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OFFICE OF EXPERIMENT STATIONS

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REPORT OF THE AGRICULTURAL STATIONS, 1948[1]

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PROGRESS IN STATION RESEARCH

It is fortunate for our national economy that the findings of agricultural research serve the needs of the country in times of abundance as well as in times of scarcity, in times of peace as well as in times of war. In 1947, as in the previous war and postwar years, the demand was for all-out production. With present abundant yields of food, feed, and fiber crops and some easing up for the time being, at least, of the intensity of foreign demand, the results of research currently reported may now be employed to emphasize such measures as soil conservation, efficiencies in production and marketing, and the interests of the ultimate consumer. In the background of economic thought is the idea that any improvement in production passes on in due course to the consumer. The principal reason why agriculture is enabled to yield such excellent products as meats, milk, food grains, fruits, and vegetables of highest quality and in ample supply is because of the practical application by farmers and stockmen of the findings of research.

One of the progressive developments provided for under the Research and Marketing Act of August 14, 1946, was the establishment of authority and procedures for the planning and organizing of

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research on a regional basis. The Act provides that up to 25 percent of the funds appropriated as grants to the States may be used for attacking broad problems of regional or national significance. The funds are allotted to the cooperating States for the solution of problems that concern the agriculture of more than one State. The problems for which these allotments are made are recommended by a committee of nine persons, elected by and representing the directors of the State agricultural experiment stations, and are aproved by the Secretary of Agriculture or his authorized representative.

Soon after the approval of the act, the so-called Committee of Nine was elected by the experiment station directors to include two directors from each of the four regions and one administrator of home economics research at large. This committee, working with the directors of the four regions and representatives of the Office of Experiment Stations, had a well-planned program of cooperative regional projects ready for immediate work as soon as the appropriation for 1948 became available. The approval program for 1948 deals with problems in the following major subjects:

1. The marketing of agricultural products, including cotton and cottonseed, fruits and vegetables, milk and dairy products, livestock and livestock products, potatoes, and poultry and eggs.
2. The improvement of cotton by means of fundamental studies in cotton genetics, and research in the mechanization of cotton production, harvesting, ginning, and cleaning.
3. Foods and human nutrition, including studies of the nutritional status and dietary needs of population groups, family food consumption in types of farming areas, and the effects on the nutritive qualities of vegetables caused by variations in soils and weather.
4. The introduction of new plants, including their multiplication and the determination of their potential value for industrial and other purposes and the preservation of valuable germ plasm of economic plants.
5. The improvement of rural housing and of farm buildings and equipment. Work in this field includes the determination of the housing needs of farm families in various sections of the United States and the development of plans to meet these needs, as well as studies designed to lead to more economical and efficient barns for dairy cattle.
6. Diseases of farm animals, with major emphasis at this time on the Newcastle disease of poultry.
7. The improvement of beef cattle through the application of breeding methods; the improvement of dairy cattle through breeding, including research on the causes and prevention of sterility; and the improvement of poultry through breeding, particularly to determine the merits and feasibility of producing hybrid poultry.

Virtually all of the cooperative regional investigations established by the State experiment stations during 1948 were planned and carried out in cooperation with one or more research bureaus and agencies of the United States Department of Agriculture. The number of experiment stations participating varied from 2 to 12 for each line of research undertaken.

Most of these regional studies will necessarily involve several years of fact-finding before the results can be made available in final form. During the first year of the work, however, considerable information on segments of the research was released in the form of progress reports and these communications have been made available for the benefit of the particular groups of producers or consumers concerned. The results thus far accumulated are discussed along with the other contributions of the stations taken up elsewhere in this report. Major benefits to future agriculture may be anticipated from such a pooling of scientific ability and experience, as well as from the improved facilities for research provided for by the new legislation.

Research is essential to the betterment of the country's agriculture, to the improvement of human welfare, and to the security of the Nation. It is the function of the experiment stations to contribute through research the information that will provide for the progressive development of the agriculture of the country. This report presents examples of the background, progress, and application of recent station findings—often in cooperation with the Department—on some of the more important problems now confronting the farmer and homemaker. Such researches provide the building stones of a more permanent agriculture, which in turn benefits the public as a whole.

AGRICULTURAL ECONOMICS

At any given time the services that scientific research renders the Nation through its agriculture may be evaluated by the lines of research that are active during the year and by the published results. Through the year ended June 30, 1948 these active lines of research in the field of agricultural economics included 130 in farm management; 39 in farm finance; 55 in land economics; 265 in marketing, compared with only 89 in 1947; 55 in prices, compared with 32 in the previous year; 20 in commodity economics; 66 in farm business; 3 in large-scale research undertakings; and 1 in agricultural industry.

Research results in farm economics of value to farmers in making necessary adjustments to a changing outlook are illustrated in the examples that follow:

The Iowa station reports that the initial pattern of farm size in the State was established by the nature of early land policies. The typical claim of the "squatters" was 320 acres, but a new pattern of farm size developed as soon as disposal of public lands began. The rectangular survey and the Preemption and Homestead Acts established a modal unit of 160 acres. During the period 1890 to 1920 the trend in farm size was away from small and large units toward those of medium size. Since 1920, however, the noticeable trend has been in the direction of larger farms. The pattern and extent of adjustment have varied by areas within the State. Thirty-four counties in the northern half increased slightly in number of farms between 1920 and 1940. The greatest farm consolidation took place in the southern third of Iowa. Numerous factors explain this trend toward larger and fewer farms. Mechanization has favored farm consolidation, and the greater part of it has come about in counties of low income. The farm size adjustments occurring in Iowa do not immediately imperil the family-size unit. On less productive lands, consolidation is necessary if incomes are to compare favorably with alternative

opportunities. Little of the decline in the State's farm population can be attributed to larger farms.

An investigation by the New Mexico station from 1938 through 1942 concerned some 20 cattle ranches in the southeastern part of the State. The average ranch contained 29 sections of land. Many southeastern New Mexico ranches are too small to afford the family a standard of living equal to that of the average for the country as a whole. With profits increasing more people may be attracted into the farm business, and ranching units may become even smaller and carry large debts, or fewer people with more capital may control larger units.

Nearly all the gross income of a cattle ranch in this area comes from the sale of range cattle. The percentages of cash expense for the 5 years were: 34.3 for feed, 15.3 for hired labor, 10.5 for lease fees, and 7.9 for interest. Other cash expenses such as for livestock, repairs, auto and truck, taxes, and miscellaneous, accounted for the remaining 32 percent. Many southeastern New Mexico ranchers believe that the open, mild-winter season, yearlong grazing of the range, and the characteristic summer distribution of precipitation, with its effects on range forage growth, favor the production of calves. The cow-calf production pattern has become established by years of practice. Ranch production data reveal, however, that grazing the yearling steers returns more income per section of land and would be a more flexible practice to follow in periods of drought. Since net pounds of beef produced per animal unit decrease as grazing becomes more intense, successful cattle ranchers should follow a conservative and flexible grazing policy. Just as the romance of livestock ranching has given way to the application of economic and business methods, so must the present-day rancher adopt a policy consistent with maximum profits over a long period of time rather than a get-rich-quick scheme.

In a study of small farms, the Wisconsin station discovered that two basic facts stand out: (1) Small farms are organized in about the same way as larger units as regards systems of cropping, sources of income, farming practices, and in most other respects. The smaller amount of work on these farms is offset to some extent by a smaller amount of available labor per farm. The small farms of the area are relatively well mechanized. Although they are worked less intensively and have less productive soils, the difference between them and other farms in the same communities is still not great. (2) These small farms have a real place in rural society. They furnish a means of retirement or semiretirement for many families where the operator wishes to continue a fairly active life without the responsibilities of a larger farm or a full-time nonfarm job. They constitute a reasonably satisfactory unit for a group of farmers who have the abilities to handle a small farm well. They are also a haven of refuge for some families that have but little incentive or are lacking in managerial ability. Finally, they furnish the opportunity for young people with little capital to get started without an excessive burden of debt.

Results of a study by the Indiana station indicated that significant changes in agriculture had taken place in Forest Township, Clinton County, as revealed by actual records on 100 farms for 1910, 1913-19, 1932, and 1945, along with other correlative information. Some of these changes are temporary, being associated with prices; others are indications of changing technologies and agricultural problems. The

average labor income of the 100 farms was $3,466 in 1945 as compared with a loss of $120 in 1932 and only a $1,057 income in the World War I period. The average capital per farm increased from $12,000 in 1932 to $42,000 in 1945. The average size of the 100 farms increased from 116 acres in 1910 to 174 in 1945. The association of size of farm with labor income was much greater in 1945 than in the earlier periods. Long-time crop changes from 1910 to 1945 included the introduction of soybeans and tomatoes, a decrease in hay and pasture acreage, and an increase in crop yields. Livestock changes included decreases in colts and beef cattle; small increases in poultry, dairy cattle, and hogs; and intensification of poultry raising.

Mechanization showed one of the most significant changes. By 1945, 67 of the 100 farms had no horses; 57 had 1 tractor each and 35 had 2 or more. By 1945, 47 percent of the hay was harvested with balers, 28 percent with buck rakes, 9 percent with choppers, and only 16 percent with hay loaders or by hand. Ninety-one percent of the corn was harvested with pickers and 92 percent of the small grain was combined. Numerous changes took place in marketing, in local government finances, and in home improvements. Many of the changes in Forest Township are indications of long-time trends in Indiana agriculture that need recognition as a basis of decision on matters of individual and public policy.

The results of a survey by the Illinois station show the kind, amount, and cost of labor used on Illinois farms. Family labor was used on 97 percent of Illinois farms in 1946, seasonal labor on 63, and year-round workers on 17 percent; commercial custom work was done on 56 percent of the farms. About one-fifth of the total labor used was hired; some hired labor was used on 67 percent of the farms, but only a few used large amounts. Year-round workers supplied 11.3 percent of the total, seasonal workers 7.7, and commercial custom workers 0.6 percent. Less than a month of labor was hired on 39.3 percent of the farms using such labor.

Only about one farm in six hired a full-time year-round worker or his equivalent. Of the total labor shown to have been used on Illinois farms in 1946 (3,154,793 work-months), four-fifths was unpaid family labor, 64 percent having been contributed by the operator and 16.4 percent by other members of the family. Seasonal workers were used mainly to supplement family and year-round hired labor during busy seasons. More than 90 percent of the seasonal workers were paid by the day; the rest were paid on a piecework basis. Of the total day labor used in the State, men contributed 90 percent; women and youth, 5 percent each. Year-round hired workers contributed 58.6 percent of the hired labor used in Illinois in 1946. Married men contributed 55.4 percent of the year-round hired labor; single men, 44.6 percent.

The average monthly wage paid married male workers was $168; single workers, $142. About an equal amount of farm work in Illinois in 1946 was done by farmers and custom workers. The machines used most often in custom operations were combines, corn pickers, hay balers, and threshers, all of which were used with tractor power. Illinois farmers in 1946 exchanged an estimated 40,000 months of labor with machines and 20,000 months without machines.

In a study by the North Carolina station of the impact of industrialization upon agriculture in Gaston and Davidson counties, it

was found that a highly significant positive relationship existed between farm family incomes and the proportion of the family labor force employed off the farm in 1943 in these counties. Even in 1943 there was a high degree of underemployment of farm family labor. Other things remaining equal, employment could not be given to this unused labor by increasing cropland acreage alone. The unused pool of farm manpower resulted in large part from the extremeness of the seasonal variations in farm-labor requirements. Existing off-farm employment opportunities, although characterized by low wages and little seasonal variation in labor, are needed to complement the fluctuations in farm labor requirements. Only about half the off-farm incomes were reflected in increased total family incomes, because there was a considerable decrease in farm labor earnings accompanying increased amounts of off-farm work. Decreased farm labor earnings were largely attributable to decreased acreages in cash crops, particularly cotton.

A report on costs and returns in milk production for local Maine markets serves as the basis for emphasizing to Maine dairymen how production costs can be reduced. An average saving of 1 cent per quart can be obtained either by an increase of 1,000 pounds in annual milk production per cow, or by increasing the size of the herd by 10 cows. Artificial insemination not only makes it possible to breed better cows on many farms, but also permits keeping another cow in place of the herd bull. The cost for artificial service was about $2 per cow less than the average cost where a herd bull was kept.

In Tennessee the State experiment station found that there was a total of 20,797,000 board feet on 6,000 acres of forest land in the sample area. This timber was growing at the rate of 209.3 board feet per acre each year. These figures applied to the project area give a total of 86,990,000 board feet of timber, with an annual increment of 5,500,000 board feet. The average yearly drain for farms having woodlands is 1,800,000 feet, leaving a balance of 3,700,000 feet that could be sold. Only 2,000 farms, or 50 percent, in Greene County have at least 5 acres of woodland per farm. Woodland in the agricultural area of this county is only about 10 percent of the total farm acreage. Of the 47,641 acres of woods, 23,820 acres, or about 50 percent, are grazed. The 26,200 acres of merchantable woodland carry 86,990,000 board feet of timber. The 21,430 acres of unmerchantable woodland have 87,800 cords of wood. The consumption of wood in Greene County is 11,100,000 board feet per year; farmers use about two-thirds of this amount.

To answer the question whether it would pay farmers to change from a soil-wasting to a soil-conserving system, the Kentucky station made a study of farming in the rolling-to-hilly areas of Type-of-Farming Area VII in Kentucky. Two representative farms of this area—where reorganization plans were under way in cooperation with the United States Department of Agriculture Soil Conservation Service—were studied intensively from the time of the present survey through a 5-year period in which the proposals for improvement had largely been carried out. As a result of improved land husbandry and the adaptation of the farm business to it, each of the farms over the 5-year period were at a slightly lower total expense than before reorganization and yielded markedly higher production and income.

On Farm No. 1 the income over 5 years averaged about $2,200 more than before reorganization; on Farm No. 2, about $1,600 more.

Major increases in income were from the sale of grain crops, beef cattle, and hogs. On both farms, the expenses were greater for crops and machinery and lower for feeds, Farm No. 1 had a higher labor expense after reorganization than before. During the 5-year period the differences between receipts and expenses ranged from $1,519 to $4,325 per year for Farm No. 1, and from $1,473 to $2,605 for Farm No. 2 The land was used according to its natural adaptation and for this purpose was classified as (1) land suited to intensive use of intertilled crops without special soil-conservation practices, (2) land requiring moderate conservation practices, (3) land requiring intensive conservation practices, (4) land adapted primarily to perennial vegetation, and (5) land unsuitable for cultivation.

From an inquiry designed to determine the cost and performance rates of tractors and tractor implements, the Georgia station found that 68 farmers owned 85 tractors; of these tractors, 24 were small, 45 medium, and 16 large. Crops averaged 207 acres, of which 96 acres were in row crops and 111 acres in small grains and legumes, including lespedeza. Farms with tractors only were smaller than those with both tractors and workstock. The investment in tractors and tractor equipment averaged $1,880 on farms with tractors only and $1,698 on farms with both tractors and workstock. Tractors accounted for about 42 percent of the value of mechanical equipment on farms with tractors only and about 44 percent on those with both tractors and workstock.

The annual use of all tractors averaged 664 hours each, but varied somewhat according to the size of tractor employed. The 24 small tractors were used an average of 757 hours as compared with 636 for the 45 medium tractors and 600 for the 16 large tractors. The total cost of operating averaged 39 cents per hour for all tractors and 27 cents for small, 39 cents for medium, and 58 cents for large tractors. Fuel was the most important item for operation, while depreciation was the most important fixed cost; the expense of operation was higher on farms with both tractors and workstock than on farms with tractors only. One of the chief factors influencing the unit cost of operating tractor implements is the amount of annual use.

In a study designated to learn how ranchmen can maintain financial solvency through both good and bad years, the North Dakota station considered severe droughts to be the greatest menace to stable range-cattle production in the western part of the State. Nevertheless, ranches in that area are better prepared to "weather" periods of drought than at any other time in history. Sixty-four percent of the area investigated—7 percent more than has been classed as best suited for grazing or grazing-forage production—is being used for grazing or the production of wild hay. Operating units have decreased in numbers and increased in size, the average size now being the largest on record. Land ownership has increased materially during the recent favorable years. More attention than formerly is now being given to feed production and winter feeding.

Among the important characteristics of ranch organizations best able to maintain financial solvency through good and bad years alike are: A sufficiently large operating unit to provide a satisfactory

living for the operator and his family under normal conditions of weather and prices and at the same time to permit the accumulation of cash reserves during favorable years; permanent or long-time control of grazing and feed-producing land through ownership, long-time leases, or grazing permits on the public range; an established rate of stocking the ranch that will provide ample forage during normal seasons with some reserve grass at the end of the season; dependable feed-producing land, preferably surface-irrigated or subirrigated, or good quality upland; a reserve supply of winter feed, preferably good quality hay; production of livestock that can be lowered in numbers without seriously reducing the breeding herd; and adequate finances, either cash reserves or dependable bank credit, adapted to a range livestock economy.

From data obtained in an investigation of the cost of producing milk, the Alabama station determined costs on both wholesale and retail farms. The size of the wholesale farm included in this study varied by areas from 93 acres on Sand Mountain to 749 acres in the Piedmont area. The total investments averaged $33,445 per farm. The average wholesale farm had 59 cows, with an average annual production per cow of 4,700 pounds of milk. The net cost of producing a hundredweight of wholesale milk varied by areas from $3.79 on Sand Mountain to $6.25 in the Gulf Coast area. The chief expenses were for feed and pasture. Practically all the feed costs in the Gulf Coast area were for purchased feed. The quarter of the year with lowest costs was usually the one of highest production.

Twenty-five farms averaging half their milk production in summer and half in winter had a total output of 5,012 pounds per cow. Twenty-nine farms averaging 37 percent of their milk production in winter and 63 percent in summer gave a total yield of only 4,295 pounds per cow. Total costs per hundredweight of milk increased with the size of the herd from 13 to 104 cows by 54 cents per hundredweight because of increased costs for feed. Pasture and feed costs made up 56 percent of the gross expense of producing milk on wholesale farms. The average retail farm had 81 cows with an average production of 5,048 pounds of milk in 1945; the capital investment in these farms averaged $37,026 including 58 percent in real estate.

On an enterprise basis, the net cost of producing, processing, and distributing a hundredweight of milk varied from $6.26 on the Montgomery market to $8.65 on the Birmingham market and averaged $7.96 for all retail farms. On a farm-cost basis, the average net cost of producing, processing, and distributing a hundredweight of milk was $8.02, or 6 cents higher than on the enterprise basis.

From a survey of the influence of management practices on the cost of producing broilers, the Delaware station determined the average to be $891 per 1,000 and 29 cents per pound; feed and chicks made up approximately 85 percent of the cost. The average "out-of-pocket" cost of producing broilers was $844 per 1,000 and 27.4 cents per pound; feed and chicks here made up about 90 percent of the out-of-pocket cost. A 20,000-bird flock was about the minimum size from which a producer might expect to get reasonably good returns on his labor and capital. Good management requires a minimum of about 13,000 broilers per man.

Each increment of 1 percent in mortality gave an average increase in cost of production of 0.2 cent per pound. The mortality rate should not greatly exceed 6 percent. The optimum floor space proved to be 0.6 to 0.7 square feet per chick. Approximately 14 weeks (weight, 3 pounds) was the optimum age to market broilers. The cost of production on the different farms varied from 22.4 to 44.7 cents per pound—a range of 100 percent. Costs were influenced by size of flocks, labor efficiency, mortality, floor space, age at which sold, quality of chicks, and feeding practices.

On the basis of data obtained from detailed cost records, the Oregon station determined that the cost of producing a ton of ungraded beans was 104 hours of man labor plus $21 for costs other than labor. Of the labor required, 92 hours were hired; the other 12 hours were contributed by the operator and his family. The expenses ranged from a low of $87.60 per ton for the 10 low-cost producers to $151.40 for the 10 growers having the highest costs; the average for all 67 growers was $104.60. This cost was based upon an average yield of 7.9 tons of ungraded beans per acre and upon fields averaging 9.3 acres in size. Labor accounted for 79.1 percent of the total cost, equipment for 8.8, supplies for 5.4, and miscellaneous items, including taxes and interest, for the remaining 6.7 percent.

The average cost of producing an acre of beans was $822.90; cash costs represented 76 percent of the total cost of production. The total labor used on beans amounted to 824.2 man-hours per acre based upon an average yield of 7.9 tons. Over 83 percent of this labor was concentrated within the harvest season (July-September). The average investment in farm property used in producing an acre of beans amounted to $784. Land accounted for over half this amount, with irrigation equipment representing 20 percent and yard equipment 11 percent of the total. The bean land was valued by the growers in 1946 at $431 per acre; their estimates of its "normal" value averaged $241.

Three factors were largely responsible for variations in costs among individual growers. These were (1) tons of beans preduced per acre, (2) hours of labor per acre exclusive of picking, and (3) acres per bean yard. Throughout this study, the data point to good management, expressed in high yields and the economical use of labor, as exceedingly important factors in lowering the costs of production. The results are further substantiated by a comparison of the 10 high-cost with the 10 low-cost producers. The latter had average-sized bean fields from which they obtained yields averaging about 10 tons per acre; the high-cost producers had fields only half as large.

A study by the Kansas station of the 50-year history of the Kansas Farmers Mutual Insurance Association (known since 1940 as Upland Mutual Insurance, Inc.) is of interest to those engaged in rural cooperative enterprises and institutions. This company has restricted its activities to fire and wind insurance and is notable for its continuity of managerial personnel. The dominant factors in the company's success are the persistent devotion of its directors and its preference for good service within a limited field rather than for expansion into other fields at the possible expense of reliability and quality.

In an analysis of dairy farm earnings, the Oregon station found the average size of 10 farms for the 7-year period 1940–46 to be 115 acres,

of which 29 were mainly in hay and silage and 50 in tillable pasture. The average number of cows on the farms studied in Tillamook County was 37 each. According to the farmers' own estimates the total value of all farm capital was $29,672 per farm, of which $23,177 was for land and buildings, $2,909 for the cows, and $2,089 for machinery and equipment. Income from the sale of dairy products and dairy cattle amounted to 96.5 percent of the total receipts on the farms studied. Total farm receipts over the 7-year period averaged $9,582 per year; farm expenses averaged $6,754, thus leaving a net farm income of $3.029 after allowing for an average annual increase in inventory of $201.

The average rate of interest earned on the total investment for the 7-year period was 7.1 percent, varying all the way from 2.8 percent in 1940 to 11.6 percent in 1946. Profit per cow (net return above all costs) averaged $27 per year for the 7-year period, but ranged from minus $10 per cow in 1940 to a plus figure of $65 per cow in 1946. Profit per pound of butterfat (net return above all costs) averaged 8 cents per pound for the 7-year period, but varied from minus 3 cents in 1940 to a plus figure of 20 cents per pound in 1946.

The most profitable group of farms was more successful financially than the least profitable ones because of the larger number of cows, greater amount of capital to work with, the fact that there was sufficient work for two full-time men (least profitable farms had too much work for one man but not enough for two), larger gross sales with less actual expense per farm, larger acreages of crops, higher carrying capacity of pastures, and lower feed purchases per farm and per cow because of greater dependence upon home-grown feeds. The results of this study emphasize the importance of as large a size of business as is consistent with the efficient use of land, labor, and capital for the successful operation of farms in Oregon.

A survey of 69 Palouse wheat-pea farms was made by the Washington station in the fall of 1946 to determine the immediate benefits from conservation farming. Farms were segregated for study on the basis of the amount of conservation applied from 1941 through 1946. The application of conservation on the farms over this period ranged from 21 to 87 percent. Net incomes on farms having the most conservation compared favorably with those having less. High-conservation farms averaged 4 percent less cropland in wheat and peas, 13 percent more in grass-legume crops, and over 8 percent less in clean cultivation than did the low-conservation farms. More livestock was reported on high-conservation farms; these averaged 20.3 animal units, compared with 12.3 on the low-conservation farms.

No consistent differences were found in wheat and pea yields. Lack of higher yields on high-conservation farms is believed to be due to the comparatively short time the program was in effect. Most of the lands on these farms have grown only one green manure crop and others none at all. Experimental data reveal that second and third applications of green manure crops in the rotation produce the highest yields. Labor requirements were about 17 percent higher on farms with the most conservation; this was due mainly to the fact that these farms had more hay crops and livestock, which in turn were important factors in increasing the income. No important differences were discovered in the tractor hours or machinery costs per acre on farms with differing amounts of conservation applied.

The Virginia station in cooperation with the Department reports that Virginia has a land area of 25,535,360 acres, of which 2,193,000 acres are in public ownership. Several kinds of public ownership exist—Federal, State, county, and municipal. More than 2,000,000 acres in Virginia are owned by the Federal Government, or nearly 8 percent of the total land area. The State owns 77,000 acres, or about 0.33 percent. County and municipally owned lands total only a fraction of 1 percent—about 88,000 acres for those units reporting. Publicly owned land constitutes 5 percent or more of the entire area in 42 counties, over 10 percent in 29, over 20 percent in 14, over 30 percent in 8, over 40 percent in 4 counties, and over 50 percent in 1 county.

About 90 percent of the total land area is privately owned and assessed for taxes. A relatively small acreage of privately owned land is tax-exempt; such land is used mainly by churches, private schools, and charitable organizations. Cities, villages, and small settlements of 100 or more population take up 2 percent of the land area, or 500,680 acres. The inland water area, which is in addition to the figures given above, is approximately 586,000 acres.

The Massachusetts station reports that the acreage of improved farm land in that State to have decreased by 50 percent during the last century, and many adjustments in crop and livestock production. Poultry and dairy enterprises that depend upon western grain areas for feed have supplanted sheep and beef cattle production. Vegetable and fruit production fail to meet the local demand. Intensive crops with a high per-acre value have been substituted for grain crops. Lower production costs in other agricultural areas have been responsible for these shifts and for abandonment of much farm land in the State. Nevertheless, efficiency of production has increased in many of the farm enterprises.

Improvement of abandoned farm land has become possible in recent years because of higher prices for farm products and the more general availability of heavy machinery. Higher profits and technological advances in agriculture have increased the interest of farmers in land improvement and soil conservation. The decision to improve land should be made only after careful study of the economic and physical factors involved, including probable costs, expected returns, total benefits to the farm, type of soil, topography and location of land, type of cover to be removed, possible changes in the farm plan, and alternative uses for the money to be paid for improvements.

The following conclusions are based on analyses of records on land improvement work, on case studies of individual clearing projects, and on the appraisal of correlative information. Type of soil and topography of land to be cleared should be adapted to the prospective agricultural use. Size and type of machinery should also be adapted to the conditions for each job. Small bulldozers at low cost per hour may be more expensive for heavy work than larger machines. High costs per acre may be justified if the returns are also large. Low costs may prove more expensive in the end if returns are low. Development of new farms by land-clearing will be justified only in unusual cases such as for the production of specialized crops with a high per-acre value.

In a study of land values during two wars, the California station found that the average price of farm land in California is higher than ever before. In the early 1920's, California real estate values

had climbed to new heights. Within 2 years after war's end, United States real-estate values tumbled abruptly to new lows, but California farm real estate remained nearly on its war-time high level for 10 years more, then dropped with the major general depression. After World War I California differed greatly from the country as a whole in behavior of land prices. United States prices dropped abruptly during the first 2 years, then continued downward until in 1930 they were only 69 percent of the 1920 peak. California prices dropped very slightly until 1931, when values were still 95 percent of their 1921 peak. From 1930 to 1933 land values in the entire country fell to the lowest point reached between the two wars. At this low point, in 1933, California values were only 65 percent of their 1921 high, but still 9 percent higher than their prewar level.

In recent years California farm real-estate values, again in common with values for the country as a whole, have climbed to even higher levels than before. On March 1, 1947, farm real-estate values in the State were 45 percent above their World War I peak, a greater increase than in any other part of the country. Up to the closing months of 1947, land values were still rising but there were signs of an approaching end and some indications of a probable decline. After World War II these values in both the United States and California continued their upward trend, and by March 1947 they had reached 102 percent above prewar level in the latter but only 92 percent in the country as a whole.

The Maryland station reports that land values continue to rise sharply in that State. The index of average value per acre of farm real estate—based on the years 1936-40 as 100—was 191 for the 6 months ended June 30, 1946, in the five counties under study; this was an increase of 20.9 percent over 1945. For these counties the average sales price ranged from $36.86 per acre in 1936 to $77.02 in 1946. Voluntary sales were the most important type of transfer, such sales accounting for 60.9 percent of all transfers in 1936 and for 83.5 percent in 1946. The number of voluntary sales increased from a total of 459 in 1936 to 814 in 1944, or an increase of 77.3 percent, but declined approximately 4 percent in 1945.

Farm operators were the most important type of buyers in the farm real-estate market. Distributed according to types of sellers during the 10-year period, 46 percent of the farms were sold by operators, 38 percent by other individuals, and 6.4 percent by corporations. The real problem is how to safeguard investments in farm real estate from the effects of a sharp drop in farm prices in the near future.

Some suggested alternatives by which present investors in farm lands can make a practical application of the findings of this study include large cash payments on present or future purchases of farms in order to reduce mortgages rapidly while farm prices are still high, reduction of present farm mortgage indebtedness to amounts that can be carried easily in a depression period, investments in equipment and improvements that will increase income and/or decrease production costs, refusal to loan money for speculation in farm lands, and use of present surplus funds to build up cash reserves as a cushion against future possible drops in farm income.

Reporting for the North Central Land Tenure Committee, the Michigan station briefly summarizes the World War II farm-land

situation as follows: Average sales prices increased steadily, active farmers were the main buyers and sellers, little evidence of speculation was found in the market, volume of sales approached all-time records, over half the sales were for cash, mortgages in 1946 were often greater than the 1941 sale price, mortgage interest rates decreased, nearly half the mortgages were for 5 years or less, and nearly a quarter of them were at 75 percent or more of the purchase price. Finally, the high farm incomes have been the strongest force in stimulating the land market.

The Texas station in cooperation with the Department reports that during 1947 the prices of farm land advanced to record levels in the sample areas of the Texas land market study. In contrast to these price trends, the volume of sales declined substantially during 1947. Only 481 bona fide land sales were made last year in the three sample counties, as compared with 790 in 1946. Both the number of sales and the acreage involved were down in 1947 to about the levels of the first war year. Those farmers who were almost exclusively owner-operators bought the majority of the tracts sold, as they have continued to do throughout the war and postwar years. In Jones County the average selling price of land rose to $65.41 per acre, or 33 percent over the 1946 average; in Ellis County the average was up to $63.78 per acre, 12 percent over 1946; and in Nacogdoches County it rose to $28.49, a 3-percent increase.

Sales volume dropped in 1947 except in Jones County, where the number of land transfers was about the same as for the previous year. This decline in turnover following the 1946 record volume indicates a tightening of the land market. Acreage volume was also down during the year. The average size of the tracts transferred remained about the same, except in Nacogdoches County, where it increased sharply. Owner-operators of farms made up almost half of all sellers in the three counties studied. Farm owners continue to be the leading buyers of farm land. Tenants figured even less significantly in the land market of 1947 than during 1946. Most buyers expected to operate the land they purchased.

The evidence at hand points to a continued increase in the size of individual operations through the purchase of additional tracts. Buyers' equities dropped slightly during 1947, continuing the decline that began in 1946. Individuals continued as the chief source of the credit used in financing farm purchases. An important change in the mortgage credit situation was disclosed by the reappearance of the Federal Land Bank as a sizable lender of funds.

A report on landlord-tenant relations prepared by a subcommittee of the North Central Regional Land Tenure Committee was issued recently in mimeographed form by the Ohio station. Attention was called to some of the developments contributing to the need for a current appraisal of changes in landlord-tenant relations. Some of these developments include the adoption of mechanical power; the increasing importance of soil conservation practices such as liming, use of commercial fertilizer, and maintenance of humus; changing price relationships; high labor costs; low interest rates; the increasing importance of building and other capital items arising from increases in livestock and equipment; the need for labor-saving devices; the demand for better living conditions on farms; new property rights grow-

ing out of group action, such as the milk and tobacco basis and conservation payments; changes in type of farming and in farm practices; introduction of new enterprises and shifts in the relative importance of the several enterprises; and changes in the relative bargaining power of land owners and tenants as the result of supply and demand and financial position.

Attention was also called to some factors contributing to harmonious relations between landlord and tenant, including an equitable division of expenses and receipts; and provisions for maintaining and improving the farm resources, for better living, and for reasonable security. Conditions affecting the lease included personal relationships, custom and legal framework, community attitudes and facilities, participation in community affairs, alternative opportunities, and size and quality of farms.

For the purpose of analyzing successful efforts and warning against possible causes of failure, the Pennsylvania station made a study of examples of successful father-and-son business agreements. Estimates from two-thirds of the counties of the State indicated that less than 5 percent of the farms in 1946 had working agreements with adult sons in the operation of their farm businesses. Less than 1 percent of all farmers had definite agreements with sons concerning reimbursement. When agreements were made they were seldom partnerships. This lack of agreement between father and son obtains because the average Pennsylvania farm has neither sufficient productive work to keep two men fully employed nor adequate income to support two families. Another reason is that only about one farm in four has more than one dwelling.

The different kinds of agreement may be classified as partnership and nonpartnership. The latter form may be subdivided into wage or wage-plus-bonus agreements, reimbursement from certain enterprises in place of wages, renting or selling the farm to the son, and loan of money or machinery. Each of these classes was in some cases used as a preliminary step to farm ownership. A high percentage of the comparatively few farm partnerships proved satisfactory to both father and son; less than 10 percent could be rated as unsatisfactory.

Factors leading to success included compatibility, farm businesses of adequate size, good farm management, a liking for farm life, satisfaction with the details of an agreement, good business judgment on the part of those in the partnership, fairness and cooperation between father and son, provision for separate houses, keeping of accurate farm records, an inclusive agreement in which both parties share in the entire business, investment opportunities for the son's savings, and, finally, the fact that the agreement was clear, equitable, and definite and provided for all foreseeable contingencies.

The South Carolina station, cooperating with the Department, the other six southeastern experiment stations, and the Farm Foundation, in a survey of land tenure discovered that in the southeastern region in 1945 the rate of tenancy was the lowest since 1890 and the number of full and part owners was at an all-time high. War-related influences accelerated and strengthened the trends that had been evident during the late 1930's. As a proportion of all farms, tenancy reached a peak in 1930 when 53 percent of the region's farms were tenant-operated, but the number of tenants continued to increase for another

5 years. From the 1935 peak, tenancy declined both relatively and absolutely, with the greatest drop taking place during the war years.

With fewer people dependent on farming, the efficiency of labor in the region increased. Land in farms increased about 3 percent between the two census periods, 1940 and 1945, but the acreage operated by all tenants declined nearly one-fifth. All of this decrease occurred on land operated by white tenants. Nonwhite tenants farmed about 1 percent more land in 1945 than during the 5 preceding years; in spite of this slight expansion in acreage, however, the increase in their numbers resulted in a decline of about 6 percent in the average size of their farms. White-tenant-operated farms averaged about 50 percent larger than those farmed by nonwhite tenants in 1945.

The total acreage of cropland harvested was down about 6 percent in 1944 as compared with 1939. About two-thirds of all farms in the Southeast consisted of less than 70 acres in 1945 and one-tenth were under 10 acres. On the other hand, about one-fifth of the farms operated by managers were over 1,000 acres in size. Full-owner operators averaged from 7 to 10 years older than tenants in these seven States during 1945. About 14 percent of all operators were 65 years of age or older, but 20 percent of the full owners were also in this age group. The biggest concentration of full owners was in the 45-to-54-age range, but the highest proportion of all tenants was between 35 and 44 years of age.

MARKETING

Anticipating the day when supplies of farm commodities may hold a less advantageous position with respect to demand than during the war and postwar periods, research is being focused on finding ways and means to reduce costs through greater efficiency in marketing and to improve the quality of commodities offered the consumer. Research along these lines would also be useful in the event of possible national emergencies. Ways to reduce the spread between prices received by growers and those paid by consumers should result in benefits to both; it would tend to enable the purchasers to buy more farm commodities on a given income and producers to sell a larger volume at a given price. Inefficient and wasteful methods should be detected and eliminated. It has been demonstrated that ways can be developed to reduce many handling costs and to eliminate or reduce much of the deterioration and spoilage during the marketing process.

An attempt is being made to gain better knowledge of what the consumer wants. If such information were available, it would be most useful to the producer in enabling him to make needed changes and adjustments in producing, harvesting, and preparing commodities for market. More information of this type should also enable the trade to follow practices that would increase sales and at the same time reduce costs. Preference studies are indispensable when it comes to establishing or revising grades in line with consumer desires. Before grades can or will come into general use, they must be in line with consumers' gradations of choice.

The Research and Marketing Act of 1946 has given great impetus to research in the field of marketing. A few of the studies by the State experiment stations indicating ways to increase efficiency in the marketing process and to improve the quality of products offered the consumer are cited in the following pages.

MILK-MARKETING COSTS

The Missouri station found that by planned routing of milk trucks the mileage traveled in hauling milk from farms to distributors or processors could be reduced by 33 percent for every 1,000 pounds of milk.

Adjustments in milk prices to changes in demand and supply did not take place as quickly between 1932 and 1946 as they did between 1922 and 1931, according to a study by the Rhode Island station. It was shown that producers, dealers, and control agencies should examine the procedures by which prices could be promptly raised and lowered along with changes in conditions. If costs rise while prices remain the same, farmers will tend to sell their cows and thus reduce production; if costs fall without change in the prices received, production will be stimulated beyond the needs of the fluid milk market. Costs of production are related to prices received through the influence they have on future supplies of milk.

The average cost of distributing 1 quart of retail milk or its equivalent, in a study by the Vermont station, amounted to 4.6 cents or about 26 percent of the average price paid by the consumer, but a large degree of variation in cost existed among the dealers. Factors largely responsible for the wide divergence in costs were volume of business, labor efficiency, size of loads, and route efficiency. Dealers with larger businesses tended to have lower distribution costs because they were more efficient in their use of labor and equipment. Thus, the amount of milk handled per dollar of wages, per mile, and per truck were the true determinants of distribution costs. Only about a fourth of the 61 distributors studied met the minimum standards of efficiency. Dealers meeting these standards had relatively low costs of distribution, while the high costs to the very inefficient ones resulted in losses from their retail enterprises.

The Maine station also made a comprehensive study of milk distribution within that State and much of the findings are similar to those from Vermont. The experiment stations of Connecticut (Storrs), New York (Cornell), New Jersey, and several other States are likewise conducting milk-marketing investigations. Each of the four regions is conducting a cooperative study of various aspects of the marketing of dairy products, and some of the findings are already in practical operation.

OPERATING GRAIN ELEVATORS EFFICIENTLY

A considerable amount of variation in both the investment and the earnings of Indiana grain elevators was revealed in a survey by the State experiment station. Volume of business proved the most important factor influencing the earnings; as the volume of business increased, the percentage of gross margin decreased but the total margin of profit advanced. The typical handling margin taken on grains during the 1943-45 period was 5 cents a bushel. Labor expense was a very important cost in doing business, averaging more than 50 percent of the total expense.

Considerable variation was also shown in the operating policies of Indiana elevators. Cooperatives and private corporations had relatively complete accounting systems but many proprietors and part-

nerships kept inadequate records. Many elevator managers failed to use even the accounting information available to them. Most of the elevators had grinding and mixing departments, and most of the managers thought grinding and mixing paid for itself. Extension of credit was not a serious problem during the years covered by this study, but many managers believed that credit extension and collection would become a real problem with the return of more normal conditions.

Credit sales averaged 30 percent of the total retail sales for the elevators investigated. Of the 107 managers interviewed, 69 percent believed that it paid to sell on credit. Analysis of the data showed little relationship between bulk grain storage capacity and financial success. Many elevator operators were optimistic about the future of the industry in Indiana. It appeared that some operators had added facilities in excess of normal use; to the extent that this was done, the elevators are in a vulnerable position.

BETTER MARKETING PRACTICES FOR POULTRY

Some of the poultry and eggs consumed in Knoxville were found by the Tennessee station to pass through eight assembling agencies on their way from the farm to the housewife. Moreover, there was a lack of uniformity on the part of the trade in the sorting and grading practices for poultry and eggs. Much could be gained if the producers would sort their eggs as to size and color, grade out the bad eggs, and market more frequently. If the poultry were offered for sale in lots of the same kind, size, and color, they could be sold to a better advantage. Much could be gained if the country stores, rolling stores, and others buying eggs direct from the farmer would discriminate against low quality poultry, candle the eggs in the farmer's presence, throw out checks and dirty eggs, hold eggs under good storage conditions, and sell them twice or more a week.

In 1943, it was estimated that improper handling and lack of grading on farms caused a loss to Tennessee producers of 3 percent in their egg sales; this amounted to about $756,000. The stations in Delaware, Colorado, and several other States are also investigating poultry and egg marketing procedures. Furthermore, many of the States are participating in cooperative regional studies along these lines.

NEW WAYS OF SHIPPING AND PACKAGING

The Arizona station has demonstrated that grapefruit can be successfully shipped in paperboard boxes. Estimates of the costs indicate that the paperboard boxes, when in production, can be sold at a price substantially below that of wooden boxes. Another advantage of paperboard boxes is that they weigh less per pound of fruit contained, thus effecting a saving in freight charges. The Tennessee station found that wrapped tomatoes ripen more quickly than unwrapped fruits at the same stage of maturity, and that green tomatoes shipped from Tennessee to northern markets should be shipped without refrigeration. This station also discovered that tomatoes are usually packed too green for shipment and that practically everyone along the line handles them too roughly.

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The New York (Cornell), Ohio, and Florida stations, as well as several others are attempting to find better methods of packaging farm commodities. The Cornell station demonstrated that only the best quality fruit should be prepacked and that most of that produced in the Northeast failed to measure up to a quality that justified prepackaging operations. The report of this station was reprinted practically verbatim in six of the leading publications dealing with the marketing of truck crops and fruits.

GREATER CONSUMPTION OF SWEETPOTATOES

Persons in the higher income brackets showed more tendency to buy sweetpotatoes on a quality basis and less inclination to be price conscious than those in the lower income brackets, according to a study by the North Carolina station. This station also discovered that more sweetpotatoes would be eaten if the consumer could be assured of constant supplies of a high-quality product. The Louisiana station found that consumers usually preferred the medium sizes. When sweetpotatoes of U. S. No. 1 grade were divided into the three size groups, small, medium, and large, and all quoted at the same price, consumers bought 31 percent of the small size, 50 percent of the medium, and 19 percent of the large size. When the small and medium sizes were combined and tested against the large size, it was necessary to reduce the price of the latter by about 2 cents a pound in order to get an equal volume of purchases.

The South Carolina station observed that by using a straight-sided shipping crate rather than the bushel tub basket, the quality of sweetpotatoes could be improved. Curing and storing practices were other important factors in determining quality. The Georgia and Ohio stations are also conducting studies on certain aspects of marketing sweetpotatoes.

PRICE ANALYSES BENEFIT GROWERS

The importance of factors influencing the price of canned clingstone peaches was investigated by the California station. A change of 1 million cases in domestic shipments of canned peaches, with income and competing canned fruit prices held constant, was accompanied by a change in the opposite direction of 14 cents a case in the f. o. b. price. For example, an increase of a million cases, if there is no change in income or price of competing fruit, will be accompanied by a decrease of 14 cents in the f. o. b. price. On the other hand, a decrease of a million cases will be accompanied by an increase in the f. o. b. price of 14 cents per case.

Similarly a change of 10 percent in the level of nonagricultural income in the United States, with domestic shipments and prices of competing fruits held constant, was accompanied by a change in the same direction of about 36 cents a case in the f. o. b. price. A change of 10 points in the adjusted index of prices of competing canned fruits, with domestic shipments and nonagricultural income held constant, was accompanied by a change in the same direction of 22 cents a case in the f. o. b. price. The stations in Minnesota, Missouri, Kentucky, and a few other States are also conducting price studies for the purpose of obtaining more exact information on the relative importance of the different forces affecting prices received by farmers.

INCREASING SALES OF APPLES

Deliveries of Washington apples, the Washington station has found, have been declining in the more distant markets of the United States. It is believed the degree to which further decline will occur in shipments to these markets will depend largely on the extent of future increases in the production of apples, quality of pack, and transportation costs in relation to prices within these areas. The trend in shipments to southern, southwestern, and, particularly, to far western areas of the United States has been upward. The opportunity for increasing the volume of deliveries of Washington apples appears to be greater in these southern and western areas than in the other sections of the country.

Some specialized trade in exports may be profitably expanded but particular attention should be given to the domestic market for the major portion of the State's apple production. If the per capita consumption of apples in the United States can be stabilized at its present level or increased in the future, it will be necessary to produce larger quantities of commercial apples to meet the demands of the increasing population. This study indicated that the future of the Washington apple industry will remain favorable, provided the growers and shippers (1) maintain quality, (2) reduce costs of production, and (3) reduce marketing costs. Continued research will be necessary to accomplish these objectives.

BETTER MARKET FACILITIES

Many cities are in need of better market facilities; most of them have grown in recent years and methods of transportation have changed. Cities with ample market facilities at the end of World War I may find that they fall short of current needs. Many medium-sized and small cities have never developed market facilities that would encourage greater consumption of locally grown produce. A great deal of factual information is needed if improvements in the local marketing situation are to be made—whether by improving current facilities, by relocating the market center, or by establishing a new market. Therefore, a number of experiment stations have been called upon to help solve marketing problems in local communities.

The Wisconsin station has made a comprehensive study of the Milwaukee wholesale market and has drawn up a set of plans and suggested regulations for an entirely new market. The study brought out the fact that the two existing markets are both inadequate and obsolete, and that a new one should be established at a different location. This work indicated that the proposed market would reduce the present cost of operation margins for most dealers by 1 percent of sales because it would mean the elimination of much unnecessary cartage required under present conditions, would reduce waste and spoilage now brought about by poor facilities and undue handling, make for more efficient utilization of labor and machinery, and eliminate many duplications.

This reduction in cost would be equivalent to 15 percent or more of present costs for all types of fruits and vegetables. The savings that might be realized by the wholesale dealers and jobbers in Milwaukee from the establishment of the modern wholesale produce

market suggested have been estimated at $162,000. Retailers and other buyers would also benefit materially because it would enable them to obtain a full line of produce in one market place and with a minimum loss of time. Moreover, retailers would also receive fruits and vegetables sooner after their arrival in the city and therefore would be in a position to offer fresher and better quality merchandise to their customers. The Wisconsin report sets forth the costs involved and suggests methods of financing the construction and management of the proposed market.

Metropolitan Baton Rouge, with a population of about 100,000, is situated in an area producing a wide variety of crops but without a city market. Through a comprehensive study of the marketing conditions in the city and the production in the outlying territory, the Louisiana station found that although the local fruit and vegetable output was large, the local growers provided only about 8 percent of these commodities consumed in the city. Most of the produce from the trade area is shipped through established agencies to northern markets. Most growers contend that the lack of conveniently located facilities prevents them from producing a greater variety of crops and doing more marketing in Baton Rouge.

Retailers regarded the quality of locally grown produce highly, and especially its freshness, but they often complained about the manner in which it was graded. About four out of five retail grocers look with favor upon the establishment of a public wholesale produce market. The study also indicated that in addition to Baton Rouge wholesalers and retailers, buyers from outside the metropolitan area would frequent a market in the city, and if it were properly located and operated, both local producers and local consumers would benefit.

From a study of the Allegheny County Farmers' Market at Pittsburgh, the Pennsylvania station concluded that the market could be operated successfully in any section of the city where a site was available that would provide (1) ample physical space for the growers to deliver and display their produce, (2) ample parking space in the area for customers, (3) accessibility to all areas of the city by automobile and public transportation, and (4) costs not in excess of an amount that would be supported by the volume of business. While location near a heavily populated area was considered desirable, it was not believed sufficiently important for consideration over the above-named factors.

The agricultural experiment stations of North Carolina, South Carolina, Georgia, and Alabama, with the Department, studied the concentration markets in these southeastern States. This work revealed that less time is required by growers to sell in auction markets than in other types. It required, on the average, about 40 minutes to dispose of a load of produce on the auction markets as compared with 3½ hours at private-sale markets. The difference was attributed partly to the fact that hours of trading are not regulated at private-sale markets. It was found that country markets should be located so that the length of haul for growers would not exceed 25 to 30 miles. Care should be exercised to avoid location at intervals closer than justified by available volume. Furthermore, since city markets possess greater drawing power, country markets should not be in too close proximity to them.

Establishments in any area should be located at a point that will make them easily accessible to all available transportation facilities and as nearly as possible at natural concentration points. This study indicates that successful operation depends upon adequate volume, suitable location, available transportation, adequate facilities, competitive regulations, impartial finances, and sound management.

TRENDS IN MARKETING LIVESTOCK

Since 1920, according to a Michigan station survey, a decreasing proportion of Michigan hogs has been sold at terminal markets, while an increasing percentage has moved to such decentralized markets as the auctions, interior packers, and both private and cooperative concentration yards. The Michigan livestock farmer today can sell (1) to a local dealer or trade buyer, (2) at a local auction market, (3) to a private concentration buying yard, (4) directly to a packing plant, (5) through a local cooperative marketing association, or (6) he can consign to a private or cooperative commission agency on a large public terminal market.

Sizable price differences were indicated for all weight groups of hogs among these six markets. Furthermore, these price differences were greater during some seasons than others. Rather definite and constant seasonal variations occurred in the price differentials between markets; in most cases they were largest in the fall, when receipts were heaviest, and narrowest during the summer, when marketings were lighter. More adequate and accurate market news services are recommended. The widespread use of such information would probably reduce the price differentials among the various markets.

The market channels through which, from time to time, slaughter livestock moves from Indiana farms were determined by the Indiana station. Twenty years ago almost all hogs, cattle, veal calves, and sheep and lambs moved from farms to slaughterers through the larger markets. Since 1925, however, there has been a decided increase in the selling of livestock at various types of local markets. During 1940, nearly three-fourths of the slaughter cattle, two-thirds of the sheep and lambs, somewhat less than half of the hogs, and two-fifths of the veal calves were routed through primary posted markets to packers. Secondary posted markets handled 6 percent of the slaughter hogs, cattle, and veal calves, and 12 percent of the sheep and lambs. Dealer markets bought 28 percent of the hogs, 20 percent of the veal calves, and 17 percent of the sheep and lambs. Seventeen percent of the hogs and veal calves moved directly from the farms to the slaughterers, but only 8 percent of the cattle and 2 percent of the sheep and lambs were sold through this outlet.

Auction markets handled 12 percent of the veal calves and 7 percent of slaughter cattle. Hogs comprised the bulk of the receipts at practically all dealer and packer markets. Two-fifths of the dealer markets did not buy cattle. Packer markets were more important for cattle than dealer markets but not as important for sheep and lambs. Nearly three-fourths of the Indiana hogs reshipped from Indiana and adjacent markets were sold to slaughterers in the eastern metropolitan area during 1940. Half the reshipped hogs went to packers in eastern Pennsylvania, Maryland, or the New York City area, at weights averaging less than 200 pounds. Medium-weight hogs, comprising

more than a third of the reshipments, were sold primarily to packers in upstate New York, western Pennsylvania, Ohio, and Michigan.

COOPERATIVES

The Connecticut (Storrs) station reports that many producer-dealers and small-merchant dealers distribute raw milk in Connecticut. At the same time there has been a trend toward more pasteurization and even proposals for compulsory pasteurization of all milk sold in the markets of the State. This study indicates the necessary buildings, equipment, and costs that would be involved, should many of these small raw-milk dealers shift to the pasteurized product. Such information would enable them to plan more adequately for the change; it would also aid in preventing overexpansion and a general uneconomic development in the marketing of milk. Furthermore, it should lead those who are already pasteurizing their milk to appraise more accurately the efficiency of present operations.

The Montana station reports that the farmers and ranchers of the State owned and operated 257 cooperative associations in 1946, compared with 232 in 1941. In 1946, cooperative oil associations numbered 99, elevators 68, rural electrification associations 17, general merchandise cooperatives 17, and miscellaneous cooperatives 56. During 1945–46, farmer-marketing associations sold produce for $36,058,168 and farmer supply cooperatives furnished their patrons with $7,764,227 in equipment, supplies, and services; managers of many Montana cooperatives were without previous experience as managers of either type of cooperative. Compensation of managers was usually small. Although the majority of cooperatives required annual audits, numerous associations were without such a check on their records. The educational program of many Montana cooperatives was weak and inadequate. Appraisal of farmer oil associations from the standpoint of consumers indicated that in general they did not compare favorably with noncooperative oil stations. The principal causes for failure of cooperative elevators were poor management, losses from bad debts, and small volume of business.

ATTACKING MARKETING PROBLEMS ON A REGIONAL BASIS

Twenty-six cooperative regional marketing investigations are under way with an average of seven States participating in each. Two or more Federal bureaus or agencies are also participating in the majority of these regional studies. Many of them are broad in scope and are broken down into a number of segments, and investigations are being made of different phases of the problems involved. The regional programs deal with marketing of the most important commodities in the region and with the most pressing problems confronting the farmers. Each region has a study under way dealing with the marketing of dairy products. The north central, northeastern, and southern regions have cooperative work in operation dealing with the marketing of poultry and eggs and the western region is conducting a study dealing with turkeys. Each region also has studies dealing with some kind of fruit. Citrus fruits, apples, and peaches are presenting serious problems. The marketing of vegetables and truck crops also needs investigation and much work is being directed toward overcoming the handicaps confronted.

Researches dealing with consumer preference and others showing the relationship between prices and quality are being conducted in each region. Potatoes are receiving more attention than any other single crop, but tomatoes and a wide variety of other vegetables are also being investigated. The north central and western regions are conducting comprehensive researches on the marketing of livestock and the cotton-producing States are engaged in a cooperative study of the marketing of cotton. An attempt to find more effective methods of preventing spoilage or deterioration of quality and reducing costs through better methods of processing, storing, packaging, and transporting are being made through regional approaches.

RURAL SOCIOLOGY

Considerably more activity in research on rural human relations occurred during 1948 than in any previous year. The number of active lines of research at the stations during that year was 75 in comparison with 65 for 1947; the funds available for their support amounted to $162,306 as compared with only $126,850 for the previous year. Some examples of the results reported during the year are given below.

A study of changes in population by the Iowa station disclosed the following: The beginning of the present century marked a turning point in the growth of Iowa's population. Previous to 1900 there had been a net migration of a million persons into the State; since 1900 there has been a net outward movement of more than a million. During World War II Iowa's civilian population declined. The State can now be expected to recoup her wartime population losses and to grow, though slowly, during the next generation. Distinctive and important changes in population characterize the present generation. Iowa cities are growing slowly but steadily. The farm population is decreasing slowly. Future growth of the small towns is uncertain; some of them are increasing, while others are decreasing in population.

The number and proportion of elderly persons in the State are increasing rapidly and will continue to do so for a generation. The number of young persons remains relatively constant but might decrease slightly. Adequate adjustment to these changes is also a major process to be continued in line with current economic and social trends. The total attendance load of the institutions under the Iowa Board of Control has increased more rapidly than the population of the State. Decreases are most noticeable in the number of criminals and in the attendance at children's homes and the soldiers' home.

Commitments of the mentally ill and the feeble-minded to State mental hospitals and schools have increased consistently and can be expected to continue doing so. Overcrowding has been a major problem in the State mental hospitals for 20 years. State schools for the feeble-minded also face the probability of some increase in the number of commitments. Consignments of the insane and feeble-minded can be expected to increase steadily and to continue doing so at a rate more rapid than that for the population of the State as a whole. Outstanding recent developments in social welfare programs include cooperative State and Federal programs developed during the depression of the 1930's to meet the needs of the unemployed.

The Michigan station found that approximately two-thirds of the State's population is in urban centers, i. e., in places having 2,500 persons or more. The remaining one-third resides in the rural portions of the State. This trend toward urbanization proceeded without interruption until after 1930, when the proportion of rural residents began to increase slightly. The largest increase between 1930 and 1940, however, came in rural-nonfarm residents, made up largely of persons residing at the fringes of the major cities. Foreign-born groups are considerably more significant in Michigan than in either the neighboring States or the nation. In 1940, one person out of every eight in Michigan had been born abroad.

Canadians are by far the most numerous among these foreign-born. Poles, Germans, English, Italians, and Russians follow, in that order. Although Negroes account for only 4 percent of the State's population, they are concentrated in only a few cities. Negroes form a larger proportion in the United States as a whole as well as in two States of this region, namely, Ohio and Illinois, than in Michigan. Although the foreign-born elements are disappearing rapidly from the State, Negroes are increasing. As is true generally, Michigan's rural-farm population is deficient in the active productive ages, being characterized by large proportions of the young and the old.

Although the State is predominantly urban, males greatly outnumber the females. Compared with the relatively normal sex ratios of 101 to 102 for the region and the country, the sex ratio of 105 for Michigan is extraordinarily high. As is generally the case, the sex ratio is most unbalanced in the State's rural-farm population and most nearly balanced in the urban centers.

A sharp drop in the farm population of Texas occurred during 1947, according to estimates prepared by the Texas station with the Department. Reversing the small-scale back-to-the-farm movement that followed World War II, the number of persons living on farms in this State declined by 51,000 during 1947. On January 1, 1948, an estimated 1,712,000 persons remained on Texas farms. Birth rates on farms continued high in relation to death rates, but the difference was not enough to compensate for the heavy migration to villages, towns, and cities. Trends in the State's farm population since 1930 have corresponded, in general, with those for the nation. However, the changes in Texas have been more sweeping; post-depression decreases were greater there, and the war took a heavier toll.

By the end of 1947, Texas farm population had declined to 73.5 percent of its 1930 level, as compared with 91 percent for the United States as a whole. Estimated net migration losses from all farms in the United States during 1947 amounted to 593,000 persons. Replacement through natural increase totaled 483,000, leaving on January 1, 1948, a farm population of 27,440,000. Approximately 750,000 babies were born in farm families throughout the United States, the highest natural increase since 1925 when the farm population was considerably larger than it is now.

Among the motives for people leaving the farm, the lack of "city conveniences" again ranked first in the minds of those cooperating in the survey. Good roads, electric power, schools, churches, and recreational facilities were repeatedly mentioned as the chief goals of the migrants. Of these, the sharpest comments dealt with the unsatisfactory condition of farm roads.

Intelligence, personality adjustment, and certain health indexes of 3,192 rural and town children in grades 4 through 8 in Spokane and Skagit Counties, Washington, were studied by the Washington station in relation to economic land-use classification. Land-class designations were secured by means of specially prepared maps, land class 1 denoting the best farm lands and land class 5, the poorest in productivity. The average intelligence of the subjects in this study expressed in terms of the Otis I. Q. was slightly in excess of the national average; namely, 103 and 103.6 for these two counties. Approximately 60 percent of the children were of predominantly American extraction. About 14 percent were of Scandinavian descent. The next two largest national groups were the British and Austro-German, each contributing about 5.5 percent of the cases. Forty-one cases were of Holland-Dutch extraction.

The average number of children per farm family ranged from 2.9 on land class 1 to 3.5 on class 5. The average for town families was 2.8 and for nonfarm rural families 3.2 children. The majority of farmers on land classes 1 and 2 were full-time farmers; the opposite was true for farmers on land classes 3, 4, and 5. In Skagit County over half the farms were dairy farms, while general farming constituted another third; in Spokane County over half were classed as diversified, with cash crop farms (truck, berries, wheat, or peas) next in numerical importance.

The Louisiana station found the total number of registered and nonregistered hospitals and clinics in the State (excepting those exclusively for veterans, service personnel, or inmates or patients of State institutions) to be in the neighborhood of 167. Of these, slightly over two-thirds fall in the general classification, whereas an additional 30 units or 18 percent are unclassified as to type and for practical purposes may be considered in the general category. The remaining 24 hospitals specialize in particular fields as follows: 6 are in the nervous and mental category, 6 tuberculosis, 6 convalescent and rest, 3 maternity, 2 industrial, and 1 eye, ear, nose, and throat. The distribution that has come about leaves substantial areas of the State entirely without hospitals of any size or description, while larger centers of population, particularly New Orleans, harbor clusters of facilities. In 12 parishes there are no hospitals with as many as 5 beds.

For a considerable segment of the population, distance remains a decisive factor in hospital usage. Medical authorities have variously stated that an average of 700 to 1,500 persons in the general population require the full-time services of a physician. This ratio for the whole State is 1,464 persons per physician on the basis of the 1945 data and 964 computed from the 1946 series. In 1945 the ratios ranged from 743 inhabitants for each doctor in 1 parish to 5,703 persons per doctor in another. In fact, only 4 parishes met the standard of 1,500 or fewer persons per physician.

A survey in 1945 showed that there were only 665 dentists practicing in the entire State. This number divided into the 1943 estimate of the population gives, for the State as a whole, a ratio of 1 dentist per 3,484 persons. In the face of the recommended population-dentist ratio of 1 dentist to something like 1,500 people, this figure leaves Louisiana with very much to be desired.

Approximately 900 students have enrolled in the Vermont State College of Agriculture during the past 45 years, but only about half

of these men received a bachelor's degree, according to a study made by the Vermont station. The average size of the graduating class was 10 students. Over 60 percent of the graduates have remained in the State. The greatest number of these men live in the smaller villages and rural areas. Many of the alumni living outside Vermont are located in bordering or nearby States. The agricultural graduates have entered nearly 100 different occupations upon graduation. Their present occupations vary about as much as did their beginning jobs. As these men aged they apparently obtained more responsible positions, but few entirely new jobs were added.

Salaries in 1946 averaged $4,007. Neither the graduate's first job nor his college major had a determining influence upon his life work. Changing jobs did not appear to impair his earning power. While many graduates shifted from one occupation to another, they seldom took up work unrelated to agriculture. Nearly 20 percent of the agricultural graduates between 1900 and 1944 received advanced degrees. Although only a limited number of concerns indicated interest in hiring agricultural graduates, some groups believed this a desirable policy. Wages offered ranged from $800 to $3,600 per year, with $1,800 most frequently mentioned.

In a study of rural education, the Louisiana station found the educational status of the State's population to be very low in comparison with that of people in the remainder of the Nation. Louisiana's poor educational showing is due largely to the inadequate schooling that has been afforded the white rural population. The educational status of the white inhabitants in its towns and cities compares favorably with that of their fellow urbanites elsewhere in the Nation. Among the white farm populations of the various States, however, that of Louisiana ranks at the bottom. Its farm population not only ranks at the bottom of the Nation's educational scale, but the farm people are more disadvantaged educationally, in comparison with the inhabitants of towns and cities, than is the case in any other State.

For several decades Louisiana has been about keeping pace with the Nation in increasing the amount of education given to white urbanites, and has now reached a point where the training given to white persons in rural-nonfarm areas comes fairly close to that afforded comparable groups in the country as a whole. The educational status of white farmers in Louisiana more nearly approximates the national average than was the case several decades ago, but the State must accelerate its pace considerably in raising rural educational standards before its farm people will reach the levels attained by farmers elsewhere. Louisiana is gaining but little headway on the Nation as a whole in the education of its Negroes. Within the State the position occupied by the youthful farmers compares even more unfavorably with that occupied by young people in other groups than is the case among their elders.

An analysis by the Missouri station of the physical and dental examination records of 4,124 individuals living in 843 agricultural families in the southeastern part of the State reveals that considerable proportions are handicapped in their effort to earn a livelihood. The examining physicians diagnosed a total of 14,700 cases of diseases and defects for the entire group, or an average of 3.8 for each individual examined. About 5 percent of all persons were free from defects.

Among specific diseases and defects, the following seem particularly worthy of note, since each of them occurred 50 or more times per 1,000 persons examined in at least one of the race or sex groups: Syphilis, nonmalignant neoplasmas, secondary anemia, malnutrition, goiter, pterygium, defective vision, hemorrhoids, varicose veins, hypertension, defective tonsils, adenoids, nasal defects, hernia, diseases of the gums, phimosis, cervicitis, defects resulting from childbirth, and other diseases and defects of the uterus. Particularly noteworthy is the evidence of poor nutrition as indicated by the incidence of secondary anemia, rickets and its after effects, goiter, obesity, poor condition of the gums, and defective teeth.

A study by the Washington station reveals rather clearly that the practice of private medicine in rural areas of the State is not the first choice among a large proportion of the rural population as the method by which they would like to have their medical service program administered. The desire for a change is marked, two out of every three persons preferring it. Of the five alternative methods, a larger majority preferred the Social Security program as outlined by President Truman to any other system. Private practice was the second most popular choice, the Medical Bureau Plan was third, the cooperative approach fourth, and tax-supported State medicine came last.

Nearly every person expressing a desire for change in the method of administering medical service programs was positive in desiring comprehensive coverage of all medical, hospital, and dental services. A large majority also indicated preference for a prepayment plan for medical bills based on an insurance principle, and expressed a willingness to pay 5 percent of the first $3,000 earned per year in order to defray the costs. Although many people expressed a desire for private practice, this does not have the support of many related attitudes of the people, which may be necessary for its continuance as an effective competitor of other systems of administering medical services.

An analysis of land tenure made by the Arkansas station in the Ozark region is based on information ascertained in personal interviews with 101 farm owner-operators and 88 farm renters in Boone County. Besides family income and several other economic measures, many social measures are used in evaluating ownership and tenancy. Primary consideration is given to the competition for use and control of land and to the stages of the process represented by older and younger operators. The rate of succession of the same families on owner-operated farms is especially low. In those families in which the present owner is over 55 years of age, an average of one male child in about six families remains in residence and seems likely to succeed the parent in operating the farm.

A comparison of the migration of operators with that of their children—even though the process is incomplete for the latter—indicates that migration is becoming increasingly more extensive. Fifty percent of the farmers less than 30 years old are renters, as compared with only 14 percent of those over 60 years of age. Owners average 10 years older than renters and the number of years they have engaged in farming exceeds the agricultural experience of renters by 50 percent. Nearly half the older owners have farmed as renters. Among operators changing from renters to owners, 56 percent became owners before the thirtieth, 85 percent before the fortieth, and 94 percent before the forty-fifth year of age.

Of operators renting a farm who became 35 years old before 1925, 68 percent became owner-operators before their thirty-fifth year. The trend toward delayed ownership was evident before 1930 but was accelerated by the depression. The normal result of operation of the tenure process is an increase in ownership, an increase in the value of the property or the size of farm business (both during the early period of renting for young renters who are prospective owners and during the period of ownership), and improvement of location in the community.

SOIL MANAGEMENT

The application of technological advances in soil science research to the problems of fertility maintenance and productivity continued to be one of the contributing factors in more efficient crop production. Although the American farmer, the American public, and the entire world are thankful for the combination of scientific findings and favorable climate of the past several years in increasing the food supply, there is also a growing awareness that the potential productive capacity of our soils is being lowered. Thought must therefore be given to the determination of more effective methods of management in order to preserve our soils for future needs. On the other hand, definite evidence is available that soil productivity can be maintained in certain areas—which points hopefully to future advancements in this important field. The findings from the State experiment stations, given below, represent but a few of the results pointing the way to systems of soil management that will make for a more permanent agriculture.

PRODUCTIVE SIZE OF FARM CHANGED THROUGH SOIL MANAGEMENT

Experiment station investigations of systems of soil management have shown that the continuation of farming methods which result in soil depletion is reducing at an alarming rate the total acreage available for production. With the establishment of the State experiment station system in 1887 many experimental fields and small plots were established for measuring the effect of certain soil treatments under the particular crop and soil conditions prevailing in the agricultural areas where the stations were located. It is also interesting that several of the State experiment stations had established soil fertility research work prior to their formal organization under the Hatch Act. In a considerable number of these experiments the soil-management system established 50, 60, or 70 years ago has been continued without change or with only minor modifications.

Information is thus available on crop yields and soil changes that have taken place over a long period of time. Supplementary fundamental studies of the chemical, physical, and biological changes which have taken place in these soils under a known management history give the soil scientist and agronomist the information needed for formulating systems of management that will lead to a more permanent and profitable agriculture.

Results from the Illinois station reported during the past year and dealing with the long-time effects of certain soil-management practices on the productive size of farms are used as an example of the type of information available from several of the State experiment stations.

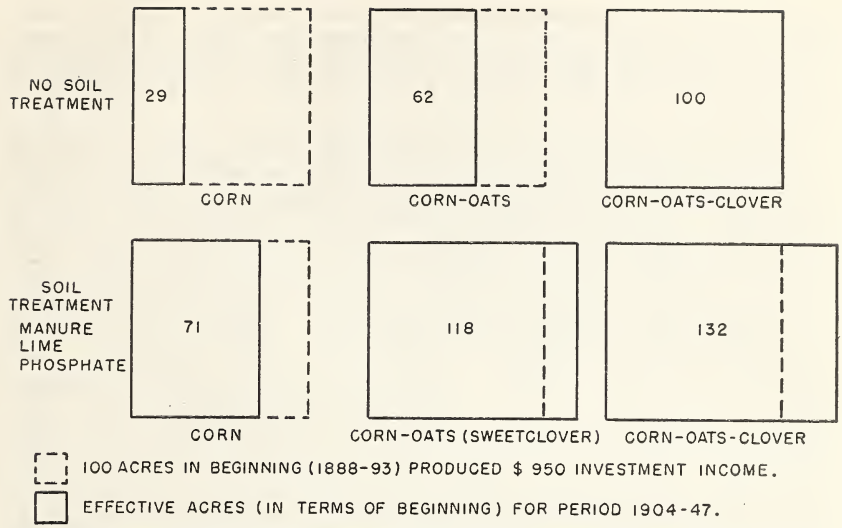

FIGURE 1.—Effect of soil management on productive size of farms, as illustrated from crop yield records of the Illinois Agricultural Experiment Station.

Figure 1 shows the productive behavior of six 100-acre farms when the results from long-time soil studies are translated into terms of productive acres.

The changes shown are based on variations in investment income—the amount of crop income remaining after deducting labor, seed, harvesting, marketing, and soil-treatment costs. The chart is based on data from two time-periods. The first is the 6-year period from 1888 to 1893, with an investment income of $9.50 an acre or $950 for a 100-acre farm. This income is used to represent the productivity of the six 100-acre farms in the beginning; these are shown on the chart as dotted squares. The second period covers the 44 years from 1904 to 1947, in which the cropping systems are contrasted both with and without soil treatments. Investment incomes varied much in this period and are shown on the chart as solid line areas.

Actually, each farm has remained a 100-acre farm, but productively, some have shrunken and others have expanded. In terms of original productivity, the 100-acre farm producing corn in continuous culture without treatment has become a 29-acre farm. The 100-acre farm producing corn, oats, and red clover in rotation, and including soil treatment, has become a 132-acre farm. All farms with cropping systems devoid of legumes have declined in productivity; those growing legumes either have not changed or have increased in productivity.

Although these results indicate a very rapid rate of decline in soil productivity, it is of interest to point out that the loss in productive acres was relatively slow in comparison with areas where the soil was originally at a lower level of fertility and where erosion had been allowed to go unchecked. The soil is a dynamic system, and changes within it may be reflected in crop yields within a shorter or longer period, depending upon its physical, chemical, and biological characteristics. The evidences of rapid soil destruction are easily detected

and progress is being made in reducing this waste, but consideration must also be given to the less evident long-time effects such as losses in plant nutrients and organic matter, as well as deterioriation in soil structure with the resulting low penetration and availability of moisture.

Along a related line of work, the Kentucky station studied the effects of soil improvement practices over a 10-year period on a 70-acre farm with gently rolling, well-drained, limestone land in southwestern Kentucky. At the start, this farm was low in productivity, about 20 acres being depleted idle cropland covered with weeds, bushes, and lespedeza. As a result of soil improvements, all this land was brought into use and the volume of crops and pasture produced the tenth year was nearly four times that of the first year. During these years the comparison was not affected by either unusually favorable or unusually unfavorable weather. The value of crops at 1936–39 average prices increased from $1,055 the first year to $3,958 the tenth year. The labor required for crop production increased from 880 to 2,200 man-hours. Annual costs for fertilizer, seed, harvesting grain and grass seeds, other crop supplies, and additional housing space for tobacco increased at 1936–39 average prices from $309 the first year to $1,041 the fourth year, and then decreased to about $600 annually for the sixth to tenth years. Differences between these costs and the value of crops produced increased each year from $746 the first year to $3,310 the tenth year. If computed at prices prevailing from 1942 to 1945 these differences were practically doubled.

The principal soil improvements were liberal use of green-manure crops, sod, or cover crops on practically all fields during the winter, and application of agricultural limestone, fertilizers, and manure. Liberal seedings of grass-legume mixtures were made throughout the period. The carrying capacity of pastures were improved from one animal unit per 3 to 5 acres, varying with weather conditions, to one animal unit per 1 to 2 acres.

Although the land was gently rolling, the types of soil on the Kentucky farm eroded easily. To aid in controlling erosion, terraces were constructed in four of the fields. One field too wet for cultivation was drained and changed into productive cropland. Where practicable, fences were rearranged to enclose land of similar type in the same field. These land improvements helped conserve the land and also increased production.

Signs of declining soil fertility are also being found in areas which have been under cultivation for relatively short periods of time. The South Dakota station found that one of the more noticeable soil changes caused by continuous cropping is a depletion of available nitrogen for crop growth. Moderate applications of nitrogen fertilizer were shown to increase the yields of wheat by 7 bushels. Nitrogen and phosphorus fertilizer together increased wheat yields 11 bushels per acre in a 3-year rotation of corn-oats-wheat. Corn yields were increased 9 bushels per acre by nitrogen and phosphorus. In a 3-year rotation of corn-wheat-sweetclover, the average yield of wheat was 31 bushels per acre as compared with 18 bushels per acre for continuous wheat. In a wheat and sorghum rotation, the yield of wheat was increased 3 bushels per acre by application of nitrogen fertilizer.

MORE EFFICIENT USE OF FERTILIZERS

Fertilizers continue to become an ever-increasing factor in the maintenance of soil fertility and in obtaining more efficient crop production. The increasing need of supplying mineral elements for most efficient crop production is being revealed each year as soil areas hitherto thought to be adequately supplied with the necessary plant nutrients are responding to applications of a single element or a combination of elements. Although fertilizer usage is essential in many areas of the country, the results of research with fertilizers by the State experiment stations have shown that certain materials and methods of application are much more efficient than others. Even though the cost of fertilizer may be relatively small in comparison with the total costs of production, the objective of fertilizer research for determining more efficient usage of materials involves also the need for employing to best advantage the limited supplies available.

Progress in fertilizer research is well illustrated in results reported by the Mississippi station. In 1942 the station undertook a study of the efficiency of commercial fertilizers; this led to the finding that anhydrous ammonia provides the cheapest available source of nitrogen for use in improving the fertility of important soil types and that aqua ammonia can also be effectively utilized in certain situations. Equipment was developed by the station for injecting this material into the soil. The practical results of this application of research work have been rather astounding.

In 1947, in the State of Mississippi alone, 200,000 acres of land were fertilized with anhydrous ammonia and in 1948, 400,000 acres. The use of this chemical is reported to have increased the income of Mississippi farmers during these 2 years by about $30,000,000. Furthermore, the use of anhydrous ammonia has already moved from Mississippi into Alabama, Arkansas, Louisiana, Tennessee, and Illinois. Some aqua ammonia is also used in Mississippi and Florida. This is an amazingly rapid wide-scale adoption of a more economical way of fertilizing soils. The returns on the investment in this research have been enormous.

To obtain efficient use of fertilizer it is necessary not only to supply the needed plant nutrients but also to provide these nutrients in proper balance for the particular crop to be grown, according to studies by the Wisconsin station. In comparison with the common mixed fertilizer used in the State, a new fertilizer analysis consisting of a 6–6–18 material, which would be considered high in nitrogen and potash but low in phosphate, gave very good results on certain crops when used as a broadcast application.

This combination proved to be most efficient for broadcasting on potatoes, canning beets, and sugar beets. In 1945, for example, the station found this new analysis the best fertilizer tested for broadcasting on potatoes in two rather different soil types—Antigo silt loam and Plainfield sandy loam. On the Antigo soil, yields of 426 bushels an acre were obtained with a broadcast of 1,200 pounds of 6–6–18 and a row application of 800 pounds of 3-12-12. This treatment increased yields by 114 percent over the 199 bushels secured without fertilizer, and by 81 percent over the 285 bushels obtained without broadcast fertilizer but with 800 pounds of 3–12–12 in the row.

In a study on the methods of application the New York (State) station found that bands of fertilizer along the rows, coupled with fertilizer plowed under are proving to be the best practice. Five methods of placement and three rates of application were tried. The fertilizer was a 6–18–6 analysis, and rates applied were 500, 1,000, and 1,500 pounds per acre. In every case the 1,000-pound rate proved most profitable when 300 pounds were applied in bands 4 inches below the surface and 2½ inches each side of the row and the balance was plowed under. Other methods tested were broadcasting before plowing, broadcasting after plowing, drilling after plowing, and applying on the plow sole.

According to results reported from the Iowa station, the number of corn plants per acre is an important factor in obtaining more efficient use of fertilizers. Adding 4,000 stalks an acre to an average stand increased the yield 8 to 16 bushels per acre on a highly fertile field. If moisture and fertility conditions are very good, the highest yield may be obtained from stands of 15,000 to 19,000 stalks to the acre. If the soil is low in fertility and fertilizer is not used, or if the soil moisture is below average, better yields may be obtained from 3 or 4 stalks to the hill, or approximately 11,000 to 15,000 stalks to the acre. Planting corn more thickly makes smaller ears even on fertilized fields, but small ears were found to shell out about as well as large ears. Fertilizer applied to fields low or moderately low in fertility makes larger ears. With adequate fertilization the stand on such a field can usually be increased 3,000 stalks to the acre without reducing size of ear.

Additional information on the fertilizer needs and response of corn to different fertilizer ratios was obtained by the North Carolina station and the Department. Improved fertilization and better methods of application resulted in a net profit of $59.90 per acre, whereas improper fertilizer application gave a profit of only $4.45 per acre.

With annual applications of commercial fertilizer containing 120 pounds of nitrogen per acre and adequate phosphorus and potash, the average yields for 1944, 1945, and 1946 were 78 bushels per acre. Test plots that received only phosphorus and potash fertilizer in the row gave an average yield of 28 bushels per acre. Fixed costs of production and power were almost the same.

Results from these experiments show that the cost of fertilizer is a relatively small item, and the return for the small additional cost is high. Returns per hour of labor when only 500 pounds of 0–8–8 per acre was applied at planting time amounted to 41 cents. Under these conditions, the total cost of producing a bushel of corn was $1.34. Supplementing this phosphorus and potash material with 120 pounds of nitrogen jumped the return per hour of labor to $1.48, and the cost of producing a bushel of corn was cut to 73 cents.

The use of chemical tests in determining the fertilizer needs of soil is rapidly assuming importance. This practice insures the efficient use of fertilizer and also conserves available supplies and gives the farmer the greatest return for his fertilizer investment. The Illinois station reported results based on State-wide trials that showed Illinois farmers could have made $5,000,000 more in 1947 if they had tested their soil instead of guessing on how much fertilizer to use for their various crops. These workers pointed out that soil testing not only saved the participating farmer an average of $50 for every $1 spent on testing

but also increased food production by using every ton of available fertilizer where it would do the most good.

BETTER LAND USE THROUGH SOIL SCIENCE

More and more individual segments of the findings from soil-science research, accumulated over the years at the State experiment stations, are being brought together into consolidated reports; these present the results of fundamental and applied research in practical form for use by the farmer. Progress along this line during the past year is represented by the studies at several experiment stations. The work of the New Jersey and Oregon stations represents the type of recommended land-use program that results from soil research. A publication by the New Jersey station and the Department on the nature, conservation, and use of Monmouth County soils presents in detail the information needed by farmers to obtain more efficient production and still preserve the soil resources.

Information on land capabilities and conservation farming in the Deschutes area of central Oregon was made available by the Oregon station and the Department. In these findings, attention is directed toward the need for applying practices that will result in conserving the limited supplies of water. Erosion by either wind or water presents serious problems, and land-use practices have been developed which will reduce these losses to a minimum. Information is given as to the choice and rotation of crops, management of pastures and grazing land, and maintenance of soil fertility.

The results of a more specialized investigation of the influence of various soil factors on grape production were made available by the Pennsylvania station to the grape growers of the well-drained lake-terrace areas.

Soil organic matter and total nitrogen content, available moisture, capillary porosity, clay and silt content, and total supply of soil minerals were all found to be directly associated with Concord grape production. This was reflected in the highly significant relationships of each of these soil constituents to properties, pruning weights, and yields. Extreme variability in the productivity of the different vineyard plots studied was shown to be closely associated with the extent to which these soil factors varied from one plot area to another. The effects of soil erosion were in many instances responsible for prevailing differences in the surface-soil characteristics in any given area. Those vineyard-soil management practices which affect the characteristics of the surface soil most, proved also to have the greatest influence on the growth and yield of the grape itself.

RADIOACTIVE ATOMS IN SOIL RESEARCH

One of the more important developments that shows promise of aid in obtaining more information about the nature and properties of our soils has to do with the use of radioactive elements. The way chemical elements are held in the soil, the way in which they are released, their rate of release, and their method of entry into the plant are perplexing problems that have required long-continued fundamental research.

The radioactive elements have the same properties as do normal elements but differ in that they release radiations similar to those obtained from radium. The radiations from such radioactive materials

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can be measured by electrical instruments. The scientist is thus provided with a valuable new method for determining what happens when fertilizer materials are added to the soil.

Several experiment stations and the Department are working jointly to develop methods and establish experiments that will give basic information applicable over a wide range of soil and climatic conditions. Much of the work is still fundamental and preliminary in nature. That progress is being made, however, is illustrated by results from the New York (Cornell) station, where radioactive calcium is being used in an effort to determine just how lime benefits plant growth on acid soils and what is the best method for applying it.

Many theories have been proposed to explain how lime benefits legumes and other crops that fail to grow well on acid soils. Many factors are involved in the growth responses of different crops to applications of lime on such soils. The relative importance of the different beneficial effects of liming acid soils, however, has never been properly evaluated because of the inadequacy of past experimental techniques. Some of the work now in progress at the Cornell station indicates that the poor growth of many crops on acid soils is not necessarily due to their low calcium supply and that the crop responses to lime cannot be attributed simply to the increased calcium supply in the soil after applications of lime. Plants are unable to take up calcium from acid soils even when they are well supplied with soluble calcium salts.

The scientists are therefore trying to evaluate the different beneficial effects of liming soils, and particularly the direct nutritive influence of calcium, by using lime in which the calcium has been made radioactive. The radioactive lime in varying amounts is thoroughly mixed with the soil to different depths. In some experiments, it is simply drilled in with the seed. The plants are then grown on the limed soils, harvested, and the yield responses to lime determined. The plants are then analyzed by the usual chemical methods for total calcium content. But here is where the new method takes over with the help of a special counting apparatus that can detect and accurately measure the radiations from the individual radioactive calcium atoms present in the plant ash—the same calcium that must have come from the radioactive lime applied to the soil in the liming experiments. When the ashes of these plants are placed in a well-shielded lead chamber next to the counter, it automatically registers and counts the radiations at rates even as high as 20,000 counts per minute. From such data as these the soil scientist can calculate exactly how much of the total calcium in the plants was taken up from the applied lime and how much of it came from the calcium supply previously in the soil.

MINOR ELEMENTS PAY BIG DIVIDENDS

Research effort on the nutrient needs of plants and the nutrients available in the soil have provided many leads to more efficient crop production through the finding of deficiencies of elements needed in small quantities or of toxic levels of other elements likewise needed only in limited amounts for best crop growth. Many of our soils that are subjected to heavy rainfall, weathering, erosion, or production in a single crop system have presented complex problems as to nutrient-element needs and the effects of one element on the use of others.

A summary of the work of the experiment stations on minor elements, or even on a single minor element such as boron, would require several volumes, The important thing from the practical standpoint is that the results of research with these minor elements extending over several years are now being applied on an extensive scale, as is illustrated in a recent report from the Florida station. With the drainage of the Everglades, vast areas of that part of lower Florida were made available for planting. It was soon discovered, however, that crops would not thrive on these lands, and the Everglades branch of the Florida station was established to investigate the reasons behind this failure of the land to produce.

Although many research findings and other influences have entered into the creation of the present vast food empire of the Everglades, the discovery by this station of deficiencies in minor elements in the soils of the area and the development of methods of applying these needed elements have been among the most important contributions obtained. At the present time, more than 72,000 acres are devoted to the production of vegetables, strawberries, and watermelons; and over 30,000 acres of sugarcane are harvested annually—with a valuation in 1948 of more than $7,061,000. Furthermore, thousands of cattle are grazing on the lush pastures of the Everglades today. Neither the cattle nor the pastures, as they now are, would have been possible had it not been for the addition of certain of these minor elements to the soils of this particular area.

The potential effect of minor elements under entirely different soil conditions is shown by experimental results from the Indiana station. Here, in 1946, manganese deficiency was found to be reducing soybean yields in the northern part of the State by as much as 50 percent of the yields obtainable where this element had been adequately supplied. This deficiency was corrected by applying 25 pounds of manganese sulfate with 100 pounds of 0–12–12 starter fertilizer. A spray treatment of 10 pounds of manganese sulfate per acre in 125 gallons of water, applied 5 weeks after planting, also effected a complete cure of the deficiency. It was estimated that the spray material and the spraying operation, or the fertilizer and its application at seeding time, would cost the farmer a total of only $3 to $4 per acre; this is the equivalent of 1 bushel of soybeans at current prices.

In the original experiments, increases in yield of 10 to 16 bushels per acre were obtained. It is further estimated that at least a million acres of northern Indiana soils are low in manganese. The deficiency is somewhat dependent upon weather conditions and is therefore much less pronounced in some years than in others. Soybean growers who correct this mineral deficiency can make an extra $50 per acre by spending only $4 per acre for spraying.

FIELD CROPS

Superior varieties of field crops and efficient production practices are essential for the most profitable farm enterprises. Agronomic research with field crops and closely related lines by the agricultural experiment stations has continued to meet domestic as well as foreign needs by bringing forth new improved varieties and strains of small grain, corn, fiber, oil seed, root, and sugar crops, and tobacco; more

effective fertilizers and soil-fertility practices; desirable crop rotations; control of weeds and harmful plants in growing crops by new chemicals; and great progress in the mechanized labor-conserving culture, harvest, and handling of the important field crops. Many of the outstanding new varieties, characterized by resistance to diseases, insects, and cropping hazards, adaptation to different environments and to mechanized farming, and of special merit for food, feed, or manufacturing purposes are products of regional and Nation-wide improvement programs, in which the State experiment stations and the Department have cooperated, and are largely the result of planned research, including selection, inbreeding, crossing, and testing over prolonged periods of time.

Examples of current advances of significance in crop-plant improvement and in new production methods and practices follow:

IMPROVED WHEATS

Most of the new productive wheat varieties, resistant to diseases and insects and enduring drought and severe winter conditions, have been developed by State experiment stations through breeding and testing work in which the Department has cooperated and which is coordinated closely in the hard spring, hard red winter, soft red winter, and western wheat-growing areas. These varieties are estimated to have increased the total wheat production of the United States by more than 800 million bushels in the years 1942 to 1946.

The wheat-improvement program carried on by the Ohio station since its founding more than 60 years ago has had the development of new and superior varieties of wheats as its goal. Among the hundreds of varieties tested in the early years of this program, those best adapted to Ohio conditions, such as Poole, Fultz, and Fulcaster, were recommended to the farmers. In 48 years of testing at the station these varieties, which serve as standards to measure progress, have averaged just above 36 bushels to the acre. Single-plant selections from these varieties—for example, Trumbull and Fulhio, both from Fultz—provided the next step. These two wheats have averaged 39 bushels per acre, a gain of 3 bushels over Poole, Fultz, and Fulcaster. Replacing these varieties, Trumbull and Fulhio had by 1930 made up nearly 80 percent of all the Ohio wheat acreage. The third step, hybridization between the best lines of old varieties, resulted in Thorne wheat, released in 1937 after 20 years of such work. Thorne, derived from Portage (a Poole selection) × Fulcaster, has averaged 43 bushels per acre, a gain of 7 bushels over the old varieties and 4 bushels over Trumbull and Fulhio. Thorne had taken over 56 percent of Ohio's wheat acreage by 1944 and had spread widely over the eastern soft red winter-wheat area.

Butler wheat, a new white-chaffed, bearded, soft red winter variety developed from a cross between a sister line of Thorne and Trumbull, became another milestone in the Ohio program. Averaging 43.5 bushels per acre, Butler slightly outyields Thorne, equals it in stiffness of straw, has definitely better resistance to scab, and gives a higher weight per bushel. It is expected to replace Thorne in areas where wheat is sown on unplowed corn ground.

Up to the present, the Ohio program has increased the potential yielding ability of wheat by about 20 percent, and still further progress

is in sight. On Ohio's 2,000,000 acres of wheat this would represent at least 6,000,000 bushels more than if farmers now grew the Fultz, Fulcaster, and Poole varieties. The planting of 75 to 85 percent of the Ohio wheat acreage in varieties developed by the station has resulted in very high uniformity and an excellent crop of soft red wheat. Satisfactory milling and baking behavior has been a "must" for all the wheat varieties released; at least 96 percent of Ohio's crop is now acceptable to the soft-wheat miller and baker.

Excellent wheats are being released by other stations in this region. Royal, a productive, bearded, soft winter variety developed by the Illinois station, stands very well and is resistant to stem rust and mosaic disease and moderately so to loose smut. It resists leaf rust better than the Fulcaster variety, although not as well as Wabash. Averaging 38.6 bushels per acre at Alhambra, Ill., Royal has the highest weight per bushel of any variety of soft red winter wheat grown in southern Illinois. The milling characteristics have also been satisfactory.

The ability of winter wheat to survive low temperatures is of prime importance to farmers growing the crop in northern parts of the Winter Wheat Belt. Iohardi, a new hard red winter variety developed by the Iowa station from a cross between Iobred and Minhardi, combines the high quality, rust resistance, and stiff straw of the Iobred parent with the superior winter hardiness characteristic of Minhardi. It also outyields by a few bushels the other winter wheats grown in Iowa. With a crop like wheat, in which yields seldom exceed 30 bushels per acre, an average of a few more bushels is of real importance to the farmer. Iohardi has a high test weight per bushel and has been superior in milling and baking tests made in cooperation with the Department. This variety is recommended for all parts of Iowa and even for southern Minnesota.

BETTER KINDS OF OATS

Since World War I, great progress has been made in breeding superior varieties of oats. Specialists of the stations and the Department, in their noteworthy coordinated breeding program, have not only sought superior agronomic qualities but also high resistance to stem and crown rusts and to Victoria blight. When such new varieties as Richland, Iogold, Rainbow, and Morota—highly resistant to stem rusts—were developed and distributed in the early breeding work, it seemed that disease problems in oats were nearly solved, but crown rust later knocked out these varieties. Introduction of Victoria from South America in 1927 provided basic resistance to crown rust, and it was also resistant to smuts. This variety crossed with Richland gave rise to Boone, Control, Cedar, Tama, Vicland, and Vikota oats. The effect of combining resistance to smut and rusts in single varieties proved very striking in its increase of oats production in the United States. But Victoria blight epidemics in 1946 and 1947, attacking only those varieties derived from Victoria crosses, emphasized the need for additional resistance to this particular disease.

A new program, fortunately well under way in 1944, was developing varieties less susceptible to crown and stem rusts and at the same time resistant to Victoria blight through crossing on the Bond variety.

Spring varieties developed from Bond crosses up to the beginning of 1948 include Clinton (now widely grown in the Corn Belt and elsewhere), Benton, Cherokee, Bonham, Advance, Eaton, Mohawk, Shelby, and Nemaha from crosses by the Iowa station and the Department, and Bonda, Mindo, Zephyr, and Andrew from crosses by the Minnesota station. They are resistant to Victoria blight, all known physiologic races of crown rust except race 45 and similar ones, to all common races of stem rust, and to many races of the oats smuts. They are also superior in yield, quality, and standing ability and their stiff straw makes them desirable for combining.

Several of the newer varieties have improved characters and special adaptations. Shelby oats, a recent product of the Iowa station with the Department and approved for distribution in Iowa and other North Central States, is productive and stiff-strawed. Selected from Anthony × Bond, it is in many respects superior under Iowa conditions to Clinton, ripening about 3 days later, growing about 2 inches taller, and yielding about 3 bushels more per acre along with a slight superiority in test weight. Shelby is less likely than Clinton and Benton to produce secondary growth in wet years. Mohawk, a superior new oats developed by the New York (Cornell) and Iowa stations with the Department from a cross of Bond and Iowa D67 and recommended for planting on New York farms to replace Vicland oats, is closely related to Clinton, which it resembles. Mohawk has a very stiff straw, is about 2 inches taller, matures 2 days earlier than Vicland, and has plump yellow kernels with high test weight. The rather short stiff straw of Mohawk adapts it to combining and to growing on heavily fertilized fields in the dairy sections. Advance, developed under the same cooperation as Mohawk and derived from Iowa D69 × Bond, is an early midseason oats with stiff straw, is several inches taller than Mohawk, and has pinkish-ivory grain.

Bonham oats—developed by the Michigan and Iowa stations with the Department from Iowa D69 × Bond and noteworthy for yield and quality in the Upper Peninsula of Michigan—is similar to Clinton and Mohawk in disease reactions and agronomic characters but has deeper yellow and plumper grains. Bred jointly by the Kansas, Nebraska, and Iowa stations with the Department, Cherokee and Nemaha oats are stiff strawed, have high test weight, and can be harvested successfully with the combine. They are about 5 days earlier than Clinton and almost as early as Neosho and Osage. Cherokee came from a D69 and Bond cross, and Nemaha from Victoria-Richland × Morota-Bond.

Andrew, a new early-maturing open-panicled yellow-kerneled variety similar to Clinton and selected from Bond × Rainbow by the Minnesota station, has excelled in yields under cooperative trials throughout the Corn Belt. Zephyr, a new medium-early large gray oats selected by this station from Bond × Anthony, is particularly suited to sandy soils and has made good yields in comparative tests. Both Andrew and Zephyr stand well and have good weights per bushel.

The new varieties, specialists believe, should prove to be decidedly the most productive oats yet grown on large acreages in the United States. Oats breeders, however, always confronted with disappoint-

ments, must use caution and vision. They must check closely and study the appearance of new races of the rusts and smuts. These problems are by no means limited to the northern areas, for Victoria blight appeared suddenly yet not unexpectedly in the lower South during 1947. Its incidence and destructiveness have necessitated decided alterations in current oats improvement programs for the Southern States.

NEW BARLEYS

Several new productive barleys possessing disease resistance and other desirable characters have recently been released to growers by the State experiment stations. Atlas 46, a new barley developed by the California station, combines resistance to powdery mildew and scald—two important barley diseases occurring in California—with all of the favorable attributes of Atlas that have made it one of the leading varieties of the State. Continuous infection with these diseases throughout the growing season causes excessive defoliation, stunting, and premature ripening; such factors result in low yields and shriveled kernels low in test weight. Mildew and scald can be controlled only by growing resistant varieties. The yield advantage of Atlas 46 over the older Atlas variety under disease conditions is in proportion to the severity of the epidemic. Released to growers in the fall of 1947, Atlas 46 is expected to replace the common Atlas both in acreage and in its use by the brewing industry.

Plains barley, a new six-rowed, smooth-awned, early-maturing barley derived by the South Dakota station from Peatland × Dryland, has plump seed, a stiff straw, makes good yields, is resistant to stem rust, and can partially escape or resist the attacks of grasshoppers. Field tests show that Plains is well suited to central and western South Dakota where earliness to escape heat, drought, and grasshoppers is especially desirable. Final evaluation of its malting quality awaits commercial-scale malting and brewing tests.

Gem, a new six-rowed barley with semismooth awns produced by the Idaho station and the Department, is recommended as a feed barley; it is suited primarily to the nonirrigated lands of Idaho, although its performance in other States shows that is should have a wide adaptation. This kind of barley is much preferred by stockmen because, when fed as hay, smooth-awned barleys are not so apt to cause sore mouths in livestock. Gem is resistant to scald, certain races of covered smut, and to some races of black loose smut, and is also moderately resistant to stripe, mildew, and net blotch. The straw is stiffer and a little shorter than that of Trebi barley and the grain resists shattering, making Gem especially suitable for combining. Frontier barley, a new variety developed by the Wyoming station and the Department as a selection from Composite cross (CI 5461), is outstanding under irrigation and surpasses barleys formerly grown on irrigated land through its higher yield, stiffer straw, and resistance to stripe disease. Thus far it has been relatively free from loose smut in the State, while Lico, Beecher, Velvon, and Glacier barleys have smutted in excess of 20 percent during some seasons. Frontier is a six-rowed, rough-awned barley with erect mid-dense heads and deep-blue kernels. It is late-maturing and should not be grown where early-maturing barleys are needed.

REXARK—A NEW RICE WITH LONG SLENDER GRAIN

Although rice with long, slender grains commands a fancy price on the market, none of the varieties with such grain have heretofore been adapted for growing in Arkansas. Rexark—a new variety developed by the Arkansas station and the Department from a cross between Rexora and Supreme Blue Rose and released early in 1948—has long slender grain, a high milling quality, and produces a milled rice of excellent value. The new rice is medium in maturity, has a rather short stiff straw that discourages lodging, and compares favorably in yield with Nira and other long-grained varieties. It appears to be adapted for general use throughout the rice section of Arkansas. The cooperative research which produced this variety has proved highly profitable to Arkansas rice-growers. More than 250,000 acres, or 70 percent, of the rice planted in the State in 1947 were seeded to varieties—including Zenith, Prelude, Arkrose, Kamrose, Fortuna, and Nira 43—developed by this station. In excess of $5,000,000, according to reliable estimates based on performance, was added to the income of Arkansas farmers because they planted these varieties.

NEW SEED FLAXES

Minerva, a new productive seed flax developed by the Minnesota station with the Department, averages 2 to 2½ percent higher in oil content than Bison, previously regarded as the best performer. Derived from a backcross of an unnamed flax, C. I. 649, with Bison, the new variety retains a high iodine number; this is an unusual and valuable characteristic for a high-oil flax. Minerva has a greenish-yellow seed (generally classed as yellow-seeded) and a very deep blue flower.

Dakota, a new seed flax released by the North Dakota station with the Department and derived from Renew × Bison, is highly resistant to wilt, resistant to rust, and resembles Bison in reaction to pasmo, being less susceptible than most of the other rust-resistant varieties. Dakota has averaged about 1 percent lower in oil content than Bison but is distinctly superior in iodine number—the index of drying quality. It is like Bison in height and maturity and has slightly smaller seed. Its good plant type and satisfactory yields under test indicate that it will be suited to a relatively wide area. Its development and release is another forward step in meeting the rust and wilt problems and also in offering as much protection as is yet possible against pasmo.

PRODUCTIVE SORGHUMS RESISTANT TO CHINCH BUGS AND DROUGHT

Dwarf kafir 44–14, a short-stalked combine variety developed by the Oklahoma station with the Department for the eastern part of the grain sorghum region, is resistant to chinch bugs; it differs from some of the old strains of kafir in having stalks short enough to combine, but its yield is similar. Kaferita 811, a pure white-seeded sorghum that has proved the most resistant to chinch bugs of any variety grown at the station, continued to show good resistance against early infestations. Use of these new grain sorghums in central and eastern Oklahoma gives the stockman a more reliable source of grain feed and provides another cash crop to cotton and wheat growers that can be economically harvested with mechanical equipment.

Sumac 1712 sorgo, promising as a home-sirup variety and also making high forage yields, is another new development of the Oklahoma station. Although its sirup yields of 90 to 125 gallons per acre may be rather low for commercial production, it is unlike other varieties tested in that its yields of sirup have not been affected by severe drought. The sirup-making tests of the station have recommended Leoti, Sumac 1712, and Honey as reliable early-, medium-, and late-maturing sorgos for sirup production.

A new strain of Honey sorgo, resistant to chinch bugs and maturing about 10 days earlier than the ordinary Honey variety has been developed by the Oklahoma station with the Department. Originating as a single-head selection in a chinch bug infested field, the new strain yields a mean of 75 gallons of average to good sirup per acre, even in a year when ordinary strains are leveled to the ground by this insect pest. Indications are that it will be a good crop for the eastern half of Oklahoma and adjoining sections of Arkansas, Kansas, Missouri, and Texas.

NEW POTATO VARIETIES

Additional potato varieties of merit were being developed and introduced through the National Potato Breeding Program in which 32 stations and the Department were cooperating. The 34 new varieties brought forth in these Nation-wide endeavors accounted for nearly 38 percent of the 1947 supply of U. S. certified potato seed. Katahdin, the first of these new potatoes to be released to growers—about 15 years ago—is still the most widely adapted late variety. It furnished about 11,250,000 bushels of certified seed in 1947, displacing Cobbler, which produced 10,434,000 bushels, for the first time in history. Chippewa and Sebago, later releases, supplied about 2,844,000 and 1,258,000 bushels of seed. Others among these varieties released within the past few years have been gaining in popularity as their adaptations and other good points have become established in different potato-producing areas.

Kennebec, a new potato highly resistant to late blight, now being increased by certified seed potato growers in Maine, New York, and elsewhere, is considered one of the most important accomplishments of planned research in the national program. Kennebec, a large smooth white potato with shallow eyes, developed from true seed by the Maine station and the Department, is highly resistant to late blight—eliminating the need for protective bordeaux spray—and to certain virus diseases including net necrosis and mild mosaic, the latter a disease that has limited the production of Green Mountain. It possesses a fairly high dry-matter content indicative of good cooking quality. Kennebec also makes good chips when "de-sugared" by storage at 70° F. for only 1 week after removal from cold storage at 40°, whereas most varieties suitable for this purpose require 2 to 3 weeks of this conditioning. In tests at four locations in Maine during 1947, it averaged 675 bushels per acre and in one test more than 700 bushels.

Chisago, Waseca, and Satapa, three new potato varieties developed by the Minnesota station from crosses between standard varieties and experimental seedlings, all set their tubers at about the same time and their skins are tougher than those of the parents. They are expected to produce tubers with great uniformity and less subject to injury in

handling. Chisago, a Cobbler cross, is a large blocky, white, smooth, early potato with shallow eyes. It produced 87 percent of U. S. No. 1 tubers compared with 70 percent for its Cobbler parent. Waseca, a Triumph cross, is an extra early red potato. Satapa, a pale red Warba cross, in the second early class, makes high yields, and in size, shape, and smoothness resembles a baseball.

A NEW SWEETPOTATO FOR CANNING

Sweetpotatoes are important in the diet, yet existing storage and transportation practices fail to make them available in the fresh state to consumers throughout the year. This has led to the development of the sweetpotato canning industry, which has needed varieties particularly adapted to the purpose.

Australian Canner, a sweetpotato with merit for canning purposes, has been released to growers by the Mississippi station and the Department, after introduction from New South Wales, followed by extensive tests in the southern sweetpotato-producing region. Its roots retain their shape during vacuum-pack and sirup-pack canning—an outstanding characteristic largely lacking in Porto Rico, Nancy Hall, and many other commercial varieties. The canned product, of very good quality, has an attractive uniform orange-flesh color, not possessed by Triumph or other commercial sweetpotatoes able to retain their shape in the can. Australian Canner roots are usually small to medium in size, reasonably smooth, with buff-tan skin, and short-tapered-spindle in shape. The flesh is salmon-colored, has a moderate solids content, and is somewhat higher in carotene than Unit I Porto Rico. It is medium to late in maturity, keeps fairly well in storage, has good production characters, and may be expected to produce as high a yield of canning-grade quality as the best strains of Porto Rico.

Jersey Orange—a selection made by the New Jersey station from strains of the Kansas station's Orange Little Stem—is moister than Yellow Jersey, and has a much deeper orange flesh color, which is retained in cooking. In field tests, Jersey Orange has equaled Yellow Jersey in yields, disease resistance, and keeping qualities and it has met with good acceptance by consumers. The new variety is introduced as a type of sweetpotato that should enable New Jersey farmers to meet competition from the so-called "yams" offered on local markets, rather than as a replacement for Yellow Jersey.

HIGH PROTEIN CORN

Livestock feeders have long observed that corn from very fertile or heavily fertilized fields has a greater feeding value than that from less productive areas; this is attributable in part to variations in protein content. The Pennsylvania station finds from fertilizer tests with hybrid corn that the protein content of the grain may be increased by high soil fertility levels—either naturally high or as improved by manure, green manures, or fertilizers, or their combinations; by the planting rate, varied directly with soil fertility; and by the particular hybrid under test. Corn hybrids with increased protein content have been developed without the sacrifice of yield or other desirable characters.

In southeastern Pennsylvania—where the station grew a number of hybrids at increasing fertility levels—the experiments demonstrated how these three factors interact in their influence on the protein content of the resulting grain. Fertilizer (10–10–10) was applied at 0, 300, 600, and 1,200 pounds per acre and planting rates were 7,100, 10,600, 14,200, and 17,900 plants per acre—approximating 2, 3, 4, and 5 stalks per hill at a spacing of 42 by 42 inches. At the lowest planting rate, increased fertility failed to influence protein content, since plant foods already in the soil were evidently sufficient for the limited stand, even without added fertilizer; but with increases in the plant population creating competition for these limited nutrient supplies, the percentage of protein decreased at all fertility levels used. When the individual hybrids grown in these tests were unfertilized they produced corn with different percentages of protein, ranging from 8.09 in Ohio C12 to 9.04 in U. S. 357. As the fertility levels were augmented by fertilizers, however, the percentages of protein (a single exception) in each hybrid were increased.

The protein content of grain at the 1,200-pound fertilizer level ranged from 9.66 percent in U. S. 357 down to 8.63 percent in Ohio C12, with the other hybrids—Iowa 939, U. S. 13, Iowa 4059, and Ohio W10—occupying intermediate positions. When planting rates were increased without added fertilizer, the protein content of grain in these hybrids tended to fall off—an effect similar to that encountered in growing the same stand on progressively poorer soil. Whenever nitrogen starvation symptoms appeared in corn leaves during the growing season, a reduction was found in the protein content of the grain.

Farmers are interested in the amount of protein per acre yielded by their corn, as well as in quality of the grain. Both the planting rate and the quantity of fertilizer applied markedly influenced the acre-yield of this protein. In these trials the most economical maximum yields were obtained with 600 pounds of fertilizer and 14,200 plants per acre. Comparable results were obtained in northwestern Pennsylvania. On highly fertile soil in the central part of the State, however, the differences in protein content due to variations in fertilizer and planting rate were smaller. The findings as a whole suggest that farmers wanting to produce high-protein corn must provide soil having the needed plant foods and grow a hybrid that can convert these nutrients into protein.

DRY COLD STORAGE OF SEED CORN

Reserves of seed corn that can survive and produce useful plants over long periods of time—particularly the more valuable foundation stocks of inbred lines—are highly essential to the national corn-improvement programs. Seeking methods by which seed stocks used in corn breeding work could be safely held over extended periods, the Ohio station with the Department stored seed corn with adjusted moisture contents in sealed airtight containers or at low temperatures; their experiments differed from the many earlier trials at the station and elsewhere. These workers found that the germinability (determined in soil at normal corn-planting time) of seed corn stored at temperatures between 0° and 28° F. can be preserved much longer

than by the customary practice of storing about 72° F. (room temperature). Seed stocks with a moisture content even as low as 11 percent retained their power of germination better over the longer periods when held at 28°. Seed corn kept at 0° in sealed cans with either 5 or 10 percent of moisture gave excellent germination after 7 years of storage.

Airtight containers, it was observed, prevent the seed from fluctuating in moisture content with every change in the humidity and temperature of the air. These workers recommend the drying of seed corn to a 5- to 8-percent moisture content, sealing in airtight containers, and storing at as low and as uniform a temperature as possible. As a result of the information supplied by these tests, the Ohio station is now storing foundation seed stocks in airtight 55-gallon steel drums.

DEFOLIATION OF COTTON

A quick and economical method of removing cotton leaves has been needed ever since the first mechanical pickers were constructed. The heavy consumption of defoliants—5,000 tons in 1946—in the alluvial areas testifies to their value for mechanical pickers, reduction of boll rot, and speeding up of hand picking in rank cotton. Defoliation at the proper stage of growth is economically sound, for it does not reduce yield when applied in proper amounts and permits machines to gather higher percentages of cotton with much less trash than is otherwise possible. The Mississippi station with the Department had found earlier that cotton plants could be selected that would under normal conditions mature an early crop and drop practically all their leaves, thus reducing late food and breeding material for weevils and making mechanical picking easier. Nevertheless, these plants had the disadvantages of greater susceptibility to aphids and of shedding their leaves too early in dry years for the development of a full crop of late-set bolls—even though their leaf drop under abundant rainfall differed but little from that of normally later varieties.

Artificial defoliation was then studied by these cooperators as possibly a better solution to the problem than the development of cottons with characteristically early leaf drop in normal seasons. Their experiments showed that regular-dusting-grade calcium cyanamid was superior for this purpose to other materials tested and could be applied by any type of dusting machinery used for boll weevil poison. The highest percentage of defoliation—desirable with machine picking—was accomplished with 30 to 50 pounds of cyanamid per acre. For hand picking under farm practice 5 to 10 pounds were used successfully to remove the outer leaves only; this retarded boll rotting on rank-fruited cotton and allowed more bolls to mature than was possible with heavier amounts. Plants were defoliated more completely and developed less second growth when the youngest top bolls were 20 days old than at any other stage of maturity. Cotton dropped its leaves in 4 to 10 days after treatment with calcium cyanamid. Although the defoliant could be applied with satisfactory results at any time of day when the air was still, a more desirable type of defoliation occurred when plants were treated with defoliant while they were dry, and later were moistened with dew.

Cotton defoliated after the bolls were 20 to 40 days old showed no differences in yields, or in staple length. Defoliation reduced the

amount of trash gathered by mechanical pickers, resulted in an average increase of one-half grade for machine-picked cotton, improved the grade of seed, and reduced picker and card wastes in spinning. Other worth-while advantages of defoliation included the destruction of heavy aphid populations developed on cotton late in the season and the prevention of damage from late infestations of leaf worm. As a result of early fall defoliation in cottonfields, the percentage of cotton locks infested by weevils was reduced and population counts in seedling plants the following spring were negative; this was in comparison with an average spring count of 58 weevils per acre for undefoliated cotton in adjacent fields.

HARVESTING AND CURING PEANUTS

Peanuts have traditionally been a crop requiring much hand labor, particularly in digging, stacking, and picking. These three operations have required 50 to 65 percent of the labor needed to produce the entire crop. Although land preparation, planting, and cultivation have been largely mechanized, little has been accomplished toward the complete mechanization of harvesting operations in such a manner as to minimize weather damage and other hazards during the curing process. Determination of the range of conditions to which peanuts may be subjected in curing and still continue to possess a quality adequate for edible and industrial products is necessary before mechanization of the harvesting phases can be satisfactorily accomplished.

The Georgia station with the Department found that removal of the tops from peanut plants as long as 2 weeks before digging failed to reduce the quality of the nuts as compared with removal at harvest; at the same time a large yield of high quality hay was obtained. Peanuts exposed to field conditions favorable to drying lost their moisture very rapidly, but the tops had no effect upon the rate of drying. Within a given variety, peanuts cured off the plants, on stubs, or on whole plants showed no consistent differences in physical and chemical characteristics of the pods or seeds. These studies, revealing that substantial modifications can be made in harvesting and curing methods without lowering the yield or quality of the peanuts, have led to three suggested procedures for conserving labor and producing high-quality nuts and hay.

Texas, ranking second only to Georgia in peanut production, has also recognized the great current need for improved methods of harvesting and drying. The Texas station has successfully harvested peanuts with a combine and has done an excellent job of threshing and obtaining high commercial grades; the threshed peanuts, however, generally carried a high percentage of dirt. The threshing was satisfactorily carried out after the plants had been dug for only 2 or 3 days. In such cases, the nuts, after threshing, must be dried for a time to reach the desired 7-percent moisture content; this necessitates storage in the open, with the probability of increasing the fungus-induced "concealed damage."

Artificial drying, successfully carried out in a column or bulk drier, has offered a solution to this problem. No indications have been found of immediate serious damage from the drying treatments that would make nuts undesirable for crushing. The station also noted

possible advantages from clipping the vines and combine threshing the stubble, from saving the hay by catching it on a slide pulled behind the combine, and from getting two rows of peanuts into a single windrow by use of a shaker-windrow attachment. The Texas, Georgia, and other State experiment stations are continuing investigations aimed at greater efficiency in production, harvesting, and curing methods and machines.

FORAGE CROPS, RANGES, AND PASTURES

During the past few years, the high cost of concentrates and grain feeds has prompted livestock growers to assume a greater interest in pastures, ranges, and forage crops and to seek means of increasing the efficiency of feeds from such sources. On the other hand, high meat prices have caused farmers, who in the past have had their chief interest in crops, to show a greater interest in a more balanced type of agriculture. Land-owners are also coming to realize that there are no more "frontiers" and that the land they occupy must serve not only them, but the generations to come. It is recognized that a permanent agriculture is a grassland agriculture and many research problems have been presented in connection with establishment of hay and pasture lands, in proper range management, and in improving old varieties of forage crops and introducing new ones. Pastures are no longer waste lands, fertilizers are no longer limited to the so-called "cash crops," and ranges are no longer considered expendible.

The experiment stations have responded to the calls for information and, in many cases, have anticipated the demand for research in various phases of grassland agriculture. The following contributions represent only a small part of the work of the stations in the field of forage crops, pastures and ranges, a field which is becoming increasingly important in the present and future economy of our agriculture.

BETTER FORAGE CROPS EXTEND USE

With more and more of the better land being devoted to the growing of forage crops and the increased attention being given to the various phases of soil improvement, there is an ever-increasing demand for improved strains and varieties of grasses and legumes. Until recent years, a farmer bought and planted clover seed, bluegrass seed, or bromegrass seed as such, ad gave little or no attention to the strain, variety, or source. Today, however, the demand for improved varieties far exceeds the supply and more attention is therefore being given to increasing seed stocks of such varieties. At the same time, work is being continued on the development of even better strains and varieties adapted to different soils and climatic conditions.

The New York State experiment station has reported that hard seeds of alsike and red clovers, immersed in water for 25 years, germinated immediately when they were removed from the water and scarified. This would explain the appearance of objectionable weeds (e. g., vetch in wheat and sweetclover in alfalfa) in supposedly pure seedings. Many times, impure seed is blamed when in reality the mixtures are caused by hard legume seeds already in the soil, and in purchasing seed the germination percentage plus the hard seed content may well be considered.

Since the introduction of Dixie crimson clover by the Georgia station in 1945, demands for this valuable hard-seeded variety have rapidly outdistanced the available seed supply. In 1948, over 3,000 acres of this clover were planted by Georgia farmers for grazing and for producing certified seed. The seed from this acreage was valued at $25,000; furthermore, the crop also furnished several months of winter grazing and soil protection.

Kentucky 31 fescue, a strain of tall fescue introduced by the Kentucky station, has proved very popular and is a valuable pasture grass, especially in areas where other grasses are unsatisfactory. Farmers have reported practically year-round grazing on Kentucky 31 pasture with an average annual carrying capacity of 1 animal per acre. Perhaps the limiting factor in the rapid expansion of this grass has been a limited seed supply, but in 1947 Kentucky produced a seed crop valued at over $1,000,000 and new seed production methods, such as row-seeding, promise to meet the demand within the next few years.

Rescue grass, a native of South America, has been growing in Texas for almost 100 years. It is a winter annual and produces green feed at a time when most other forage plants are dead or dormant. The name was given to this grass by early stockmen because it frequently carried grazing stock through periods of short feed. On established stands, the seedstalks grow so close to the ground that animals cannot graze them, thus insuring annual reseeding. The Texas station has developed a new strain, which has been given the name, "Texas Rescue 46." This strain has been consistently superior to native and imported strains, having an upright growth, high disease resistance, and high yields of forage and seed. Over 60 acres of Texas Rescue 46 were harvested by registered seed growers in 1947 and 60,000 pounds of seed were made available for further increase. Seed stocks of this valuable new strain were put on the commercial market in the fall of 1948.

First introduced in 1943 as a product of the Texas station sorghum-breeding program, Sweet Sudan grass is rapidly replacing common Sudan grass as a pasture and forage crop. It is estimated that 85 percent of last year's acreage of Sudan grass in the United States was devoted to Sweet Sudan—a $100,000,000 crop. Because of greater palatability and food value, beef cattle gain about one-half pound more per day on Sweet Sudan than on common Sudan. At a conservative estimate, assuming Sweet Sudan to be a 10-percent better feed than common Sudan grass for cattle, this new crop, a result of scientific breeding, is now adding $10,000,000 annually to the income of Southern cattle growers.

Since the use of new and better varieties of forage crops is largely limited by short seed supplies, improved seed production methods are of primary importance. The Idaho station has found that seed yields of grasses are materially improved by fertilization and row culture. By planting in cultivated rows, the amount of seed required is reduced by as much as 50 percent and productive capacities are maintained over a longer period of years than is obtained from solid stands. On moderately fertile soils, all grasses sown for seed respond to nitrogenous fertilization, the response becoming more pronounced with increasing age of the stands.

The difficulty of preparing some soils for grass seeding and the necessity of plowing and reseeding every few years frequently prevent the full use of grass crops. The Vermont station has found that high quality grass hay can be maintained almost indefinitely without plowing and reseeding by use of complete fertilizers high in nitrogen. Yields have frequently been tripled by the use of this system.

IMPROVED PASTURES AND RANGES PROVIDE ECONOMICAL FEEDS

Good pastures produce good meat and milk, but poor pastures provide little more than exercise for the grazing animals. Until recent years many pastures were restricted to lands too wet or too steep for cultivation but, with rising prices of grain feeds, stockmen have sought means of growing better pastures and extending the grazing season. Favorable livestock markets have induced many farmers to place less emphasis on a strictly cash-crop system of farming and to adopt a more stable type of agriculture. This change has brought about the realization that grazing animals can harvest and utilize a crop more efficiently and more economically than is possible with dry-lot feeding. In addition, the soil is improved and protected from erosion.

The growing of an efficient and productive pasture and the maintenance of a good range require as much care and planning as the raising of harvested crops and a large amount of research effort is now being put into pasture and range management. Grassland farming is undergoing radical changes. Even in the northeastern section of the United States, long regarded as a natural pasture region, new grass and legume varieties and strains and new systems of pasture management and fertilization are so successful that old pasture methods are being rapidly discarded. In the Southern States, the 1-crop system of farming is giving way to a more permanent and stable type of agriculture in which both permanent and temporary pastures play a large part. The Western States are concerned with depleted ranges and many studies are under way that will aid stockmen in improving and making more efficient use of their grazing lands.

Ladino clover and smooth bromegrass are rather recent introductions in northeastern pasture areas but these crops are being seeded on an ever-increasing scale. The New Hampshire station has reported that smooth brome-Ladino mixtures have maintained better stands and produced more forage than any other mixture or single-species planting. Experimental Ladino-smooth brome pastures have produced twice as much dry matter per acre as ordinary pastures, even when fertilization practices were the same. A survey of one typical county in New Hampshire, made in the fall of 1947, revealed that about 40 percent of the farms were growing Ladino clover and it is estimated that this percentage has increased markedly during the past year.

During 1948, the West Virginia station completed a series of pasture renovation experiments. These studies were made to compare the effectiveness of different methods of improving poor pastures and to provide information as to the most effective and practical methods, seed mixtures, and management in the renovation of an old sod. The

results of these studies indicate that renovation is not a substitute for surface treatment and proper pasture management. Pasture renovation may be justified to obtain a quick response to treatment on areas of very poor species composition and to introduce desirable new plants that are not present in the native sod. To secure good stands of white clover, Ladino clover, alsike clover, and lespedeza, it was necessary to kill out 50 to 75 percent of the old vegetation by shallow plowing or disking. Kills of 75 percent or more were required to assure stands of alfalfa, red clover, and most grasses.

Recent findings at the Ohio station have substantially reduced poultry-production costs. It was found that poultry on a Ladino clover range could be raised successfully without the need of other feed except for a low-protein supplement of corn and minerals. Less feed was consumed and the mortality rate was lower than when the chickens were confined. Furthermore, there was greater economy in feeding poultry, as well as more rapid growth, on Ladino range than on bluegrass or "run-of-the-farm" range.

The Southern States are realizing more than ever that animal production, especially of beef, must be based on pastures and forage crops rather than on corn. Highly acceptable grades of beef are now being produced with little or no corn in the ration. The Louisiana station has found that permanent pastures, augumented by supplementary grazing crops, permit cattle to graze and make satisfactory gains throughout the entire year. In Mississippi, the station's program of pasture investigations has brought increased profits to farmers. The adoption of improved pasture grasses and legumes and the use of proper liming and fertilizer practices have stepped up the carrying capacity of pastures and brought unexpectedly high production at greatly reduced costs. Records kept by some farmers show that investment in proper fertilizers, in accordance with experiment station recommendations, has paid out within 2 months in the form of increased production.

In the past, lack of winter grazing in Georgia has greatly limited the numbers of livestock carried and the profits derived from them. Today, however, the results of Georgia station experiments with such forage crops as oats, ryegrass, crimson clover, and orchard grass, are enabling farmers to obtain winter grazing in sufficient quantity, with dependability, and at economic costs. Grazing trials have shown that yearly gross income of $40 to $60 or more per acre can be obtained from good pastures. In one experiment, improved permanent pasture produced a gain of 418 pounds of beef per acre, or 178 percent more than unimproved pasture. The feed produced on 1 acre of improved pasture was equivalent to 73 bushels of corn. Livestock can thus provide an added income enterprise for cotton farmers of the South.

Wire grass, which predominates on much of the unimproved range lands of Florida, is not considered a nutritious grass, but the Florida station has determined that burning produces a new growth much improved in composition and capable of yielding profitable gains in grazing cattle. Burning produced the following percentage increases in wire grass forage: Nitrogen 160, phosphorous 115, potassium 58, calcium 29, and magnesium 152. Application of lime with a complete fertilizer increased the nitrogen and mineral content of the herbage

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still further. An additional advantage of off-season burning is that it permits top seeding of improved grasses and legumes, and successful stands have been obtained where wire grass competition had been eliminated.

Increased pasture yields are being obtained by Kansas farmers through the use of fertilizers on grasslands. When nitrogen fertilizer becomes readily available, it is likely to be widely used on pastures. The accompanying table is a summary of nitrogen fertilization studies on smooth bromegrass made by the Kansas station.

Summary of nitrogen fertilization experiments on smooth bromegrass

Material produced	Dry-matter yield per acre when nitrogen is applied on indicated pounds-per-acre basis—					
	0	20	60	100	140	200
	Pounds	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Pounds*
Seed	117	216	376	573	243	237
Forage	1, 357	2, 546	3, 536	4, 331	4, 686	4, 752
Protein	91	110	221	325	417	516
	Percent	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*
Protein in forage	9. 31	9. 75	9. 50	10. 74	11. 65	13. 93

In a test of native and seeded ranges, the Colorado station found that, on a 2-year-old seeded dry land range, cows without calves made an average gain of 132 pounds in 49 days. During the same period, cows on native range gained about 30 pounds. The seeded range was a mixture of the cool-season grasses, intermediate wheatgrass, Russian wild-ryegrass, and smooth bromegrass. Gains on the seeded range were shown to decline rapidly as the cool-season grasses matured. Greater gains were made under a season-long conservative grazing system, but in dry years the deferred-rotation grazing system provided more feed and peak gains were extended for an additional month.

Range studies in New Mexico revealed that over a 7-year period mesquite invasion had been at the rate of 110 plants per acre. Heavily infested mesquite range produced 70 percent less forage than a similar area with light infestation. On well-preserved grassland, rodents had no material effect on stand and forage production, but on range land infested with undesirable shrubs the damage was severe.

Most stockmen consider grasses to be low in root reserves during spring and, therefore, susceptible to injury by excessive spring grazing. Preliminary studies at the Oklahoma station support this belief but there is some indication that certain grasses, particularly blue grama and buffalo grass, are low in root reserves in the late summer and fall months. This would explain the results of tests denoting that close grazing in August and September is more detrimental to these grasses than equally close grazing at other seasons of the year. Further studies must be made, however, before such results become conclusive.

An estimated 50,000 acres of depleted range and abandoned cropland in Colorado are reseeded each year. Research by the Colorado station indicates that good reseeded stands have a grazing capacity double that of good native range and five to ten times more than that of abandoned cropland. The intermediate wheatgrasses have shown great promise for such reseedings. Three Russian strains of intermediate wheatgrass produced stands superior to standard grasses when seeded in moderate weed cover. On older abandoned cropland, however, disking is necessary to eliminate competition by the weedy grasses.

ORCHARD AND SMALL FRUITS

The popular conception of fruit visualizes the fresh product as displayed on the fruit stand or market counter. Yet a large part of the Nation's crop reaches the consumer in the processed state as dried fruits, juices, jellies, and preserves or as the canned or frozen product. New processes such as freezing preservation mean new problems for the research worker. A growing need appears for new varieties that will retain their flavor, color, and shape upon processing, for new and improved methods of growing and handling to secure and maintain the highest possible quality, and for better sprays and dusts that will mean freedom from diseases and insect pests. Station workers are doing their best to meet these needs, as is indicated by the following examples of constructive and useful work.

MANURE AND STRAW MULCH BENEFICIAL TO APPLE TREES

Soil management of the orchard has for many years been studied at various experiment stations in the apple-producing areas of the country. Around the turn of the century, there was a time when clean cultivation throughout the entire growing season was considered the best practice; apple and pear orchards were kept as free of vegetation as a tilled field. Under this practice, yields were satisfactory for a few years until the organic matter in the original sod and soil turned under at the time of planting had become exhausted. The yields then rapidly declined, the trees became unthrifty, and the soil was compacted and difficult to work. Where such clean-cultivated orchards were on sloping ground, a severe erosion of the soil took place. Cover crops came into the picture as a means of retaining the soil and adding organic matter when plowed under. Since the cost of seeding and turning under the cover crops was a heavy item, interest soon developed in mulching orchards with straw, second-grade hay, and other organic materials.

Certain results reported by the Indiana station indicate that mulching of apple orchards is an effective practice when the straw is mixed with stable manure. In the orchard areas where considerable manure was incorporated in the straw mulch, tree growth and fruit production were greatly improved. The amount of growth was adequate but not excessive and thus encouraged the development of fruiting spurs in all parts of the tree. As the mulched trees grew only moderately, the amount of annual pruning was reduced, and the cost of spraying and harvesting was less than in the taller trees receiving mineral fertilizer. Fruits from the mulched trees were large and attractive and the tendency toward "off-years" was replaced by tendency toward moderate-sized crops every year.

Trees in bluegrass sod receiving an annual application of nitrogen made excellent growth and yielded heavily, but with a definite trend toward alternate large and small crops. As compared to the straw-manure mulched trees, the fruit was smaller in size and lower in quality, giving a net result of lower commercial value.

Trees in cultivation without added nitrogen were poor in growth and produced only small crops of low-quality apples. Even when nitrogen was applied to the soil the situation was not greatly improved since erosion continued to carry away the soil and each year its physical condition became progressively less favorable to the trees.

The Indiana workers concluded that an effective soil-management system in the apple orchard must not only provide for vigorous growth of the trees but must also protect the soil from erosion losses and destruction of its organic matter. Combinations of sods and mulches meet these needs economically and successfully.

PURIFICATION OF STORAGE AIR PROLONGS LIFE OF APPLES

Recognition that other factors besides low temperature and high relative humidity are concerned with the successful storage of fruit led the New York (Cornell) station to undertake intensive studies on ways and means of improving the efficiency of fruit storages. Emphasis was placed on the apple because of its importance in New York and because the McIntosh, one of the State's leading market varieties, is a late-fall apple with limited storage life.

The problem was approached from the standpoint of removing the ethylene, a gas given off naturally by ripening apples that stimulates the ripening process in less mature varieties stored in the same compartment. Moreover, the station workers were concerned with other undesirable gases known as "scald gases" which, when allowed to accumulate in the storage, cause a diseased surface condition on apples known as "scald." In essence, the problem was one of developing effective procedures for freeing the storage air of poentially harmful gases. To facilitate this purification of the air, these workers devised an ingenious apparatus whereby the storage air was passed through canisters containing activated coconut-shell carbon. In some tests, the carbon was brominated but since, in general, the results were not as good with this supplement, the bromine was soon discarded.

Consistently good scald control was obtained with air-purification by the activated coconut-shell carbon method when only a single apple variety was present in the storage room. With mixtures of varieties, scald was reduced in all except one—the highly susceptible Rhode Island Greening. Air purification gave as good results in scald control with variety mixtures as did the older procedure of distributing shredded oiled paper in the packages.

On the average, air purification by the activated carbon method added about 3 weeks to the effective storage life of apples. With the Wealthy, Cortland, and McIntosh varieties, the extension in storage life approached a full month; this would be a material advantage in the profitable marketing of these varieties during years of heavy production. An incidental benefit of the air purification consists in keeping the storage chamber free from undesirable odors. The Cornell workers point out that air purification would complement other important factors concerned in the successful storage of fruit such as

the proper time for picking, careful handling when the fruit is harvested and packaged, and maintenance of proper temperatures and relative humidities.

WAX SPRAYS INCREASE YIELDS OF CHERRIES AND PEARS

Remarkable increases in the yield of cherries and pears were obtained by the Michigan station from the application of wax-emulsion sprays. Both of these crops are of major importance in Michigan as indicated in estimated average yields over a 10-year period (1935 to 1944) of 1,109,000 bushels of pears, 34,000 tons of sour cherries, and 3,257 tons of sweet cherries. This State leads the Nation in sour cherry production. The wax material used was a proprietary emulsion manufactured by a Michigan chemical firm interested in spray materials. The beneficial effects on yield resulted chiefly from an increase in the size of individual fruits. The most consistent responses were obtained with cherries where a significant increase in fruit size was recorded for every treated orchard. In one Windsor sweet cherry orchard, the increase in size amounted to 23.6 percent. The trees were sprayed with the wax emulsion incorporated in the usual fungicide material—once when the first sign of color appeared on the cherries and again a week later. In the case of Black Tartarian sweet cherries, the increase in size averaged 14 percent. Results with the Montmorency sour cherry were not so striking as for the sweet cherries, but in the two orchards under investigation the gains in size of fruit reached 7.5 and 12 percent.

No injury was observed in any of the cherry orchards treated with wax emulsions. Analyses of the fruit from waxed and nonwaxed trees showed only a slight difference in sugar content and this in favor of the treatment.

Bartlett pear trees sprayed with wax emulsion had better and more attractive foliage and produced fruits of larger size, 10 to 16 percent more of the pears on the waxed trees being above 2¼ inches in diameter than on the control of untreated trees. On the other hand, Kieffer pears did not benefit materially from the wax treatments.

No increase in size of fruits was recorded on Delicious and Golden Delicious apple trees. The workers believe that mite injury, moisture shortage, and sun scald may have influenced the results of applying wax sprays on apples.

The beneficial effects obtained with the cherries and Bartlett pears had the double advantage of increasing the yield and at the same time the percentage of large-sized fruits, thus placing more of them in a higher price range.

INJURY TO APRICOTS CORRECTED BY BORON

Apricots produced by certain orchards in the Wenatchee Valley of Washington were rendered unmarketable because of defects in the fruit such as off-shapes, cracking, and internal injuries. Three definite symptoms were observed: (1) Internal browning and formation of corky tissue around the pit cavity, (2) cracking of the fruits, and (3) shriveling of the surface with acute malformation and uneven ripening of the flesh. The apricot is an important crop in this State, some 27,300 tons having been produced in 1946, with a farm value of

over 3 million dollars. Hence, the growers were much concerned and appealed to the Washington station for aid.

A survey by this station indicated that the trouble was nutritional and that it was probably attributable to a deficiency of boron in the soil in which the apricot trees were growing. Applications of borax to the soil at the rate of one-half pound per tree resulted, during the succeeding year, in normal fruits free from any of these faults. At the same time affected trees not receiving the borax treatment again produced fruits with all the symptoms previously observed.

Analyses of fruit from borax-treated and comparable affected trees revealed a marked difference in boron content in favor of treatment. A corresponding but somewhat smaller increase in boron content was observed in the leaves of the treated trees. The increased boron content of the fruit from this treatment was correlated positively with the production of unblemished fruit, indicating beyond doubt that a lack of boron was the causal factor concerned.

The cost of the borax was trivial indeed compared with the increased returns accruing to the grower from the treatment. This is a striking example of how research can benefit the grower by aiding him in solving a critical problem.

PROMISING NEW BERRIES FOR TEXAS

Slowly but steadily the fruit breeders of the Nation are providing growers with new fruits having more desirable qualities and better adaptation to the various regions of the country. In late 1946, the Texas station introduced three new berries: Earli-Ness, Big-Ness, and Regal-Ness, which are proving highly desirable for both home and commercial use in the berry-producing area of eastern Texas. These berries have an interesting history. Back in 1913, the station succeeded in crossing the wild dewberry of eastern Texas with a red raspberry. The second generation of this cross proved completely fertile and a selection from this generation was named Nessberry in honor of the station worker who made the original cross. The Nessberry had a delightful flavor and was well adapted to eastern Texas but did not become popular because the berries were hard to separate from the plants and stocks were difficult to increase. The Nessberry was then crossed back to its wild dewberry parent and from the resulting progeny the three berries later named Earli-Ness, Big-Ness, and Regal-Ness were obtained.

All three mature early and greatly extend the picking season for blackberry-type fruits in Texas. Freezing experiments indicate the new berries to have definite value for this type of preservation, which has become increasingly popular with the advent of home and commercial freezers. All three varieties have outyielded the Lawton blackberry in carefully replicated tests. From their red raspberry parent, these new berries have received added and distinctive flavor.

Descriptive notes on the varieties show that Earli-Ness is well named. It came into fruiting in 1946 on April 18, while strawberries were still in production. The plants are vigorous and productive and the fruit of good commercial quality. Big-Ness, named because of its unusual size, is considered of particular value for the home garden. The fruits are a little too soft for shipment in the fresh state. Regal-

Ness ripens about a week later than Earli-Ness, which it resembles in both plant and fruit characters.

At College Station, Texas, a combined planting of the three new berries and the Lawton blackberry gave continuous heavy production from about April 25 to July 1. In view of the fact that eastern Texas produces almost one-tenth of all the blackberries grown in the United States, these new berries are an important addition to the potential crop.

Since the growth habit of the three new Nessberries is intermediate between that of a blackberry and a dewberry, with canes occasionally attaining as much as 30 feet in length, the plants require training to a wire support. The station is now making crosses between the Nessberries and the upright Lawton blackberry in the hope of obtaining varieties possessing all the good qualities of the Nessberries but with the upright growth habit of the blackberry. Such a cross would be more acceptable to Texas growers who are accustomed to handling plants with erect canes.

THE BLUEBERRY BECOMES A CULTIVATED CROP

Perhaps the most remarkable development of recent years in American fruit growing has been the rapid promotion of the blueberry from the status of a wild fruit to that of an important cultivated crop. For some 300 years, the blueberry had been gathered from the wild and, although widely used and appreciated, no particular effort had been made in the way of improvement. The Department initiated progress in this direction. Promising plants were collected from native sources, and these in turn were crossed with one another to obtain better quality and size. As a result, there is now a creditable list of varieties covering the entire fruiting season. Further improvement is under way with promising new seedlings apparently destined to replace within a short time the varieties now being grown.

Various State experiment stations, working formally or informally with the Department, have taken an active and important part in the betterment of the blueberry. This has been done by testing new seedlings and selections and determining their adaptation to specific areas. Concurrently, the culture of blueberries has not been overlooked. Propagation by cuttings has been studied at Maine, New Hampshire, Massachusetts, Michigan, and Washington stations, and elsewhere. Fertility requirements have been investigated by the above stations as well as by the North Carolina, New Jersey, Connecticut (Storrs), and other stations. The Michigan station has crossed the high- and low-bush blueberry in an effort to develop intermediate types better suited to horticultural use.

The blueberry has certain advantages over most other berries. It grows well on acid soils ill-adapted to general agriculture. The fruits are not quickly perishable and thus may be kept for a considerable time in the fresh state. There is a strong demand by the bakery trade for canned and frozen blueberries to use in making pies, muffins, and other items. Packaged in clean wooden containers, covered with glassine paper, the large-fruited named varieties command a ready sale at excellent prices to the grower. Altogether, the blueberry as a cultivated crop is an important addition to our American fruits.

Future horticulturists will certainly look back on the present period of blueberry improvement as a remarkable achievement and as an indication of what might well be done with other native fruits.

NEW STRAWBERRIES INCREASE LOUISIANA'S CROP

Louisiana devotes more acres to strawberries and produces more of them than any other State in the Union. The production in 1946 was 1,075,000 crates, according to the United States Department of Agriculture, and the total value something over $11,000,000. For many years, Louisiana's strawberry production was based largely on the Klondike variety, an excellent shipping berry but highly susceptible to leaf spot (*Mycosphaerella fragariae*) and leaf scorch (*Diplocarpon earliana*). Recognizing the need for better varieties, the Louisiana station initiated a breeding program with a view to developing a variety as good or better than Klondike and at the same time carrying resistance to these two diseases. The station introduced Klonmore in 1940. This variety was carefully selected from a group of seedlings obtained from a cross of Klondike with Blakemore, a Department introduction. Klonmore is a high yielder, excellent in table quality, a good shipper, and the plants do not require spraying for control of the leaf diseases. So acceptable has Klonmore proved to Louisiana growers that 80 to 85 percent of their total strawberry acreage was planted to this new variety in the 1948 season. Because of its productivity, station authorities estimate that the new variety has added about $2,000,000 income to growers above what would have been obtained with the older Klondike variety.

The Louisiana station employed a rigorous and effective technique in determining the potential resistance of the strawberry seedlings to leaf diseases. From the time the first true leaves developed, the young plants were sprayed repeatedly with a spore suspension of the two leaf spot fungi. In this way over 90 percent of the seedlings were quickly eliminated, not only reducing costs of growing the plants to maturity but giving an accurate reading on resistance.

In addition to Klonmore, the Louisiana station introduced Konvoy, a seedling of Fairmore by Klondike in 1942. Konvoy is a little too soft for shipping but is desirable for home use and for quick-freezing preservation.

Marion Bell, introduced in 1946, promises to become a popular variety. It is a good shipper and, although rather similar to Klonmore, has a brighter gloss, which should appeal to the consumer. Like Klonmore and Konvoy, Marion Bell is resistant to both leaf spot and leaf scorch.

NEW GRAPES FOR CALIFORNIA

The introduction during the spring of 1948 of five new grape varieties by the California station was a highly promising event. California produced something over 2,800,000 tons of grapes in 1948, or over 90 percent of the Nation's 3,000,000 ton crop. Of California's current production, about 50 percent are classed as raisin grapes, 25 percent as wine grapes, and 25 percent as table varieties. The significant feature in this introduction of new varieties is that at present practically all of California's large crop is produced by varieties originated abroad and brought to this country as rooted cuttings or vines.

The breeding and selecting of varieties in California gives promise of vines better adapted to the various regions of the State and to the needs of the industry.

The five new grapes are: Scarlet, for fresh juice and jellies; Ruby Cabernet and Emerald Riesling, for table use and wine-making; and Perlette and Delight, for early ripening seedless table varieties. Something of the immensity of the task involved in producing these new varieties is indicated in the station's announcement that during the 10 years from 1931 to 1940 over 23,000 seedlings of known parentage were grown and tested. Great patience and keen observation were needed to examine all of these seedlings and to select the few that promised to surpass in some respect the named varieties already at hand. In addition to the five grapes named, a few others are still under trial in various grape-growing areas of the State and will probably yield more new varieties adapted to local conditions.

Of the five new grapes, Scarlet is perhaps of greatest interest. This variety is offered as a substitute for the well-known Concord, which fails to do well in California because the high summer temperatures prevent good growth and proper ripening. Scarlet has an interesting background. One of its parents was Golden Muscat bred by the New York (State) experiment station at Geneva from a cross of Muscat Hamburg with Diamond. From its Diamond grandparent, Scarlet obtains some of its eastern grape (*Vitis labrusca*) characters; in these it differs from most of California's grapes, which are pure for the European grape (*Vitis vinifera*). Scarlet was so named because of its bright red juice and the early fall coloring of its leaves. The berries are said to be somewhat too small for the table trade, giving the variety its greatest value for juice and jelly. Semicommercial tests indicate that Scarlet juice should prove useful for preservation by canning or freezing. Its high sugar content and high acidity combined with attractive color make Scarlet juice a most appealing product.

MODERATE PRUNING INCREASES GRAPE YIELDS

Declining and erratic yields in the Fredonia grape, a promising new variety originated and introduced by the New York (State) experiment station, led to investigations in which this station established that the amount of pruning given to the vines in the dormant season has an important influence on subsequent productivity. The results were consistently in favor of light as compared with heavy pruning. Where yields of 2.5 tons to the acre were obtained with heavy pruning, moderate pruning increased yields by almost a ton and light pruning by 2 tons. The degree of pruning was carefully determined by the number of buds left; and as an adjustment for differences in the vigor of individual vines, the exact number of buds left per vine was determined by the weight of the prunings removed; the larger the weight of prunings the greater was the number of buds left.

These findings were limited to the Fredonia variety, but preliminary work on the Concord indicated that the same general principles would probably prevail in all varieties of the Eastern type. Research will presumably be needed on all important varieties to establish their individual requirements. The total grape crop in New York is large, the average annual yield over the 10 years, 1935 to 1944, being esti-

mated at 58,740 tons. New York is the leading producer of Eastern-type grapes; it is surpassed in total production only by California, where the European or vinifera type prevails. The increased yields reported from the measured pruning of the Fredonia grape are highly significant and very much worth while.

A critical study of the causal factors underlying the effects of severe pruning in the Fredonia grape showed that the pollen produced by severely pruned vines is less effective in producing a set of fruit than that from lightly pruned vines. The station workers concluded that this reduction in capacity to set fruit results from some undetermined influence on the pollen that renders it less capable of functioning effectively in the process of fertilizing the embryo grapes.

Pruning of the vine is an old art brought from the Old World to the New. Some pruning is known to be desirable and necessary to keep the vines in a thrifty condition, but this work with the Fredonia variety indicates that careful consideration must be given by growers to the proper amount of pruning needed to keep their vines in a thrifty and productive condition.

VEGETABLES AND ORNAMENTALS

Attractive garden products on the table of the average American are taken pretty much as a matter of course because of the advanced methods of culture, marketing, and processing employed by the horticultural industry. To maintain and improve these standards of quality is a constant challenge to research workers. Lettuce must be crisp and succulent and must have a leaf color as attractive as that attained at the moment it is harvested. Tomatoes must have attractive shape, color, and a taste approaching the delicious flavor of vine-ripened fruit picked from the plant on a warm summer day. Discolored and wilted celery, misshapen muskmelons, shriveled snap beans, or cauliflower damaged by insects or disease are not tolerated and are a liability throughout the entire marketing process.

More perishable horticultural products are placed on the consumer's table unchanged in appearance from that seen in the field than are placed from all other agricultural groups combined. This means extensive problems dealing with short-lived produce and including a large number of different genera and species, each of which has its own requirements for successful handling. Efforts are continuously directed toward better varieties resistant to plant pests, optimum growing conditions in the environments concerned, and, finally, toward improved methods of transportation, storage, and processing to bring products with garden freshness to the table.

Each State has its own local problems to contend with, and geographic regions occasionally have these problems in common so that coordinated action is possible in all the areas concerned. Thus the web of knowledge is woven and the findings, when published, become available to all concerned.

PELLETED VEGETABLE SEED

Wooly matted vegetable seeds transformed to pour from the hand like buckshot are no longer a dream of the seedsman and vegetable grower. In 1948, over a dozen kinds of pelleted vegetable seeds were

available that could be drilled into the ground or sown by hand with an ease and economy greater than ever before. Not only does this mean a saving in seed, but it offers great possibilities in fertilizer practices and pest control as well as in avoiding the costly hand labor of thinning seedlings.

Considerable attention was focused on the matter of single-seed sowing through problems encountered in the development of the vast sugar-beet industry. It was realized that hand work would have to be reduced in the laborious and wasteful method of sowing and thinning this crop. Sugar-beet seeds are clustered together in balls that may contain up to five or more viable or potential sprout germs. Workers at the California and Colorado stations and in the Department first developed machines so that single seeds could be sown and thus cut down the labor of thinning and blocking as the plants emerged through the soil and grew. As manpower shortages became more acute at the start of World War II, further research at the California station at Davis resulted in the development of segmented or sheared seed. The seed balls are mechanically divided to give fewer germs per unit; this, in the field, means fewer sprouts to be thinned.

As a consequence of this research about 4 to 5 pounds of seed can now be sown per acre where heretofore the planting of 20 pounds was considered average.

Noteworthy as these accomplishments were, research workers did not abandon their quest for even greater efficiency. Investigations by the Farmers and Manufacturers Beet Sugar Association in cooperation with a chemical company resulted in treating and coating the seed units to permit greater economy in sowing. Workers at the New York (Cornell) station developed another method of pelleting—in this case using onion seeds—and at the same time applying a fungicide in the coating material to control the onion smut. The success of this endeavor stimulated further cooperative effort between the Cornell and Illinois stations in improving methods for coating and handling, as well as increasing efficacy for the control of diseases carried by onion seed.

Gradually the potentialities of seed pelleting are being realized. At the California station seeds of lettuce, tomato, and onion have been pelleted and tested for responses in the laboratory and field; germination of the coated seed both in cold frame and field proved a success. Such differences as were found in favor of the responses of uncoated seed would be inconsequential in commercial field sowings. Employment of the clay cover in pelleting caused only a slight delay in germination; on this, further research is now centered.

At the Michigan station the possibilities of pelleted seed were recognized. Seeds of carrots, cabbage, endive, onion, radish, and tomato were pelleted and germinated under both field and controlled-greenhouse conditions. Seeds sown in flats under glass at 40°, 50°, 60°, and 70° F., were found to germinate more rapidly when uncoated, particularly at the higher temperatures. The difference in emergence ranged from 2 to 4 days for tomatoes and 1 to 2 days for radishes. The percentage of total emergence was less from pelleted seeds in some tests but not in others. These differences were apparently related to pre-emergence damping-off. Subsequent experiments were started in which various fungicides and plant stimulants were used in the

coating of seeds of carrot, tomato, melon, cucumber, and snap beans. These seeds were then sown in the field. Under such conditions it was found that emergence of pelleted seeds was increased over those that had not been coated.

The pelleting of seed is still in its infancy. Major and minor fertilizing elements added to the coating may serve to improve the vigor of seedlings. Some problems of seed dormancy, storage, and irregular germination can be approached through a controlled seed covering. Further work also will doubtless be performed on the fungicidal and possibly the insecticidal value of suitable seed coverings. One problem solved often leads to new fields of investigation, and thus the continuity of research is established and a more efficient agriculture results.

THE RUTGERS TOMATO

The goal of a plant breeder might well be that of producing a new variety that ultimately would be used as a standard of comparison and excellence—even 20 years after it was first created. Such is the success story of the Rutgers tomato, produced by the New Jersey station from a cross made in 1928. Enthusiastic acceptance came only after years of painstaking research, diligent observation, and record-taking for comparison.

Each season for 6 years workers at the New Jersey station carefully studied selections from a cross made in 1928 between the Marglobe and J. T. D. varieties. Selections were made for earliness, vigor of foliage, freedom of the fruit from cracks and disease, smoothness, productiveness, and uniformity of type. The next year some 75 among the best plants were selected, and then followed extensive field tests to reduce further those considered worthy of introduction to the vegetable industry. Enthusiasm mounted as the crop-years passed. Trials under the variations of environmental factors from year to year gradually reduced the number of selections in the contest for supremacy. By 1933 the number had been reduced to 25, and these harbingers of a new tomato were sent out to a number of growers in New Jersey. Here for the first time the selections were subject to the close scrutiny of those whose livelihood depended upon serving the market with a quality product. A year later four selections emerged as worthy of a rigid trial at 75 farms in the tomato-growing region of the State of New Jersey. At harvesttime, after a season of searching examination, number "500" emerged from anonymity, and on September 19, 1934, this superior selection was given the name "Rutgers."

Noteworthy figures are involved in the acceptance of this tomato from the time it was named and made generally available to the seedsman, the tomato-growing industry, and the home gardener. According to records of the New Jersey State Department of Agriculture, 933,755 pounds of certified Rutgers tomato seed were produced from 1935 to 1947. This represented a steady annual increase, reaching a maximum of 215,201 pounds in 1947. During this same year New Jersey reports that three-fourths of its acreage certified for tomato seed production was planted in Rutgers. The Department's Bureau of Agricultural Economics reported that of 468,341 pounds of tomato seed produced in the United States, 240,557 pounds were Rutgers in

1947. That year the farm value of tomatoes for the United States was nearly $200,000,000.

One phase of the story remains yet to be told. Even when a superior variety is established, the work is still not complete. Variability remains a factor that may deteriorate a superior stock from year to year if record-keeping comparisons and culling are not maintained. Workers at the New Jersey station have exercised rigid control over the seed they have certified. In one year separate records were kept on over 800 plants. The number of fruits, the size of each, the interior color, and the vigor of the plants were recorded. Only 312 of these plants reached a standard sufficiently high to be accepted as mother plants for the following year's work. Through such painstaking research at this station, the Rutgers tomato was given to industry and to the home gardener, and its quality at the same time maintained.

The search for even better varieties continues. In the South an extensive tomato-breeding program is centered at the U. S. Regional Vegetable Breeding Laboratory at Charleston, S. C., with the stations in Alabama, Arkansas, Florida, Georgia, Kentucky, Louisiana, Mississippi, Missouri, North Carolina, Oklahoma, South Carolina, Tennessee, Texas, Virginia, Hawaii, and Puerto Rico actively cooperating through the Southern Tomato Exchange Program (STEP). In these trials Rutgers is the leading variety used to measure the success of new seedlings that may in the future attain the enviable record built up since 1928 by workers at the New Jersey station.

HYBRID SWEET CORN

Remarkable results in the production of new varieties of sweet corn in the United States have been achieved by the Connecticut (State) experiment station. In 1924 investigations were started to determine whether the pure line method for breeding early sweet corn was feasible and practical. Less than a quarter of a century later, in 1947, over 1,600,000 pounds of seed of the station hybrids were produced by seedsmen. Other commercial varieties, utilizing one Connecticut inbred, accounted for another 600,000 pounds of seed.

Many varieties under such familiar names as Marcross, Carmelcross, Lincoln, and Lee, have been produced over the years as a result of this highly productive research undertaking. Others, such as Pocahontas, Plymouth, Pershing, and Hanford, still are undergoing rigid trials prior to commercial production.

This work, starting with a study of the potentials of the pure-line method of corn breeding, first advanced by George Harrison Shull in 1909, culminated in the introduction of Redgreen, Crossgreen, and Greencross. Improved concepts of both uniformity and productivity resulted from these varieties.

Other States and the Department were actively engaged in this endeavor which has proved so highly profitable to the vegetable industry. The Indiana station and the Department in 1933 announced the introduction of the famous Golden Cross Bantam; this variety fixed beyond all doubt the importance of the pure-line method.

The spectre of bacterial wilt that threatened early-market sweet corn was dealt a decisive blow when the Connecticut (State) experiment station developed Marcross C13.6. For the early-season market

this variety produces remarkably large ears averaging 8 inches long and weighing one-half pound after the husks are removed. Carmelcross, developed later, proved to be resistant not only to bacterial wilt but also to smut and is now replacing Marcross in fields where smut can result in crop failure.

One of the aims of the breeding program was the development of a series of superior varieties that could all be planted on the same date but would mature over an extended period to assure a long uninterrupted supply of ears at their prime for harvest. Seedsmen have made much of this feature, and year by year new varieties are being developed from a number of sources to place fresh sweet corn on the table of the American home throughout the corn season.

Woven into the sweet corn breeding work at this Connecticut station are many names of historical importance in the United States. The nomenclature of newly developed hybrids covers the span of years from the very early maturing Patrick Henry to the very late maturing Oak Ridge; the time of maturity suggested that part of the span of American history from which each name was chosen.

A milestone of this outstanding research was reached in June 1948 with the publication of Bulletin 518 from the Connecticut (State) experiment station, entitled "Hybrid Sweet Corn." This publication contains text and illustrations giving a complete history to date of the sweet corn breeding at the station. The report not only relates to the extensive yet precise labor that has gone into the years of investigation but also reveals the value of coordinated research between agencies to accomplish a broad research goal.

Success brings new ideas and higher aspirations, and thus it is with the breeding of sweet corn. Further improvement of techniques, the maintenance of inbred seed stocks, the development of high quality and greater resistance to insects and diseases, still remain to challenge the zeal of the scientist.

A NEW CUCUMBER VARIETY

A new cucumber variety bred by the South Carolina station produced a crop worth $1,000 an acre when older varieties barely met the cost of production. The reason is that the new variety—Palmetto—is resistant to the disease enemy number one—the downy mildew.

Downy mildew disease frequently causes failure of the fall cucumber crop in the South, and an elaborate schedule of spraying must be followed to avoid a crop failure. Palmetto has been grown successfully at the truck station in Charleston and by workers at other stations, even after widely grown varieties succumbed to the disease. Florida and Texas also report the success of this variety.

The story behind the development of the Palmetto cucumber reveals years of research utilizing the modern tools of the geneticist. In 1943 a downy-mildew-resistant variety known as Porto Rico 40 which produced short fruit was crossed with a long-fruited susceptible kind called Cubit. After six generations a promising line was segregated. Then followed rigid trials during two more generations of development to insure a pure line before the variety was released to the seed trade as a boon to the fall cucumber-producing areas of the South. In the summer of 1948 commercial seedsmen were growing

Palmetto seed in California so that growers could be supplied with seed for planting in the fall.

Palmetto bears attractive, dark green fruits similar to the well-known Cubit variety. The fancy grade cucumbers are 8 to 9 inches long with a taper at each end slightly more pronounced than Cubit. The fruit color is excellent and equals or surpasses that of other popular cucumbers produced in the fall. Further breeding work is in progress, and sister lines of the Palmetto show great promise of producing a spring variety resistant to downy mildew. This will doubtless largely replace varieties now grown in the South for marketing in the Northern States during the spring months.

Through this work at the South Carolina station, the greatest danger to cucumber production in the Southeast has been removed, at least for some time, and we now have an excellent cucumber that will continue to make thousands of acres in the Southland productive.

A NEW SQUASH

Five generations of inbreeding were required before the Minnesota station was willing to select two promising varieties of squash to distribute among growers for ultimate release as a named variety. The better of these was finally chosen and given the name, "Rainbow."

The new variety, of the banana type, is the latest to be developed at Minnesota since 1921 in its squash-breeding program. One of the aims of this work has been to produce small or family-size squash of a quality comparable to the larger types. As a consequence, Kitchenette, Greengold, and now Rainbow have been made available to grocery stores and homes where facilities or need for larger squash are limited.

The typical Rainbow squash weighs 3 to 4 pounds. It is about 14 inches in length and 4 inches in diameter, with a taper toward each end. The shell is of medium hardness, but smooth and sufficiently thick to ship well. The flesh is 1 to 1¼ inches thick, the greater thickness occurring at the base and apex. The flesh is light orange yellow in color and fine in texture. It is edible to the shell and moderately dry.

Reports from a number of widespread locations reveal that Rainbow will mature in from 65 to 120 days. Individual plants yield from 4 to 6 fruits giving from 10 to 21 pounds of squash. Storage tests indicate that it will keep as well as the Banana variety; indeed, specimens of this squash from ordinary storage have been used even up to the end of March. For the table, it can be prepared in various ways—baked in the shell, boiled, or steamed and the flesh makes an excellent filler for pies.

COMMON SALT FOR BEETS

An increased income of $20 an acre through expenditure of but $2.50 for an application of salt to grow an acre of beets is an accomplishment reported by the New York (State) experiment station at Geneva. Working for 5 years on several types of soils, scientists have found that this eightfold return for the money expended is a real contribution to the economy of truck farm operations. These results mean a higher tonnage of beets on the same acreage or as many tons on a reduced amount of land.

With present fertilizer practices in truck farming, it appears that the chemical element, sodium, may be the limiting factor in beet production. When sodium chloride (common salt) is added to the soil, a larger crop is realized. Both common granulated salt and the cheaper forms of rock salt are equally effective in giving a needed boost to the yield.

Salt is effective in increasing the yields either of small beets, which are now much in demand for canning, or of the larger ones that were in demand during World War II when quality was subordinate to quantity.

In order to produce the maximum number of small beets, the workers at Geneva have conducted tests comparing plots where the rates of seeding were 10, 12, and 15 pounds of seed per acre. The 15-pound rate brought the highest net return; when salt was applied with this rate of seeding, an increase of $27 per acre was realized.

THE SUCCULOMETER AIDS SWEET CORN MARKETING

Sweet corn is now being harvested with more assurance of a high-quality canned product through development of the succulometer. This machine, which both predicts and checks for quality control, was developed by the Maryland station in cooperation with the National Canners Association. It is based upon the principle that the amount of juice forced out of the kernels under a pressure of 500 pounds per square inch is a direct indication of the stage of maturity.

Now, from the Wisconsin station, comes a favorable report on this machine. As tested there, it has been found both accurate and rapid and is recommended for supplementing established tests for maturity in sweet corn and possibly other horticultural crops.

Indexes for determining the best time to harvest sweet corn for canning have been for years an object of concern among fieldmen and processors. The popular thumb-nail test, coupled with appraisal of the ears for color, firmness, and size, is widely used. Although expert fieldmen employ this method with success, it remains a subjective test and as such leaves much room for improvement.

The objective field and laboratory tests developed to measure the quality of raw sweet corn include both chemical and physical means, based on sugar, starch, fiber, pericarp, alcohol-insoluble solids, moisture content, refractive index, the pressure tester, and the tenderometer. Some of these methods have also been used to determine quality in the canned product. Time and laboratory facilities, however, are often limited or unavailable at harvesttime. Furthermore, the demand for more precise quality control has increased as marketing standards have improved and enlightened consumers have come to expect a superior product.

The stage of maturity in sweet corn for canning is closely correlated with its moisture content. Tests for moisture by oven-drying and later by the more rapid Brown-Duvel test still serve as criteria for quality in the raw product. For canned whole-kernel corn determination of the alcohol-insoluble solids is widely used to set the standard of excellence.

The succulometer makes it possible to measure quickly and accurately the maturity both of raw corn kernels as they are cut from the cob and of whole kernels at any stage of the canning process. The

accuracy of the succulometer has been investigated both at the Maryland and the Wisconsin stations. Maryland reported an accuracy equivalent to the moisture test on raw corn and to the alcohol-insoluble-solids test on the canned product. The Wisconsin station found close agreement between the Brown-Duvel and the succulometer tests.

In these ways, research men from the horticultural, agricultural engineering, and agronomy departments of the State experiment stations have collaborated with commercial organizations in developing and testing a machine that contributes to the betterment both of vegetable growing and of the canning industry. An accurate and rapid objective test for maturity in either raw or canned sweet corn is now provided to supplement and improve the established methods and to add further efficiency to the marketing of the canned product.

IMPROVED GREENHOUSE WATERING METHODS

The growing and marketing of ornamental plants in the United States has developed to a point where economists at the New York (Cornell) station now estimate it to be a billion-dollar-a-year industry. Even before the war pay rolls for those gainfully employed in this business totaled over 109 million dollars annually. Ornamental horticulture is an intensive type of agriculture, the very nature of which requires a relatively large amount of manual labor; this is particularly true in operations where plants are raised under glass. The margin of net profit is not large for the average grower, and operations that can reduce man-hours and thus aid in producing a crop more economically than before are constantly being sought.

In those States where the growing and marketing conditions are more favorable for raising greenhouse plants and flowers, the experiment stations are at present conducting research to improve operations and in this way, particularly, to reduce the unit cost of producing flowers and plants and thus to expand the consumer market.

One of the most laborious and time-consuming operations in growing plants under glass is that of keeping the crop adequately watered. During the past decade much attention was directed toward improved methods of applying water.

The New York (Cornell) station demonstrated that watering by use of burlap or woven glass wicks that draw water from a reservoir up to the soil in receptacles where plants are growing would reduce the labor of surface watering. Also demonstrated was the practical application of a subirrigation method for bench crops. This is a practice that was tried late in the nineteenth century at the Ohio station, but later abandoned largely because of the cost of watertight benches. Various types of such benches have more recently been developed, and these have again stimulated interest in improved and speedier subirrigation methods. The soil tensiometer developed by soil physicists in 1936 has been adapted to give a rapid and objective technique for determining the moisture content of the soil in greenhouse benches, particularly where new watering methods are under test.

By controlled subirrigation, called automatic watering, workers at the New York (Cornell) station were able to grow flowers and potted plants in numbers and quality at least equal to those produced by the surface-watering method and at a great saving of time for watering.

Another method investigated at Cornell shows much promise where watertight benches are unavailable; it employs two lines of copper tubing down the length of the greenhouse bench, each having small orifices 12 inches part. Potted plants are set on the bench with their bases on the moist sand, which is saturated whenever the plants show the need of water—usually once a day. This method permits the entire bench to be watered at one time, and the operation is complete when water drips through the bottom of the bench. More or less frequent applications can be given according to the needs of the plants.

Improved methods for watering plants in open benches have been developed at the Ohio station, and the "Ohio State System" is now popular. After the plants are benched a pipe—drilled every 12 inches to accommodate specially designed nozzles—is installed down the center of the bench on the surface of the soil. From these nozzles water is sprayed horizontally and equably over the surface of the soil. Although the flow is manually controlled, the operator is available for other duties as the watering progresses. Recently this station has also published the results of an economic research conducted in part under a fellowship from the Society of American Florists. This study concerned the time required to water and fertilize carnations in 2,000 square feet of bench space. Through trials of several watering systems new methods were shown to lead to noteworthy reductions in the operating costs.

At the Iowa station asters and stocks have been grown in the four types of Iowa soil largely used by greenhouse growers in that State. Subirrigation techniques are being developed for these soils to reduce further the costs of flower production.

At the Colorado station carnations were grown in both soil and gravel in order to compare the costs of production. Those plants grown in gravel were both fed and watered by a nutrient solution pumped into watertight benches. These trials revealed operating costs for growing carnations in soil to be 28 percent higher than those for gravel culture.

From these various developments industry is learning of and adapting its operations to practices that will greatly reduce the costs of production. Such advanced methods also reduce the routine work of skilled gardeners and standardize a procedure that is subject to error of judgment when accomplished by hand methods.

PLANT DISEASES

The year was marked by continued worth while progress in research on plant diseases and their control. Although a number of investigations in this field were completed or discontinued, most of the plant-disease studies proceeded actively toward their respective goals and several new and promising lines of work were initiated.

The diversity of crops and the extensive scope of plant disease investigations included make it difficult to present an adequate or balanced picture of the advances made by the experiment stations. All that is attempted, therefore, is to discuss a few of the lines of cooperative work receiving emphasis through this period and then to present a digest of the results of a few typical investigations reaching the stage of practical application during the year.

RESEARCHES IN PLANT DISEASE EPIDEMIOLOGY

The cooperative State-Federal study of plant-disease epidemics, started in the previous fiscal year to acquire basic information for forecasting and warning purposes, was expanded to include the setting up of several regional research centers and to provide for extending the scope of the work. Important benefits were realized from this program in the form of improved grower control of disease through better crop protection. This was made possible by the guidance developed from the research on downy mildews effectively carried out during the 1947 season for the producers of potatoes, tomatoes, cucumbers, melons, and tobacco. Growers of these crops were also enabled at times to save large sums of money by omitting routine sprays they would normally have applied but for the assurance provided by these widespread investigations that here and there local or regional conditions were unfavorable to disease development and that the usual sprays were, at the moment, quite unnecessary and would only be a waste of time and money. There is every reason to expect that this type of research, because of its direct, season-to-season usefulness, will develop into a permanent Nation-wide cooperative contribution to agriculture, eventually embracing many other types of crop diseases for which methods of making reliable predictions can be worked out.

COOPERATIVE WORK ON NEW FUNGICIDES

The year was marked by great expansion in organized cooperation among State and Federal plant pathologists. Scores of workers participated in coordinated experiments designed to gain as rapidly as possible the needed information as to how the more promising among the hundreds of recently developed fungicides may be expected to perform in controlling important diseases of major crops under the wide range of soil and climatic conditions prevailing in different regions. To facilitate joint planning and reporting, the national organization of plant pathologists, the American Phytopathological Society, set up a special committee on fungicides under which appropriate subcommittees, manned for the most part by experiment station scientists, sponsored the work with particular crops or crop groups.

The results of the trials with these materials during the 1947 season proved to be of the greatest value. They disclosed many factors that exert a strong influence on the effectiveness and safety of various new fungicides. They added much to the limited information already available concerning the particular diseases for which they were individually satisfactory or unsatisfactory and the crop varieties that were sensitive to and hence unfavorably affected by certain compounds, even though the latter might be extremely efficient in preventing infection. Needed facts were brought out by which to improve recommendations to growers as to what fungicides are likely to give good returns in different localities. Perhaps even more important in the long run for making best use of these newer materials, being developed in such large numbers by the chemical industry in the United States, is the evidence provided as to the direction future research should take in order to give enlightenment on many essential questions still unanswered.

The results of these cooperative fungicide trials are too voluminous to be summarized here but the Department has placed the facilities of its mimeographed publication, "The Plant Disease Reporter," at the disposal of the different subcommittees and the summarized results for 1947 were issued in March and May 1948, in Supplements 174 and 175 of this serial. Something of the scope of these cooperative endeavors may be judged from the following table:

Cooperative investigations with new fungicides—1947 season

Crops involved	Different materials	Cooperators	States
	Number	*Number*	*Number*
Cotton	33 seed treatment formulas (5 materials).	13	[1] 11
Apple	10 sprays	28	18
Peaches, cherries, grapes	30 different spray and dust materials or formulations.	15	9
Onions, carrots, celery	10 sprays	5	5
Cucumber, squash	5 sprays, 4 dusts	8	7
Snapdragon, chrysanthemum, gladiolus.	5 sprays, 8 corm treatments	5	5
Potatoes	6 sprays	15	[2] 14
Tomatoes	10 sprays, 18 treatments	18	[3] 16

[1] 21 locations.
[2] 21 experiments.
[3] 18 tests.

Another significant cooperative venture of the year was the assembling of data contributed by some 145 professional workers regarding the results secured during 1947 in 47 States and provinces of this country and Canada from experiments comparing 130 different fungicides used in sprays, dusts, fumigants, and other treatments on some 57 different kinds of plants, seeds, or propagating stock or for application to the soil. A digest of the results was prepared by another subcommittee and made available. This information is of great value to plant pathologists and other interested technologists as a report of current progress in the development and use of new crop protectants and pesticides.

CHERRY LEAF SPOT CONTROL IN THE EAST

No disease of cherry has more sweepingly destructive effects in favorable seasons than the cherry leaf spot caused by the fungus, *Coccomyces hiemalis*. It is particularly damaging in the moist and warm growing seasons that often prevail in the Cumberland-Shenandoah Valley orchard region of the eastern United States.

Infected leaves drop prematurely. In bad years trees may stand almost naked long before the end of the season. Loss of leaves is, of course, a loss of the food-making organs. Trees that lose their leaves are thus only partially nourished and become devitalized. Such trees are subject to winter injury and cannot produce normal crops. Therefore, in the wake of repeated heavy outbreaks of cherry leaf spot in

this area, growers have suffered greatly from reduced cherry harvests and in severe winters from the death of hundreds of devitalized trees in exposed orchards.

That cherry leaf spot infection can be greatly reduced by spraying with certain chemicals has been known for a good many years, but efforts by growers of the region to apply this information were meeting with erratic and often disappointing results. This led plant pathologists of the Virginia, West Virginia, and Pennsylvania stations to unite forces in an effort to learn the reasons for the reported failures to hold the disease under control and then to develop a fruit-spraying program that fruitmen could depend on to work effectively every year under the prevailing conditions in this tri-State orchard district. These aims have been accomplished and the profitable sour cherry industry of this part of the country has been delivered from the threat of possible extinction resulting from the economic effects of this disease.

It was in 1940 that the initial cooperative investigations were started in these three States. In each case 14 replicated experimental plots were set up in a uniform manner with identical methods for taking the records so that the results might all be pooled and analyzed together. Bordeaux mixture and lime-sulfur were compared with each other and with a number of the newer materials, especially the "fixed" copper compounds. The outcome was most enlightening. Important local factors influencing the results with certain materials showed up clearly when the extent of protection produced by them in the different experimental orchards appeared not to be the same.

The cooperative experiments were continued to gain more complete evidence on the best fungicides and schedules of application for the area under wide seasonal differences. In 1943 a three-State joint bulletin was published covering the first three seasons. Finally, in 1948 another bulletin, summarizing the findings and recommendations through the 1947 season, was issued by the Pennsylvania and Virginia stations, the West Virginia station having discontinued its participation before that time.

The 8 years of teamwork have brought out many important facts that might not have become evident had the work been conducted in only one location or had it been carried out at separate locations without coordinated plans for setting up the experiments. Furthermore, evaluation of the merits and disadvantages of different spray materials—especially of the newer types of synthetic fungicides that have come onto the market in recent years—was greatly speeded up by this cooperative program.

That the cherry industry is profiting greatly as a result of this coordinated effort is indicated by a recent West Virginia station survey that showed an average yield of 48 pounds of cherries from each 9-year-old tree under improved spray practices built upon this research, as compared with one-fourth pound per tree produced in 1946 on trees sprayed according to the old schedule in 1945—a bad leaf-spot season followed by severe cold. A 12-percent gain in production for the whole area is attributed to use of the improved protective methods.

In summation, the experimental results indicate that no single fungicide as yet available to growers is completely satisfactory. The

best leaf-spot control, most consistently met with to date, has resulted from a program of applications that may include the old fashioned lime-sulfur spray or various "fixed" copper sprays for application before the cherries are picked, with boardeaux mixture and the "fixed" coppers as perhaps the most effective of the thoroughly tested fungicides for post-harvest spraying. Some reduction in fruit size may be expected but no other sprays have as yet given consistently comparable disease control with less injury or greater fruit solids content. One of the new synthetic fungicides has exhibited great possibilities in this respect but certain problems of formulation and standardization must be met before it can be recommended without reservation. Other new fungicides gave results justifying further study as potentially valuable materials. Measures taken to reduce the overwintering stage of the disease were found to be important in getting maximum leaf-spot control in bad years.

FORESTALLING THE EUROPEAN BROWN ROT MENACE

The value of discovering a new foreign plant disease of great potential destructiveness before it has completely invaded the country is well illustrated in the following account of one of the European brown rot fungi, which appeared on our shores not long ago. The usefulness of experiment station research in such a case is also exemplified by the results of the hard work of a number of experiment station scientists through which orchardists of the United States are now prepared to deal successfully with this invader.

The European brown rot here discussed is not to be confused with the common brown rot long familiar to American orchardists, caused by the fungus, *Sclerotinia fructicola*, and responsible for heavy losses of peaches, plums, and cherries in the field and on the market in most of the nonarid sections of the country. The fungus causing this form of the disease has apparently not been reported in Europe up to the present time, but there are at least two related brown rot fungi that have long been known to cause considerable damage to fruit on that continent. Neither of these parasites was known to exist in the United States until early in this century, when it was discovered that one of them had reached the Pacific coast and was damaging stone fruits all the way from British Columbia to California. This fungus (*S. laxa*) is the cause of a blight affecting both blossoms and twigs, particularly severe on apricots, and sometimes quite troublesome on peaches, prunes, and cherries. It also produces occasional rotting of the fruits. There are certain reasons for believing that this fungus may have been introduced to the Pacific coast from Europe somewhere around 1900. Fortunately the other European form of brown rot (*S. fructigena*), as well as an Oriental form (*S. mali*) capable of doing considerable damage to the fruit, have not yet, insofar as known, crossed the oceans to America.

The European form of brown rot that made its appearance on the Pacific coast about 50 years ago was not known to occur east of the Rocky Mountains until it was discovered in the sour cherry orchards of Wisconsin in 1941. Thus far it has been reported from no other area east of the Great Divide. Now that this foreign disease has established itself at the edge of the eastern orchard areas, however, it must be considered probable that ultimately it will invade every

orchard district in the eastern and southern United States where stone fruits are grown.

That the menace is serious cannot be denied, but there is good reason to believe that the kind of sweeping destruction the European brown rot might have brought to eastern orchard areas will never take place. Research work already carried out by experiment station scientists has led to the development of practical methods of control that promise to reduce the onslaughts of this disease to minor proportions, both on the Pacific coast and in the East.

Although it does not appear to be within human power to stop the natural spread of this malady, it may be confidently expected that plant pathologists in all fruit-growing States will watch for its first appearance in their own territories and will immediately institute experiments to find out how the methods of control worked out by their colleagues may be adapted to local climatic conditions and orchard practices. In this way growers in the Eastern and Southern States will not only be forewarned but will also be well prepared to defend themselves against the enemy when it arrives.

Close study of the disease in this country was first begun by the Oregon station, which in 1913 reported its occurrence in that State and then developed means of distinguishing between the European and American types of the parasite. Many facts of importance about the life history of the causal organisms were worked out by that station and a search for preventive measures was begun. The Washington station also started investigations on both kinds of brown rot.

The California station made a most important contribution to control methods when in 1942 it announced the finding that use of dormant arsenite sprays would greatly reduce the development of the fungus spores giving rise to the primary bud and blossom infections of the European form in early spring. Until this discovery, growers had been forced to depend on sprays applied at blossomtime. These gave only partial protection against the billions of spores that drift about in the air of badly infected orchards at that time of year.

In areas favorable to the disease, the apricot suffers greater destruction from this European brown rot than any other kind of tree because of the tendency of the parasite, after destroying the blossoms, to grow down into the tissues of the spurs and into the smaller branches, killing them to such an extent that much of the fruiting wood may be destroyed. After demonstration of the practical value of the dormant eradicant spray against this disease, a marked reduction in the losses sustained by California apricot growers has taken place.

As soon as the presence of the European brown rot was found in the sour cherry orchards of Wisconsin, the State experiment station at once began a program of experimental spraying to learn how best to deal with this infectious disease under climatic conditions differing totally from those prevailing on the Pacific coast. Studies were undertaken, of course, to determine the time and origin of the first infections and the factors influencing the seasonal activities of the fungus. In this way the proper times for applying effective sprays were determined. Since the Wisconsin station had pioneered some years ago in demonstrating the potential value of dormant eradicant sprays for making the control of apple scab more effective—after which the California station had showed their value in dealing with the European

brown rot on apricot—it was only natural that the Wisconsin investigators should include a study of eradicant sprays as an adjunct to blossom sprays in dealing with this fungus rot as it occurred on sour cherry. The result, as recently announced, has been the development of a combination of eradicant and protective spraying that works effectively in that State and is now being recommended to the growers of cherries.

These orchard investigations were conducted by the Wisconsin station and covered a 3-year period involving as many different seasonal conditions. It became clearly evident at the end of that time that, even under the 1943 conditions favorable to heavy infection, as high as 99 percent of the spur blight could be prevented in that area by an eradicant dormant spray of lime-monocalcium arsenite with fish oil applied just before budbreak in the spring, followed by a protectant spray of bordeaux mixture early in the blossoming period. This two-spray program was then recommended for adoption by growers in the district invaded by the disease. The completeness of control met with in the field trials augurs well for the elimination of European brown rot as a serious threat to the Wisconsin sour-cherry industry.

SOIL FUMIGATION AGAINST ROOT KNOT

Among the many plant-disease-inducing organisms harbored by the soil, one of the chief offenders is the root knot nematode or eelworm. Particularly is this true in the Southern States where the climatic conditions favor a more or less continuous multiplication and activity of these minute roundworms. Much of the soil used for large-scale production of vegetables and tobacco in these areas is therefore already heavily infested and in some States formerly considered free, the pest has recently made its appearance and is rapidly spreading through such carriers as farm machinery, nursery stock roots, and irrigation water.

The problem of control is rendered more difficult in that these nematodes are known to attack approximately 1,300 different kinds of plants—including important garden, truck, orchard, and field crops as well as ornamentals, shade plants, and weeds. Eradication by rotations with immune or resistant crops or by fallowing the land is at best uncertain and may require long periods of time. Moreover, the available immune crops are not what the farmer calls "money crops" and operators hesitate to give up raising the better paying products; even when this method is used, only temporary reduction in losses follows, for the root knot appears again when susceptible crops are returned to the soil.

During the past four or five years the situation has been greatly improved by the discovery of new soil fumigants that can be applied at costs approaching a level of practical and profitable field application, namely, around $10 to $40 per acre, depending on the material used, the type of crop involved, and the manner of application. Spot treatment of a widely spaced crop, such as watermelon in hills, can be carried out at a very low per-acre cost; on the other hand, with closely spaced or narrow-row plantings and general field applications, the costs become progressively increased. These newer fumigants are liquids applied to the soil at depths of 6 to 8 inches; there they volatilize into gases that penetrate 15 to 20 inches into the soil and kill

a large proportion of the many soil-inhabiting pests, including the root knot nematodes. Mechanical applicators of various types adapted to both small-plot and field usage have been developed. Many of these materials—such as dichloropropane-dichloropropylene (D-D) and ethylene dibromide appearing in different formulations and under various trade names—have given satisfactory performance when applied in proper amounts and under suitable soil and weather conditions. To gain information on the best way to use them, experiments must be conducted in the different soil-types and climatic areas of all nematode-infested regions.

In this work many of the State experiment stations and the Department have taken an active part. Extensive work has been previously reported from Texas, California, Hawaii, and other stations. During the year, Arizona, Colorado, Florida, Mississippi, Oklahoma, and South Carolina have reported successful control of root knot under the widely varying conditions of these southern regions. The Florida station, for example, reports profitable increases in both yield and quality of vegetables from use of the newer soil fumigants. According to its findings, the value of the very susceptible cucumber crop in infested soil would have been increased by more than $300 per acre through use of soil fumigants applied in the hill. Comparable results were reported from the other stations named.

Typical of work along this line are the experiments reported by the South Carolina station which for the most part utilized the comparatively new fumigant D-D, although the much more costly chloropicrin (the "tear gas" of World War I) was also employed along with it as a standard because its effectiveness against this pest had already been established. The major results of the first 2 years' work were the establishment of the proper dosage and the best spacing for injecting the material into the soil. Since introducing the fumigants into the soil by means of an injector involves somewhat costly equipment, the experiments of the past 2 years were designed to test the less expensive drip method of applying them in a furrow afterwards covered with soil. Either procedure gave excellent commercial control of root knot at a cost of about $40 per acre. Since, however, even the most thorough point-injection as well as the drip method at heavy dosages failed to eliminate the nematode completely, it appears that the most practical control will be achieved through annual application of the fumigant in the row by the simpler drip method.

The cost of material and labor will probably restrict the use of D-D on a field scale in South Carolina to highly valuable crops such as tobacco or melons. This fumigant has already been applied to a considerable number of commercial tobacco fields of the State and it appears that the practice will expand. The method is also being employed at an increasing rate in plant beds and home gardens.

"SPOT" DISEASE OF NORTHERN SPY APPLES CONTROLLED

In New York State the Northern Spy variety of apples has been found subject to a spotting in storage not caused by any kind of infection; this abnormal condition occurs on the red or blushed but only rarely on the yellow portions of the fruit. In a 1943–44 survey by the New York (Cornell) station 40 percent of the 61 lots of this variety examined around the State showed the disorder and in one lot 47

percent of the individual fruits were affected. The spots developed to a greater extent on apples picked from the outer parts of the tree and were worse on late than on early picked fruits. Moreover, ringing the trees served only to increase the amount of the disease. All of these factors operated to cause a deepening of the blush on the fruit, thus indicating that the trouble is associated in some way with the red pigment.

Since ripe-apple vapors did not increase the spotting in storage, this disorder—unlike apple scald—does not seem in any way related to volatile products given off by the fruit. Treatment with 50 percent carbon dioxide for 6 days reduced the amount of spotting but at the same time resulted in severe carbon dioxide injury. The outcome of this approach toward control suggested that final solution of the problem might lie in storage under controlled-atmosphere conditions. Further trials along this line revealed that either 5 or 10 percent carbon dioxide with 2 percent oxygen at 40° F. not only eliminates the spotting but also adds considerable to the storage life of the fruit as compared with the usual practice of storage in ordinary air at 32° F.

FUNGICIDAL AEROSOLS

A long-felt need has existed for practical adaptation of the high-pressure liquefied-gas principle of aerosols—found so successful against many insect pests—to the control of diseases in plants. A survey by the Rhode Island station preliminary to attacking this problem indicated a potential annual market for fungicides estimated at one-half to 5 million dollars if such could be found that are effective as earosols for controlling plant disease in greenhouses and for use about the home. The convenience of fungicidal aerosols for inhibiting mildew on clothing, furnishings, and walls also offered a further commercial outlet. Through persistent search at this station over the past 2 years, the situation now seems to have been met. Effective fungicides soluble in the liquefied gas used for aerosols and at the same time nonpoisonous to the plants it is used to protect, have been discovered and successfully tested out.

In the search for suitable materials none of the older or newer fungicides commonly employed for dusting or spraying plants proved to be soluble in the aerosol base. The problem then was to find other chemicals, poisonous to fungi, that would meet this requirement. Based on a knowledge of chemical structure and solubilities, 47 compounds belonging to 15 types of chemicals were put to the test. Among them, 10 proved both soluble and fungicidal. Strangely enough the best one of all was a chemical, copper naphthenate, long known as a powerful fungicide but hitherto discarded completely for spraying or dusting vegetation because of the damage it caused to living foliage. Properly formulated as an aerosol, however, this chemical proved in the Rhode Island station experiments to be noninjurious to test plants of 59 varieties belonging to 40 botanical species. It was also found completely effective in the control of 11 different plant diseases used in these trials, including black-spot of roses, anthracnose and powdery mildew of beans, and early blight of tomatoes. Even when employed at temperatures ranging from 55° to 102° F. and at varying degrees of humidity up to 100 percent the copper naphthenate aerosol, when properly applied, proved safe for the test plants under all these conditions.

In addition to devising this method of protecting greenhouse-grown plants from certain diseases by means of a copper-containing vapor, the station has also found a mold-inhibiting aerosol that appears promising for home use in protecting cloth against the mildews often so troublesome under warm and humid conditions. With this chlorinated diphenyl formulation, which has thus far most nearly met the specifications, one application fully protected cotton cloth for more than 21 days under surroundings representing the most extreme conditions of the humid Tropics.

SCAB-FREE POTATOES

Because the surface craters of scab infection lower the market value of potato tubers, it was important for growers that measures to control the disease within the soil acidity range favorable to the crop be sought. Scab gives little or no trouble on highly acid soils but potatoes have been observed to give lower yields on such soils than on those within the less acid range of pH 5 to 5.5. To get best crops, therefore, it has been considered desirable to lower the acidity by applying lime on very acid potato soils. Moreover, because of the better growth of peas and other leguminous forage and green manure crops on less acid soils, it is also desirable that the amount of lime in the soil be maintained as high as is compatible with the production of potatoes free from this disease.

The micro-organism causing potato scab belongs to the actinomycetes—a group intermediate between the bacteria and the fungi. Studies by many experiment stations have long since shown that infection is seldom severe in acid soils, but that as the soils become increasingly neutral or alkaline the malady tends to get progressively worse. One of the most likely avenues of control therefore seems to lie in striking a balance between the soil reaction most favorable to the crop and the one least so to the parasite.

Studies on potato scab in Aroostook County by the Maine station have now demonstrated that on the loam soils that make up a large proportion of the potato areas of the State, scab-free potatoes can usually be produced at pH values of 5.5 or greater acidity. On soils naturally high in lime or which have been limed to pH values toward the alkaline side above 5.5 scab may become a serious matter. An experiment at Aroostook Farm, conducted during 12 years on the same land, has given information of considerable value in revealing that even on soils limed at rates of 2 to 3 tons of ground limestone per acre scab may not become serious for several years. Except for severely infested land with a high content of lime, this experiment has demonstrated that once the infection has entered a field one or two applications of acidifying materials, such as sulfur or ammonium sulfate, will enable the production of scab-free tubers even of a susceptible potato variety.

As a result of these intensive studies carried out over a considerable period of time, much more precise information is now at hand on how much lime can be safely applied to different types of soils without allowing serious inroads by the scab organism. In general, the work has led to a recommendation for more lime on potato soils than had previously been considered allowable, and thus to the production of larger potato crops as well as to better growth of the legumes used

in potato rotations. More specifically, the grower may now apply the newer knowledge to his own particular conditions with something more nearly approaching the precision of a doctor's prescription.

LEAF ROLL FREE SEED POTATOES

In recent years the virus-induced leaf roll disease has become one of the major problems in producing potatoes for seed and table stock in many of the principal potato-growing areas of the United States. It is spread from diseased to healthy plants by aphids or plant lice; all parts of the plant—roots, stems, leaves, and tubers—become infected and once the virus has entered the tubers, they in turn carry it to their progeny. Naturally, therefore, the first step in controlling the disease consists in assuring a virus-free foundation seed stock for producing certified seed potatoes. Both the Department and many of the State experiment stations have taken part in developing various methods of producing seed stock sufficiently free of virus disease for certification.

Perhaps the simplest and most rapid procedure for determining whether the tubers from a given hill are carriers of the virus is through "tuber indexing;" this refers to the practice of raising a plant in the greenhouse from a "seed piece" or "eye" cut out of each selected potato to determine quickly whether any virus infection is present in the parent tuber. If the seed piece or eye produces a healthy plant the tuber is saved and increased by planting, in order to produce foundation stock for growing certified seed potatoes.

Two phases of the disease occur: One, known as "net necrosis," is seen as dark brown strands when a slice is cut off toward the stem-end of the tuber; the other involves a dwarfing of the plant itself, with a characteristic stiffening and upward rolling of the leaves as the most constant and conspicuous symptom. The New Hampshire station, in testing tubers in the greenhouse for virus content, discovered that many of them known to contain the leaf-roll virus failed to show the leaf-rolling symptoms in the foliage. Studies were immediately planned to determine the conditions favoring either the suppression or the development of the typical symptoms. These experiments were carried out in the greenhouse under controlled environmental conditions of temperature, light intensity and duration, soil moisture, and soil nutrients, each being studied individually and in various combinations with respect to its influence on the appearance of leaf-roll symptoms in the foliage of Green Mountain and other varieties of potatoes.

Additions of nitrogen, phosphorus, potassium, and 5–10–10 fertilizers to the soil at planting time failed to mask the leaf-roll symptoms in infected plants when grown in the field. The New Hampshire workers found, however, that at the time of year when tuber indexing in the greenhouse is under way, a high proportion of known infected plants failed to show leaf roll when grown in soil high in nitrogen or when a complete fertilizer was used. On the contrary, fertilizers high in phosphate not only allowed the symptoms to develop but greatly intensified their expression. Moreover, leaves from healthy plants, as well as from infected plants with their leaf-roll symptoms suppressed, were devoid of starch after 12 hours, as indicated by the iodine test. On the other hand, leaves showing definite leaf-roll symptoms were

still packed with starch even when tested after 72 hours. This evidence revealed the leaf rolling symptoms to be definitely associated with an excess of starch in the foliage because of failure to transform it into soluble products for the nutrition and growth of the plant as a whole. Furthermore, these symptoms were better expressed on plants grown in pots than in beds and in 3-inch than in 6-inch pots, in wet soil than in dry soil, and under high rather than low light intensities. In other words, such factors as light and moisture, which influence the activity of the green leaves in photosynthesis and plant growth, were also found highly influential in the development of these symptoms under greenhouse conditions.

The practical value of applying the results from this 4-year study to the more rapid and accurate tuber indexing is obvious. In the northern potato areas of the country, between late fall and early spring when the days are short and cloudiness is frequent, tuber indexing for rapid, clear-cut, and dependable results must be conducted under low nitrogen-high phosphate nutrition, in small pots, and in relatively moist soil. These findings also suggest the possibility of overcoming the effects of leaf roll on yields in the field production of potatoes as an avenue for further research.

INSECT PESTS

Flies in some areas are reported to be much more resistant to DDT than they were a year ago. If further investigations prove that houseflies are consistently more resistant in certain areas—or everywhere for that matter—this change in the insect will force a change in fly-control practice.

A change in the insect itself, such as this, is merely one of the numerous varying conditions that must be met in the everyday practical control of insect pests. In fact, the control of destructive insects requires a varied and constantly changing set of operations.

Although the principles of insect control apply broadly, what to do in a given instance usually depends on so many local conditions that the final answer has to be worked out almost on an individual case basis. The abundance, activity, and habits of the insect need to be known before hand, so that the potential damage can be estimated; insect ravages must be anticipated and checked in their early stages or irreparable losses may follow.

To determine how much damage an insect infestation will do requires accurate information. If past experience has shown that a particular pest always completely destroys a crop, the profit or loss relation of control is comparatively simple; this is also true when a definite proportion of the crop is always destroyed. With many crops and agricultural products, however, insect injury varies from year to year as well as from place to place. An incipient infestation may be present one year and cause no appreciable damage because it was checked by weather conditions, parasites, predators, or other factors; while another year the same intensity of infestation on the same date as before may develop into a plague that will completely destroy the crop or cause a reduction in yield of almost any amount from 1 to 100 percent. The control of destructive insects on a profit or loss basis is often exceedingly complicated.

In addition to knowing how much damage an insect pest is going to do, accurate information is also usually needed most on how to stop the losses already taking place. What would be the most effective and the cheapest way? If an insecticide is called for, which one is the best? Numerous other questions need to be answered before economical control can be accomplished.

It can readily be seen that sound judgment and accurate information on many points are needed to control destructive insects on a profitable basis. Entomologists at the State experiment stations in cooperation with those in the Department have been gathering the facts on the best methods of combating destructive insects under the constantly changing conditions in the various localities in the United States. That they have made great progress and that their findings have been applied to the commercial production of crops and livestock are revealed by the following items from their reports.

NEW INSECTICIDES RESULT IN MORE COTTON

Alabama farmers who dusted their cotton early last year without subsequent treatments might have picked a 50-percent larger crop had they waited until the plants were setting and maturing the bolls. This estimate is based on the results of trials with new insecticides carried out by the Alabama station. In these tests chlorinated camphene applied after the plants were setting and maturing a crop gave an average of 536 more pounds of seed cotton per acre than when the same insecticide was applied early, and 403 more pounds than no treatment at all. This insecticide was highly effective against both the boll weevil and the bollworm, but it failed to eliminate heavy cotton aphid populations. Where it was used throughout the season, however, there was no build-up in aphid numbers In other experiments, plots treated with chlorinated camphene yielded an average of 571 more pounds of seed cotton than the untreated plots.

A mixture containing 3 percent benzene hexachloride (BHC) and 5 percent DDT gave excellent control of the boll weevil, bollworm, and cotton aphid. Areas treated with this mixture produced an average of 496 more pounds of seed cotton per acre than the untreated areas. In other plots, alternate applications of calcium arsenate and calcium arsenate containing 2 percent nicotine gave excellent control of the boll weevil and cotton aphid; this treatment increased the yield of seed cotton 338 pounds per acre, whereas calcium arsenate alone, which allowed serious damage by aphids, increased it by only 164 pounds. The alternate calcium arsenate and calcium arsenate-nicotine treatment is usually applied at 8 pounds per acre as compared with 10 pounds of chlorinated camphene or BHC–DDT dust. The bigger yields from insecticide-treated fields show that the gross income from cotton could have been increased an average of $47 per acre by the use of insecticides on more than a third of the 1,532,000 acres in Alabama during 1947.

Fleahoppers frequently cause serious damage to cotton in certain sections of Texas. Trials of the new insecticides by the Texas station have shown some of these to be highly effective in controlling both the young and the adult stages of this pest. In central Texas increased yields of seed cotton amounting to 100 pounds or more per acre were obtained from one application of insecticides to control the fleahoppers.

The cotton of some Texas farmers is damaged every year by Lygus bugs that migrate from alfalfa to cotton after the alfalfa seed has matured. In its search for better cotton insect control, the Texas station found some of the newer insecticides to be highly effective in controlling these bugs on alfalfa as well as on cotton. In fact, the control of Lygus bugs on alfalfa grown for seed not only increased greatly its yields but also prevented injury to the adjacent cotton crops. On the other hand, timely control of Lygus infestations on cotton when no control was used on nearby alfalfa fields produced a 30-percent increase in the yields.

INSECTICIDES IMPROVE SWEET CORN

New Jersey sweet corn growers produced better roasting ears when they used the new insecticides Ryania and 1,1-bis(*p*-chlorophenyl)-2,2-dichloroethane (TDE) to kill the worms. These results were made possible because of research by the New Jersey station on methods of controlling damage by the European corn borer and corn earworm under the conditions existing in the State.

Sweet corn is a very attractive food material to these insects. The moths of both species lay their eggs on the plants but, while the corn borer may work its way into either the stalk or the ear, the earworm usually feeds on the silk and enters the ear through the tip. Once within the ear, both kinds of worms feed on the kernels—and it takes only a few worm-eaten kernels to greatly reduce the sales value of corn for roasting ears.

Excellent progress has been made by the New Jersey station in controlling these pests. Nevertheless, although some of the newer insecticides have exceptionally high insecticidal properties, they may cause stunting or other plant injury. Other possible hazards include impairment of quality or objectionable residues after the corn is harvested.

The New Jersey station findings to date indicate that Ryania powder is the most effective and the safest insecticide yet found for combating the European corn borer on sweet corn and that TDE is the most promising against the corn earworm. Some New Jersey growers estimate that in 1947 Ryania dust increased their return from sales of sweet corn by 20 to 25 percent in that the treatment reduced the amount of corn smut and at the same time gave excellent control of the European corn borer. The growers who used TDE against corn earworm reported that the market value of worm-free corn averaged 50 to 75 cents per bushel more than untreated corn.

BEAN BEETLE CONTROL

The commercial bean growers of New Mexico have been enabled to use insecticides more profitably because of researches by their State experiment station. Workers at this station have been making a careful study of the habits, activities, and control of the Mexican bean beetle in the irrigated valleys of the southern part of the State. These investigations have revealed that the beetles survive better in and come out earlier from trash in the bean fields and along irrigation ditches than when overwintering in the neighboring pine woods of the Mesilla Valley or Organ Mountains. No great differences were observed, however, in the longevity of over-wintering adults in dif-

ferent environments or in the number of generations that developed from them.

In 1947 the injury from the first generation was most severe on the second (April 15) of four experimental plantings of string beans. Little difference was found in the susceptibility of first-generation larvae when fed on plants dusted with rotenone or cryolite. The more pertinent facts gained from the studies of insecticidal control of the Mexican bean beetle under these conditions in New Mexico have been released to the commercial growers. As a result it has been estimated that the green bean growers in two counties of the State realized from $6,000 to $10,000 additional income by increasing their production through timely applications of insecticidal dusts and sprays. In addition, the use of properly timed insecticides resulted in a 20-percent increase in the yield of dry beans, which had an estimated value of $468,000.

CONTROL OF APPLE INSECT PESTS

The control of insects that damage apples has for years been a major item in the cost of producing this crop. Each year the research of the experiment stations has provided sound bases for improving the control of these pests under the varied conditions of apple production in the different States. Instances of reduction in the number of spray treatments, in the cost of applying them, and of the benefits of improved control methods against these destructive insects well illustrate the progress now being made.

Damage by the codling moth (apple worm) to apples has been especially difficult to control in Colorado because of the development of a strain of moths resistant to lead arsenate. The Colorado station has investigated this problem from many angles, including the use of egg-killing materials, chemically treated bands on the trees, and fermenting-bait traps. These researches have materially aided the fruit growers of the State. Investigations during the last 3 years have revealed, however, that new insecticides such as DDT give promise of a much higher degree of control with 3 to 5 fewer applications and probably without the previously required washing of the fruit to remove spray residues. These results are exceedingly encouraging to the apple growers of the State, to whom the codling moth problem has at times appeared hopeless.

The Maine station has cooperated in developing two homemade spray booms for apple orchards. These consist of about 15 nozzles mounted one above the other, thus enabling one side of a tree to be sprayed from top to bottom as the rig passes by. With fairly good weather and a boom on each side, a man can spray one side of the trees in two rows at the same time.

The results of experimental tests by the Maine station showed that these booms can save 45 percent of the time required for spraying, 30 percent of the gallonage, and 73 percent of the man-hours of labor for application. This was not only an economic gain, but, it also provided more effective protection, since the same equipment could cover an orchard in a shorter time and thus take advantage of the period of highest efficiency for the treatment.

Research by the Ohio station has also proved the value of DDT for apple insect control under the fruit-growing conditions of the State.

In 1945, before DDT had come into general use in Ohio orchards, about 45 percent of the apple crop in Ottawa County was damaged by the codling moth. In 1946 and 1947, when DDT was in widespread use, injured fruit amounted to only 5 and 6 percent of the crops, with minor blemishes making up more of the injury. As this county produces 400,000 to 500,000 bushels of apples a year, it is assumed that about 200,000 bushels were raised in quality and grade and therefore increased in value by about 50 cents per bushel. This adds up to a saving of around $100,000 per year for Ottawa County growers alone from the use of DDT.

Codling moth damage was not as severe in other Ohio counties, but in many of these orchards a definite saving has resulted from use of this insecticide. The Ohio station estimates that a least 20 percent of the apple crop of the State outside Ottawa County was in this way advanced in grade. If only 25 cents per bushel is allowed for this increase, the added value to Ohio apples from this source would be $125,000. It is thus readily seen that station research leading to the use of DDT has increased the value of the Ohio apple crop by at least $225,000 per year.

Virginia station workers have investigated the use of DDT for control of apple insects under the various soil and climatic conditions of the fruit-growing regions of that State. They found DDT effective against the codling moth and some other insects but, as compared with lead arsenate, it increased the problem of controlling mites and the redbanded leaf-roller. In preliminary trials, parathion has given unusual promise in controlling apple pests, including the mites and leaf-rollers. Several other materials used in these experiments have also shown promise against the mites.

In years when the apple crop is light, damage from the codling moth is usually severe. This follows naturally from the concentration of the worm population in the fewer fruits that have set. DDT has improved this condition. The station estimated that in 1947 the commercial use of DDT against this pest, as recommended for Virginia, resulted in avoiding at least $1,000,000 in damage to the comparatively light apple crop of that year.

DDT PROTECTS PEACHES

Fruit growers have often been worried by oriental fruit moth worms in their peaches but had almost stopped any direct insecticidal attack because the previously available materials were so ineffective as to be of questionable value. A poison, such as lead arsenate, must be swallowed to act, but the young worms avoided this by spitting out the first few mouthfuls as they started to bore into the fruit. However, the discovery of the insecticidal action of DDT has given peach growers a material that is proving highly effective against this insect. The State experiment stations have now developed methods of using it effectively on peaches under the varied orchard conditions existing in different parts of the country. The results of work in Ohio and Michigan demonstrate that real progress has been made.

On a cost-efficiency basis the Ohio station workers found 50 percent wettable powder to be the most practical form of DDT to use against oriental fruit moth damage on the principal commercial peach varieties grown in that State. When the control schedule was limited to

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two applications, they found that the sprays should contain a minimum of 1 pound of actual DDT per 100 gallons of water. DDT dusts proved relatively ineffective in controlling fruit moth in the two-application schedule. The Ohio station's tests in orchards sprayed with DDT in 1947 showed a ratio of 4 bushels of culls to 96 bushels of clean fruit, while in untreated orchards the ratio was 28 bushels of culls to 72 of clean fruit.

The Michigan station workers found that new DDT spray schedules would control oriental fruit moth as effectively as it had been done over the preceding 2 years—and without leaving excessive residues at harvesttime. Two or three sprays of 1 pound of actual DDT, depending on the variety, gave control of the worms with residues of 2 to 3 parts per million when no spray was applied within 3 weeks of harvesttime. Best results were obtained when spraying was begun about July 15 and continued at 2-week intervals. One variety of canning peaches showed an infestation as low as 1 infested peach in 5,000 as a result of better timing of the DDT treatments. The timing of sprays on Elberta was more difficult because of variations in the ripening dates.

Canners had ceased processing peaches in the form of pickles because of the so-called invisible injury produced by the feeding of the fruit moth worms. As an outcome of this research, the pickled-peach industry has now been rejuvenated. The benefits accruing from these studies on the use of DDT against this troublesome pest came to a total saving of 7 to 10 percent of the annual peach crop of 4 million bushels formerly lost to its ravages. In Michigan alone, at least 300,000 bushels of peaches a year were saved by the proper use of DDT in fruit moth control.

BERRY PRUNING CONTROLS BORERS

Uncontrolled, the red-necked cane borer makes the commercial production of boysenberries impossible in Oklahoma. The Oklahoma station workers have been studying the habits of this insect in order to determine the most vulnerable point in its activities during the year, so that effective low-cost control measures might be worked out and applied.

By observing the dates of appearance of the beetles in 1947 these workers determined that 95 percent of them emerged from May 25 to June 4; this checked with the results obtained in 1945 and 1946 to give a good 3-year average. Tests at Yale and Ardmore, Okla., to compare three different dates of pruning were begun in 1946 and completed in 1947. These dates were (1) shortly before harvest (late May), (2) shortly after harvest (late June), and (3) during the winter (December); the first two prunings gave 98 to 100 percent control of the borers. No significant differences were noted between the cane lengths of plants pruned before harvest and during the winter, but those pruned after harvest averaged slightly over 5 feet, or 20 to 30 percent shorter than for plants pruned on the other two dates. The degree of winter killing could not be correlated with the date of pruning.

Since commercial production of this berry crop in Oklahoma is impossible without control of the red-necked cane borer, the value of summer pruning can be estimated as the net value of the entire crop;

this, during the past 3 years, has ranged from $40 to $100 per acre. Under conditions of drought, the before-harvest pruning is estimated to increase production over after-harvest pruning by 20 to 30 percent.

POTATO YIELDS AND QUALITY INCREASED BY DDT

DDT increases the efficiency of potato production but, since the insect damage to this crop differs from region to region over the country, the benefits from its use also vary. In some localities severe losses from insect attack occur in untreated fields every year; in other places the damage is often moderate and may be only slight. The agricultural experiment stations, cooperating with the Department, have taken an active part in seeking the best ways to use DDT and the other newer insecticides to yield profitable returns under all these varied environmental conditions. The following results are typical of their more recent accomplishments:

The Nebraska station found that DDT gives excellent control of the potato leafhopper with correspondingly reduced hopperburn, and is also effective in controlling flea beetles and the Colorado potato beetle, in an area having light to moderate insect infestations in 1947. The plants treated with DDT appeared slightly larger and the yield of A-size potatoes was increased by 35 percent. In another test the yields were increased 7 percent by DDT spray and 26 percent by the dust. At harvesttime the specific gravity (indicating quality) of potatoes from plots sprayed with DDT was significantly higher than for those from untreated plots.

The value of using DDT on dry-land potato fields as a regular annual practice, irrespective of local insect infestations, was tried out in a replicated field test conducted by the Nebraska station. The plots were treated with DDT and sulfur, but a very light insect population was present as had also been the case in 1946. A nonsignificant gain of 5 percent (not quite 5 bushels per acre) was harvested from the treated plots.

The growth, quality, and yield of different potato varieties under Nebraska conditions as influenced by insect control with DDT was evaluated in another series of plots initiated by this station. Fourteen varieties were planted in a nonirrigated field where the potato leafhopper was the most important pest encountered, and the tubers were harvested on two different dates. The average increase in yield from spraying was 11.5 percent (31.4 bushels per acre) for the early harvest date and 32.8 percent (92.3 bushels) for the late; similarly, increases in A-size potatoes per acre were 12.2 percent (24.4 bushels) and 37.7 percent (77.1 bushels). The variation in responses of different varieties to the spray treatment was considerable. Leafhopper infestations were heaviest on the two varieties that gave the highest response to DDT treatment. Quality, as expressed in specific gravity, seemed to be improved in certain varieties by spraying. Some evidence of a higher ascorbic acid content was also seen in those tubers harvested from plots where the insects had been controlled.

The beneficial action of DDT on potatoes grown under Ohio conditions has been demonstrated by research at the Ohio station. Prior to the use of DDT 97 bushels per acre, according to Department statistics, was the average yield of potatoes in Ohio over the 10-year period, 1929 to 1938. Ohio station investigations of the effect of DDT

on potatoes started its widespread use by the growers in 1946. In 1947 this State grew 42,000 acres of potatoes, with a total production of 5,460,100 bushels. This was an average yield of 130 bushels per acre, or an increase of 33 bushels over the 1929–38 average. The increase of 198,000 bushels of potatoes followed the general use of DDT on the Ohio crop. The average price received by growers in 1947 was $1.65 per bushel, or a total of $326,700 for the increase in yield; the use of DDT was a major factor in this higher production.

GAINS FROM CATTLE GRUB CONTROL

Extra gains by range steers and more milk from dairy cows followed the control of cattle grubs in trials by workers at the Oklahoma station. As part of their research program against the insect pests of cattle the station workers observed not only the above benefits from routine grub control but also great reductions in the damage to hides and in the direct losses from heel fly activity. The whole story of what the different life stages of this pest do is a fascinating one—and quite unusual, even for the insect world. The heel flies appear in spring or early summer and lay their eggs on cattle. This period—commonly known as "fly time"—is characterized by wild running of the cattle, which often seek out shady places or stand in water to evade these harassing pests. The fly glues its eggs to the hairs and when the grubs hatch out they crawl down to the skin and burrow directly into the flesh. During a certain period after these grubs enter the body their movements are unknown, but later they begin to appear in the body cavities and especially in the tissues of the gullet. In late fall they start to move again by a route still not clearly known, and finally appear beneath the skin of the back. Here they cut holes through the skin, living in cysts beneath these openings until 30 to 40 days later they crawl out. The fully matured grubs then drop to the ground, change to a resting stage called the pupae and after about 30 days emerge as heel flies and again repeat the life cycle.

The Oklahoma station workers, who have seen grub holes in cattle hides and watched cattle become restless and stop feeding because of heel fly activity, found that control of the grub stage not only prevents these losses but produces other tangible benefits as well. Their tests revealed that rotenone sprays applied to range steers control these worms and result in a gain of an extra one-tenth pound per day during the grub season. They also found that hydrogen peroxide treatment during the same period controls the grubs in dairy cows and increases their milk flow by one-half pound per day.

LOWERING HESSIAN FLY DAMAGE TO WHEAT

During a single year, 40,000,000 bushels of wheat represented the estimated damage by hessian fly in Kansas. This maximum loss occurred in 1925; since that time the work of the State experiment station in cooperation with the Department has brought about a substantial reduction in the damage from the feeding of this pest.

Investigation of the activities of the fly have shown that most of the adults come out rather early in the fall unless volunteer or early sown wheat is available for it to breed on during the summer. By destroying volunteer wheat and planting after the flies have almost completely stopped laying eggs in the fall, most of the damage can be

avoided. The date that is safe for planting wheat to avoid injury has been established by the Kansas station and Department workers for the different wheat-growing areas of the country where this insect is a serious pest. This date—called the "fly-free" or "safe-seeding" date—was worked out through painstaking observations over a period of years and varies from place to place, depending on climatic conditions.

The Kansas station workers have followed the relation of seeding dates and wheat yields for 16 consecutive years at Hays, Kans. The crop has varied from year to year according to the intensity of fly infestation and other factors; the average, however, was always highest for wheat sown on the safe-seeding date. Wheat sown 3 weeks before this date averaged 23 bushels per acre for the 16-year period; 2 weeks before it, 24 bushels; 1 week before it, 26.2 bushels; and on the safe-seeding date, 26.3 bushels. The proportions proved to be the same for the entire State.

The use of wheat resistant to hessian fly furnished another means of reducing losses of wheat in Kansas. The Kansas station workers found that in certain areas of the State adapted to Pawnee wheat, use of this variety reduces losses from this pest. In adapted areas, Pawnee differs from susceptible varieties such as Turkey, Tenmarq, Blackhull, Comanche, and Red Chief in the following ways: (1) Although Pawnee does become infested, it usually has only about half as many plants and about a fourth as many tillers involved as do susceptible varieties under the same conditions; this is because fewer worms (larvae) develop on this variety. (2) Hessian fly larvae developing on Pawnee wheat average smaller in size and grow more slowly than on the susceptible varieties. (3) Plants of susceptible varieties are often killed by the fall generation; this is rarely true for Pawnee. (4) Tillers of Pawnee are less injured by spring infestation than are tillers of these other varieties.

The total effect of these various factors results in a higher yield of Pawnee than that of susceptible varieties under hessian fly infestations. In the absence of this pest, Pawnee has given from 17 to 42 percent higher yields than these other varieties in Kansas station trials; in the presence of the fly, it has sometimes given more than twice the yield of susceptible ones. However, the Kansas workers have also obtained some evidence that the strain of fly able to feed on Pawnee wheat may become more abundant with an increasing acreage of this particular variety.

DDT HELPS SOYBEAN GROWERS

The production of soybean seed is often seriously reduced in parts of Louisiana by the feeding of caterpillars and leaf beetles. Investigations by the Louisiana station have determined the insects causing the damage and the methods for controlling them. Usually the soybeans were found to be free of insects until about midsummer. In 1947 these infestations became general in the fields of southern Louisiana and severe in certain localized areas. By August 1, the velvetbean caterpillar constituted about 75 percent of the total caterpillar population, with 20 percent green cloverworms and 5 percent loopers. Leaf beetles reached destructive numbers by late summer, especially in the Delta area.

Tests with various new insecticides showed DDT, parathion, and benzene hexachloride to be the most effective against large velvetbean caterpillars. As low as 1 percent parathion killed practically all insect life in a soybean field. More than 75 different species were killed the first day, many of which were important predators and parasites.

Studies by the Louisiana workers of the activities of insects attacking soybeans in 1947 made it possible to forecast when infestations of these pests were likely to appear. In Madison Parish, where soybeans produced a $750,000 crop during that year, 7,000 acres were dusted with DDT applied according to recommendations based on the forecast. This resulted in an increase of 5 bushels per acre (25 percent) over undusted fields, giving growers a net profit in this one area amounting to an estimated $95,000 for the season. This increase was mainly from the control of leaf bettles. In years when the caterpillars are abundant in Louisiana, savings from dust treatments ranging from 50 to 100 percent of the crop are common.

DDT INCREASES ALFALFA AND BLUEGRASS SEED YIELDS

Alfalfa seed producers have suffered serious and sometimes complete loss of their crops from insect damage. To meet this situation in their State the Idaho station workers have found that for the most part good control of the Lygus bugs, which do the damage, can be obtained by use of 5 percent DDT applied at the rate of 30 pounds per acre to alfalfa being grown for seed. In some of the seed-producing areas of the State one application proved sufficient; in others three applications were necessary on account of differing conditions. Yields on treated fields varied from 4 to 12 bushels of clean seed per acre, whereas the maximum for untreated fields in the same areas was never more than 2 bushels. Many untreated fields did not yield sufficient seed to warrant harvesting. Results like these explain why practically all alfalfa seed growers are now turning to DDT for control of legume bugs. As a further commercial application of the research by this station some of the growers are also using DDT on red clover seed fields and have reported extremely favorable results.

More efficient methods for insecticidal control of the insects attacking alfalfa grown for seed are also being developed by the Kansas station workers for the particular conditions prevailing in that State. They too have found that DDT dust controls the leafhoppers and plant bugs that are the main pests of this seed crop in Kansas. In these trials the improvement in foliage and the increase in bloom and seed set over the untreated check plots were readily visible. By controlling these insect pests, 3-, 5-, and 10-percent DDT dusts increased the seed yields by 184, 284, and 246 percent.

As a result of the research on alfalfa insects at the North Dakota station, a grower in the State who had 30 acres of alfalfa was able to act quickly and effectively. Here, the Lygus bug was the main pest endangering his developing seed crop. Since the alfalfa was in bloom at the time, some concern was expressed about the danger of destroying beneficial pollinating insects, should an insecticide be applied. It was finally decided, however, that this danger might be avoided by applying the DDT in the evening, after honeybees and other pollinating insects had left the field for the night.

The next step was to wait until after sundown and then spray 20 acres with DDT as recommended from the results of the station work; the other 10 acres were left untreated as a control on the test. From the 20 sprayed acres 2,800 pounds of clean alfalfa seed were harvested; from the unsprayed 10 acres, 180 pounds. This was at the rate of 140 pounds of seed per acre for the treated and 18 pounds for the untreated area.

In a 1947 survey of the injury to Kentucky bluegrass grown for seed, the Kentucky station found that meadow plant bugs were not sufficiently numerous to cause noticeable damage but that a European species of plant bug (*Amblytylus nasutus*) was present in injurious numbers. The numbers of these bugs on plots that had received nitrate in the spring were significantly greater than on the plots that had not been so treated. Furthermore, there were over twice as many bugs on fields that had not been grazed in the fall and spring as on those that had been grazed. A DDT dust gave practically complete control of both of these pests. The average yield of clean bluegrass seed was 154 pounds per acre from untreated plots, or in terms of rough-cured seed 28.2 bushels with a clean-out of 37.6 percent. The average yield of clean seed from treated plots was 289 pounds per acre, or 36 bushels of rough-cured seed with a clean-out of 56.8 percent—an 88 percent increase in clean seed over the untreated bluegrass. The gross return per acre for rough-cured seed at 1947 prices amounted to $44.80 per acre on untreated grass and $65.20 per acre on the treated. The cleaned seed from untreated grass (154 pounds) had a retail value of $77 and from treated fields (289 pounds) $144.50 per acre. The cost of DDT and its application was about $4 per acre.

Caution should be used in applying DDT and other insecticides to plants to be used as feed or food. As forage plants which are used for seed production are rarely also used for feed, the problem of objectionable residues seldom arises here. However, where insecticides are applied to plants that will later be eaten, careful consideration should be given to the possibility of an objectionable residue, since some of the new insecticides are known to accumulate in the fatty tissues of animals and are given off in milk and butterfat.

HONEY PRODUCTION

The beekeeper also has his problems. Among the newer ones is the use of new synthetic insecticides on crops in bloom and their drift to the flowers in fence rows and adjacent fields. The employment of chemical herbicides along roadsides and fence rows and in crops to kill weeds, many of which formerly produced nectar and pollen for the bees, presents another new problem. The sweetclover weevil gives the beekeeper further trouble in that it has spread rapidly and may soon infest the entire area in which sweetclover is an important farm crop. This pest is a serious menace, young sweetclover plants often being destroyed before they can establish themselves. In some neighborhoods the injury has been so serious as to discourage the planting of this crop. The reduction in acreage has resulted in much smaller honey crops and compelled some beemen to move to new locations.

The appearance of a new insect pest may cause a far-reaching shift in the farm program; in fact this has happened to sweetclover in

localities where other legumes are equally available. As yet the beekeeper has found no other plant that yields similar honey crops over a vast region of the midwestern and intermountain country. The control of this pest therefore becomes of special importance to beekeepers in these areas.

The State experiment stations in cooperation with the Department have been applying scientific research methods to many problems of the beekeeper, and with encouraging results. The following portions of reports by the South Carolina, Connecticut (State), and Missouri stations are examples of the progress now being made.

SELECTED HONEY PRODUCERS

Although much attention is at present being given to the value of the pollination activities of honeybees, the main income produced by them is in most instances still derived from the honey crop. To improve bees in this respect the South Carolina station has been making selections based on the honey production of individual colonies. The colonies tested in 1947 were headed by queens whose mother had headed the highest producing colony of the preceding season. The 1946 queens were in turn from high producers of the 1945 season. The investigations by these station workers showed that the largest crop of honey produced by any colony on test in 1947 was 200 pounds. On the other hand, the largest crop produced by any colony headed by queens of the nonselected stock was 160 pounds. The average production of five colonies headed by queens from selected stock was 155 pounds as compared with an average of less than 138 pounds produced by eight colonies from nonselected stock.

In other words, the selection of queens from high-producing colonies had increased the average honey production under 1947 conditions in that section of South Carolina by slightly more than 12 percent. Selection from both parents is planned for future improvement studies. This will be made possible through use of the newly perfected artificial insemination equipment.

SULFATHIAZOLE CHECKS FOULBROOD IN BEES

American foulbrood, as the name implies, is a disease of the brood (larvae) of honeybees. Although the bacteria that cause it were not controlled by the older germicides, sulfathiazole will check the disease and has been found to be tolerated by the bees when fed in a sugar sirup.

Six hives of bees were treated with one-half gram of sulfathiazole to a gallon of sugar and water by the Connecticut (State) experiment station workers. Among the hives receiving this treatment until all visible evidence of the disease had disappeared, four hives passed through the next season without recurrence of the trouble. During the next season, incipient infections occurred three times in one of the hives, but the colony removed the diseased material each time and remained free of all visual evidence of it throughout the latter part of the season. The disease reappeared in the sixth hive early the next summer and became worse as the season progressed, necessitating additonal treatment in the autumn and following spring. These Connecticut workers found up to 20 parts per million of sulfathiazole in the honey of some of the treated hives.

Another hive was sprayed at weekly intervals with a solution of one-half gram of sulfathiazole in a gallon of water. The disease in this hive was never eliminated entirely and the next season became progressively worse so that the spray treatment was abandoned. Neither X-ray treatments nor penicillin showed promise as control measures.

The Missouri station workers, who have been very active in developing the sulfathiazole treatment, found that when one-half gram of sulfathiazole in a gallon of sugar sirup was given as such or combined with pollen substitute and fed to colonies infected with American foulbrood they promptly cleaned up the combs and reared normal healthy broods. One-half level teaspoonful of sodium sulfathiazole to 1 gallon of sugar sirup gave similar results. When one-half gram of sulfathiazole dissolved in one-half pint of grain alcohol was repeatedly sprayed into diseased combs, the bees failed to clean up the combs promptly. Moreover, when this spray struck adult bees and brood, it caused some mortality.

Colonies fed sulfathiazole in sugar sirup at the Missouri station's experimental apiary have remained free of all signs of American foulbrood infection since 1945, but have continued to receive some sulfathiazole each summer.

The Missouri workers further report that the sulfathiazole treatment for American foulbrood is now rather universally accepted by practical beekeepers and the larger commercial honey producers as an effective control measure. A conservative estimate of the saving to American beekeepers as a result of this research was, during the last year, at least 100,000 colonies of bees worth $1,000,000 and a crop of honey worth $2,000,000. Furthermore, the improvement in fruit and legume pollination by the 100,000 colonies saved by the sulfa treatment is an added benefit to crop production.

ANIMAL HUSBANDRY

The progressive nations of the world are often said to be the great consumers of animal proteins—meat, milk, eggs. Without arguing the question, the fact remains that in the United States the demands for these products continue to be great and are reaching new and higher levels. During a large part of the history of our country, the ratio of yields of animal products to the consuming population was such that the abundance made for cheaper living. During and since the recent war, however, the situation has changed; increasing demands are now being made upon our livestockmen to supply a maximum of the various kinds of animal products.

As a people we have grown in numbers, however, and more land, previously used for range, is going under fence and irrigation to produce other types of agricultural products. This has put a new drain on existing facilities, creating new problems, or intensifying old ones. On the other hand, in certain areas old crops are giving way to soil-conserving practices; this is all to the benefit of the animal industries. But even should these two trends balance, the growth of our consuming public from 105,710,620 in 1920 to an estimated 145,000,000 at the present time simply means there is less to go around. In these times of increasing prices the urge is to find ways of reducing the costs of production, for already the retail sales values of some

animal products have met with consumer resistance or have already started a downward trend.

The State experiment stations have recognized the need for more efficient production and have concentrated research effort on the problem. No great reduction in animal products has occurred in this country because the research workers at the State experiment stations have been cognizant of the changes taking place and have directed their attention toward solving these ever shifting problems. Indicative of these improved techniques, now widely practiced by the growers of animal products, are the following summaries of a few of the outstanding research findings in the field of animal husbandry.

REDUCING SELENIUM POISONING

The buffalo and the Indian knew their selenium lands, at least enough to stay out of them. As the country's population moved westward in its urge to settle the West a new malady appeared in livestock. It was first called "alkali disease" or "blind staggers," because of the symptoms produced. Animals lost their hair and hoofs, thus becoming lame and dying—some suddenly, others much later. Post mortem examinations showed pronounced liver lesions and edema. Invariably among affected flocks and herds the death rate was high, in some cases approaching 100 percent, thus materially adding to the costs of production.

The malady was first described in an army report of 1857 to the 36th Congress from Fort Randall, Nebraska Territory, as a "very fatal disease" affecting the cavalry horses. Even in those early days, the idea of soil minerals and their relation to plants and animals had already been set forth by scientists in both Europe and the United States. It is not surprising, therefore, that this report attributed the cause to the forage consumed by these horses. Since the early report, this condition has from time to time been attributed to various causes by some of the State experiment stations, but it was not until 1935–36 that the South Dakota and Wyoming stations related selenium poisoning to effects on the enzyme systems of the plant. Then, in 1937, the South Dakota station reported on long-time investigations, which demonstrated without question that the real cause of the "alkali disease" came from eating feeds produced on soils containing selenium.

This finding led to a cooperative attack by the Department and various State experiment stations to ascertain the amounts of this mineral in toxic plants and where they were to be found. These researches have revealed that the toxicity produced by selenium-containing soils is apparently limited to areas with a rainfall of 20 inches or less. Nevertheless, the South Dakota, Wyoming, Colorado, and other State experiment stations, with the Department have found that certain species of plants, known as "converter plants," grow only where selenium is found in the soil. As a result, it is now possible to mark with appropriate "danger signs" those areas where such species occur. The problem is not quite as simple as this, however, because other plants may also take up selenium, even though they are not limited to the selenium-bearing soils.

Continued studies have revealed that there are two types of selenium poisoning—the chronic and the acute. The Wyoming station pointed out that animals often may not show outward signs of trouble until

several months after eating the toxic plant material and that the symptoms in such cases are then acute. During this time it was shown by the South Dakota station that the symptoms endure over a longer period, that arsenic in proper concentration is an antidote, and that certain forms of sulfur are also counteractive.

Why certain selenium-containing soils were less poisonous than others was an interesting phase of the question, and for a long time it was believed that the toxicity was due to organic compounds of selenium in the plants. Recently the Wyoming station has completed investigations showing that a large number of plants contain the inorganic selenate and that the amount of the selenite form in these same plants is not significant from the standpoint of toxicity. Further, in any one genus the species follow consistent patterns in the way in which they contain this element.

The known areas of dangerous pasture are gradually being extended with increasing knowledge of the indicator plants involved. On the western ranges grazing cattle and sheep are frequently driven long distances and not all the danger areas have as yet been charted. Can anything be done to assist when animals have already become exposed to selenium poisoning? Fundamental studies are now being directed toward finding how and in what way selenium acts in the animal body and toward laying a firm basis for prevention of such losses in the future. Meanwhile, the posting of danger signs is materially lowering the costs of production by enabling stockmen to avoid a large part of the unsafe areas of the range.

THE PLACE OF HORMONES IN ANIMAL PRODUCTION

Wherein lies the secret of the life processes and the perfect bodily harmony of a prize-winning animal? Without question the reasons will eventually be traced in high degree to the relationships between the body as a whole and its ductless glands—those producers of the endocrine or hormone secretions. The work already completed in this field by the State experiment stations has resulted in a business enterprise worth many millions of dollars to our drug industry and has brought increased income to packing-house plants from the recovery and sale of material previously deemed of value only as hog feed or fertilizer.

Perhaps the chief pioneer research along these lines in the United States was done by the Missouri station, where studies had long been under way in trying to ascertain some of the phenomena of milk secretion and production in the dairy cow. Although it was the early French scientist, Bernard, who first pointed out the distinction between the ordinary secretions and those from the ductless glands (internal secretions), it was only during the last half century that our knowledge of their relationships had become of practical value.

Because the thyroid gland is related to iodine nutrition, and in its absence becomes enlarged, it was only natural that the first work should have been done on this organ. Only 30 years ago the observation was made that when this gland was removed, the milk production of goats declined but did not stop. It was not until 1934, however, that the Missouri station definitely proved that in the absence of the gland the feeding of thyroid tissue resulted in a distinct rise in the amount of milk produced.

Later work at the Missouri and Pennsylvania stations showed the activating agent to be thyroxine, which chemists earlier had isolated from gland material. For practical use to maintain milk production, some cheap, readily available, yet effective source of this material was needed. Therefore, workers at the experiment stations began searching for a combination that would do the job. It was known that iodine is an essential part of thyoxine, which is an iodo-protein. Since many of these iodo-proteins had been prepared in the past, it was only natural for research workers to begin investigating both their possibilities and their shortcomings. Iodinated casein was found most effective in studies by the Department and by the Missouri, Pennsylvania, West Virginia, Illinois, New Jersey, Ohio, and other experiment stations. Some use was made of these findings in England during the war for maintaining and increasing the production of milk. Through long-time experiments there and at our own State experiment stations, workers began to realize that this new blessing must be used with caution. The problem has now reached the stage where it is recognized that further careful investigation must be carried on before establishment of the long-time and far-reaching effects of feeding thyroprotein materials to lactating cows.

The Missouri station has been a fertile source of information on many of these hormonelike materials. Studies on the ovary have resulted in the production of estrogen and estrongenlike materials, and their practical and profitable use with various classes of fattening livestock has been demonstrated at the Missouri, Indiana, Oklahoma and other stations. A real problem is now presented, however, in that it still remains to be shown whether or not harmful effects may follow the consumption of meat from the animals so fed.

Work on the thyroid problem led to the discovery of materials that inhibit the activity of the gland. This is important from the standpoint of animal production, and particularly of fattening animals, because of the functioning of the thyroid gland in relation to metabolism, growth, and other physiological processes. Particularly with poultry, lambs, and swine have desirable effects in feed economy been reported through supplying thiouracil or thyroid inhibitor in experiments by the Louisiana, Missouri, Michigan, and Indiana stations. Again, a way is opened up toward further reductions in the costs of production.

Research has clearly shown that these hormone and antihormone materials are directly related to the practial problems of animal husbandry. Many questions, however, still remain unsolved. More progress could be made in the genetic improvement of our domestic animals if we had a clearer picture of the optimum amounts of these various hormones actively concerned in the most highly efficient animals; when any one of them is out of line, limits are placed on production.

IMPROVED PASTURES PRODUCE MORE BEEF

The science of nutrition has established the basic nutritive requirements for most farm animals in terms of protein and energy. Beyond this, the needs for higher production must be provided for; these are taken care of by holding to the standards progressively arrived at through continued research. We are now beginning to ascertain and understand that some of our best and cheapest production is ob-

tained from good forages because they are rich in the proper combination of nutritive elements needed for maximum conversion of feed into animal products. There is evidence that the value of grasses and legumes depends fundamentally on the soil upon which they grow. Beyond this there is the problem of searching for and establishing the particular forage crops that are superior in yield and in the ability to survive under different climatic conditions and to stand up under local management practices. Only through a concerted attack by agricultural scientists as a whole can the most satisfactory progress be made. Fundamental to all is the improvement of grazing areas and a better knowledge of their value. The experiment stations and the Department have been working on these problems long enough to give answers to many of the problems involved.

The New Mexico station has long been investigating the nutritive value of the available forages of the State by means of digestion trials, forage and blood analyses, and mineral-feeding experiments. Although these studies have shown the range grasses of the region to be low in phosphorus, only certain sections were found where this deficiency was severe enough to cause injury. These workers also found that some of the grasses and browse plants on the semidesert areas have continuous activity throughout the winter so that carotene, the precursor of vitamin A so essential to good reproduction, is never completely absent.

Nevada, also, has made its contribution on the grazing values of forage areas. Studies of this kind are of particular value in regions of low rainfall, and especially in times of drought such as have occurred in this State during the past several years. These station workers have pointed out that a daily forage allowance must include not only the amount actually consumed, but also the quantity destroyed by uncontrolled conditions and for which an allowance must be made in arriving at the actual carrying capacity of a given area. The conclusions were arrived at through a study of the kinds of plants present, the density of their growth, the amount of feed available, and the needs of the animals. As a result of this work Nevada ranchers are now in a better position to estimate how many cattle or sheep their ranges can profitably carry. That the findings are being put to work is indicated by the fact that Nevada is one of only two western States that have shown an increase in the cattle population during recent years.

Although the results of such studies are invaluable to those concerned, one of Nevada's most important problems still remains unsolved. This concerns the reproductive rate of animals on the ranges; at present it runs about 50 percent. Is this reduced fecundity ascribed to the kind of feed available, to some inherited character, or to other causes? This is as yet an unanswered question. Thus it is seen that even as one problem is solved others appear.

Associated with the carrying capacity and the productiveness of the forage, is the stage of maturity at which it is used and the species of plants available. Some fundamental studies, applicable to many regions, have been conducted at the Illinois and other stations; these have provided a method for future research. On the basis of digestion trials and careful records of rates of consumption these workers found that the species of forage, its stage of maturity, and the size of the animal are all important aspects in the study of pastures. The species

of forage grazed proved to be the most significant factor in the rate of feed consumption, with its resulting effect on the amount of nutrients available for livestock production.

Applying the results of such studies to the western and southern range areas, the Montana station has reported on the feeding value of various native and introduced species of grasses. These workers discovered that downy chess and the wheat grasses are highly nutritious at the flowering stage. Moreover, the Florida and Texas stations have shown that young plants are high in protein and the important minerals so necessary to the health of livestock.

With such a background of information from these and other experiment stations, the next step involved a knowledge of how pastures and ranges should be managed to produce the highest economic returns. Distance from water is a most important factor, as has been pointed out by New Mexico stations workers who have developed a method for correcting the carrying capacity of a pasture based on the distance from water and a study of precipitation over a long period of years. Furthermore, work at the North Carolina, Georgia, Alabama, and other stations in cooperation with the Department has shown the value of prescribed burning in the costal-plains forested area, both for reducing the hazards of uncontrolled fire and in particular for providing succulent forage to the stock.

A good combination of grasses and legumes is essential to maximum returns. Typical of the productive value of grass-alfalfa pasture are the results reported by the Washington station, which found that such forage supplied an average of 131 steer-days of feed per acre and produced 223 pounds of beef per acre without grain supplements. This gave over 2½ as much beef as that obtained on straight grass pastures, with an average daily gain of 1.77 pounds by yearling steers.

In Hawaii the producer of beef must depend entirely on pastures for his market cattle. Although the climate is equable the year around, there are occasions when the winds fail to bring rain over long periods of time; this seriously complicates the problem. The Hawaii station has found grass pasture alone to be inferior to a pasture of pigeonpea with some admixture of grass. The increased live weight per acre-day was 1.22 pounds on the legume pasture, but only 0.80 pound on grass alone. This study also showed that permitting the steers free access to cane molasses further increased the average daily gain per animal by about one-fourth pound a day when slightly over 6 pounds of molasses were consumed. In addition, the feeding of molasses improved the grades and dressing percentages and resulted in better marbled carcasses.

No discussion on the value of pastures would be complete without reference to the valuable work at the Missouri station with Korean lespedeza, which was found so widely adapted to the State that it is now grown on more than 92 percent of all farms. This station has long been interested in the maximum use of pasture for beef production. Steers grazed during the summer on wheat-lespedeza and bluegrass pastures gained up to 286 pounds per head when grazing at practically 1 acre per head. Other combinations with lespedeza produced gains as high as 447 pounds during the nearly 5 months of the grazing period. These experiments have revealed that 30-month-old cattle can be marketed from pasture with no grain at all. In such cases

the dressing percentage was over 60 percent and the carcasses graded middle good. This is indeed a real economy in beef production.

The Nebraska station has also demonstrated that pasture can effect a saving in market-cattle production. In its experimental trials, the pasture-fed steers made larger gains. One month's pasture per steer effected a saving equivalent to 61 pounds of shelled corn plus 80 pounds of alfalfa hay in the feed.

That younger cattle also can be profitably marketed from pasture has been ascertained through experiments conducted jointly by the West Virginia station and the Department in the Appalachian area. These findings indicate that well-wintered calves can be put in good marketable condition at about 16 months of age when fed no more than 8 pounds of corn daily for about 100 days during the first half of the pasture season.

If beef production is to have a place in the South, the chief dependence must be upon pastures. The Florida station has made an intensive study of returns that can be expected from grazing the native and improved pastures of that State. The per-acre gains over a grazing season that can be expected from wire grass are 5 to 10 pounds; from carpet, Bahia, Napier, or Bermuda grass, 50 to 300 pounds; from carpet grass and lespedeza or other grass-lespedeza mixtures, 100 to 250 pounds; and from carpet grass and clover or other grass-clover mixtures, 200 to 675 pounds. Moreover, the wire grass was nutritionally improved by burning over. The Florida workers point out that the gains per acre vary widely according to prevailing rainfall, soil type, fertilization, and management. In these trials the average daily gain of beef animals ranged from as low as 0.2 pounds for wire grass up to 2 pounds per day for grass-clover mixtures. Moreover, the improved pastures enhanced the quality of the beef produced.

The Florida station has also suggested the need for temporary pastures to suply feed during the winter months, when the usual sources are low or poor in quality. Several stations in the southern region have presented solutions to this problem through grazing the animals on winter grains. The Mississippi station, for example, reports that the net profit per acre through grazing steers on winter oats may be as high as $75 in terms of the beef produced and the grain harvested afterward. This practice is being widely adopted by the cattlemen of that State and is typical of what is happening in other parts of the region.

However, the problems are by no means fully solved. For instance, although high per-acre yields of beef have been obtained from improved pastures in Louisiana, station workers there are convinced that attention should be given to a continued search for better forage and types of management that would put a more desirable market finish on young grass-fattened cattle.

Moreover, in Texas, Mississippi, and elsewhere, animals grazing on winter grains may suddenly die from a condition described as "grass tetany." This results in a substantial economic loss and further reduces the already scarce supplies of livestock products. Contrasting theories of the exact cause of this malady exist, and additional reasearch will be necessary before final answers to the questions are available. Already, the Texas, Wyoming, and other stations and the Department are attacking various phases of this serious problem.

BETTER FORAGE FOR DAIRY HERDS

One of the serious problems of the dairyman has to do with the late summer feeding period, when pastures are becoming old or turning brown.

Pennsylvania station workers, cooperating with the Department, have pointed the way toward solving this dilemma through studies of various grass-legume combinations; they found that orchardgrass-Ladino clover is a third more productive in terms of milk than well fertilized bluegrass, and such pasture is available during the whole grazing season. These investigations are also bringing out the importance of proper management for maximum returns from pasture lands.

The hot summers of the Corn Belt also present a real problem from late July to early September. One answer to the problem of overcoming this handicap was provided by the Illinois station, which reports that a sweet Sudan-soybean mixture is palatable to the cows and continues greener throughout the season. A further advantage of the sweet Sudan was found in its greater resistance to disease as compared with the common variety. Dairy farmers in Mississippi and other Southern States are putting to work the results of a study by their State experiment station, which demonstrates the seeding of winter grains alone or in combination with a legume to be a highly remunerative practice. Added returns above cost from the lower rate of grain feeding and the higher production of milk ranged from $400 to $700 on Mississippi farms adopting these recommendations.

Even as far north as Tennessee, winter grazing was found by the Tennessee station to be most desirable, although it proved advantageous at that station to give the cows some hay because of the reduced growth rate of winter forage. The most profitable groups consisted of cows grazing on pastures seeded to rye and crimson clover or to bluegrass and white clover. In this way material savings were effected during the 150 days of winter grazing. For the summer, this same station has shown that on irrigated permanent bluegrass pastures, cows gained slightly in weight, produced 35 percent more milk, and returned 27 percent more income above feed and irrigation costs than did cows on the nonirrigated areas. In addition, the irrigated areas provided 47 percent more days of grazing per cow.

What is the value of pasture? From a long-time study the Kentucky station has calculated that in the Lexington area the average yield of bluegrass pasture per acre is equivalent to 49.5 bushels of corn or 2.2 tons of alfalfa hay, along with a material saving in labor. The Connecticut station has also been interested in this problem since it is one of the major items in arriving at the total annual feed consumption of the dairy animal. These station workers have made a 10-year study revealing that on a yearly basis, pasture accounted for 36 percent of the total nutrient intake. Thus the importance of providing adequate summer pasturage to reduce the purchase of expensive nutrients in the form of concentrates is again emphasized.

FORAGE ALSO MAKES PORK

One does not ordinarily think of the hog as a grazing animal, yet it has been shown by several of the experiment stations that making

the maximum use of pasture does materially decrease the cost of pork production.

The Georgia station has long been leading in southern areas by showing how grazing can fit into a better hog-production system. There, a year-round grazing program has been developed and is now in use by the farmers of the State. The crops employed include the strictly grazing types, such as rape, lespedeza, alfalfa, green small grains, and winter clovers and others to be "hogged off," such as peanuts, corn, and velvetbeans. Every acre of such grazing has been estimated to save 800 pounds of corn and 500 pounds of tankage; in addition, a material saving in labor is also effected.

The Florida station too, has shown the value of grazing crops for pork production. Corn interplanted with cowpeas produced 451 pounds of pork per acre, while pigs on Florida Runner peanuts alone averaged a 1.49-pound daily gain or 245 pounds of pork per acre. Planting corn and peanuts in alternate rows increased the pork production to 321 pounds per acre. Although sweet potatoes produced only a small average daily gain (1.1 pounds per day), the largest total gain (531 pounds) was obtained on this ration. Such a result followed because six pigs could be fattened on 1 acre of sweetpotatoes, but only three on an acre of peanuts. Perhaps one cause of the lower daily gain on sweetpotatoes was the excessive diarrhea caused by grazing on this plant.

The value of grazing for reducing the cost of production has also been pointed out by the New Jersey station. Pigs fed a limited supplementary ration while on alfalfa pasture followed by rape pasture—each for 35 days—put on gains at a cost of 7.6 cents per pound as compared with 14.9 cents for those fattened in the dry lot.

The saving in feed that can be made through the use of pasture has been emphasized by the Pennsylvania station. This station points out that for growing pigs full attention should be paid to the type of protein supplement fed; this will vary with the kind of pasture being used. Ladino clover proved to be the best known pasture for pigs in this State.

Whether its great benefits result from the quality of protein it supplies, the associated effect of the various nutrients, or from the pigs eating more of the clover has not yet been established. Over a 70-day period, pigs on Ladino pasture supplemented with tankage and corn made an average daily gain of 1.33 pounds as compared with 1.24 pounds for those in dry lot. Orchardgrass was inferior as a pasture crop, producing an average daily gain of only 1.05 pounds. Material savings in the amount of concentrate feed needed to reach market weight were always obtained on the Ladino clover pastures.

Nevada is not thought of as a hog-producing State, nor does it have an abundance of grain for fattening purposes. Under these circumstances the advantages of the maximum use of pasture are self-evident. Workers at the Nevada station found that pasturing pigs on alfalfa with an unlimited supply of barley produced 1.38 pounds of average daily gain; the use of skim milk increased the gain to 1.55 pounds. No advantage followed the feeding of tankage or any such form of protein supplement and the gains on pasture, although slightly less, were much more economical.

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An economic study by the Minnesota station revealed that on farms in that State where good pastures were available to hogs there was a saving of 36 pounds of feed for every 100 pounds of pork marketed. In further work along this line, the New York (Cornell) station found that liveweight gains made entirely on pasture were somewhat superior and at the same time just as economical as those made by hogs finished in dry lot during the last part of their fattening period.

QUALITY OF THE RANGE FOR SHEEP

Although to a great extent, the knowledge on values of pasture for cattle might be applied also to sheep, some areas exist where only through grazing by sheep will any use at all be made of the land. Very little is known, however, as to the composition of the forage in such regions. Researches being carried out by the Utah station are therefore of prime importance in increasing our knowledge of what can be expected from these marginal lands. The type of approach made by these workers is new and although the work is still incomplete, brief reference to it is made here to suggest how the stations are always on the alert to tackle any problems that are in need of solution.

The Utah workers set out to determine the nutritive content of the sheep's diet under range conditions. The method is based on the collection of a predetermined number of different kinds of plants, followed by chemical analyses of certain parts of the vegetation both before and after it has been grazed. The measure of the nutrient content of the forage consumed is then determined by the difference in weight and chemical composition of the plants before and after having been grazed. Sheep were found to be highly selective, consuming leaves and tender stems, but not eating the coarser portions of the plants; their diet was thus much higher in nutritive quality than had hitherto been supposed.

Seven species comprised the major plant cover on the range under study. It was found that mountain brome and aspen peavine together accounted for over 72 percent of the sheep's diet. Wild rye was not consumed at all, meadow rue and sweet anise made up 3.7 and 4.6 percent of the diet, serviceberry 10.6 percent, and western chokeberry 7.6 percent. Although usable, the new method of research does have disadvantages; it is only through such studies, however, that progress can be made in this difficult field.

DAIRY PRODUCTS

MILK AND MILK PRODUCTS IN AMERICAN DIETS

For years nutrition workers have been stressing the great value of milk and its products in the diets of Americans. The results of this effort can best be understood by a study of the consuming habits of our populace during the past 18 years, as shown in the accompanying table rearranged from the Department's "Annual Statistics, 1947."

The total per capital consumption of dairy products has remained relatively constant during this period, although there have been years when the annual-use figure has reached 837 pounds. The number of milk-producing animals has increased from 22,218,000 in 1930 to 24,475,000 in 1946. Along with this increase in number of cows the milk production per cow has gone up from 4,508 pounds to 4,891

Per-capita civilian consumption of certain dairy products in pounds, 1929 and 1946

Year	Total milk	Fluid milk and cream	Condensed and evaporated milk	Dry whole milk	Butter	Cheese	Ice cream	Non-fat dry-milk solids
	Lb.	*Lb.*	*Lb.*	*Lb.*	*Lb.*	*Lb.*	*Lb.*	*Lb.*
1929	811. 7	356. 3	13. 6	0. 11	17. 4	4. 6	10. 0	[1] 1. 6
1946	810. 0	425. 0	18. 8	. 51	10. 3	6. 9	22. 9	3. 4
Pounds of increase or decrease	−1. 7	+68. 7	+5. 2	+. 40	−7. 1	+2. 3	+12. 9	+1. 8

[1] No data prior to 1935.

pounds per year. Fortunately, therefore, along with our increase in population we have had a total increase in annual milk production of almost 20,000,000 pounds between 1930 and 1946.

Utilization of the various products originating from milk has shown a steady increase, with the exception of butter. This expansion in the over-all use of dairy products is to a great extent attributable to research at the State experiment stations; the net result has been to improve the diets of our people through increased consumption of milk solids and to expand the market for milk through utilization of products previously disposed of as waste. All this has aided in improving the economic position of the dairyman and enabled him to retain his markets. The importance of this expansion can be the better appreciated when it is realized that the constant and ever-growing demand for milk and its products accounts for not only one-fourth of the consumer's food dollar, but also for a quarter of the total weight of food he consumes.

ADVANCES IN CHEESE MAKING

Lack of space prevents reporting work on all dairy products, but typical of the progress being made in the whole field of this multimillion dollar industry are the advances in the making of cheese.

From time immemorial, man has attempted to change the great bulk of perishable fluid milk produced in areas distant from markets to a palatable and nutritious form that could be stored and transported without danger of loss. Thus, since the remote time when it was first realized that the coagulation of milk produced a curd satisfying these conditions, mankind has had access to cheese as a part of his diet, and in most sections of the world one finds various forms and types of this valuable dairy product. In past times, the micro-organisms and environmental conditions prevailing in the place of origin were responsible for the quality of a particular kind of cheese. The United States has been populated by peoples from many parts of the world who have brought their own tastes in cheese to our shores but, because they could not bring with them all the factors concerned in the making of a good product, cheese making in America was for a long time an

"art" rather than a science. Now, however, researches by the State experiment stations and the Department are providing a background of science for the manufacture of this highly esteemed product of the farm.

If one were satisfied with curded milk without additional flavor and solely on the basis of its nutritional value, perhaps less need would exist for other than a plain unsalted product. The problem of preservation, however, necessitates a certain amount of treatment, and if the product is to sell, it must also meet the requirements of those who buy. One of these requirements is flavor, and its measurement and origin have presented many exacting problems over the years. Those things that we judge by taste or smell are indeed rather elusive and fleeting, but bacteriologists and chemists are, by their researches, discovering facts and principles that will enable the cheese maker to take advantage of them in producing a high-quality product.

Cheeses of good flavor are never a drug on the market, but one of the chief problems of the manufacturer is to achieve a uniformly high quality in his finished product. It has long been recognized that micro-organisms play an important role in the production of good cheese and that some organisms are specific to a particular kind of cheese. In the early researches, the New York (State) experiment station made some outstanding contributions, which have been continued and expanded upon by this and other experiment stations and the Department. For example, some of the earliest and most fundamental work on milk chemistry was carried out at this New York station. These pioneer researches have since provided the soundest basis for a modern attack on all the problems confronting the cheesemaker.

Because of the importance of micro-organisms, bacteriological studies have made their contribution to the subject. Some of the earliest investigations of flavor were conducted from this approach because of the marked changes long known to be brought about by bacterial action in other fields of study. Reports from the various experiment stations and the Department dealing with this phase of the problem are many and valuable and have resulted in marked improvements in the manufacture of cheese. It is, therefore, now possible to produce in this country cheeses previously characteristic only of other parts of the world.

With the introduction of the clarifier and of pasteurization as dairy processes to insure a more healthful product, it was only natural that milk treated by these processes should also enter into the manufacture of cheese. The Cheddar cheese maker now had more factors under his control—he could eliminate the defects caused by gas-forming bacteria, for instance—but at the same time a completely new set of problems confronted him. It was earlier recognized that in the ripening process a desirable flavor is produced sooner in Cheddar cheese made from pasteurized milk. During ripening the latent or introduced micro-organisms are at work in developing the finished cheese. Many chemical compounds are concerned in this process as the various constituents of cheese are broken down in the curing process. Casein, lactose, fat, minerals, gases, and the enzyme system and pigments are there together.

Some of the breakdown products from these milk constituents are extremely important in the devolopment of flavor. Among them are

the alcohols, aldehydes, ketones, and acids resulting from carbohydrate breakdown; the esters, related to the breakdown of fat and carbohydrates; and the nitrogen and sulfur compounds derived from the casein and other protein materials. All this wealth of constituent materials has furnished the bacteriologist and chemist with excellent, although difficult, points of attack in their combined efforts to ascertain and control the causes of desirable quality in different types of cheese.

Tests for adequate pasteurization, by determining the absence of the phosphatase enzyme, have been standardized and improved by work in the Department and at the experiment stations, and it has been pointed out by the Iowa and other stations that different organisms can produce phosphatase even in sterile milk or bottled-pasteurized milk.

Following the early studies at the Wisconsin station, showing that pasteurized milk could be rendered suitable for cheese making, it was later discovered by other Wisconsin workers that cheese quality could actually be improved through the use of pasteurized milk and that the yields were up to 4 percent greater than when identical nonpasteurized milk was employed.

Now, as the field of technology advances, work at the New York (Cornell) station offers a rapid new method using modern techniques to make a high-quality cheese that is also safe for human consumption. By this procedure, Cheddar cheese from raw milk is pressed over night, cut up into small blocks weighing 1.3 pounds (a suitable consumer size), and then pasteurized by radio-frequency heat obtained by placing each block between the electrodes of an oscillator. Following pasteurization, the cheese is air-cooled to 70° F. Heating to 146° had no noticeable adverse effects, and pasteurizing temperatures even as low as 130° destroyed all but 0.01 percent of the bacteria in 2-day-old cheeses and caused disappearance of the phosphatase that indicates complete pasteurization.

With older cheeses, lower pasteurization temperatures can be used, and with cheeses ripened for 2 months at 60° F., the radio-frequency treatment produces definite signs of curing as measured by various chemical and bacteriological tests. The results of investigations such as these should bring about great economies in cheese manufacture by reducing the inventory tie-up that occurs in the storage hitherto so necessary to yield a salable product.

BETTER CHEESE STARTERS

One of the contributory factors to poor cheese flavor is the lack of proper acid development following addition of the starter. The problem of slow acid-producing starters is not new but has become more pronounced in recent years with increases in our knowledge of the ripening process. The Indiana station has shown the importance of a good starter culture to inoculate a batch of milk destined for cheese making. To insure the use of a good live culture, these workers have developed a rapid method of determining the acidity or "activity" of a starter being used in the cheese factory. They have also shown the value of nonfat dry-milk solids for use in preparing both mother starters and batch starters. One of the causes of slow-acting starters appears to be a virus-like "bacterial killer" (bacteriophage), the

origin of which is still obscure, though it has been recovered from the air of dairy plants and is sometimes present in pure cultures of bacteria.

In studies directed toward elucidating some of the relationships between bacteriophage and cheese-starter cultures, the Iowa and Indiana stations have compared the resistance of different cultures to the action of these bacterial killers. The Iowa studies have shown that various cultures of the same organism isolated from natural sources may vary in this respect; on the whole, however, these isolations from natural sources appear to offer the immediate answer to the bacteriophage question in cheese factories where slow acid-production is a problem. Other Iowa studies have shown the value of the electron microscope in studying bacteriophage and have even defined the shape and measurement of the individual particles responsible.

Fortunately, as recently shown by investigations at the Washington station, single-strain cultures of certain organisms may become adapted to growth in the presence of the bacteriophage formerly attacking them, and the length of time during which this acquired resistance endures may vary with different strains of the organism. These data further reveal that the acquired resistance may last for as long as 4½ months.

That factors other than bacteriophage are important in determining the rate of acid production by starter cultures has been brought out by Oklahoma station researches. These indicate that the points of practical importance consist of increasing the solids-not-fat content of the milk used in making the cultures, incubating them at 70° F. (rather than 80° or 90°) until they are thoroughly ripe, employing enough inoculum to insure a thoroughly ripe culture, and using freshly ripened cultures for inoculating the cheese milk.

ORIGINS OF FLAVOR IN CHEESE

Whether cheese flavor is ascribable to fatty acid esters or to protein breakdown has long been discussed; recent work tends to indicate that nitrogenous compounds are extremely important because of the marked changes that occur in the protein constituents. The Iowa station has investigated the nitrogen picture by adding the various amino acids known to be present in cheese. These studies failed to reveal that the separate addition of some 19 amino acids had any reproducible effect on the development of flavor in Cheddar cheese. By a determination of what amino acids occur in cheese, the Wisconsin station has discovered in further studies that a direct relation exists between the degree of flavor and the presence of most of the nine amino acids investigated. These workers also believe that a small quantity of diacetyl is essential to good flavor.

Perhaps the most interesting findings have been those of the New York (Cornell) station, which has made a careful study of an amine (tyramine) that is the breakdown product of tyrosine. Although earlier work at the New York State experiment station first reported the presence of this aromatic amine in Cheddar cheese, its exact significance remained to be ascertained and interpreted in the light of knowledge accumulated in the succeeding 40 years. The recent Cornell announcement definitely relates intensity of flavor to increases in the concentration of tyramine and also states that higher temperatures in ripening are conducive to increases in the amount of this amine

produced. Moreover, the Cornell station has worked out a chemical method for determining the amount of tyramine present in a cheese.

By no means do these investigations signify that the problems of cheese making are all solved; for one thing, it still remains to be disclosed just what is the further effect of different amounts of this substance on the development of flavor. Such questions remain for solution by the chemist and bacteriologist. That chemists and bacteriologists need to work together on these problems is further suggested by studies at the New York (Cornell) station and in the Department; these involve the different organisms associated with cheese flavor and quality in general. Both these studies have as objectives the production of a more desirable and rapid-curing product.

One of the chief difficulties in cheese investigation has been the getting of a proper sample for analysis. The Wisconsin station has presented an improvement in sampling which, in the case of moisture determination, will limit the error to 0.27 percent. Other studies at this station have shown the advantage of a Waring-type blender to make a water suspension of the cheese, and have offered improved techniques in preparing this solution for analysis.

Some years ago the Utah station pointed out the value of hard-curd milk in yielding a superior-quality Cheddar cheese, ascribable to the better retention of fat and the improved texture of the finished product. As early as 1911 the Wisconsin station showed that as the size of the curd particles increased, more moisture was retained; this improved the curing and keeping properties of the resulting cheese.

The Oregon station has reported that Cheddar cheese need not be made entirely from whole milk and that for high-fat-content milks the use of nonfat dry-milk solids may be advantageous. The benefit from this procedure lies in the fact that in times of surplus, milk can be dried, stored, and later made available for adjusting to a constant fat-to-nonfat-solids ratio in those regions, such as Oregon and the Southern States, where high-fat milk is produced. Cheddar cheese of high quality has been produced by this station under semicommercial conditions, but further studies need to be made before all the wrinkles are smoothed out.

A further indication that workers at the State experiment stations are keeping their feet on the ground even while putting a basis of science into cheesemaking is shown by the results of investigations at the Wisconsin station directed toward increasing the efficiency and reducing the cost of Cheddar cheese manufacture. With decreases in the number of factories and increases in the output per factory, labor-saving devices and techniques are now being introduced. The problem is to produce a quality product under these new conditions and procedures. The Wisconsin workers have found that maintenance of the temperature at 100° F. during the entire draining process improves the texture of the stirred-curd cheese and that in all respects the procedure yields a product similar to that obtained by the old matted-curd process.

POULTRY INDUSTRY

Slightly over a tenth of the total gross national income from agriculture is derived from the poultry industry. This young giant has risen in only a few decades from a relatively unimportant position in the farm economy to a good fourth place in the list of major agri-

cultural products of the country. During 1947 cash receipts from poultry totaled 3.4 billion dollars, or over 800 million dollars above that from wheat—the fifth commodity in rank. Of this amount, approximately 61 percent came from the sale of eggs, 22 percent from chickens (excluding broilers), 8 percent from broilers, 7 percent from turkeys, and 1 percent from ducks, geese, guinea fowls, pigeons, quail, pheasants, and other poultry.

With the growth of the industry, not only have many problems appeared in the normal course of its development, but also challenging demands for more economical and efficient methods of production and for products better adapted to the needs and desires of the consumer. In the solving of these problems excellent progress has been made. For example, as a result of intensive research in breeding, nutrition, and incubation, the number of chicks hatched has been raised from 60 or less to 70 per 100 eggs incubated—an achievement that increases the returns of the industry by 1.5 million dollars a year. Other equally important accomplishments could be cited; a few of them are included in this report.

IMPROVING EGG QUALITY

Over 55,300,000,000 eggs were produced in the United States during 1947, or about 375 for every man, woman, and child. The per-capita production has more than doubled during the past 50 years; the population, 2½ times. In other words, the population has increased 2½ times, while egg production has increased fivefold. The average annual output per hen has been steadily improved until in 1947 it stood at 159 eggs, compared with 134 for 1940; this is a remarkable showing in view of the fact that many low- and nonproducing birds were included in the survey. To the research worker who has labored through the years to develop high-producing breeds, better-balanced feeds, and more productive managerial techniques, credit must be given for this outstanding record.

Consumers insist on high-grade eggs. To meet this demand the poultryman must produce eggs of the highest possible initial quality and then take every precaution to maintain this quality from the farm to the table. Buyers and sellers, including wholesalers and retailers, have a financial interest in the various factors of processing and distributing that affect egg quality, for the simple reason that there is less wastage in marketing a high-grade product.

BLOOD SPOTS IN RELATION TO EGG QUALITY

One widespread problem in producing high-quality eggs is the occurrence of blood and meat spots, which are very objectionable to consumers. The New Jersey station, in a recent examination of over 23,000 eggs, found that over 47 percent of them had such spots. Almost a decade ago, when work on this problem was initiated at the Illinois station, nearly all the White Leghorn hens on the university farm produced defective eggs. To investigate the extent of this problem the Illinois workers examined all the eggs in 30-dozen lots received from each of 10 breeders of White Leghorns and 10 breeders of the heavy varieties, including Barred Plymouth Rocks, New Hampshires, and Rhode Island Reds. The States of Michigan, Missouri, Minnesota, Ohio, and Iowa, as well as Illinois, were represented. Of

the Leghorn eggs, about 25 percent contained meat spots or blood clots; of the heavy breeds, nearly 43 percent were defective.

The tendency of hens to lay eggs containing blood clots has been demonstrated by a number of workers to be hereditary. The most permanent method of eradicating the difficulty therefore lies in genetic selection against individuals and families coming from recognized blood-spot producers, which would involve a long time. However, since the condition was found to be more prevalent than commonly assumed and the damage amounts to millions of dollars annually, the Illinois station attempted to find a more rapid method of preventing the defect through improvement in nutrition.

The feeding of Cerogras, a proprietary product consisting of dehydrated cereal grasses, caused a reduction of blood clots from 46 percent to 6 percent during a 6-week period of feeding. Moreover, access of the birds to range also substantially reduced the bleeding. Great variation, however, exists in both Cerogras and range grass with respect to the potency of the constituent that corrects the malady. Range suffering from drought, for example, was much less effective in preventing ovarian hemorrhages than when grown under more favorable conditions. Apparently, too, the nutritional condition depends in part on the genetically enforced requirements of the individual bird. The evidence now at hand indicates that grass is capable of preventing the ovarian bleeding only when the requirements for the dietary constituent are not more than is contained in the amount of grass that a hen can consume. The Illinois workers are now attempting to discover just what it is in the grass that corrects the defect.

CLEANSING SOILED EGGS

A serious marketing problem results from dirty eggshells, particularly during the damp spring months and under conditions of muddy poultry yards and wet floor-litter. Egg albumen contains an active germicidal agent that prevents invasion by small numbers of bacteria. If the shell is soiled, however, the egg may become inoculated with too many organisms for the egg albumen to destroy. As a result, the bacteria force entrance through the albumen into the yolk and eventually spoil the egg.

The Missouri station has demonstrated that during cool weather, soiled eggs may be cleaned successively with a 1 percent solution of lye-water, so that they keep unusually well—even for 6 to 8 months in storage. Nevertheless, it is very important that the temperature of the cleansing solution be considerably higher than that within the egg (about 115° F.), in order to increase the internal pressure through expansion of the contents and thus minimize the danger of bacterial invasion.

During hot humid weather micro-organisms penetrate in such large numbers as to overcome the germicidal effect of the egg white. Under such conditions, pasteurization by immersing the eggs in water at 130° F. for 15 minutes has proved successful. In the experience of the Missouri station, losses in storage may be reduced by 90 percent through this treatment.

The New Jersey, Maryland, and New York (Cornell) stations have also worked on this problem. Through the combined efforts of the engineering and poultry departments at Cornell, an effective and prac-

tical automatic egg washer and drier has been developed. Cleansing of eggs by hand is a slow, tedious, and unpleasant job, requiring time and energy that could be spent more profitably elsewhere. The egg washer, however, can clean and dry five cases of eggs an hour, which is at least five times as rapid as hand-cleaning with a buffer. When the cleaner-drier is used in conjunction with a grader, it becomes possible for two persons to wash, dry, grade, and pack five cases per hour. Another commendable feature of the appliance is its relatively low cost of manufacture.

Dirty eggs washed in this equipment for 22 seconds with the feed water at about 165° F. will keep in storage much longer than dirty eggs cleaned by any other method tried. Increasing the temperature of the wash water even up to 175° hastens the cleansing without harming the quality of the eggs.

GRADING EGGS BY ELECTRONICS

The New York (Cornell) station has developed an automatic electronic egg grader in addition to the cleaner-drier mentioned above. Essentially, this marvelous timesaver measures the relative ability of an egg, when placed in a coil, to conduct an electric current of radio frequency. Conductivity is registered directly on a meter, the readings of which are automatically corrected for egg weight.

This apparatus offers distinct advantages over other systems of grading: It is mechanical and entirely automatic. Its evaluation of the egg is unaffected by color of shell or yolk. Furthermore, it is so highly sensitive as to distinguish several quality-gradations in fresh eggs, as well as any changes produced by age or high temperatures within either fertile or infertile eggs. Finally, the device can be used to evaluate eggs for marketing, processing, storage, and hatching, as well as for the identification of good breeding hens.

SEALING EGGS FOR PRESERVATION

Although in the past much work has been done on oiling eggs for preservation, little of it relates to the effects on interior quality. In 1942, the Washington station emphasized the importance of oiling within a few hours after the eggs were laid if the beneficial effects of the naturally occurring carbon dioxide were to be obtained. Then the Iowa station started investigations on the effects of heat-treating shell-eggs to determine the possible complementary effect of oiling them on thermostabilization.

The results obtained at Iowa indicate pentane-mineral oil mixtures to be very efficient for preventing losses in quality. Eggs dipped in mixtures containing 10 percent or less of this oil were practically free of "shine" within a few hours after treatment, a factor of commercial significance because of objections of the trade to an oily appearance. For all-round preservation, it was found that eggs should be treated within about 18 hours after being laid. A combination of oiling and heat treatment at 130° F. for 15 minutes gave the optimum benefits from both processes.

In experiments at the Louisiana station with a commercial creamlike material treated eggs were held for 2 months without loss, and almost 74 percent were still rated as Grade A after more than 4 months in storage. The Oklahoma station is running tests on a highly promising

plasticlike sealer which, in combination with a proprietary bactericide, has proved very effective not only in protecting eggs from the growth of micro-organisms but also in reducing weight losses through evaporation.

FREEZING EGGS WITHOUT BREAKAGE

At this period, when quick-freezing and deep-freezing are in common use for the preservation of foods, attempts to freeze shell-eggs successfully have hitherto failed because swelling of the contents during the process breaks the shell. Consequently, whenever this type of preservation is used, the egg contents are removed from the shells, stirred to break the membranes, and stabilized by adding some such material as sugar or salt. The use of eggs so treated has been limited to bakeries, confectionaries, and similar commercial establishments.

What appears to be a new and at the same time practical method of freezing eggs without damage to the shells has now been developed by the Louisiana station. This technique also minimizes undesirable changes in the egg contents, such as those taking place in ordinary cold storage—displacement of yolk, weakening of the vitelline membrane, loss in weight, and acquisition of off-odors and off-flavors. After thawing, the eggs so treated taste like ordinary fresh eggs and can be used satisfactorily for household purposes.

In carrying out this new method, the eggs are first dipped into an acidified water solution to remove the outer waxy coating from the shell, then removed and wiped. After this preliminary treatment they are placed under vacuum in the presence of drying agents until they lose about 5 percent of their weight. This partial desiccation can also be carried out without use of a vacuum by placing the eggs in a drying chamber with dehydrating agents, or even by using dry air or any other method that will cause the loss of moisture.

The Louisiana process involves treatments that change the relationship between the bound water and free water in the egg. The necessary decrease in weight based on the water content and its water-ice curve has been estimated to be slightly over 6 percent. Elimination of only 2 to 3 percent, however, was found to suffice for freezing eggs under vacuum and without cracking.

BUILT-UP LITTER

For many years emphasis has been placed on the need of cleaning out floor litter from chicken houses every week or two, in order to avoid excessive dampness and to prevent disease. In recent years, however, the use of built-up floor litter has become the practice of many poultrymen, primarily because of the scarcity of labor and materials.

Researches by the Ohio station have shown that in both brooding and laying houses the same litter may be used for more than a year without causing trouble. Less difficulty was also experienced from coccidiosis with built-up litter than with biweekly replacements. In addition, built-up litter in a laying house is apparently a source of special nutritional factors necessary for optimum reproduction when breeding stock is kept under confinement. In a brooding house, such litter also supplies nutrients—including the still unidentified animal protein or vitamin factor—required as supplements to feedstuffs of plant origin for the support of normal growth in the chicks.

Regarding the prevention of coccidiosis, these workers point out that the new procedure is in line with the old contention that dry litter is a valuable safeguard, inasmuch as the frequent stirring plus the addition of hydrated lime promotes dryness. Strong indications have been found that chemical and bacterial processes involved in the built-up litter act not only against the protozoan parasite, but also aid in synthesizing valuable nutritional factors. The lime is apparently not as necessary as at first believed, and actually may have a detrimental effect on formation of the growth factors.

SALVAGING VEGETABLE REFUSE

Every year many tons of vegetable cannery wastes are thrown away. A survey made during 1944 revealed the following estimated quantities of leafy refuse (expressed in thousand tons): Peas 1,981, cabbage 1,537, cauliflower 354, lima beans 292, carrots 164, beets 120, spinach 39, broccoli 36, rutabagas 4, and turnips 4. Before the close of World War II, the Delaware station reported that these dried wastes were excellent sources of carotene, riboflavin, tocopherol, and other vitamins, and therefore could be made into valuable supplements to poultry rations. This station, in collaboration with the Department, has compared meals of various leaf wastes with alfalfa leaf meals as concentrates in chicks diets.

The plants were first separted by hand into leaves, petioles, stems, pods, and other parts, and the relative proportion and chemical composition of the various parts were determined. The relatively more nutritive leaf blades were then separated from the stems by fractional drying followed either by screening or by air separation. Leaf meals having high vitamin and protein content and low fiber content were prepared from beet, broccoli, kale, rhubarb, rutabaga, turnip, and spinach wastes.

Evaluated on the basis of feed efficiency and shank color of the birds, broccoli and turnip leaf meals when fed at a level of 8 percent were superior to alfalfa meal, whereas lima bean vine and carrot leaf meals were equal to the alfalfa meal. On the basis of bird weight at 14 weeks, broccoli and carrot leaf meals gave better results than alfalfa, whereas lima bean vine and turnip leaf meals gave equally good gains. Kale leaf meal at a level of 1½ percent was equal to broccoli leaf meal at 1 percent supplemented with riboflavin. Chickens found most of the leaf meals much more palatable than alfalfa meal. None of the wastes showed toxicity, not even spinach, rhubarb, and beet, which contain considerable oxalic acid.

The Maryland station has conducted similar tests on a homogenized, fermented mixture of vegetable refuse consisting of cabbage, carrots, celery, onions, parsnips, turnips, sweetpotatoes, and potatoes. Chick diets containing this product, as a vitamin A supplement, caused the birds to grow faster than did a control diet containing alfalfa. Working on the same problem with breeding hens, the Wisconsin station discovered that such dried cannery refuse as pea vines and soybean hay makes a fair substitute for alfalfa meal. The hatchability of eggs was higher on pea vines supplemented with riboflavin than on unsupplemented pea vines. The results obtained at the experiment stations suggest that large quantities of vegetable wastes available throughout the country might well be processed in such a manner as to have considerable feeding value for poultry.

SALVAGING POULTRY OFFAL

Considerable work has been done on the preparation and utilization of poultry byproducts. In the vicinity of slaughtering and processing plants, disposal of the offal becomes a serious problem. A number of experiment stations, in addition to the Department, have conducted research into the matter of putting to practical use the poultry viscera, including discarded whole chickens, blood, feathers, and manure. Several years ago the Iowa and Nebraska stations discovered that a satisfactory meat scrap and a salable oil could be made from the offal left after poultry evisceration. Chicken scrap compared favorably with two other protein concentrates when fed to chicks over an 8-week period. Likewise, it has been determined that the protein of feathers can be assimilated both by chicks and by rats.

Further work at the Wisconsin station on feathers as a source of protein in animal feeding has shown that such material can give consistently good results, provided it is carefully processed. Uniformly excellent growth was obtained when keratin-containing materials were finely ground and fed as 30 percent of the ration. When supplemented with certain amino acids such as tryptophane, lysine, methionine, and histidine, these wastes could be fed with good results as 18 percent of the ration. The Delaware station has made an extensive survey of this problem and is laying plans for intensive research on the utilization of all the byproducts of the poultry industry. Through such a concerted attack on this problem of wastes it is hoped that all refuse may soon be put to practical and profitable usage.

UNIDENTIFIED FACTORS REQUIRED FOR GROWTH OF CHICKS

One of the most interesting fields of poultry investigation has been with the so-called "chick-growth" or "animal-protein" factor or factors. No one knows definitely whether one or several factors are involved; recent work, however, strongly suggests that there may be several.

It has long been known that fish meal stimulates chick growth, but in this case the higher quality protein was assumed to be the cause. Recent work by the experiment stations in New York, Washington, Ohio, Maryland, Oklahoma, Wisconsin, Idaho, and Indiana, as well as by the Department, reveals that animal proteins, in general, contain a growth-promoting factor not found in vegetable protein, and that fish meal contains more of it than meat meal.

This factor not only affects the rate of chick growth and livability but is also required for good hatchability. It is transmitted through hatching eggs to the chicks and influences their livability during the first 4 weeks. Hatcherymen in particular are therefore interested in it. The requirements for the factor are decreased for both chicks and poults after 8 weeks of age.

The Oklahoma station has reported that chicks hatched from breeding flocks fed an unsupplemented corn-soybean-oil meal breeding ration suffered a mortality of 80 to 90 percent during the first weeks of the growing period when they in turn were fed a similarly deficient chick-starter ration. The addition of only 1 percent of fish solubles to this starter ration reduced the mortality in subsequent tests to 25 percent.

The Idaho station has shown that an all-mash diet containing 6 percent herring meal, 5.5 percent meat meal, and 5 percent dried skim milk furnishes an ample supply of the chick-growth factor for maximum growth, regardless of the adequacy of the breeder diet or the inadequate body storage in the newly hatched chicks.

A supplement of 5.3 percent fish meal in the hen's diet permitted a sufficient transfer of the unidentified growth factor into the eggs to permit maximum growth up to 4 weeks of age even when the chicks were fed a deficient ration. When the hen's diet was supplemented with either 7.7 percent rendering-plant meal or 9.2 percent packing-plant meal, the chicks appeared to have obtained a marginal quantity of the growth factor from the egg, since maximum growth to 4 weeks was not obtained when the chicks were fed a soybean-oil meal diet.

These results indicate that fish solubles may prove to be the best and cheapest source of this factor and should thus be used in poultry breeding and starting rations, especially where fish meal or liver meal is not included or the meat-meal level is limited to less than 10 percent.

MORE OXYGEN FOR EGGS INCUBATED AT HIGH ALTITUDES

The research achievements of the poultry industry thus far discussed are of national significance, but equally important problems have been the concern of purely regional or local investigation. For example, it is more difficult to secure satisfactory hatchability of eggs at high than at low elevations. The difficulty is not the result of bad feeding, breeding, or management, inasmuch as eggs produced at high altitudes will hatch satisfactorily when shipped to lower elevations for incubation; on the other hand, eggs produced at or near sea level will give poorer hatches when incubated at higher elevations.

In 1942 it was demonstrated that an oxygen concentration of not less than 14 percent is required for adequate development of the chick embryo. The New York (Cornell) station reported 4 years ago that early growth of the chick embryo is accelerated by exposure to oxygen concentrations above 21 percent for the first 5 days of incubation and that hatchability can be influenced either favorably or unfavorably by exposure to different oxygen concentrations during the early part of this period. The highest hatchability was obtained on an oxygen concentration of 32 percent, whereas a reduction in hatchability occurred on concentrations below 21 percent.

The possible restrictions that low oxygen pressures place on chick incubation should be particularly apparent in the Rocky Mountain States. Because of the economic importance of the question to poultrymen in this region, the Wyoming station in 1947 undertook a study of the effects of supplying additional oxygen on embryonic growth rate and mortality. The results point quite conclusively to oxygen starvation as a major factor in poor hatches at high altitudes.

Two forced-draft incubators of 400-egg capacity were especially designed and built for this investigation. One incubator had additional oxygen supplied from a compressed drum, while the other, as a control, used only the normal atmospheric supply. In one trial the average percentage of oxygen in the test machine was 25.2, which under Laramie conditions exerts a partial pressure equivalent to that at an elevation of 1,000 to 1,500 feet. In another trial the quantity of oxygen was 25.7 percent. The oxygen concentration in the control

incubator, on the other hand, was 20.2 percent, which is normal for Laramie. Eggs of both chickens and turkeys were used in these tests.

The hatchability of chicken eggs was increased approximately 18 percent by the introduction of additional oxygen into the incubator during the 3 weeks' incubation. Addition of oxygen during the first and third weeks produced better hatches than did that during the first and second weeks. Moreover, the addition of oxygen during the third week gave better hatches than when it was used only during the second week of incubation. Hatchability of turkey eggs was increased over 100 percent by use of oxygen during the whole 28 days of the incubation period. The added oxygen produced chicks and poults with more vigor, longer down, and less stickiness than when hatched in normal air.

These studies are being continued by the Wyoming station along broader lines. The blood of the embryos of both turkeys and chickens incubated in a high-oxygen atmosphere is being tested for hemoglobin content. Thus far, high hatchability has been associated with a low hemoglobin content of the blood of 18-day chicken and 25-day turkey embryos.

The recent tests also reveal that high hatchability through the use of additional oxygen apparently depends on the presence of a concentration of carbon dioxide in the incubator higher than that usually recommended. Such facts as these must be obtained before the practice of adding oxygen to incubators can be recommended for general use by the industry. Before any radical change in managerial technique can be advocated, as many as possible of the major effects, both good and bad, must first be discovered and given proper consideration.

VETERINARY MEDICINE

Veterinary research includes a field of work in which vitally essential and spectacular findings such as "wonder drugs," vaccines, and the like, portrayed to the public in popular style, often inadvertently sabotage the painstaking and time-consuming research that is so necessary for eventual full control or eradication of any disease. There are many examples of this type of work; among the more recent ones is a series of studies on the Newcastle disease of poultry.

PRESENT STATUS OF RESEARCH ON NEWCASTLE DISEASE

Now that various types of vaccines are available for preventing the disastrous ravages from Newcastle disease (avian pneumonencephalitis) of poultry it is natural to ask the questions: What is next? Is the use of a vaccine—whether virulent, nonvirulent, or killed—really the last work in its control? First it may be well to review briefly the results of research on these vaccines by a number of our agricultural experiment stations.

The California station, for example, reported in 1945 that encouraging results had been secured with a method of vaccination using formalized vaccine injected intraperitoneally. With this technique, egg production did not fall off nearly so badly in vaccinated as in unvaccinated flocks and the death loss was held at a low level. These results were obtained on birds 3 to 4 months old, but no protection was conferred when chicks were vaccinated at the age of 2 weeks.

During the War, specialists in this field were called in from various industries and scientific laboratories, including the Connecticut (Storrs) experiment station, to take part in a cooperative research program under the direction of a War Department commission. In the report of their finding they present direct evidence that a substantial immunity may persist for periods of several months to 4 years following use of a living modified virus vaccine or with virulent Newcastle virus itself.

Early in 1947 workers at the Maryland station reported transmission of Newcastle virus to a rodent (Syrian hamster); this has since led to the development of a modified virus vaccine exhibiting a low pathogenicity and at the same time a high degree of protection.

Massachusetts station workers reported during the year that their low-virulence vaccine can be used by the stick method (needles carrying a drop of vaccine) to immunize sexually immature birds without producing an active outbreak of the disease. Such birds exhibited a slight decline in feed consumption and laying hens dropped off in egg production and quality as in spontaneous outbreaks of the disease. These workers state that it appears feasible to combine the viruses of Newcastle disease and fowlpox into one vaccine. The Newcastle disease "take," according to their observations, precedes that for fowlpox, and the character of the reactions induced by the two viruses is not the same.

The New Jersey station recently announced that it had released its Newcastle vaccine for public use and that biological laboratories should now be able to produce it in large quantities. It is of the "live virus" type, which produces life-long immunity, and is said to be safe for use on chicks 4 to 6 weeks of age. The station also reports that it is possible to combine Newcastle virus with pigeon pox virus for simultaneous immunization by the feather-follicle method.

Workers at other stations over the country are trying to find ways of improving vaccines by modifying the virus strains in various ways. They are also looking for a safe method to immunize day-old chicks from susceptible flocks.

Investigators are divided in their opinion as to the possibility of spreading Newcastle virus directly or indirectly following the use of live virus vaccines. This needs further study under field conditions.

All of this is excellent work and vaccines represent our first line of defense. Weapons of defense, however, do not necessarily rule out the possibility of further aggression subtly aimed at vulnerable weak spots. Nor should their possession preclude the search for newer and better mechanisms of control, as well as for the means of eventually eliminating the causes of aggression. Some of the interesting and profitable station findings in other phases of this problem follow:

At the North Dakota station it was found that cats are able to spread Newcastle disease in their feces; probably any animal eating diseased birds could do the same. The California station reports that artificial cultivation of the virus in the test tube appears to have been accomplished. That the virus may be air-borne is also indicated by its recovery from the air of two poultry houses containing spontaneously infected chickens and by the occurrence of the disease in chickens

within 7 days after exposure in a poultry house out of contact with any other than air-borne contaminated material. Japanese doves were added by these workers to the list of susceptible bird species.

The Minnesota station has uncovered a new symptom of Newcastle disease—the coughing up of blood—which was observed in a few outbreaks among adult birds; this symptom is also encountered in laryngotracheitis. In fact, it is difficult in many outbreaks of respiratory infections in adult birds to differentiate between infectious bronchitis, laryngotracheitis, and Newcastle disease.

At the Connecticut (Storrs) experiment station, Newcastle virus was shown to remain active for several weeks on such materials as feed bags, eggshells, and feathers at incubator, room, and refrigerator temperatures, thereby pointing to the potential hazard of transmission by inanimate carriers. In contrast, the virus could not be demonstrated in recovered birds 3 weeks after infection, thus failing to point out live carriers as important sources of spread.

Great need still exists for basic or fundamental work in this whole field. Our knowledge of viruses is still relatively meager. Thorough basic research by qualified investigators such as those now working on the Newcastle problem may well lead to information that may be translated to the study of other viruses that plague the livestock world—such, for example, as the one causing hog cholera. Various biological products for preventing this disease have been available for a number of years past, yet, as with the poor, it is still always with us. One may even visualize some of the findings coming out of Newcastle virus research as facilitating a more ready understanding of the problem of foot-and-mouth disease, a malady which, in spite of the vaccines for its prevention, now threatens us from south of the border.

One may therefore take the view that it is not sufficient merely to develop vaccines; it is also necessary to investigate as completely as possible the nature and causes of the disease, its reservoirs of infection, its mode of spread, how it may be differentiated from closely allied and in many cases confusingly similar diseases, more about its possibly numerous strains, how it may be killed in or on the animal tissues as well as on equipment that may carry it, and its possible relation to neurotropic diseases in other animal species and in man. The agricultural experiment stations are busily engaged in a coordinated effort to ferret out these facts.

Actually, the study is not yet completed with the advent of preventive vaccination; rather, the work has just begun and will be carried on in the usual painstaking and time-consuming way, aided by the important stop-gap procedure that vaccination offers.

INFECTIOUS SINUSITIS OF TURKEYS

Infectious sinusitis is a disease of turkeys that is present in all sections of the country. Death losses from it are usually low but economic losses to the producers—when 10 to 90 percent of their flocks become involved—may be exceedingly high. Affected birds maintain good appetites as long as they can see to eat, but as the disease advances they become progressively thin and inferior in quality. The course of the disease is chronic and may continue in a flock for many weeks. The exact cause was for a long time unknown. Recently, however,

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virus agents (bacteria-free) capable of inducing sinusitis when inoculated into susceptible birds have been isolated by workers at the Iowa, Connecticut (Storrs), Virginia, and Washington stations.

Furthermore, workers at the Rhode Island station report the isolation of a virus from a chronic respiratory infection of chickens which, upon inoculation into the sinuses of susceptible turkeys, reproduces the same type of symptoms of sinusitis and central-nerve involvement previously observed in this host. Of further interest in connection with this chicken virus is the fact that in addition to other lesions, it also causes joint involvement in an embryo after having been passed serially through seven other embryos. Although these virus strains may not constitute the only causes of sinusitis in turkeys, they do offer important basic leads and open up this field for further investigations that should eventually remove one economic hurdle now facing the turkey-raising industry.

MASTITIS—ECONOMIC HURDLE NO. 1 FOR THE DAIRYMAN

Workers at the Connecticut (Storrs) experiment station report that of the various forms of mastitis in cattle, the acute coliform type usually either destroys the milk-producing capacity of a dairy cow permanently or results in her early death. Until recently no treatment had been successful. In their more recent studies the causative bacterium was ordinarily an encapsuled strain of *Aerobacter aerogenes* and experimental transmission by way of the teat canal caused acute mastitis with high fever within a few hours; moreover, large parenteral doses of streptomycin proved highly effective and intravenous doses of sodium sulfamethazine moderately so in their experimental treatment of the disease.

Workers at the Minnesota station report that coliform mastitis failed to respond satisfactorily to penicillin therapy. In acute cases, sodium sulfamethazine given intravenously or by way of the mammary gland, along with a sulfonamide administered orally, proved to be the best among the treatments under trial. Chronic mastitis usually followed, however, with the organism still present. Repeated treatments with sodium sulfamethazine did not destroy the bacterium, as evidenced by repeated isolation of a coliform organism from the milk of diseased quarters.

In reporting observations at the Pennsylvania station, the workers emphasize the importance of bacteria other than streptococci during the initial stages of udder trouble, and the secondary mastitic role of streptococci in general and of *Streptococcus agalactiae* in particular. Their data further emphasize the inherent weakness in the theory that udder troubles are the result of lack of sanitary precautions and the fallacy of attempts to control by so-called sanitary measures alone. They state further that coliform bacteria would appear to be of even greater importance in udder inflammations than previously considered.

Streptomycin, according to the California station, is helpful in treating specific cases of coliform mastitis that had been a baffling problem in one of their cooperator herds.

First tests on 400 cows by Tennessee station workers indicated that half the cows were infected with streptococcic mastitis and that a

fourth of all quarters were infected. Penicillin infusions, when used in all infected cows in the herd, resulted in 42 percent of cures following one treatment, but many of the cures were not permanent. In their opinion the incidence of mastitis has been more closely correlated with lack of stable sanitation than with unclean milking machines. They feel that a general appreciation of the ineffectiveness of chemotherapy without accompanying good management would save dairy farmers about 75 percent of the medical costs involved in mastitis treatment.

The Washington station reports that cows raised in eastern Washington are four to five times as apt to be infected with staphylococcic as with streptococcic mastitis. When cows with *Streptococcus agalactiae* infection were introduced into eastern Washington herds, there was less tendency for this organism than for staphylococci to spread to newly freshened heifers. This situation was not true for western Washington. Many of the staphylococci isolated from these cows were suggestive of human rather than animal types.

Virginia station workers report the isolation of pathogenic staphylococci from the udders of cows exhibiting no mastitis. Their results indicated that the majority of these staphylococci possessed the characteristics of pathogenic forms and that they also produced a toxin that might cause food poisoning. From this evidence it would seem possible that staphylococci present in udders may be potentially dangerous and they must be considered in any mastitis control program.

MORE ABOUT BRUCELLOSIS

A finding of great interest in relation to the spread of brucellosis comes from work at the University of California, reporting measurements of the density of organisms in the atmosphere of stockyards and revealing that the causal bacterium, *Brucella*, was present in sufficent concentration to cause infection of those breathing it.

Since the last annual report—in which mention was made of Michigan station work on the mucoid phases of the swine strain of *Brucella*, prepared as a live-cell suspension vaccine—field trials have been set up to test the efficacy and safety of the vaccine at farm levels. Two hundred and thirty Michigan veterinarians are cooperating in this large-scale testing program. The vaccine is still very much in an experimental stage and keen observation combined with careful recording of facts over a period of several years will be necessary before final listing of its good and bad features will become possible.

At this early date the new vaccine is reported to possess the following advantages over the older *Brucella abortus* Strain 19 vaccine: (1) Generally, its use in calves causes so little reaction that they do not go off feed; (2) lactating cows do not suffer lowered milk production for a few days following its use; (3) the attendant positive reaction following vaccination seldom lasts as long as 100 days in either young or adult cattle; and (4) its use on pregnant cows is attended with safety regardless of stage of gestation. These and subsequent findings are being subjected to a merciless grilling by experiment station workers and livestock sanitary officials of Michigan, West Virginia, Maryland, Ohio, Pennsylvania, and Virginia; on the basis of their long-time trials the findings will eventually be established as fact or thrown out as fiction.

NOW APPEARS THE "X DISEASE" OF CATTLE

A mysterious condition in cattle—known as the X disease (hyperkeratosis or proliferative stomatitis) and responsible for heavy losses in affected herds—was recognized in New York as early as 1941. Since that time scattered outbreaks have occurred over the country and during the last year it was observed in at least 32 States. The disease is chronic, affecting particularly the young animals and bringing about heavy death losses among them. Thus far its cause, prevention, and cure are all unknown.

Observations by various experiment station investigators, the Department, and State livestock sanitarians have developed a picture of the disease as characterized by profuse watery discharges from eyes and nose in the earlier stages, followed by loss of appetite and condition, depression, and a thickening and wrinkling of the skin ("elephant hide"). Pregnant animals may abort, diarrhea may be present—particularly in the later stages, and papillary projections may occur on the surfaces of the tongue, cheek, and palate.

According to the various investigators this disease may appear in either purebred or scrub cattle, implying that it may occur regardless of better or poorer systems of care, feeding, and management. A majority of the workers believe the disease may be of nutritional rather than infectious origin—that soil, vegetation, or other feeds may be responsible. They also suggest that it may be due to toxic material or an overabundance or deficiency of certain elements in the soil or in the plants fed upon. Others feel that certain of their observations point to an infectious agent. In other words, our knowledge of the disease at this stage is rather meager and calls for intensive study to ferret out the basic facts. Formal research memoranda are being drawn up by several of the State experiment stations for the purpose of studying the disease under local conditions and a number of them, with the Department, have initiated cooperative action to trace down the factors responsible for this serious malady and to develop the means for combating it.

AGRICULTURAL ENGINEERING

Some of the more important problems facing the farmer today and in the years immediately ahead involve the finding and making use of all possible means for increasing the productive efficiency of his business enterprise. Crops and livestock are being constantly improved, both in quality and in yield. To keep pace with the impact of prices and competition the operator must pay increasing heed to his output from farm labor and to the use of labor-saving devices. In the past, industry had far outstripped him in this respect. The agricultural experiment stations, in many cases cooperating with the Department and with the manufacturers of machinery, are now making rapid advances in providing the farmer with all sorts of equipment and techniques for the saving of human effort and at the same time for doing a better job.

Special studies of selected farming operations have disclosed information of aid to the farmer in appraising more objectively the things he is doing in making needed adjustments wisely. Although there are great differences among individual farms and localities,

some of the basic reasons behind improvements in man-hour output have to do with proper selection and utilization of the methods employed, the way the work is organized, the kind of equipment and methods of using it, and the arrangement of the farmstead and buildings in which the work is to be done. As indicative of the progress made, some examples of specific findings in agricultural engineering research that have been brought to successful application during the year are presented in the following pages:

LININGS FOR IRRIGATION CANALS

An efficient irrigation system involves the adaptation of equipment and practices to the type of soil and contour of the land. It is well known that a system proving satisfactory in one area may not necessarily work well in another. Soils vary in texture from loose and porous sands to sticky clays that are relatively impervious to water. Moreover, the general slope of the land is likely to change even over relatively short distances.

The equipment for irrigation is limited to a few standard tools—ditches and pipe lines for distribution of the flow to the sides of the field, delivery gates on the ditches or siphons, and outlet valves on the pipe lines. In adapting these tools of irrigation to different types of soil, a number of factors—including seepage, simplicity of operation, maintenance, damage by rodents, the life of the system, first cost, weed contamination, degree of interference with cultivation, and contour of the land—operate to determine the best method of irrigation for each particular case. Of the water used for irrigation in the arid west, it is estimated that one-third is lost through seepage in conveyance from the place of storage to the farm.

Large irrigated land areas in the West have become unproductive because of the rise of ground water and alkali concentration resulting from low conveyance efficiencies (ratio of volume of water delivered to volume taken in at head of canal expressed as a percentage) and in the application of irrigation water. What has happened is that excessive amounts of water, seeping from the high-line canals to the lowlands of the valleys, cause a rise of the water table with resulting upward flow of alkali-laden water toward the land surface. Water evaporating from this surface leaves the alkali deposited on the soil and, if long continued, prevents or lowers the productivity of the crop plants being grown.

This condition has for many years been a major concern to the State experiment stations in those regions where extensive irrigation is required for crop production. Search for impervious and inexpensive native materials that could be applied as canal linings to reduce seepage losses has been one of the objectives of a cooperative study initiated between the Department's Soil Conservation Service and the Utah station. Experimental trials revealed that lining a main-canal section with a layer of clay 4 inches thick and covering it with a thin layer of gravel would save 4.2 cubic feet of water per second or 1,500 acre-feet during the first 6-month season. This water had a value of $2,000 or two-fifths of the cost of the lining operation.

These results have prompted expansion of the research activity on this problem so vital to certain areas in the West. The search now continues for other naturally occurring low-cost materials that will

do the job, as well as for better machinery and methods for efficiently and effectively applying and compacting the mass. The costs of annual maintenance of linings of this type are as yet undertermined and this factor is of major importance. If it is finally demonstrated that such linings are reasonably permanent, as they are at present believed to be, then it will become economically feasible to line many of the earth canals that now sustain excessive seepage losses. It appears from these studies that justification of the costs of canal-lining operations should be based on the premise that the annual outlay must not exceed the value of the water saved each year, because these costs must be paid by the stockholders of each irrigation company.

From the standpoint of the general welfare of the people in an irrigated valley or State, canal lining may prove of value in three different ways: (1) Saving of vital irrigation water, (2) reduction in costs and necessity for drainage of irrigated land, and (3) conserving soil productivity. There is a great opportunity for applying the results of these investigations, since it is reported that the Western States have in the neighborhood of 125,000 miles of canals, only a small proportion of which are now lined for the prevention of seepage.

RADIANT HEAT FOR FROST PROTECTION

One of the principal hazards of the fruit, truck-crop, and vegetable industries is that of damage by frost. This not only causes great losses but also results in high fluctuations in farm income and at times produces severe shortages in various types of agricultural products. In some parts of the continental United States killing frosts occur as early as September, followed by periods of warm growing weather for 2 to as high as 8 weeks' duration. Obviously, a sure means of frost protection for high-value crops would be of inestimable value and profit to the country as a whole. As an indication of the extent of these losses, it is estimated that damage from this cause in the State of Michigan alone runs between 10 and 20 million dollars a year, and that equal or greater annual damage is suffered by California and Florida. A conservative estimate for the United States as a whole would amount to between 50 and 100 million dollars.

This problem has had the attention of agricultural research workers for many years, the principal methods tried—and with varying results—being the use of smudge pots, air-circulation devices, and water sprays. Intensive studies of the oil-burning smudge pot have been made by the California and Florida stations over the past 35 years, with results uncertain and both initial expense and cost of operation excessive. Smoke and deposits of carbon particles on the crops have also produced discoloration and serious downgrading of the farm products as well as health hazards to inhabitants of the countryside.

Exploration of air-circulation methods for frost protection have been based primarily on the fact that cold air will often stratify on a clear night, producing within 10 to 15 feet of the ground a layer cold enough to cause damage, while the air above is much warmer. In theory, it was felt that if the air could be stirred and mixed by mechanical devices the composite temperature would be sufficiently high to prevent the formation of frost. Low-flying helicopters as well as high velocity fans have been tested in several locations, and with promising results,

but these methods have not proved dependable enough to warrant widespread adoption. Large stationary fans erected on high steel towers are receiving widespread use in some areas, particularly for orchard protection; successful results, however, depend on natural warm-air strata and there is always the possibility that still colder air might be brought in to cause a worse situation than before.

Cranberry growers of Oregon have made rather extensive use of a water-spray frost-protection equipment with reasonably satisfactory results. The cost of installation is high, amounting to $300 to $400 per acre. The principle underlying this system is based on the heat-liberating properties of water as it crystallizes into ice. Some varieties of plants may be coated with a layer of ice at 32° F. without injury; in such cases it is only necessary to maintain a constant film of water on the plants to prevent frost damage.

Two main types of conditions cause damage from frost. The first, occurring infrequently and causing the least trouble, consists of a large body of cold subfreezing air moving into an area. The second, and more usual situation, occurs when the air temperature is down to freezing, there is practically no wind and the sky is clear. Under these conditions, even though the normal air temperature may be several degrees above freezing, heat from the earth and vegetation is radiated to outer spaces so rapidly that surfaces are cooled below 32° F., with the resulting formation of frost. The rate of this heat radiation has been known for many years as being in the neighborhood of 1 calorie per square centimeter of soil area or nearly a million British thermal units an acre per hour.

Michigan station workers have felt that if some means were perfected to add sufficient energy to the earth and the plant to counteract this radiation loss, frost could be prevented from forming. Over the past 3 years they have been exploring the possibilities of radiant heat sources to carry energy directly to both plant and soil and have developed a device that appears to be very practical and positive, and at the same time relatively inexpensive. This device consists essentially of a highly efficient oil burner, developing a temperature of 1,500° F., with a heater tube operating at a low red heat and a special type of reflector that directs the radiant heat down against the crop plants.

Tests have shown that one unit, burning approximately 10 gallons of oil an hour, can protect about an acre of vegetation from moderate frosts when employed in groups of units spaced throughout the crop area.

Although the apparatus is still in the developmental stage and needs to be further tested on many types of vegetation, its effectiveness for preventing frost both on trees and on low-growing crops has already been demonstrated and these promising results are now leading to commercial manufacture of the equipment. Much remains to be done in finding the best methods of handling the apparatus and how best to adapt its use to different types of plants and situations. Only extensive experiments on various crops grown at different stages of development and under many environmental conditions of land topography, soil cover, atmospheric temperature and humidity, and relative clearness of sky will finally establish the areas where frost protection can be effectively and economically carried out. High-value crops subject to serious damage from low temperatures of short duration will undoubtedly prove most practical for the use of this method.

DRYING CROPS FOR SAFE STORAGE

The successful results obtained in experimental drying of high-moisture corn to safe storage conditions by the use of natural and forced ventilation, either with or without supplemental heat, may mean one of the potentially big mechanization developments in agriculture.

Technicians of the State experiment stations and the Department in the Corn Belt (Indiana, Illinois, Ohio, Michigan, and Iowa) have shown conclusively that artificial drying of corn pays well, since net gains over the cost of drying range from 10 to as high as 70 cents per bushel over the sale price of the product stored in the ordinary way, and, depending on weather, condition of corn and crib, and type of drier used. The drying operation has the further advantages that the quality is improved, farmers are able to pick earlier and under better weather conditions, picker losses are reduced, the harvested crop is cleaner, and the pickers may be out of the field in time to permit planting of small grains in rotation before the bad weather of fall begins. This earlier harvesting, along with the sowing of small grains, also aids in solving the corn borer problem, since all cornstalks harboring this pest for the following seasons' infestations can be eliminated from the field.

Agricultural engineers are now looking to the development of a safe and economical heating unit for the crop-drying job—a unit so flexible that the farmer could use it for his farrowing house, farm shop, and for almost any other warming or drying process.

The impact of these successful results with corn is leading to their rapid and widespread application to other crops throughout the country. The rice-producing farmers, who used machines adapted to combining, harvesting, and threshing in one operation as they move across the fields, soon found that rice harvested in this way was too damp for safe storage. Workers at the Arkansas, California, Louisiana, and Texas stations have in recent years developed bulk and sack driers that economically reduce kernel moisture to safe-storage conditions. The improved machinery and new methods for the rice harvest are saving about 8 cents a bushel in the cost of production.

One type of equipment developed for drying rice in sacks is now being used in California for drying the almond crop. This apparatus consists of a rectangular tunnel or duct about 2 feet deep, 6 feet wide, and 30 to 40 feet long. It is closed at one end, fitted to a fan at the other end, and provided with a top containing rows of holes somewhat smaller than a sack of nuts. When the sacks are placed over these holes, air is blown through the tunnel and forced upward through the contents of the sacks. The air may be either heated or unheated, depending upon atmospheric conditions. Natural gas or butane fuel is usually employed to supply the heat. The moisture content for safe storage of the almonds must be reduced to 6 or 7 percent from a maximum of 30 percent when harvested. Experience in the use of this drier has shown that on the average these conditions can be reached in 6 to 12 hours, depending upon variety of nuts, initial moisture content, weather conditions, and amount of heat used.

NEW WASHER FOR POTATO TUBERS

Washing is an essential operation before shipping potatoes for marketing as table stock. When this is done in cold weather, adequate removal of the wash water from the surface has posed a difficult problem because if the tuber is not dry before packaging, serious spoilages frequently occur. The Minnesota station has initiated studies directed toward a solution of this problem. Initial trials have shown that if the tuber is washed in water at an approximate temperature of 140° F. and held there for about 2 minutes, enough heat will be held in the surface portions to provide the latent heat of vaporization necessary to remove the film of moisture. A pilot plant constructed on this principle has been designed and placed in operation. The equipment automatically scrubs the potato, immerses it in a vat of hot water for the 2-minute period, and then elevates it by conveyor for the sacking operation. Thirty seconds is all the time required, after dripping, for effective drying of the tuber.

Test runs of stored potatoes have indicated that they can be adequately cleaned and dried even when the outside air is cold and the relative humidity high. The method and simple equipment required is a valuable contribution to the potato-growing industry, since it promises to save the farmer large quantities of his product that otherwise would be lost by the older methods of processing for the consumer.

REMOVAL OF NIGHTSHADE BERRIES FROM CANNING PEAS

The problem of removing immature berries of the troublesome nightshade weed that infests commercial pea-growing areas of Oregon and Washington—where about one-fourth of the Nation's supply of canned peas is packed—has now been solved. The berries of this weed pest, closely resembling peas, contaminate the mechanically harvested shelled peas because they are not removed by the usual cleaning methods. Through a cooperative study by the Department, the Washington station, and certain pea concerns, a simple and inexpensive separation process, based on differences in wettability between shelled peas and nightshade berries, has been developed. Addition of a small amount of mineral oil to the product as it comes from the mechanical sheller and before feeding into the top of a tank of foaming emulsion causes the peas to sink to the bottom, while the nightshade berries, other weed seeds, and the general debris float harmlessly away. In the standard methods of processing peas for canning, all but a minute trace of the oil is removed.

MECHANICAL SAMPLER FOR LEMONS

A new, experimental mechanical sampler for lemons recently developed cooperatively between the California station and a citrus producers' cooperative offers a means for the adequate sampling of incoming fruit to establish an accurate grower equity in the crop produced; it also offers possibilities for reduction of the operating costs in packing houses. Use of the new equipment would allow handling of the entire fruit storage inventory as a unit and would eliminate the practice now

followed of segregating the individual grower's fruit into identifiable lots through the packing house. The machine is essentially a slat conveyor unit over which all the washed fruit passes. The sampling is accomplished by means of 15 separate drops in the conveyor arranged in four lines, each of which can be opened or closed independently to permit use of any number of drops from 1 to 15 in obtaining the representative sample.

The slats have been constructed concave to the fruit on the assumption that each will carry a single row of fruit alone instead of half of each of two successive rows as in the conventional type. Slat and drop-opening dimensions are of sufficient size to prevent bridging over of the fruit. This feature assures that a minimum number for the sample unit will be taken without being influenced by the shape characteristics of any particular fruit.

The pilot model has been installed in a commercial packing shed for observation of its action on fruits, and investigations are under way to determine whether electronic principles and devices might be added to count, size, and sort for color.

It is appreciated that this improved sampler may need some refinements as will be determined by its commercial use, but it incorporates the principles needed to take statistically accurate samples of large and small lots as delivered to the shed with full justice to the producer of the orchard crop. Universal acceptance and use of the machine should constitute a material advance over most present-day methods.

PASTEURIZING WALNUT MEATS

The sale of black walnut meats in many rural areas of West Virginia during recent years has become increasingly important as a source of supplemental income to farm families. Many farmers have spent long winter hours hand-cracking the walnuts for sale of the meats in spring. In some cases these meats were sold directly to the consumer and in others to a retailer. As this activity increased, larger and larger quantities of meats were sold directly to retailers, who in turn supplied the ultimate consumers.

As the industry grew it became apparent that some faster and easier means of cracking and separating the meats was necessary; at this point the West Virginia station was asked to cooperate in the development of a satisfactory mechanism. With some redesigning, machines already developed to handle similar materials were at first put into use. When, later, it was found that they did a satisfactory job of cracking and separating the meats, the private operators began to buy whole nuts from the farmers and to crack and separate them by these machine methods.

This was a real advance, but when attempts were made to sell the meats outside the State, operators ran afoul of Federal laws; the meats could not be shipped across State lines without inspection and approval to determine whether the product was free from micro-organisms and other foreign materials. The latter could be removed, but micro-organisms presented a more serious problem, so West Virginia scientists were again brought into the picture. Pasteurization seemed to offer the best solution, and various specialists of this station soon determined experimentally that if the nut meats were subjected to a

temperature of 180° F. at a relative humidity of 60 to 70 percent for 30 minutes, the micro-organisms would be killed without appreciable change in the flavor or quality of the meats. Ideas were collected and evaluated and work was started on the development of an experimental machine that would do the job of pasteurization.

The equipment finally developed for the satisfactory production of an acceptable product consists essentially of an aluminum-lined, well-insulated, plywood box approximately 6 feet on all sides, wherein is installed a special conveyor mechanism, circulating fan, and thermostatically controlled electric heaters and humidifiers. The nut meats are fed into this pasteurizer through a 4-inch slot in the top of the box into which a hopper is fitted. Continuous belts 34 inches wide and 11 feet long, made of a proprietary coated fabric and mounted on a series of rollers, convey the meats through the machine. After the nut meats are fed onto the top belt, they travel its length, fall off and drop into an aluminum chute, which conveys them onto the next lower belt and so on to the bottom. When they have traveled the length of this belt they drop into a chute that carries the meats to the outside of the box.

Uniform temperature and humidity are maintained by means of the circulating fan and the strip and immersion heaters controlled by preset wet and dry thermostats. About 2 hours are required to raise the temperature and humidity to the proper operating point above room temperature, but from then on the pasteurizer is completely automatic in operation except for agitating the feeder arrangement at brief intervals to prevent the meats from sticking together, feeding the meats into the entrance hopper, and taking them away.

The nut meats processed by this method have proved highly acceptable for shipment through interstate trade channels, thus opening to the farmers a wide outlet for a very remunerative agricultural product.

AUTOMATIC POULTRY FEEDER

The chore time required to care for a large flock of poultry adds up to a very formidable figure. The agricultural experiment stations situated in the large poultry-production areas of the country have been engaged for many years in trying to develop labor-saving devices, structures, and production practices that would help alleviate some of the drudgery from this important industry.

During the past year, workers at the Pennsylvania station have made another valuable contribution in their development of an automatic poultry feeder for mash. This equipment has demonstrated its flexibility by actual trials showing it to be capable of supplying feed to different numbers of birds through the use of feeding troughs varying in length from 15 to 65 feet.

The feeder consists of a hopper holding 300 to 500 pounds of mash. At the top, an electric motor and speed reducer turn a shaft that drives the feeding mechanism and the conveyor chain located at the base. The conveyor chain carries feed from the hopper along one side of the trough to the end, and then back on the other side of the trough to the hopper. Small metal scrapers are attached to the conveyor chain at every fourth link. The trough is designed to prevent feed from being wasted by the birds through billing or hooking the

mash while feeding. A standard feed-hopper grid also prevents the birds from getting into the trough, and standing rails running the length of the trough are located on each side.

Operation of the feeder is controlled by a time clock and is synchronized with the lighting schedule used in the pens. The timer operates the feeder so that it runs for a few minutes at regular intervals of one-half hour; when it begins to operate, the birds are attracted to it in much the same manner as when a person adds fresh feed to an ordinary feed hopper. The feed in the trough is thoroughly mixed and fresh material is added automatically during each cycle of operation.

A metering device located in the bottom of the hopper makes it possible for the feeder to hold a constant level of mash in the trough at all times, regardless of the amount eaten by the birds. If most of the feed is consumed, the feeder mixes the mash and adds just enough to reach the prefixed level. Thus the trough cannot be filled too full; this feature eleminates considerable waste, such as often occurs when hoppers are filled unevenly by hand methods. The new equipment saves mash, time, and labor in the meeting of poultry-feeding requirements.

SELF-FEEDER FOR FORAGES

Livestock farmers would like to eliminate the annual second handling of two or more tons of forage for every animal carried. For this purpose, stacks have long been the common "self-feeders" used in midwestern areas. It is well recognized that not only does this practice result in much wastage, but that occasional animals are suffocated when a stack falls over. Many farmers have installed portable fences around these stacks in an attempt to avoid such hazardous conditions—and with considerable success; the wastage, however, continued.

Current interest in self-feeding of hay seems to be at an all-time high on account of the increasing costs of labor and the need for more economic utilization of all types of feed. On their own initiative farmers have attempted to develop structures for accomplishing automatically the time-consuming operation of handling forage; at best, however, these feeding devices yield only about half their contents—although with somewhat less wastage.

During the planning of research to show how a hilly northeastern farm could operate on a grassland-farming program with a minimum of labor and imported feeds, the New Jersey station determined that the production, storage, and self-feeding of the best possible forages would be required.

The agricultural engineers, economists, and animal husbandrymen at the station listed the functional requirements of a feeding structure for forage and at once started work toward the design and construction of a test set-up that would be completely self-feeding, of sufficient capacity to store the entire crop, and that would reduce wastage to a minimum, eliminate hazards to livestock, and be easy to fill with machinery available on the farm.

The preliminary structure consisted essentially of an existing barn of 14-ton capacity, in which especially designed feeding gates were installed. These gates were hinged timbers held in place at the top

by "V" straps and pipe-spacers, free to swing inward, with forward movement regulated by two lengths of chain bolted at the center and bottom of the separate timbers. Through the center of the structure a slatted, inverted V of wood was installed to hold the forage to the gates and a duct for forced drying of the hay. Waste heat from a gas engine driving the blower was used in the curing process.

Actual operation demonstrated this preliminary design of feeding structure to be entirely feasible. All kinds of forages up to 50-percent moisture content were cured and fed practically without hand labor. Chopped hay, long loose hay, and baled hay were fed equally well.

A larger unit with a capacity of 30 tons and incorporating all improvements in design was erected. In this equipment chopped forage was emptied by 25 yearling feeders in about 5½ months, with practically no wastage and less than 3 hours of hand labor over the whole period. Bridging of chopped forage and wastage in the final model is controlled by the properly designed feed gate together with the correct shape and height of the inverted slatted V through the center of the structure.

Cooperation with industry during the past few months has produced an all steel set-up of Quonset type, 40 feet long. The structure is expected to dry 80 tons of high-moisture chopped hay that can be self-fed without hand labor.

HOME ECONOMICS

Much experiment station research has been undertaken with the specific objective of solving problems that confront the homemaker in the economical operation of the home for the health and satisfaction of the family. The few studies selected for discussion here have a bearing on the homemaker's problems in the preservation of food, and in its selection for economy, quality, and nutritive values. Other work discussed is concerned with solving home laundry problems arising when hard water must be used.

HOME CANNING

The quantities of food canned annually in homes have increased from about 2 billion jars before the war to an estimated 4 or 5 billion jars in 1943. Since that time, however, there has been a reduction in the annual home-canning pack owing to various economic and other factors. With the present importance of home canning, a number of problems in connection with its success have come to the attention of food-preservation investigators.

Research on home canning has been carried on at the Massachusetts station in an effort to better understand and appreciate the various factors that contribute to the spoilage of home-canned foods. Among the complaints received by this station from home canners was that of an excessive loss of liquid from glass jars during processing, particularly in those products that had been processed in a pressure canner.

This problem was approached several years ago when glass jars with wire-bail closures were the principal ones used. Workers at this station reported that fully sealing jars with wire-bail closures before

processing seemed to reduce the liquid losses and improve the general appearance of the product. Results obtained from testing over 16,500 jars warranted recommending that such jars should first be fully sealed before processing and the pressure in the cooker released slowly after processing. A practical survey of the use of this method by 64 home canners who packed 50 different products revealed that 85.5 percent had experienced no noticeable loss of liquid.

Work has continued at the Massachusetts station with jars and closures other than the bail-type in an effort to complete the answer to losses of liquid. In addition, the influence of this method of processing on the effectiveness of venting (release of expanded gases from the jars) was observed. With home-canned foods, particularly fruits, oxygen or air entrapped within the container can be a cause of surface darkening, off-flavors, and loss in vitamin content.

Laboratory tests were made with different types of closures, some of which, because of their physical character, could be processed fully sealed. Two-piece metal lid closures fully sealed, bail-type jars fully sealed, bail-type jars partially sealed, three-piece closures with glass lids partially sealed, and zinc porcelain-lined mason caps turned back one-fourth inch were tested. In each test nine pint jars were processed in a 7-quart capacity aluminum pressure canner, and the liquid loss was determined by head-space measurements.

The results of these tests showed that the relative tightness of the jar seal during processing had a definite effect on the tendency of the jar to lose liquid during this period. Closures requiring a partial seal showed a greater loss than those fully sealed during the processing.

In experiments conducted with pressure canners in which the pressure was allowed to fluctuate ± 2 pounds during processing at 10 pounds pressure, excessive losses of liquid were also noted. This loss was not so great, however, as that caused by rapid cooling brought about by opening the petcock of the canner as soon as the process was completed.

Investigations were also made of the effect of re-using wire bails on bail-type jars as a causative factor in liquid loss. During usage up to six or seven consecutive times, the wire bails failed to show any marked tendency to loosen and thus allow significant losses of liquid.

To reduce home-canning losses caused by entrapped air in jars at the time of processing, this station has recommended that a partial seal be made on those jars containing fruits and other acid foods usually given a short process in a water bath. This permits a more effective exhaust of air than when jars are fully sealed. When foods are processed at 10-pounds pressure, however, venting and exhaustion of air from the jars during processing is satisfactory, and liquid loss is reduced when jars can be fully sealed.

Through experiments on the problem of liquid losses, the Nebraska station has further substantiated the theory of the Massachusetts workers that it is apparently a function of the type of seal employed. Information on the expansion of food and liquid within the jar during processing is being obtained by this station through the use of a pressure cooker equipped with a window through which glass jars connected to pressure vacuum gauges can be observed.

The losses of liquid from glass jars is sometimes an element involved in the spoilage of home-canned foods. Among other factors con-

cerned, inadequate processing time is an important cause of spoilage. Research to establish safe-processing times has been conducted at the Massachusetts and other stations, some of it in cooperation with the Department.

HOME PURCHASE OF FROZEN FOODS

During a survey in Syracuse, N. Y., by the New York (Cornell) station, 1,089 records were obtained from consumers, showing their purchases of frozen foods; 194 similar records were obtained in Ithaca, N. Y. Perhaps the most immediate result encountered had to do with the relationship between income and the consumption of frozen foods. Families in the low-income group bought practically no frozen food; those in the medium-income groups bought about one-fourth pound per capita per week, while those in the high-income group bought about 1 pound per week. It was also disclosed that professional people spent more than twice as much for frozen food as did any other occupational group. Moreover, the middle-aged group purchased twice as much as the young or old group of consumers. The most important reasons given for using frozen foods were convenience, ease of preparation, and better quality. Preference for fresh products and lower costs for them were given as the two main reasons for not using frozen products. One of the main values of this study is that it delineates the nature of the consuming market for frozen foods.

STORAGE INFLUENCES QUALITY AND NUTRITIVE VALUE OF POTATOES

Because of the importance of potatoes in the American diet, there have been many studies over the years concerned with their culinary quality and nutritive value. These studies, carried out in relation to production and marketing practices, have been conducted in all regions of the country. Of nutritional significance is the finding that the potato is a source of ascorbic acid (vitamin C). The amount present has been shown to vary with the variety, season, and maturity of the tubers at harvest time, as well as with the conditions under which the tubers are stored. When held in winter storage, potatoes decrease measurably in their ascorbic acid value. This has been observed in studies at many of the State experiment stations, thus indicating that the problem is one of storage regardless of location, variety, or other variables.

The detailed results from many studies have been interpreted by nutritionists to mean that the potato is an important source of ascorbic acid in the American diet. Estimates, weighted to take into consideration the various factors influencing the vitamin content, indicate that potatoes are not so rich a source of ascorbic acid as are a number of other common foods, notably the citrus fruits. Because potatoes are eaten frequently and in large amounts, they do, however, make a significant dietary contribution of this vitamin. The possible exception occurs in later winter and early spring when the tubers have suffered great losses of ascorbic acid because of storage.

Another problem which had received attention, even before the vitamin losses in stored potatoes were studied, involved the loss of mealiness and the development of a sweet taste with cooking when the tubers had been stored at low temperatures to maintain dormancy. These stored potatoes also made poor saratoga chips or french-fried

potatoes because of too rapid browning when fried. Researches in the Department, at a number of experiment stations, and in other agencies, traced the difficulty to the action of enzymes that caused conversion of some of the starch to reducing sugars. These sugars imparted the sweet flavor and, by their caramelization at high cooking temperatures, produced the undesirable browning. Continued study of the problem showed that the temperature of storage played a very important role in this enzymatic carbohydrate conversion. The sugar development was pronounced in those potatoes stored below 40° F. When they were subsequently placed in warmer temperatures of 50° to 60° F. for a period of time, the sugar reverted to starch and the culinary quality of the tubers improved. It is now appreciated that potatoes which have been stored at low temperatures to maintain dormancy may have their quality improved by a conditioning period at higher temperatures.

These main facts are understood, but the details of the problem continue to need attention. At the Wyoming station, where dry-land and irrigated potatoes were grown, it was found that tubers from the same variety, grown under different environments, varied in their ability to turn sweet at low temperatures. Among the lots tested, the irrigated Irish Cobblers withstood this enzymatic action better than either dry-land Cobblers or Bliss Triumphs. When the stored potatoes were subsequently conditioned at 50° to 60° F. for 30 to 40 days, the sugar decreased. Slightly different conditioning temperatures and times have been suggested by other workers.

The temperature of storage, so important in governing the carbohydrate relationships in potatoes, has likewise proved to have a very significant influence on the rate at which ascorbic acid disappears from the stored tubers. This has been demonstrated in experiments at New York (Cornell), Minnesota, Nebraska, North Dakota, Idaho, and other stations, where potatoes were found to suffer continuous losses of the vitamin during winter storage. The losses were more rapid at 35° F. than at 40° and at this latter temperature more rapid in turn than at 50° F. The Nebraska station work showed that a low storage temperature is to be avoided except as needed to keep the tubers dormant. The ascorbic acid content of the potatoes for late winter use could be doubled or tripled by storing at high temperatures (50° to 60°) until sprouting began and then lowering the temperatures to maintain dormancy. Potatoes harvested in mid-October and held by this method until early March retained more ascorbic acid than did other lots held only until November but at the uniform temperature of 40°.

Work by Minnesota station investigators resulted in information that presents a new picture of practical importance. In this study three varieties of potatoes (Chippewa, Irish Cobbler, and Triumph) were stored at 35.6° F. and analyzed at 2-week intervals for total ascorbic acid as well as for reduced and dehydroascorbic cid. At the end of 6 weeks, during which interval vitamin loss had occurred, the potatoes were divided into two lots, one of which continued to be held in storage at 35.6° while the other was returned to room temperature. At the end of another 6 weeks, the potatoes held at the low temperature

had decreased in ascorbic acid to approximately one-third of the initial value. The lot returned to room temperature had regained a significant part of the vitamin lost in cold storage, as evidenced by increases in the values for total and reduced ascorbic acid. The physiology and chemistry of these changes will undoubtedly be the subject of further study. It appears, however, that potatoes conditioned for a few weeks at room temperature, following a period of cold storage, improve not only in quality but also in vitamin value. This finding is of importance to homemakers, who customarily hold potatoes in the kitchen for a time, and also to those concerned with securing adequate amounts of ascorbic acid in the diets of low-income groups.

BLOOD REGENERATION

The role of protein-rich foods in blood regeneration, studied in nutrition investigations at the Nebraska station, was discussed briefly in a previous report. The women blood donors who were subjects in this research had shown that hemoglobin regeneration was improved when foods rich in protein were included in the diet at levels sufficient to furnish 75 grams (somewhat less than 3 ounces) of protein a day. Even with this improvement, the return to the hemoglobin levels determined at the time of blood donation was not complete at the end of 10 weeks.

A standard time for complete recovery from a loss of blood, such as that incurred by blood donors, has not been set. An intervening period of 8 to 10 weeks is usually required between blood donations, and the hemoglobin level prior to donation is the basis for acceptance or rejection of a donor. With this knowledge, the Nebraska workers reasoned that it would be desirable to have the blood constituents return to normal concentration even more promptly than was observed on the experimental diet, which furnished more protein than most of the self-chosen diets of the women donors.

It seemed advisable, therefore, to find some dietary supplements, given either before or after a blood donation, that would hasten replacement. For this purpose, 120 subjects, each of whom donated a pint of blood, were divided into groups to determine the rate of recovery of hemoglobin, red cells, and serum protein at 3 levels of dietary protein both with and without supplements of iron, copper, or riboflavin either prior to or following the blood loss. The effect of a high-protein diet before rather than after blood donation was also tested.

The greatest hemoglobin regeneration was obtained when the diet after blood donation contained 90 grams (a little more than 3 ounces) of protein a day. At this high-protein level improvement was not effected by supplements of iron and copper, whether given in the 5 days before donation or later along with the post-donation diet. Feeding protein at the high level for 5 days prior to donation, after which the women returned to their self-chosen diets, had a favorable effect on hemoglobin regeneration. This practice was not as effective, however, as the feeding of protein at a high level in the daily diet following blood loss. Poorest recovery occurred among the women

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on self-chosen or on unsupplemented controlled diets which furnished only 50 grams of protein a day. At this low-protein level the supplements of iron, copper, or riboflavin improved the rate of hemoglobin recovery.

These results obtained by the Nebraska station indicate that the self-chosen diets furnishing 50 grams or less of protein per day did not supply the essentials for the regeneration of hemoglobin within the 6 weeks following the donation of a pint of blood. The results strongly suggest that diets should furnish 90 grams of protein daily when there is need for blood regeneration. To meet this standard, the daily diet would need to include such foods as one quart of milk, one egg, two servings of meat, and one serving of cheese or legumes. If the protein level is low in the post-donation period, the use of iron tablets may be indicated.

HOME LAUNDERING

The trend toward commercial laundry services, use of mechanical laundering equipment in the home, and new commercial products on the market have introduced many new problems to the homemaker relating to the choice of detergents, water softeners, and other products employed in washing.

Even with the most modern equipment, home laundering can, according to work by the Montana station, produce satisfactory results only when the homemaker gives attention to the correct use of cleansing substances. The hardness of the water, dependent upon the amount of certain soluble calcium and magnesium salts present, plays an important part in the use of cleansing agents that dissolve or aid in the removal of many kinds of soil.

Prompted by inquiries from farm homemakers, research workers at the Montana station made a study of water-softening problems in relation to home laundering. Although soap is not regarded primarily as a water softener, it does serve this purpose when used directly with hard water because it must first remove much of this hardness before the desired lather or suds appear. Estimates of the amount and cost of soap required per year to just soften the water for farm-home dishwashing and laundering showed that the use of soap for water softening was both wasteful and relatively costly. It was estimated that the average family might use as much as 120 pounds of soap a year for softening hard water alone without producing the desirable sudsing effect. The importance of water softening was further demonstrated in a recent study conducted by the New York (Cornell) station to determine the average cost of doing laundry at home. Soap was proved to be the most important item among laundry-operating expenses and at the current price of granulated soap, the type commonly used, the costs for the weekly washing were 8 cents for softened and 13 cents for unsoftened water.

Apart from the wastefulness of soap as a water softener, there is the further disadvantage that in removing calcium compounds from the water it reacts with them to form a sticky gray scum. The scum readily adheres to fabrics and to the surfaces of washing equipment; this may result in poor cleansing as well as in a coating of curd on the washing machine that retards its action and causes spotting of the materials.

In view of these limitations in the employment of soap, the Montana workers tested other water-softening compounds and found that, if properly used, they were less expensive and more satisfactory than soap. Among these materials were washing soda, and other compounds such as trisodium phosphate and sodium hexametaphosphate, now on the market under commercial trade names. None of these formed the sticky gray scum during the softening process. For satisfactory performance and economy, however, these water softeners should not be used in excess. The Montana station workers, therefore, presented simple formulas for calculating the correct amount to be used in relation to the hardness and quantity of water to be softened. The exact hardness of a water supply may be determined by chemical analysis, but an approximation may be made by the homemaker herself through the use of a simple test recommended by workers at the New York (Cornell) station. This test employs a standard solution of soap in alcohol and measures the number of drops required to just soften a measured amount of water; the number of drops used is converted by a simple formula into an estimate of the relative hardness.

Soap, although not economical as a water softener, has in its varied forms occupied an important place among detergents. In recent years, however, there have been developed other chemical compounds, nonsoap in nature, which exhibit high-quality detergent properties. These compounds exert a cleansing action similar to soaps, even possessing an advantage in that they are not affected by hard water because their calcium and magnesium salts are soluble.

In making a choice between synthetic detergents and soaps it is important to consider not only their relative economy but also their effects on the service qualities of the fabrics laundered. Wearing tests are nearing completion at the Kansas station which demonstrate the effect of using soapless detergents on cotton-broadcloth uniforms after a concentrated series of washings. Certain color-fading and fabric-weakening effects are beginning to show up, but the tests must be completed before definite conclusions can be drawn. The Montana station found in its study, however, that the breaking strength of cotton yarns and fabrics was, in general, decreased about 35 to 40 percent during wear and laundering, but that no significant differences between the action of soap and a nonsoap detergent were indicated. In the Montana experiments, cotton fabrics laundered with nonsoap detergents did not fade as rapidly as those washed with soap.

The Montana station workers have also presented experimental evidence of practical value in relation to the cleansing action of detergents. In washing silk and all-wool fabrics, soap of good quality, used in sufficient amount to soften the water and form an excess of suds, and the nonsoap detergent, sodium lauryl sulfate, were shown to have similar cleansing ability. In laundering soiled cotton, linen, rayon, or mixed cotton and wool fabrics, however, soap exhibited cleansing power superior to that of the nonsoap compound.

Many theories about the cleansing efficiency of various detergents still remain to be settled. Moreover, the rapid increase in the use of automatic and semi-automatic washing machines adds further to the need for more research in home-laundering methods.

STATISTICS—PERSONNEL, PUBLICATIONS, INCOME, AND EXPENDITURES

PERSONNEL AND PUBLICATIONS

The research personnel of the experiment stations in 1948 included 2,646 staff members devoting full time to station research and 2,747 who divided time between research and teaching or extension work. The total in both categories, 5,393, represented an increase of 103 over the total of 1947 and there were 25 more full-time workers in 1948.

Publications of the experiment stations in 1948 included 854 bulletins, circulars, and reports; 2,690 articles in scientific journals; and 929 miscellaneous publications. By comparision with 1947, the stations published 173 more bulletins, circulars, and reports, 874 more articles in scientific journals, and 266 more miscellaneous publications.

Data by individual States relating to personnel and publications are showin in table 1.

INCOME AND EXPENDITURES

Appropriations under the authorizations of the Hatch, Adams, and Purnell Acts for use by the experiment stations in 1948 totaled $4,500,000, each State, Hawaii, and Puerto Rico receiving $90,000. A total of $2,661,268 was appropriated under the Bankhead-Jones Act of June 29, 1935, with allotments to the individual States, Hawaii, and Puerto Rico as shown in table 2. These allotments are made primarily on the basis of rural population adjusted in accordance with the provisions of the Department of Agriculture Organic Act of 1944.

Under title I, section 9, of the Research and Marketing Act of 1946, $2,500,000 was appropriated. Of this total $75,000, authorized by section 9 (c) of the act was available to the Office of Experiment Stations for administration. Of the remainder $1,789,539.90 was allotted to the States, Hawaii, and Puerto Rico, under the formulas described in sections 9 (b) 1 and 2; $620,950 was allotted to the States for cooperative regional research projects authorized by section 9 (b) 3; $4,050 was expended for travel by the Committee of Nine established in accordance with section 9 (b) 3, and $10,460.02, which would have been paid to Alaska in accordance with sections 9 (b) 1 and 2, was transferred to the departmental appropriation "Research on Agricultural Problems of Alaska" as required by the Department of Agriculture Appropriation Act for fiscal year 1948. The amounts allotted under sections 9 (b) 1, 2, and 3 are shown in table 2.

The total of Federal-grant funds appropriated under the Hatch, Adams, and Purnell Acts, and title I of the Bankhead-Jones Act, was $7,161,268 or $44,940 less than in 1947. This reduction occurred because of the fact that $15,000 Hatch funds, $7,500 Adams funds, $20,000 Purnell funds, and $2,440 Bankhead-Jones funds allotted to Alaska in 1947 were transferred from these appropriations to the departmental appropriation "Research on Agricultural Problems of Alaska" in 1948, as required by law.

Expenditures of Federal-grant funds are shown under object classes by individual experiment stations in tables 3, 4, 5, 6, 7, and 8,

expenditures of non-Federal funds in table 9. The 1948 expenditures of non-Federal funds which include State appropriations, research grants, and income from other sources totaled $35,350,241.56, as compared with $27,699,999.22 in 1947. The 1948 non-Federal fund expenditures by all of the stations aproximated $3.69 for each $1 of Federal grants.

TABLE 1.—*Organization, personnel, and publications of the experiment stations for the year ended June 30, 1948*

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	56	33		1	90	12	296	25	201	11	91
Arizona	Mar. 19, 1889	July 1, 1889	24	36			60	11	350	12	82	5	10
Arkansas	Mar. 7, 1889	Apr. 2, 1888	20	33	1	1	55	14	534	6	12		
California	Mar. 12, 1889	Mar. 13, 1888	106	225			331	43	1,615	325	4,261	221	2,002
Colorado	Mar. 25, 1889	Feb. 20, 1888	35	70		4	109	15	124	41	(1)		
Connecticut:													
State	May 18, 1887	May 18, 1887	60				60	12	506	34	249	15	64
Storrs	do	Apr. 1, 1888	19	11	3	3	36	7	577	20	199	1	6
Delaware	Apr. 14, 1887	Feb. 21, 1888	15	14	1	5	35	11	314	20	97	8	27
Florida	June 7, 1887	Mar. 16, 1888	114	14	5	5	138	32	978	91	353	74	86
Georgia	Dec. 24, 1888	Feb. 18, 1888	90				90	17	286	18	95	24	24
Hawaii	Mar. 31, 1911	July 1, 1929	30	13			43	4	105	11	95		
Idaho	Jan. 23, 1891	Feb. 26, 1892	13	28	1	5	47	3	114	18	(1)	5	(1)
Illinois	May 11, 1887	Mar. 21, 1888	53	109	6	3	171	17	466			28	192
Indiana	Jan. 19, 1889	July 1, 1887	109	67	6	3	185	33	1,281	60	320	144	390
Iowa	Mar. 1, 1888	Feb. 17, 1888	87	126	22	8	243	27	1,146	85	640	4	340
Kansas	Mar. 3, 1887	Feb. 8, 1888	48	112			160	12	510	103	(1)		
Kentucky	Feb. 20, 1888	Apr. 29, 1888	78	23	2	11	114	25	952	33	107		
Louisiana	July 12, 1888	Apr. 5, 1887	73	39	1		113	15	584	54	514	33	463
Maine	Mar. 16, 1887	Feb. 16, 1888	32	20	2	2	56	16	805	12	68	5	33
Maryland	Mar. 6, 1888	Mar. 9, 1888	16	24	6	18	64	4	123	22	171	15	71
Massachusetts	Apr. 20, 1887	Mar. 2, 1888	69	20			89	25	395	29	149		
Michigan	Apr. 12, 1889	Feb. 26, 1888	81	100	4	9	194	24	1,323	60	410		
Minnesota	Feb. 4, 1889	Jan. 26, 1888	42	116	4	4	166	5	134	64	501	32	193
Mississippi	Jan. 31, 1888	Spring, 1888	42	17		11	70	18	283	22	211	31	52
Missouri	June 11, 1889	Jan. 31, 1888	16	97		3	116	52	1,231	51	(1)	1	12
Montana	Feb. 16, 1893	July 1, 1893	32	32	1	11	76	8	376	7	41	2	44
Nebraska	Mar. 31, 1887	June 14, 1887	39	46	1		86	15	382	31	(1)		
Nevada	Feb. 8, 1889	Dec. 1887	15	1		1	17	3	49				
New Hampshire	Aug. 4, 1887	Feb. 22, 1888	10	40	1	7	58	6	161	6	32		

New Jersey	Mar. 16, 1887	Mar. 5, 1888	64	62	----------	2	128	30	498	79	563	40	295
New Mexico	Feb. 28, 1889	Nov. 14, 1889	20	21	1	1	43	14	282	6	30	5	6
New York:													
Cornell	Mar. 30, 1887	Apr. 30, 1888	33	139	2	20	194	12	851	578	2,800	----------	----------
State	(2)	----------	67	----------	----------	----------	67	17	423	50	(1)	12	15
North Carolina	Mar. 7, 1887	Dec. 5, 1889	90	48	----------	10	148	11	337	30	(1)	2	32
North Dakota	Mar. 8, 1890	Oct. 15, 1890	37	23	----------	1	61	9	300	10	68	----------	----------
Ohio	Mar. 16, 1887	Apr. 2, 1888	109	34	2	1	146	16	592	74	(1)	----------	----------
Oklahoma	Oct. 27, 1890	Aug. 14, 1891	39	65	1	----------	105	30	825	40	154	2	555
Oregon	Feb. 25, 1889	July 2, 1888	60	65	----------	6	131	45	1,140	24	(1)	----------	----------
Pennsylvania	June 3, 1887	June 30, 1887	----------	168	----------	----------	168	17	510	35	181	15	213
Puerto Rico	Aug. 16, 1933	Nov. 14, 1935	73	----------	----------	----------	73	14	412	5	16	21	101
Rhode Island	Mar. 31, 1887	Nov. 3, 1888	20	10	1	5	36	3	186	19	68	4	25
South Carolina	Dec. 22, 1887	Jan. 1888	63	21	3	1	88	7	388	10	63	----------	----------
South Dakota	Mar. 11, 1887	Nov. 17, 1887	22	24	2	1	49	15	346	6	(1)	----------	----------
Tennessee	Mar. 29, 1887	July 24, 1887	53	16	1	8	78	8	263	21	203	19	625
Texas	Apr. 2, 1887	Jan. 25, 1888	175	2	----------	----------	177	20	1,061	82	738	90	587
Utah	Mar. 8, 1888	Nov. 6, 1889	25	40	----------	6	71	4	104	7	59	4	80
Vermont	Nov. 1888	Feb. 28, 1888	8	12	4	7	31	14	275	3	(1)	----------	----------
Virginia	Feb. 29, 1888	June 13, 1888	85	12	1	6	104	18	424	10	45	22	65
Washington	Mar. 9, 1891	May 1, 1891	77	52	2	----------	131	39	907	85	544	25	125
West Virginia	Feb. 22, 1889	June 11, 1888	21	43	1	7	72	5	144	16	108	1	20
Wisconsin	(3)	July 1, 1887	60	89	4	16	169	9	330	213	(1)	----------	----------
Wyoming	Jan. 10, 1891	Mar. 27, 1891	21	30	----------	----------	51	11	178	27	268	8	55
Total	----------	----------	2,646	2,442	92	213	5,393	854	26,776	2,690	14,716	929	6,899

[1] Total pages unknown.
[2] First made eligible to receive part of the State allotment of Federal funds by legislative act approved May 12, 1894.
[3] Session of 1887.

TABLE 2.—*Income of the experiment stations for the year ended June 30, 1948*

Station	Federal grants [1]					Non-Federal							Grand total
	Hatch, Adams, and Purnell [2]	Bankhead-Jones	Research and Marketing 9(b)1 and 9(b)2	Research and Marketing 9(b)3	Total	State appropriations	Special endowments, industrial fellowships, etc.	Fees	Sales	Miscellaneous	Balance from previous year	Total	
Alabama	$90,000	$89,423.99	$59,168.78	$12,000	$250,592.77	$366,315.00	$69,500.61		$376,351.08	$2,345.10	[3] $231,023.89	$1,045,535.68	$1,296,128.45
Arizona	90,000	14,392.26	15,745.02	4,750	124,887.28	270,853.48	8,820.69		10,953.66			290,627.83	415,515.11
Arkansas	90,000	69,148.00	49,377.35	13,200	221,725.35	250,000.00	4,875.00		139,763.27		24,650.32	419,288.59	641,013.94
California	90,000	88,718.14	45,708.74	4,300	228,726.88	3,250,805.12	157,204.41		180,147.55		180,075.95	3,768,233.03	3,996,959.91
Colorado	90,000	24,243.48	20,871.32	18,200	153,314.80	181,250.00	98,050.70		93,012.26	2,695.68	90,228.01	465,236.65	618,551.45
Connecticut:													
State	45,000	12,191.48	9,022.69		66,214.17	273,519.28	13,980.00					287,499.28	353,713.45
Storrs	45,000	12,191.47	9,022.69	2,250	68,464.16	177,325.21	30,546.11			1,800.00		209,671.32	278,135.48
Delaware	90,000	5,622.44	12,150.73	2,000	109,773.17	51,003.78			97,918.04	16,331.14	34,351.24	199,604.20	309,377.37
Florida	90,000	37,680.70	20,473.11	6,900	160,053.81	2,303,889.92	61,527.05		169,575.76		35,908.85	2,570,901.58	2,730,955.39
Georgia	90,000	94,499.88	60,477.64	14,800	259,777.52	127,250.20	37,694.37		86,017.40	48,760.00	116,528.60	416,250.57	676,028.09
Hawaii	90,000	9,727.90	14,225.20		113,953.10	347,160.00	14,895.47		32,936.86		901.77	395,894.10	509,847.20
Idaho	90,000	15,404.82	17,802.48	13,500	136,707.30	156,596.34	22,100.54		63,637.79			242,334.67	379,041.97
Illinois	90,000	93,841.73	52,936.33	22,400	259,178.06	972,004.95	145,406.37		276,714.11			1,394,125.43	1,653,303.49
Indiana	90,000	68,142.18	43,553.36	9,400	211,095.54	677,289.91	147,840.59	$96,866.00	527,010.48	9,142.65	598,510.79	2,056,660.42	2,267,755.96
Iowa	90,000	69,803.53	44,943.65	39,300	244,047.18	568,360.75	243,193.09		276,071.53		209,447.25	1,297,072.62	1,541,119.80
Kansas	90,000	53,614.76	33,811.85	4,800	182,226.61	182,553.22			189,890.57	40,803.66	189,683.16	602,930.61	785,157.22
Kentucky	90,000	88,327.81	57,702.48	2,500	238,530.29	124,740.00		264,147.78	68,520.00			457,407.78	695,938.07
Louisiana	90,000	61,211.40	42,589.22	11,300	205,100.62	661,323.77	25,241.46					686,565.23	891,665.85
Maine	90,000	22,408.10	18,989.50	18,475	149,872.60	174,873.35			49,951.17	50,575.31	27,450.57	302,850.40	452,723.00
Maryland	90,000	32,781.37	23,027.77	6,000	151,809.14	212,464.00	41,247.50		82,936.59		82,992.76	419,640.85	571,449.99
Massachusetts	90,000	20,231.15	17,875.55	6,750	134,856.70	291,679.11	19,828.16				30,706.27	342,213.54	477,070.24
Michigan	90,000	79,697.18	47,556.30	14,200	231,453.48	550,818.37			44,792.33			595,610.70	827,064.18
Minnesota	90,000	62,041.49	44,038.61	16,550	212,630.10	1,046,207.76	73,976.17	8,432.75	221,111.64			1,349,728.32	1,562,358.42
Mississippi	90,000	78,610.72	57,897.34	29,600	256,108.06	433,466.93	64,094.73	17,046.83	241,328.76	15,516.04	439,539.22	1,210,992.51	1,467,100.57
Missouri	90,000	83,175.73	53,019.62	14,650	240,845.35	173,890.00	34,293.84	115,783.56	99,119.38		213,055.71	636,142.49	876,987.84
Montana	90,000	16,687.31	17,256.69	3,800	127,744.00	291,182.33	8,500.00		298,242.73	18,850.80	133,555.09	750,330.95	878,074.95
Nebraska	90,000	41,505.16	28,871.52	5,400	165,776.68	335,715.43			337,444.46			673,159.89	838,936.57
Nevada	90,000	2,962.52	10,869.29	500	104,331.81	13,831.81			31,733.25		7,688.01	53,253.07	157,584.88
New Hampshire	90,000	9,216.35	13,550.99	3,200	115,967.34	22,973.60			8,418.68		33,529.34	64,921.62	180,888.96

New Jersey	90,000	33,865.35	21,199.00	17,400	162,464.35	540,812.35	208,658.27				7,308.89	756,779.51	919,243.86
New Mexico	90,000	15,725.69	17,386.59	6,800	129,912.28	64,125.00			52,841.75		92,799.14	209,765.89	339,678.17
New York:													
Cornell	81,000	92,116.31	45,311.37	25,000	243,427.68	1,328,636.19		286,280.10		3,977.00		1,618,893.29	1,862,320.97
State	9,000	10,235.14	5,034.59		24,269.73	599,881.58			25,317.44			625,199.02	649,468.75
North Carolina	90,000	114,926.05	72,509.04	26,700	304,135.09	628,130.22			77,655.06	42,947.58		748,732.86	1,052,867.95
North Dakota	90,000	26,411.59	22,159.19	2,500	141,070.78	312,453.14	12,190.17		107,836.22		46,227.42	478,706.95	619,777.73
Ohio	90,000	101,527.47	57,473.25	6,250	255,250.72	773,249.73			227,623.47		1,502,537.75	2,503,410.95	2,758,661.67
Oklahoma	90,000	73,409.02	44,965.74	6,800	215,174.76	488,033.00	24,302.80		240,732.11		125,429.93	878,497.84	1,093,672.60
Oregon	90,000	24,689.53	21,273.58	62,500	198,463.11	535,629.58	42,618.00	152,175.64	150,107.63			880,530.85	1,078,993.96
Pennsylvania	90,000	146,599.60	65,182.02	13,675	315,456.62	393,167.07	83,539.08		122,489.96	122,686.28	59,211.45	781,093.84	1,096,550.46
Puerto Rico	90,000	57,647.71	46,141.87	2,500	196,289.58	298,278.89					40,648.01	338,926.90	535,216.48
Rhode Island	90,000	2,653.11	10,821.54	8,175	111,649.65	35,000.00	24,137.48		21,852.96		35,712.53	116,702.97	228,352.62
South Carolina	90,000	64,344.59	44,427.92	22,260	220,972.51	294,800.00	22,404.35		192,734.11		32,528.95	542,467.41	763,439.92
South Dakota	90,000	26,082.74	21,458.88	5,400	142,941.62	144,500.00	5,221.57		81,599.27		12,498.15	243,818.99	386,760.61
Tennessee	90,000	83,564.09	56,809.26	11,600	241,973.35	237,630.34			147,276.64			384,906.98	626,880.33
Texas	90,000	161,288.82	92,768.25	38,750	382,807.07	972,956.00	49,221.14		844,757.32	66,426.80	471,809.24	2,405,170.50	2,787,977.57
Utah	90,000	11,336.91	14,654.56	10,800	126,791.47	285,582.11	42,871.46		49,075.50		28,315.28	405,844.35	532,635.82
Vermont	90,000	11,274.80	14,595.30	1,000	116,870.10	33,000.00			2,308.05	16,000.00	8,468.31	59,776.36	176,646.46
Virginia	90,000	77,043.23	49,169.49	6,800	223,012.72	348,034.21			56,789.93		44,259.81	449,083.95	672,096.67
Washington	90,000	36,025.87	25,779.25	18,500	170,305.12	929,490.36	66,195.53		111,876.55			1,107,562.44	1,277,867.56
West Virginia	90,000	60,514.13	35,836.40	3,175	189,525.53	135,200.00	7,700.00		107,516.89		53,945.30	304,362.19	493,887.72
Wisconsin	90,000	65,188.76	44,012.32	14,050	213,251.08	917,449.24	468,477.00		349,700.00			1,735,626.24	1,948,877.32
Wyoming	90,000	7,294.44	13,034.67	9,650	119,979.11	160,132.78	4,339.62		77,393.15		66,633.89	308,499.44	428,478.55
Total	4,500,000	2,661,268.00	1,789,539.90	620,950	9,571,757.90	24,945,515.41	2,384,693.33	940,732.66	7,051,083.36	458,858.04	5,308,160.85	41,089,043.65	50,660,801.55

[1] Includes unexpended balances from the previous year as follows:
Hatch—Connecticut State, $10.55; Connecticut Storrs, $617.06; New York Cornell, $4.48; Rhode Island, $133.14.
Adams—Arkansas, $0.83; Kansas, $23.15; Maryland, $0.01; New York Cornell, $23.40; North Dakota, $0.03; Rhode Island, $24.69.
Purnell—Arkansas, $1,362.69; Connecticut Storrs, $1,373.40; Hawaii, $2,632.31; New York Cornell, $1,357.92; New York State, $99.20; North Dakota, $0.14; Rhode Island, $139.39.
Bankhead-Jones—Arkansas, $37.28; Connecticut Storrs, $422.58; Hawaii, $1,345.85; Maryland, $0.01; Minnesota $0.01; New York Cornell, $0.98; New York State, $53.55.

[2] Hatch, $15,000 for each State, Hawaii, and Puerto Rico. Adams, $15,000 for each State, Hawaii, and Puerto Rico. Purnell, $60,000 for each State, Hawaii, and Puerto Rico.

[3] Revised to include TVA.

NOTE.—Federal-grant funds formerly paid to the Alaska Agricultural Experiment Station of the University of Alaska were transferred to and made a part of the appropriation "Research on Agricultural Problems of Alaska." This appropriation was administered by the Agricultural Research Administration of the Department of Agriculture.

TABLE 3.—*Expenditures and appropriations under the Hatch Act (Mar. 2, 1887)*[1] *for the year ended June 30, 1948*

Station	Expenditures												Unexpended	Appropriations
	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	$13,912.02	$43.05	$23.09	$94.67	$144.00	$50.89	$27.58	$543.40	$161.30			$15,000.00		$15,000
Arizona	13,956.01	6.29	7.00	19.50				38.06	973.14			15,000.00		15,000
Arkansas	9,319.06	183.41		34.96		1,842.99	85.06	1,572.98	1,804.14		$157.40	15,000.00		15,000
California	15,000.00											15,000.00		15,000
Colorado	10,588.48	908.57		414.54	850.90	1,248.98	112.02	399.58	175.75		301.18	15,000.00		15,000
Connecticut:														
State	6,620.00					333.55	279.52	254.77				7,487.84	$12.16	7,500
Storrs	2,575.00	167.47	5.03			117.11	8.50	201.66	4,276.36			7,351.13	148.87	7,500
Delaware	9,297.97	543.09	11.61	1,445.74	742.24	954.10	255.29	1,224.33	525.63			15,000.00		15,000
Florida	15,000.00											15,000.00		15,000
Georgia	9,840.36	381.67	3.36	.66		21.04	174.42	2,160.69	2,417.80			15,000.00		15,000
Hawaii	14,971.23							18.69	10.08			15,000.00		15,000
Idaho	8,325.43	2,282.52	259.86	886.48		426.66	186.73	911.03	1,721.29			15,000.00		15,000
Illinois	14,571.58										428.42	15,000.00		15,000
Indiana	15,000.00											15,000.00		15,000
Iowa	15,000.00											15,000.00		15,000
Kansas	13,904.68	150.71		71.69	13.37		63.76	598.67	197.12			15,000.00		15,000
Kentucky	13,491.08	147.42				1,286.50		75.00				15,000.00		15,000
Louisiana	13,206.66	365.67	.36	41.17		235.15	533.84	552.88	64.27			15,000.00		15,000
Maine	11,147.98	777.97	62.77	576.64	386.03	884.09	42.69	780.83	341.00			15,000.00		15,000
Maryland	8,172.86	2,699.92				167.75		3,959.17				14,999.70	.30	15,000
Massachusetts	6,747.09	1,087.60		5.00		119.76	417.72	3,531.87	630.96	$2,460.00		15,000.00		15,000
Michigan	9,350.00					4,953.66		696.34				15,000.00		15,000
Minnesota	11,971.71	1,018.07					268.11	1,319.83	134.15		288.13	15,000.00		15,000
Mississippi	11,231.96	503.64	8.67	413.54	6.76	855.50	207.79	1,108.16	663.98			15,000.00		15,000
Missouri	12,266.89	4.40		90.00	5.00		19.05	525.86	1,790.93		297.87	15,000.00		15,000
Montana	13,646.79	189.21	4.83	6.82		411.99	57.87	616.99	65.50			15,000.00		15,000
Nebraska	15,000.00											15,000.00		15,000
Nevada	11,473.50	80.10		419.37	161.75	216.15	115.35	2,089.97	35.06		408.75	15,000.00		15,000
New Hampshire	11,965.65	375.44	22.94	468.13	1,000.00	520.54	103.09	402.12	142.09			15,000.00		15,000

New Jersey	11,663.00	252.45	3.00	10.00	176.15	934.25	168.39	668.75	1,124.01			15,000.00		15,000
New Mexico	13,184.08	519.70	5.08		394.35	557.23		240.12	99.44			15,000.00		15,000
New York:														
Cornell	11,505.72		24.12				349.49	1,544.53	63.13			13,486.99	13.01	13,500
State	954.78								545.22			1,500.00		1,500
North Carolina	9,709.60	973.74	22.59	124.53		1,108.18	379.70	2,681.66				15,000.00		15,000
North Dakota	14,468.07							2.43			529.50	15,000.00		15,000
Ohio	13,199.98	566.63	34.05					874.34	325.00			15,000.00		15,000
Oklahoma	4,231.49	1,368.77	39.64		38.31	554.55	1,527.83	5,684.77	1,554.64			15,000.00		15,000
Oregon	12,462.08	1,452.08					26.25	87.09	972.50			15,000.00		15,000
Pennsylvania	10,464.06					4,369.30			166.64			15,000.00		15,000
Puerto Rico	11,085.30	1,923.16		52.92	171.98			1,364.74	401.90			15,000.00		15,000
Rhode Island	11,045.74	26.63	1.85	731.53		1,095.57	148.30	1,950.38				15,000.00		15,000
South Carolina	11,740.09	104.91	1.49	524.77	100.00	630.00	438.06	1,121.28	339.40			15,000.00		15,000
South Dakota	10,694.66	1,245.02	5.79	84.57	8.00	980.96	314.60	1,666.40				15,000.00		15,000
Tennessee	14,217.51		1.63	228.53	23.45		13.28	515.60				15,000.00		15,000
Texas	10,430.06	1,668.18		95.69		[1]	32.82	60.22	2,713.03			15,000.00		15,000
Utah	15,000.00											15,000.00		15,000
Vermont	9,366.34	386.39	35.35	534.79	2,804.68	926.00	198.67	438.28	125.06		184.44	15,000.00		15,000
Virginia	12,893.46			18.33	1,563.79		54.55	469.87				15,000.00		15,000
Washington	12,427.49	221.60					263.54	709.59	1,050.28		327.50	15,000.00		15,000
West Virginia	13,241.67	77.08		34.05	383.22	287.25	35.52	941.21				15,000.00		15,000
Wisconsin	14,126.84	425.78		6.05			247.20	194.13				15,000.00		15,000
Wyoming	13,500.00	300.00	11.53	5.52		1,182.95						15,000.00		15,000
Total	599,166.01	23,428.34	595.64	7,440.19	8,973.98	27,272.65	7,156.59	44,798.27	25,610.80	2,460.00	2,923.19	749,825.66	174.34	750,000

[1] Extended to Hawaii by act of May 16, 1928; 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, 1948*

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	$11,248.22	$89.35	$40.93	$0.16	$410.32	$505.40	$1,789.91	$915.71			$15,000.00		$15,000
Arizona	12,118.93	1,114.47	36.09	63.84		56.32	1,347.70	262.65			15,000.00		15,000
Arkansas	11,674.91	136.57			377.41	122.82	959.28	1,095.36	$19.87	$511.08	14,897.30	$102.70	15,000
California	15,000.00										15,000.00		15,000
Colorado	11,071.23	231.69	59.94		482.67	230.06	2,226.60	559.11		138.70	15,000.00		15,000
Connecticut:													
State	7,500.00										7,500.00		7,500
Storrs	7,500.00										7,500.00		7,500
Delaware	12,017.19	506.01	10.80	1.80	33.57	247.88	414.13	749.35	36.28		14,017.01	982.99	15,000
Florida	15,000.00										15,000.00		15,000
Georgia	11,784.07	91.34	15.96			118.97	1,158.29	1,646.42	184.95		15,000.00		15,000
Hawaii	12,428.34						132.57	848.85			13,409.76	1,590.24	15,000
Idaho	13,744.91	227.89	11.09	3.50		242.41	689.12	81.08			15,000.00		15,000
Illinois	14,200.39							286.58		513.03	15,000.00		15,000
Indiana	13,689.29			440.31			870.40				15,000.00		15,000
Iowa	15,000.00										15,000.00		15,000
Kansas	13,112.96					121.82	1,504.03	261.19			15,000.00		15,000
Kentucky	15,000.00										15,000.00		15,000
Louisiana	12,856.80	597.29	44.26	4.96		111.55	1,365.17	19.97			15,000.00		15,000
Maine	14,176.85	68.35				8.32	643.16	103.32			15,000.00		15,000
Maryland	14,000.00						134.84	865.16			15,000.00		15,000
Massachusetts	15,000.00										15,000.00		15,000
Michigan	15,000.00										15,000.00		15,000
Minnesota	12,165.80	329.30	1.68			47.18	656.06	1,509.50		290.48	15,000.00		15,000
Mississippi	12,157.97	153.25	69.83		243.13	644.76	847.62	883.44			15,000.00		15,000
Missouri	11,243.16		94.24		26.80	149.89	2,429.01	859.21		197.69	15,000.00		15,000
Montana	12,680.64	553.32	28.70	17.03	48.00	228.67	1,230.61	213.03			15,000.00		15,000
Nebraska	15,000.00										15,000.00		15,000
Nevada	12,888.75	59.35	5.03			1.50	1,019.37	494.00		532.00	15,000.00		15,000
New Hampshire	14,106.46	137.17	26.95	7.16	5.00	34.30	401.86	281.10			15,000.00		15,000

New Jersey	13,440.00	17.00				41.00	1,044.08	457.92			15,000.00		15,000
New Mexico	12,844.02		47.30		268.11	234.86	1,344.19	261.52			15,000.00		15,000
New York:													
Cornell	8,943.11	79.06	19.79			10.95	3,086.12	1,296.56			13,435.59	64.41	13,500
State							59.00	1,359.10			1,418.10	81.90	1,500
North Carolina	11,853.68	44.39				14.00	3,087.93				15,000.00		15,000
North Dakota	14,551.50						20.00			428.50	15,000.00		15,000
Ohio	13,602.90		35.52				1,067.38	293.70			14,999.50	.50	15,000
Oklahoma	8,228.61	46.30		22.52	5.55	1,369.16	2,475.05	2,852.81			15,000.00		15,000
Oregon	14,945.35	39.25				14.50	.90				15,000.00		15,000
Pennsylvania	14,436.40		2.97			92.59	20.07	447.97			15,000.00		15,000
Puerto Rico	10,945.16	179.50			6.84	308.13	1,634.73	1,925.64			15,000.00		15,000
Rhode Island	14,385.14						614.86				15,000.00		15,000
South Carolina	13,502.32	306.94	3.91	48.38	55.85	118.23	576.17	388.20			15,000.00		15,000
South Dakota	11,766.78	531.57	21.24	34.83		125.24	1,764.42	755.92			15,000.00		15,000
Tennessee	14,371.79		14.75		9.33	45.00	417.34	141.79			15,000.00		15,000
Texas	14,033.49			10.52		35.88	107.88	790.23		22.00	15,000.00		15,000
Utah	14,881.98		1.03			14.15	102.84				15,000.00		15,000
Vermont	12,728.05	140.93	4.69	7.63		129.33	631.16	813.22		544.99	15,000.00		15,000
Virginia	14,057.05	244.96				11.15	506.03	180.81			15,000.00		15,000
Washington	11,593.52	611.58		5.67		76.46	1,995.61	279.16		438.00	15,000.00		15,000
West Virginia	13,250.00	26.17				99.62	818.34	805.87			15,000.00		15,000
Wisconsin	12,419.66	73.65				3.50	2,503.19				15,000.00		15,000
Wyoming	13,717.44	75.00				72.69	720.30	414.57			15,000.00		15,000
Total	657,864.82	6,711.65	596.70	668.31	1,972.58	5,688.29	44,417.32	25,400.02	241.10	3,616.47	747,177.26	2,822.74	750,000

[1] Extended to Hawaii by act of May 16, 1928, and to Puerto Rico by act of Mar. 4, 1931.

TABLE 5.—*Expenditures and appropriations under the Purnell Act (Feb. 24, 1925)*[1] *for the year ended June 30, 1948*

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	$44,399.36	$1,023.95	$176.76	$87.75	$1,641.75	$485.27	$920.85	$6,883.29	$2,361.51	$2,019.51		$60,000.00		$60,000
Arizona	43,748.45	2,760.08	270.81	108.51			1,292.45	7,997.02	3,822.68			60,000.00		60,000
Arkansas	40,558.40	1,017.03	2.22	5.00	1,377.87	3,304.35	515.47	4,649.78	6,924.68		$987.16	59,341.96	$658.04	60,000
California	60,000.00											60,000.00		60,000
Colorado	43,938.25	1,984.52	59.68	134.49	1,376.71	73.45	1,193.92	7,074.64	3,003.70		1,160.64	60,000.00		60,000
Connecticut:														
State	23,679.67	124.68	16.76			900.65	1,361.45	1,638.71	2,114.91			29,836.83	163.17	30,000
Storrs	25,328.52	218.86		4.98			163.12	315.88	3,763.89			29,795.25	204.75	30,000
Delaware	41,877.49	2,844.20	28.16	15.22	789.32	2,943.86	926.76	6,776.34	3,798.65			60,000.00		60,000
Florida	60,000.00											60,000.00		60,000
Georgia	46,034.17	2,383.67	82.80	20.11		132.17	797.60	8,142.99	2,292.50	113.99		60,000.00		60,000
Hawaii	51,190.09						79.55	2,792.21	4,738.15	1,200.00		60,000.00		60,000
Idaho	44,920.96	1,798.89	73.06	143.42		17.75	853.94	9,438.68	2,753.30			60,000.00		60,000
Illinois	48,996.14	1,171.66	68.75	4.30		225.15	2,399.29	4,979.91	1,231.14		923.66	60,000.00		60,000
Indiana	52,554.88	2,271.25	14.82	54.78	32.60		187.31	2,790.57	2,093.79			60,000.00		60,000
Iowa	59,828.00					172.00						60,000.00		60,000
Kansas	56,459.36	901.98	8.56				116.95	1,881.98	631.17			60,000.00		60,000
Kentucky	52,496.91	2,607.52	21.59	10.15		4,073.78	120.93	604.52	64.60			60,000.00		60,000
Louisiana	47,905.06	2,312.36	302.03	53.49	70.38	515.90	2,955.98	4,240.37	1,644.43			60,000.00		60,000
Maine	44,049.45	1,570.37	41.92	8.87	1,000.00	931.95	1,400.73	9,696.84	1,299.87			60,000.00		60,000
Maryland	54,595.02		4.08	8.65			144.89	3,313.71	1,933.65			60,000.00		60,000
Massachusetts	49,799.75	1,084.98				42.10	305.50	3,427.35	5,340.32			60,000.00		60,000
Michigan	59,350.56		12.24					285.84	351.36			60,000.00		60,000
Minnesota	48,998.54	1,298.77	88.26	49.00	62.50	309.15	1,204.57	3,704.60	3,808.25		476.36	60,000.00		60,000
Mississippi	42,165.97	3,213.56	175.08	599.10	414.61	2,028.16	619.88	4,643.23	6,140.41			60,000.00		60,000
Missouri	44,791.26	1,178.96	244.91	18.08	96.00	773.95	832.89	9,567.12	1,806.88		689.95	60,000.00		60,000
Montana	52,752.06	1,237.44	12.90	79.23	5.58	1,063.61	817.52	2,518.77	1,512.89			60,000.00		60,000
Nebraska	51,191.63	1,350.19	14.50			76.18	981.32	3,038.08	3,348.10			60,000.00		60,000
Nevada	37,161.92	1,562.63	97.15	294.47	142.79	22.30	306.65	11,495.10	6,692.89	1,498.35	725.75	60,000.00		60,000
New Hampshire	54,965.44	1,675.04	87.38	31.89	130.52	452.25	477.63	1,232.96	946.89			60,000.00		60,000

New Jersey	50,019.69	1,009.10	13.12		454.00		1,488.42	4,625.62	2,390.05			60,000.00		60,000
New Mexico	50,410.82	1,611.68	66.26	114.67	1,750.98	695.70	443.36	4,370.96	535.57			60,000.00		60,000
New York:														
Cornell	43,731.33	1,364.67	13.47	45.12	781.32	11.10	1,661.65	2,019.68	3,849.24			53,477.58	522.42	54,000
State	4,981.03						49.22	475.81	455.57			5,961.63	38.37	6,000
North Carolina	46,765.32	5,080.52	15.00	296.98	14.01	100.75	568.68	7,039.74		119.00		60,000.00		60,000
North Dakota	55,223.04	374.42	1.26	11.21	7.92	142.21	21.07	1,463.84	783.03		1,972.00	60,000.00		60,000
Ohio	53,423.32	1,623.31	38.65		28.20		6.88	3,461.18	1,418.14			59,999.68	.32	60,000
Oklahoma	38,221.59	3,024.10	600.49	35.32	668.35	106.54	3,893.98	5,718.68	4,779.68	2,951.27		60,000.00		60,000
Oregon	57,560.83	472.75	17.95	25.50	12.15		14.17	741.62	1,155.03			60,000.00		60,000
Pennsylvania	56,378.63	796.18	5.16	2.50		1,149.72	325.00	840.20	502.61			60,000.00		60,000
Puerto Rico	41,629.76	1,910.69			8.54	2,177.00	167.57	4,715.28	9,391.16			60,000.00		60,000
Rhode Island	53,585.55	581.60		1.90		855.12	12.40	4,963.43				60,000.00		60,000
South Carolina	46,791.40	699.02	705.74	320.53	691.77	1,638.02	1,278.37	4,882.33	2,714.01	278.81		60,000.00		60,000
South Dakota	42,657.75	3,556.57	98.97	108.25	30.41	3,921.71	602.06	6,257.05	2,767.23			60,000.00		60,000
Tennessee	54,858.89	622.37	92.94	4.53	199.14		943.43	2,290.33	988.37			60,000.00		60,000
Texas	48,602.28	451.12	81.08	434.53	77.56	4.65	577.06	4,155.12	5,577.80		38.75	59,999.95	.05	60,000
Utah	52,947.61	2,450.88	70.90		45.00		426.23	2,303.34	1,756.04			60,000.00		60,000
Vermont	47,495.80	1,701.20	64.09	59.02	105.80	1,617.41	1,263.79	3,272.68	3,220.47		1,199.74	60,000.00		60,000
Virginia	51,597.00	526.74	9.01	66.96	573.14	2,144.02	531.05	2,555.40	1,996.68			60,000.00		60,000
Washington	48,588.02	1,115.11	3.10	14.63	5.45		619.99	4,172.34	4,408.36		1,070.75	59,997.75	2.25	60,000
West Virginia	51,885.46	472.53	.90		362.40	123.69	5,886.53		1,268.49			60,000.00		60,000
Wisconsin	56,495.70	683.94	5.32				54.71	1,857.33	903.00			60,000.00		60,000
Wyoming	56,797.00	1,611.30	.22			410.50	155.63	576.46	448.89			60,000.00		60,000
Total	2,494,385.13	69,332.39	3,808.05	3,273.14	12,956.77	33,642.12	41,968.40	195,888.91	125,730.03	8,180.93	9,244.76	2,998,410.63	1,589.37	3,000,000

[1] Extended to Hawaii by act of May 16, 1928, 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, 1948*

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	$63,864.31	$1,435.50	$383.36	$83.81	$1,596.79	$217.32	$4,356.56	$13,618.76	$3,274.18	$593.40		$89,423.99		$89,423.99
Arizona	11,345.66	1,084.91	35.06	153.66			50.13	1,322.53	400.31			14,392.26		14,392.26
Arkansas	46,577.69	1,819.18			326.04	1,757.53	682.99	3,931.43	6,951.73	5,042.24	$1,018.74	68,107.57	$1,040.43	69,148.00
California	88,642.05							76.09				88,718.14		88,718.14
Colorado	20,077.53	724.55		61.68	627.92	86.19	486.29	1,461.43	255.63		462.26	24,243.48		24,243.48
Connecticut:														
State	9,375.00	193.78	7.99			587.08	681.35	520.47	778.58			12,144.25	47.23	12,191.48
Storrs	7,499.54		15.59					4,310.93	78.85			11,904.91	286.56	12,191.47
Delaware	3,902.72						142.53	1,572.09	5.10			5,622.44		5,622.44
Florida	26,773.40	669.14	14.65	9.17	48.67		57.25	10,108.42				37,680.70		37,680.70
Georgia	62,510.26	1,733.97	284.15	.48	475.00	1,006.22	1,699.76	18,773.61	7,713.88	302.55		94,499.88		94,499.88
Hawaii	6,484.52		6.83					675.84	2,560.71			9,727.90		9,727.90
Idaho	12,862.11	383.40	107.71	8.44			89.51	1,539.91	413.74			15,404.82		15,404.82
Illinois	79,358.18	1,530.98	307.62	10.55	28.00	22.98	1,270.36	3,470.76	4,930.23		2,912.07	93,841.73		93,841.73
Indiana	59,912.89	1,763.65	49.25	27.21			738.91	4,696.12	708.15	246.00		68,142.18		68,142.18
Iowa	65,303.53						4,500.00					69,803.53		69,803.53
Kansas	45,851.43	348.25			151.28		1,048.88	4,582.90	1,632.02			53,614.76		53,614.76
Kentucky	81,310.98	267.88	13.80	46.85		1,869.50	161.29	3,754.09	903.42			88,327.81		88,327.81
Louisiana	45,712.48	2,589.09	59.76	24.99		669.45	3,588.05	6,320.29	2,059.79	187.50		61,211.40		61,211.40
Maine	18,497.04	937.62		18.60	152.98	1,128.32	825.41	701.31	146.82			22,408.10		22,408.10
Maryland	29,515.19		1.00				20.75	2,703.89	537.70			32,778.53	2.84	32,781.37
Massachusetts	20,107.20	44.25						55.70	24.00			20,231.15		20,231.15
Michigan	75,593.85	48.65	5.78			1,055.43	1,040.67	1,618.96	333.84			79,697.18		79,697.18
Minnesota	41,906.44	1,971.04	223.83	119.12	512.11	1,221.41	1,768.62	7,902.91	6,124.80		291.21	62,041.49		62,041.49
Mississippi	52,086.56	1,217.79	307.22	328.10	1,217.05	632.31	694.12	11,041.07	9,786.50			77,310.72	1,300.00	78,610.72
Missouri	56,015.66	906.20	310.81	298.45	692.63	1,718.95	833.75	18,727.36	2,511.02	454.32	706.58	83,175.73		83,175.73
Montana	14,998.84	29.05		67.05	56.87		156.22	664.31	714.97			16,687.31		16,687.31
Nebraska	35,938.47	155.16	29.76	.81	120.00	441.20	452.52	2,324.75	2,042.49			41,505.16		41,505.16
Nevada	2,955.00			.77							6.75	2,962.52		2,962.52
New Hampshire	8,536.31	170.64		12.95	63.00	72.90	190.55	137.36	32.64			9,216.35		9,216.35

New Jersey	26,056.62	477.81	9.65		196.00	177.50	340.87	5,910.57	696.33			33,865.35		33,865.35
New Mexico	10,998.92	39.00	21.16		246.73		259.91	4,054.97	105.00			15,725.69		15,725.69
New York:														
Cornell	65,465.12	2,500.72	147.18	65.88	1,068.80	21.75	1,957.62	15,985.59	4,902.76			92,115.42	.89	92,116.31
State	6,358.44							587.24	3,289.46			10,235.14		10,235.14
North Carolina	84,000.87	4,365.27	347.60	402.63	268.86	282.19	4,050.33	21,208.30				114,926.05		114,926.05
North Dakota	24,988.47		1.75	.87			69.57	490.43			860.50	26,411.59		26,411.59
Ohio	83,520.13	666.70	62.09			65.22	252.19	11,949.44	4,515.41	496.29		101,527.47		101,527.47
Oklahoma	39,449.59	1,512.18	624.24		269.12	153.64	3,147.27	10,122.08	13,457.87	4,673.03		73,409.02		73,409.02
Oregon	22,935.07	382.45	1.88	38.66			33.13	530.60	767.74			24,689.53		24,689.53
Pennsylvania	127,972.79	3,720.95	12.60			3,996.63	62.80	7,985.60	2,848.22			146,599.59	.01	146,599.60
Puerto Rico	38,859.12	808.02	4.10		904.13		287.11	14,700.92	2,084.31			57,647.71		57,647.71
Rhode Island	2,383.91	125.33					100.00	43.87				2,653.11		2,653.11
South Carolina	51,185.20	327.51	72.64	210.21	1,062.48	95.67	1,359.88	6,306.99	3,724.01			64,344.59		64,344.59
South Dakota	17,049.61	593.00	110.46	24.43		161.80	117.69	6,073.65	1,952.10			26,082.74		26,082.74
Tennessee	69,791.64	1,043.48	132.63	14.59	150.69	5.70	1,923.11	7,547.37	2,846.58	108.30		83,564.09		83,564.09
Texas	139,016.11	2,659.97	111.57	354.47	207.43	136.79	2,146.22	9,358.95	7,138.76	82.95	75.26	161,288.48	.34	161,288.82
Utah	10,857.87	363.81	4.06				44.48	60.19	6.50			11,336.91		11,336.91
Vermont	9,178.75	111.51	3.51	44.99	63.77		227.62	956.11	395.86		292.68	11,274.80		11,274.80
Virginia	63,873.39	595.11	20.58	61.41	11.33	483.00	918.92	9,839.62	1,231.83			77,035.19	8.04	77,043.23
Washington	25,329.94	585.80	159.55	.50			47.37	5,105.57	4,037.14		760.00	36,025.87		36,025.87
West Virginia	52,293.23	1,831.63	17.58		1.12	323.08	19.27	4,528.82	1,499.40			60,514.13		60,514.13
Wisconsin	59,601.74	264.76	4.07			17.27	27.92	4,772.19	500.81			65,188.76		65,188.76
Wyoming	5,860.24	500.00	134.00			8.75	64.73	319.55	244.25	162.92		7,294.44		7,294.44
Total	2,130,541.61	43,499.69	4,167.07	2,491.33	10,518.80	18,415.78	42,994.48	275,051.91	111,165.44	12,349.50	7,386.05	2,658,581.66	2,686.34	2,661,268.00

TABLE 7.—*Expenditures and appropriations under the Research and Marketing Act of 1946, secs. 9 (b) 1 and 9 (b) 2, for the year ended June 30, 1948*

Station	Expenditures												Unexpended balances [1]	Allotment
	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	$30,084.55	$2,694.08	$285.29	$122.36	$935.67		$1,259.06	$4,874.50	$13,068.11	$502.45		$53,826.07	$5,342.71	$59,168.78
Arizona	7,521.19	1,991.97	8.60	64.54		$11.50		920.18	1,044.33			11,562.31	4,182.71	15,745.02
Arkansas	18,404.57	3,126.06		270.46	10.00		105.17	2,175.79	4,555.95	6,384.00	$81.24	35,113.24	14,264.11	49,377.35
California	9,105.56	370.35					833.15	2,356.64	11,124.89			23,790.59	21,918.15	45,708.74
Colorado	8,865.69	696.00	48.60	16.30	274.34		82.33	1,824.81	563.31		262.26	12,633.64	8,237.68	20,871.32
Connecticut:														
State		23.62	1.17				40.46	194.70	2,234.09			2,494.04	6,528.65	9,022.69
Storrs	3,897.00		42.31	3.00								3,942.31	5,080.38	9,022.69
Delaware	2,043.97	623.26	210.00					246.93	210.00			3,334.16	8,816.57	12,150.73
Florida	7,076.06	1,370.20					111.35	3,520.75				12,078.36	13,394.75	25,473.11
Georgia	36,363.93	2,424.68	203.26	194.85		14.78	829.82	9,593.54	7,408.93	677.79		57,711.58	2,766.06	60,477.64
Hawaii	4,185.00						5.50	2.09				4,192.59	10,032.61	14,225.20
Idaho	4,195.67	3,059.30	22.29	77.67	6.00		41.96	966.00	4,706.09			13,074.98	4,727.50	17,802.48
Illinois	12,044.89	1,295.20	1.76	3.00			54.40	1,709.58	1,913.67		122.09	17,144.59	35,791.74	52,936.33
Indiana	10,550.21	616.93	13.47	3.71			83.10	4,355.57	6,314.06			21,937.05	21,616.31	43,553.36
Iowa	29,109.73			.40			172.63	6,479.69	1,415.00			37,177.45	7,766.20	44,943.65
Kansas	16,811.79	1,043.50		44.80	120.05		544.45	3,331.20	8,940.93			30,836.72	2,975.13	33,811.85
Kentucky	31,521.50	3,604.92	11.72	9.20			6.32	2,296.16	1,117.77			38,567.59	19,134.89	57,702.48
Louisiana	9,721.34	2,114.56	393.81	42.83	40.66		81.53	3,600.59	2,628.61	1,852.40		20,476.33	22,112.89	42,589.22
Maine	10,801.71	3,492.43	14.35	95.40	185.90		1,412.72	882.07	2,104.92			18,989.50		18,989.50
Maryland	10,220.10	372.34	30.40				750.00	2,390.67	3,828.30			17,591.81	5,435.96	23,027.77
Massachusetts	8,012.93	896.20		62.50			160.00	1,538.39	4,600.27	2,605.26		17,875.55		17,875.55
Michigan	18,385.55	1,353.13	26.48	156.42		528.15	2,716.57	5,438.76	4,540.07			33,146.13	14,410.17	47,556.30
Minnesota	6,342.17	1,008.32	192.80	3.00			74.09	3,159.83	1,101.39			11,881.60	32,157.01	44,038.61
Mississippi	27,214.98	3,051.01	358.45	278.54	335.22		704.65	8,840.84	3,993.37	557.01		45,334.07	12,563.27	57,897.34
Missouri	24,229.00	1,098.94	97.48	272.70	323.71	75.75	556.41	5,219.62	5,314.35	137.50	254.57	37,580.03	15,439.59	53,019.62
Montana	11,081.27	507.62	17.37	83.90			262.91	343.49	2,117.76			14,414.32	2,842.37	17,256.69
Nebraska	12,745.62	1,251.02	8.74			42.67	90.35	6,162.75	2,312.28			22,613.43	6,258.09	28,871.52
Nevada	5,183.14	486.95	7.71	22.49	299.69		22.39	1,323.79	3,348.13		175.00	10,869.29		10,869.29
New Hampshire	2,544.74	537.79	9.32	4.58			150.00	10.44	2,407.06			5,663.93	7,887.06	13,550.99

New Jersey	7,358.18	461.76	76.30		15.00		968.58	919.35	2,603.00	8,796.83		21,199.00		21,199.00
New Mexico	2,134.99	1,404.47		16.10	56.50			669.54	947.29			5,228.89	12,157.70	17,386.59
New York:														
Cornell	16,904.00	2,528.50	3.45	7.42	676.72		610.73	1,811.50	8,063.93			30,606.25	14,705.12	45,311.37
State	621.00							841.71	466.85			1,929.56	3,105.03	5,034.59
North Carolina	30,733.02	1,791.70	101.22	316.60	25.09	37.90	2,555.22	19,646.47		1,312.00		56,519.22	15,989.82	72,509.04
North Dakota	15,298.37	1,611.19	41.72		8.32		37.94	3,336.10	15.00		197.25	20,545.89	1,613.30	22,159.19
Ohio	13,832.51	941.47						1,443.54	4,145.35			20,362.87	37,110.38	57,473.25
Oklahoma	20,111.73	604.28	2.06	19.84			1,192.66	8,670.51	4,180.89	5,150.00		39,931.97	5,033.77	44,965.74
Oregon	11,124.61	743.72	39.55	2.30			11.50	109.03	1,055.83			13,086.54	8,187.04	21,273.58
Pennsylvania	32,959.54	7,878.38	14.55				60.25	748.57	11,087.85	2,572.04		55,321.18	9,860.84	65,182.02
Puerto Rico	25,846.61	818.14	12.71				15.00	1,740.28	2,634.99			31,067.73	15,074.14	46,141.87
Rhode Island	5,697.97	31.50		.45				1,423.50	12.00			7,165.42	3,656.12	10,821.54
South Carolina	21,804.02	4,726.93	26.93	344.12	324.83		308.34	3,262.04	8,395.97			39,193.18	5,234.74	44,427.92
South Dakota	11,192.80	1,086.73	.75	9.70			130.56	2,261.25	1,365.00			16,046.79	5,412.09	21,458.88
Tennessee	26,786.04	1,749.17	298.61	58.70	429.07		299.05	12,375.21	6,395.08	101.00		48,491.93	8,317.33	56,809.26
Texas	49,406.57	3,168.42	82.54	466.60	161.51	15.73	1,092.33	4,218.53	5,802.18			64,414.41	28,353.84	92,768.25
Utah	10,643.72	248.01	75.70				153.40	1,584.51	981.38	100.00		13,786.72	867.84	14,654.56
Vermont	6,572.86	590.02	5.74	1.87		27.50	186.04	1,697.77	833.35	118.90	71.78	10,105.83	4,489.47	14,595.30
Virginia	32,807.56	4,287.35	46.81	113.87	385.00	35.00	165.74	2,807.96	2,375.66	4,268.64		47,293.59	1,875.90	49,169.49
Washington	7,863.84	866.40	21.72				54.32	5,154.46	2,906.88		47.50	16,915.12	8,864.13	25,779.25
West Virginia	10,217.64	1,701.84					48.39	1,503.57	1,911.38			15,382.82	20,453.58	35,836.40
Wisconsin	12,837.72	1,184.79	20.45	2.10	3.90	21.15	13.25	6,518.76	14,448.99			35,051.11	8,961.21	44,012.32
Wyoming	2,046.92	76.00		10.00				41.45	447.75			2,622.12	10,412.55	13,034.67
Total	753,067.08	77,611.15	2,876.19	3,202.32	4,617.18	810.13	19,054.62	166,544.98	183,990.24	35,135.82	1,211.69	1,248,121.40	541,418.50	1,789,539.90

[1] These unexpended balances by provisions of Title I, sec. 9 (a) of the Research and Marketing Act remain available for expenditure during the fiscal year ending June 30, 1949.

TABLE 8.—*Expenditures and appropriations under the Research and Marketing Act of 1946, section 9 (b) 3, for the year ended June 30, 1948*

Station	Expenditures												Unexpended balances [1]	Allotment
	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	$1,261.80	$3,472.04	$25.52	$44.04	$265.66		$52.84	$408.35	$4,812.85			$10,343.10	$1,656.90	$12,000
Arizona	1,090.52	519.68	12.05	18.42				460.50	946.92			3,048.09	1,701.91	4,750
Arkansas	6,832.84	2,200.37		6.74				1,296.01	2,820.54		$25.00	13,181.50	18.50	13,200
California	3,437.01	4.60					86.80	45.10				3,573.51	726.49	4,300
Colorado	3,341.10	2,240.11		32.78	232.81		153.98	2,513.48	2,152.84			10,667.10	7,532.90	18,200
Connecticut:														
State														
Storrs	2,100.00	12.81						87.26				2,200.07	49.93	2,250
Delaware													2,000.00	2,000
Florida		3,098.82						13.39	1,580.79			4,693.00	2,207.00	6,900
Georgia	4,362.43	1,087.75	1.85	1.34	65.00		19.39	226.70	3,531.00			9,295.46	5,504.54	14,800
Hawaii														
Idaho	9,062.10	95.00						3,256.50	1,086.40			13,500.00		13,500
Illinois	10,372.20	2,382.52					8.72	55.70	149.64		193.46	13,162.24	9,237.76	22,400
Indiana	391.00	1,354.63										1,745.63	7,654.37	9,400
Iowa	8,547.31	4,328.70	35.90	278.48		$165.11		1,931.80	270.84			15,558.14	23,741.86	39,300
Kansas	2,270.07	515.32					33.11	128.24				2,946.74	1,853.26	4,800
Kentucky	600.00	82.59		1.95								684.54	1,815.46	2,500
Louisiana	3,243.06	901.74	9.18	28.00			9.49	340.32	496.88			5,028.67	6,271.33	11,300
Maine	11,734.14	4,293.01	14.85	88.15	31.80	50.00	436.67	339.33	1,487.05			18,475.00		18,475
Maryland	1,158.87						95.00	309.06	3,216.63			4,779.56	1,220.44	6,000
Massachusetts	5,850.00											5,850.00	900.00	6,750
Michigan	3,031.12	2,274.64	1.84	9.47	50.39	34.13	44.40	669.12	662.49			6,777.60	7,422.40	14,200
Minnesota	2,432.71	3,170.88			26.25		28.23	1,029.11	88.49			6,775.67	9,774.33	16,550
Mississippi	20,811.44	991.05	106.62	109.85	.75	38.57	6.50	1,389.62	2,575.03			26,029.43	3,570.57	29,600
Missouri	2,243.02	1,142.63	18.18	1.35	6.50		123.00	2,209.84	612.68		35.83	6,393.03	8,256.97	14,650
Montana	523.56	1,057.08		146.62		491.39	70.71	82.63				2,371.99	1,428.01	3,800
Nebraska	2,098.37	339.73	23.88	18.73			1,154.18	1,194.73	450.14			5,279.76	120.24	5,400
Nevada	350.00	130.45		2.05							17.50	500.00		500
New Hampshire	2,566.66	593.05	8.12	9.47		6.55		11.22				3,195.07	4.93	3,200

New Jersey	498.56	245.65	5.87			79.84		277.57	3,791.05			4,898.54	12,501.46	17,400
New Mexico	1,670.45		137.20					6.61				1,814.26	4,985.74	6,800
New York:														
Cornell	14,502.82	4,741.17	1.31	214.31	360.33		403.17	541.64	612.81			21,377.56	3,622.44	25,000
State														
North Carolina	10,669.49	2,803.00	101.38	29.83			501.80	1,319.17	3,426.27			18,850.94	7,849.06	26,700
North Dakota		376.12										376.12	2,123.88	2,500
Ohio	4,214.14	879.09						87.32	102.50			5,283.05	966.95	6,250
Oklahoma	363.80	642.11					602.01	33.00	2,304.16			3,945.08	2,854.92	6,800
Oregon	20,919.45	10,857.27	769.28	506.08	82.15	243.63	845.27	4,081.26	8,829.72			47,134.11	15,365.89	62,500
Pennsylvania	5,023.62	1,561.94	15.96	127.15				67.34	4,781.91			11,577.92	2,097.08	13,675
Puerto Rico	500.00						32.00	682.67	1,285.33			2,500.00		2,500
Rhode Island	4,682.25	2,194.87					334.16	443.73	49.50			7,704.51	470.49	8,175
South Carolina	9,443.65	2,556.27	76.74	116.10			60.25	1,028.76	6,204.68			19,486.45	2,713.55	22,200
South Dakota	1,798.31	141.08	60.03					970.58	285.00			3,255.00	2,145.00	5,400
Tennessee	8,406.54	1,934.79	27.41	132.89			78.10	134.71				10,714.44	885.56	11,600
Texas	18,450.72	1,676.46	3.72	109.06				140.00	256.30			20,636.26	18,113.74	38,750
Utah	5,072.66	1,200.70	1.00				156.46	969.64		$875.63		8,276.09	2,523.91	10,800
Vermont	382.32	453.45		8.00			48.04	22.34	82.82			996.97	3.03	1,000
Virginia	774.60	5,767.27	1.27					175.22	81.64			6,800.00		6,800
Washington	8,425.67	2,895.80	1.00	81.65		43.58		338.57	496.73		60.50	12,343.50	6,156.50	18,500
West Virginia		457.97							542.74			1,000.71	2,174.29	3,175
Wisconsin	4,233.13	1,590.23	25.19	44.22	8.00		55.00	2,393.86	1,980.30			10,329.93	3,720.07	14,050
Wyoming	3,525.30	2,414.73		22.71			453.09	6.50	377.93			6,800.26	2,849.74	9,650
Total	233,268.81	81,679.17	1,485.35	2,189.44	1,129.64	1,152.80	5,892.37	31,718.50	62,432.60	875.63	332.29	422,156.60	198,793.40	620,950

[1] These unexpended balances by provisions of Title I, section 9 (a) of the Research and Marketing Act remain available for expenditure during the fiscal year ending June 30, 1949.

TABLE 9.—*Expenditures from non-Federal funds for the year ended June 30, 1948*

Station	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	Unexpended balances
Alabama	$374,596.47	$17,218.58	$6,021.92	$4,264.33	$8,872.91	$1,603.17	$36,364.43	$182,372.76	$70,449.65	$32,997.85		$734,762.07	$310,773.61
Arizona	199,645.91	6,374.40	504.98	2,068.80	7,063.60	6,650.66	8,929.44	22,437.56	36,952.48			290,627.83	
Arkansas	202,073.71	17,256.87	2,335.12	2,309.58	11,874.59	168.95	9,386.18	80,859.50	45,147.32	4,218.24	$2,780.62	378,410.68	40,877.91
California	2,408,793.14	114,086.46	12,196.62	30,717.58	32,310.75	57,491.89	190,740.57	380,028.62	313,179.40			3,539,545.03	228,688.00
Colorado	212,723.62	8,570.82	1,728.09	2,577.33	15,007.01	1,936.81	9,194.81	80,618.31	22,825.21		3,115.49	358,297.50	106,939.15
Connecticut:													
State	195,167.33	1,169.80	37.86	1,425.19	5,801.32	4,735.13	7,517.39	22,593.49	8,100.49	1,148.00		247,696.00	39,803.28
Storrs	114,528.59	2,020.21	284.36	332.14	165.60	7.80	1,696.60	32,268.36	4,301.61	40,168.75		195,774.02	13,897.30
Delaware	70,810.52	3,021.82	290.47	1,950.06	3,290.41	267.59	3,515.59	60,040.13	9,914.47	15,534.87		168,635.93	30,968.27
Florida	1,108,294.17	45,402.45	5,925.10	9,286.86	19,225.88	16,014.61	25,414.58	303,786.06	124,740.13	391,033.31		2,049,123.15	521,778.43
Georgia	152,494.96	4,873.40	974.78	2,217.94	6,330.49	5,361.93	21,400.34	77,428.06	36,503.74	40,553.67		348,139.31	68,111.26
Hawaii	295,012.45	4,755.43	1,025.01	2,132.88	6,643.95	85.59	16,713.31	44,440.96	19,903.56			390,713.14	5,180.96
Idaho	131,634.48	7,940.00	825.00	920.00	875.00	625.00	300.00	37,001.53	17,547.63	5,100.00		202,768.64	39,566.03
Illinois	856,407.83	60,000.00		20,000.00		40,000.00		301,603.05	114,823.87	1,290.68		1,394,125.43	
Indiana	717,540.10	21,906.41	8,668.78	9,259.49	24,367.61	13,270.93	63,442.52	442,039.48	159,350.94	47,740.29		1,507,586.55	549,073.87
Iowa	566,904.83	24,740.99	3,802.38	4,446.04		24,109.84		371,353.79	80,215.31			1,075,573.18	221,499.44
Kansas	249,319.07	7,115.13	2,374.72	2,067.09	7,150.23	231.07	25,402.04	97,779.20	41,792.35	17,117.36		450,348.26	152,582.35
Kentucky	307,674.14	17,166.71	1,518.67	2,636.91	895.12	24,729.52	11,016.57	72,677.87	19,092.27			457,407.78	
Louisiana	427,365.34	27,160.04	7,256.23	4,012.99	5,631.31	5,645.57	38,312.97	88,226.28	82,954.50			686,565.23	
Maine	142,544.25	15,397.54	4,399.26	1,624.82	20,981.66	3,458.50	11,586.61	35,475.44	14,391.02	11,803.59		261,662.69	41,187.71
Maryland	153,625.33	6,574.32	745.83	905.31	1,073.08	1,144.71	14,148.88	85,753.98	33,501.19	9,297.37		306,770.00	112,870.85
Massachusetts	246,717.05	5,631.09	337.68	2,441.53	1,425.64	4,042.65	1,651.03	29,296.68	21,350.30	588.92		313,482.57	28,730.97
Michigan	429,960.55	19,068.74	1,290.49	1,371.09	2,156.70	24,100.58	13,047.48	63,490.84	31,776.52	189.95		586,452.94	9,157.76
Minnesota	814,102.02	19,397.01	6,477.44	6,158.71	19,110.74	4,781.11	106,557.31	205,502.15	93,075.45	74,566.38		1,349,728.32	
Mississippi	432,410.25	16,140.51	10,315.67	4,429.25	10,130.32	9,813.20	33,037.54	266,144.84	127,221.41	179,320.46	20,560.61	1,109,524.06	101,468.45
Missouri	199,061.92	9,930.85	1,944.12	2,458.06	8,537.81	19,050.99	35,296.69	89,961.83	26,363.44	1,446.64		394,052.35	242,090.14
Montana	232,956.53	8,862.28	3,883.40	3,688.04	21,265.39	2,377.49	8,781.02	126,959.68	63,413.73	53,525.24	5,997.44	531,710.24	218,620.71
Nebraska	223,652.51	9,171.18	11,357.10	4,509.38	2,293.04	623.36	20,002.24	282,450.10	119,100.98			673,159.89	
Nevada	20,072.59	1,744.31	905.93	419.11	2,996.09	468.08	2,843.57	12,283.53	6,023.36	1,252.40	138.00	49,146.97	4,106.10
New Hampshire	37,187.67	1,548.05	104.24	187.07		130.00	214.44	5,855.59	5,043.43			50,270.49	14,651.13
New Jersey	510,961.74	22,300.10	1,672.01	384.07	30,590.29	8,100.99	31,599.02	114,286.89	29,207.70		6.22	749,109.03	7,670.48
New Mexico	65,291.04	1,777.02	250.26	309.00	4,998.28	1,342.31	7,226.97	18,688.99	5,176.17	40,928.05	3,935.39	149,923.48	59,842.41
New York:													
Cornell	1,139,967.05	30,420.40	3,696.30	11,060.14	53,946.68	4,541.03	26,155.80	203,209.43	140,199.39	5,697.07		1,618,893.29	
State	491,394.95	9,196.95	1,058.04	4,141.91	12,419.50	9,694.85	12,975.36	58,263.96	26,053.50			625,199.02	

North Carolina	436,083.33	20,641.08	3,337.70	5,057.41	8,327.86	9,656.92	32,425.91	94,891.40	95,507.15	42.804.10		748,732.86		
North Dakota	193,461.64	6,729.83	1,314.70	1,662.86	2,316.27	5,307.63	37,264.14	62,336.65	47,981.05	44,332.06	3,171.17	405,878.00	72,828.95	
Ohio	554,192.96	11,398.03	3,432.74	3,885.20	40,071.12	7,186.14	13,270.00	184,888.39	65,816.96	195,750.04		1,079,891.58	1,423,519.37	
Oklahoma	373,587.85	18,932.21	1,951.34	2,321.63	16,140.77	5,299.89	36,764.65	211,183.62	53,841.51	50,800.70		770,824.17	107,673.67	
Oregon	551,963.29	37,707.81	4,051.89	7,316.32	11,877.39	7,081.89	27,325.54	132,206.52	63,765.20		37,235.00	880,530.85		
Pennsylvania	485,529.57	35,453.90	96.20	3,209.46	6,082.07	4,685.29	8,487.84	125,020.47	48,503.85			717,068.65	64,025.19	
Puerto Rico	226,332.01	4,206.58	1,780.63	2,601.44	9,855.63	15,000.00		63,950.70	13,099.91	2,100.00		338,926.90		
Rhode Island	65,736.65	3,043.68	73.08	268.14	36.76	105.66	1,779.74	20,940.16	3,969.09	900.00		96,852.96	19,850.01	
South Carolina	224,134.28	8,825.25	144.53	2,505.91	5,623.73	1,443.52	47,546.45	123,884.48	80,163.52	12,308.33		506,580.00	35,887.41	
South Dakota	105,557.25	6,840.33	1,694.12	2,345.41	754.96	637.70	6,424.71	82,532.05	21,603.57			228,390.10	15,428.89	
Tennessee	199,627.69	6,515.64	2,859.58	2,241.74	3,030.44		18,482.78	103,171.05	39,081.65	9,896.41		384,906.98		
Texas	923,457.24	26,250.67	2,737.17	5,642.23	22,147.96	10,134.81	36,928.00	249,331.89	281,553.29	142,281.06	25,628.60	1,726,092.92	679,077.58	
Utah	192,938.93	17,341.06	1,868.06	3,017.63	6,093.64	4,867.09	10,915.29	47,757.85	57,415.04	43,710.57		385,925.16	19,919.19	
Vermont	29,333.65	2,016.84	512.63	495.01	1,273.34	317.76	5,339.81	3,893.27	7,700.59	382.60	707.06	51,972.56	7,803.80	
Virginia	278,934.80	19,999.81	3,634.82	3,201.26	7,873.59	5,733.70	10,012.78	51,327.69	36,134.55	13,118.55		429,971.55	19,112.40	
Washington	707,762.76	34,811.48	5,020.41	5,071.49	12,256.11	6,170.83	17,479.73	183,952.52	86,517.85	31,034.36	17,484.90	1,107,562.44		
West Virginia	107,219.91	5,138.15	483.67	1,520.84	8,094.72	6,131.68	17,660.22	74,303.43	21,478.36	15,211.67		257,242.65	47,119.54	
Wisconsin	1,337,260.24	27,831.00	3,725.00	2,914.00	7,015.00	7,314.00	54,987.00	272,948.00	21,632.00			1,735,626.24		
Wyoming	111,008.80	9,596.92		5,383.93	5,975.50	1,767.52	5,839.30	63,369.16	44,201.69	5,181.52		252,324.34	56,175.10	
Total	20,835,014.96	871,220.14	142,926.13	207,374.61	522,277.86	395,447.94	1,183,405.19	6,447,068.24	3,039,659.35	1,585,331.06	120,760.50	35,350,485.98	5,738,557.67	

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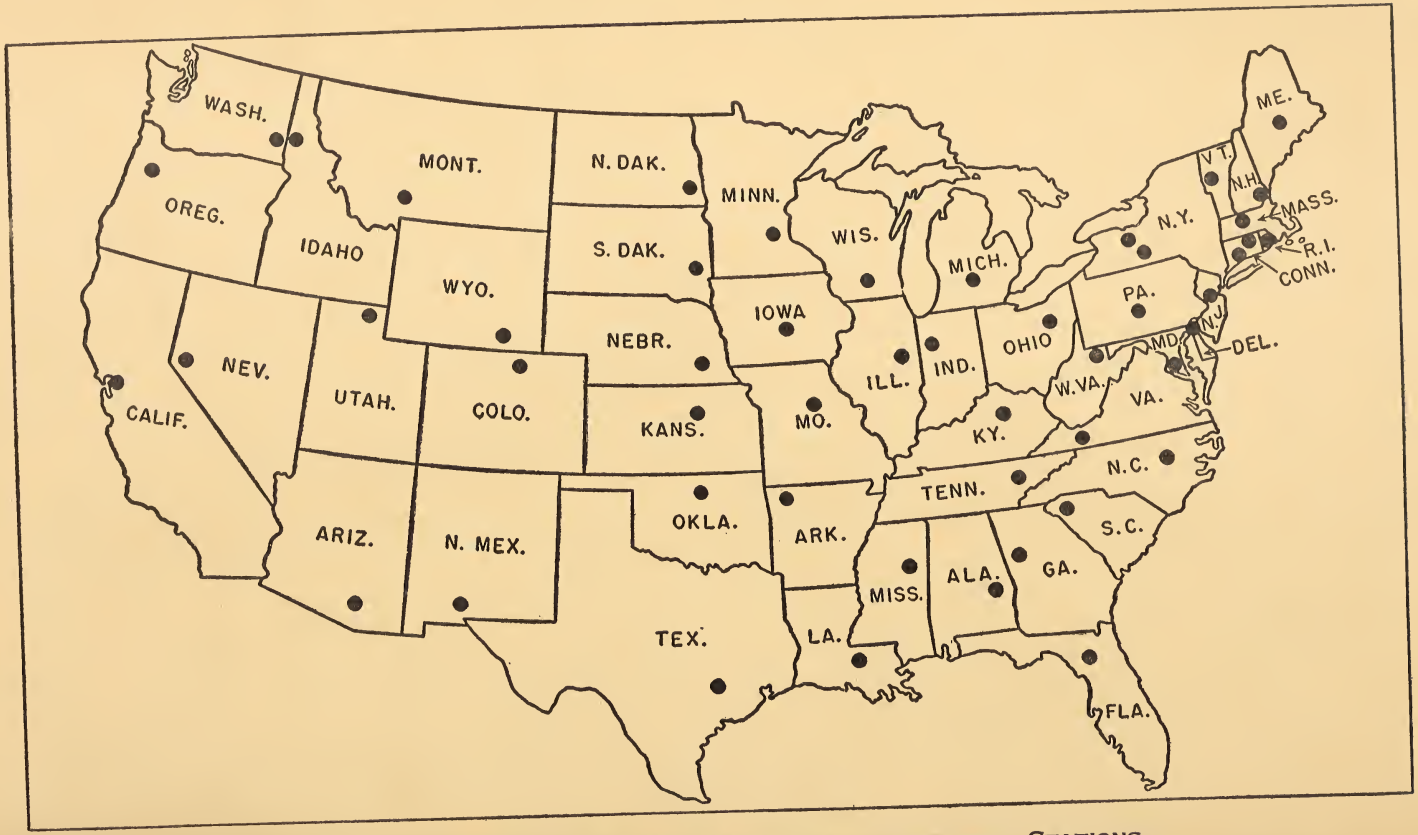

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