	1,100,000.00	477,565.83
Mississippi	870,000.00	570,000.00	1,100,000.00	608,455.48
Missouri	865,097.24	569,999.90	1,100,000.00	644,012.64
Montana	780,000.00	567,417.04	1,100,000.00	129,838.97
Nebraska	869,932.16	570,000.00	1,099,995.00	324,754.02
Nevada	868,331.08	566,145.10	1,100,000.00	21,703.86
New Hampshire	869,250.00	570,000.00	1,100,000.00	70,592.35
New Jersey	869,959.97	569,392.06	1,100,000.00	258,591.83
New Mexico	834,509.05	570,000.00	1,100,000.00	118,268.38
New York	869,733.34	568,973.69	1,098,583.86	770,695.89
North Carolina	870,000.00	570,000.00	1,100,000.00	873,339.74
North Dakota	826,491.45	569,589.62	1,099,737.21	206,568.89
Ohio	870,000.00	565,020.68	1,091,402.82	778,868.86
Oklahoma	801,919.88	557,842.65	1,099,887.70	572,767.40
Oregon	855,156.64	565,000.00	1,100,000.00	179,430.41
Pennsylvania	869,967.43	569,995.41	1,100,000.00	1,130,557.21
Puerto Rico	164,638.71	153,339.74	215,913.48	414,304.53
Rhode Island	869,775.04	564,331.80	1,098,831.77	19,527.97
South Carolina	869,541.37	568,360.12	1,100,000.00	498,019.04
South Dakota	813,250.00	565,000.00	1,100,000.00	204,621.68
Tennessee	870,000.00	570,000.00	1,100,000.00	635,723.64
Texas	870,000.00	567,592.26	1,100,000.00	1,250,929.86
Utah	835,000.00	569,821.94	1,100,000.00	87,968.32
Vermont	869,072.14	565,660.96	1,098,798.56	86,444.18
Virginia	868,766.58	568,544.94	1,099,974.86	588,733.82
Washington	808,414.48	566,080.11	1,100,000.00	262,149.84
West Virginia	869,804.16	566,263.82	1,099,942.89	458,870.44
Wisconsin	870,000.00	570,000.00	1,100,000.00	504,382.69
Wyoming	825,000.00	568,850.59	1,100,000.00	56,610.98
Total	41,841,859.13	27,664,801.84	53,334,747.76	20,320,117.53

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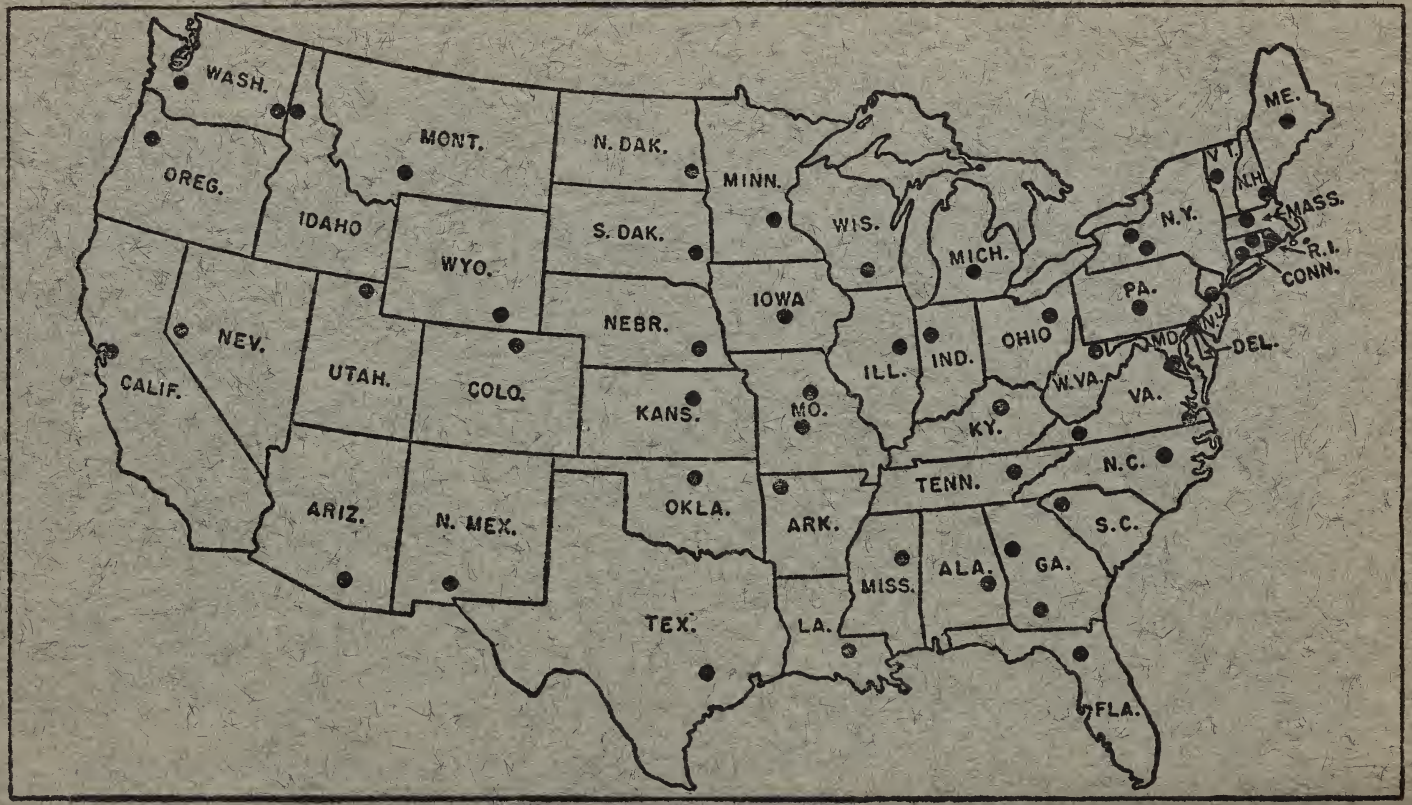
NOTE.—The full official titles, locations, and personnel of the agricultural experiment stations will be found in the list of Workers in Subjects Pertaining to Agriculture in Land-Grant Colleges and Experiment Stations, published annually by the United States Department of Agriculture.



HEADQUARTERS OF STATE AGRICULTURAL EXPERIMENT STATIONS