Historical Document
Kansas Agricultural Experiment Station

AGRICULTURAL EXPERIMENT STATION

KANSAS STATE COLLEGE OF AGRICULTURE
AND APPLIED SCIENCE

MANHATTAN, KANSAS

NINTH BIENNIAL REPORT OF THE DIRECTOR

1936-1938

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KANSAS AGRICULTURAL EXPERIMENT STATION

Manhattan, Kansas

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†C. O. JOHNSTON, Plant Pathology (Leaf rust).
†C. H. FICKE, Plant Pathology (Wheat footrot).

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W. H. MARTIN, Dairy Manufacturing.
W. H. RIDDELL, Dairy Production.
W. J. CAULFIELD, Dairy Manufacturing.
GLEN H. BECK, Dairy production.

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R. L. PARKER, Bee Investigations (State Apiarist).
R. H. PAINTER, Staple Crop Insects.
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H. R. BRYSON, Staple Crop Insects.
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†G. B. WAGNER, Flour Mill Insect Investigations.
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†H. H. WALKDEN, Cereal and Forage Insect Investigations.
†W. T. EMERY, Cereal and Forage Insect Investigations.
†H. D. YOUNG, Investigations in Fumigants.

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MARTHA M. KRAMBER Human Nutrition (On leave).
BERNICE, L. KUNERTH, Technician.
KATHARINE HESS, Clothing and Textiles.
HAZEL FLETCHER, Clothing and Textiles.
MYRTLE GUNSELMAN, Household Economics.

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†KARL F. FINNEY, Regional Wheat Research Laboratory.
†MAX E. MCCLUGGAGE, Regional Wheat Research Laboratory.

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HAROLD M. SCOTT, Physiology.
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L. M. RODERICK, Animal Pathology.
C. H. KITSELMAN, Bang's Disease Investigations.
*HERMAN FARLEY, Anaplasmosis Investigations.
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FLORENCE STEBBINS, Genetics.
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*L. E. WENGER Forage Crops and Diseases.
LAWRENCE REED, Assistant to Superintendent.
†A. F. SWANSON, Cereal Crops and Diseases.

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†F. L. TIMMONS, Bindweed Investigations.
†A. L. HALLATED, Dry Land Agriculture.
†F. G. ACKERMAN, Soil Erosion Investigation.

COLBY BRANCH STATION

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TOM BENTLEY, Dairyman.

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ALVIN E. LOWE, Assistant in Agronomy.

TRIBUNE BRANCH STATION

T. B. STINSON, Superintendent.

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LETTER OF TRANSMITTAL

OFFICE OF DIRECTOR, June 30, 1938.

TO His Excellency, Walter A. Huxman, Governor of Kansas:

I have the honor to submit herewith the report of the Agricultural Experiment Station of the Kansas State College of Agriculture and Applied Science for the biennium ending June 30, 1938. The report includes a brief history of the station with major accomplishments since its organization fifty years ago. The report also contains brief descriptions of the work in progress during the past biennium, summaries of some of the more significant results, changes in the personnel of the station staff, a list of the publications of the station and of the published scientific contributions of the station staff, and a statement of receipts and expenditures during the biennium.

L. E. CALL, *Director.*

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DIRECTOR'S REPORT[1]

Fifty Years of Service to Kansas Agriculture, 1888-1938

The close of the biennium marked the completion of fifty years of service to Kansas agriculture by the Kansas Agricultural Experiment Station. The station was organized as a result of the acceptance by resolution of the Kansas legislature on March 4, 1887, of the Hatch act, previously enacted by the federal congress "to establish agricultural experiment station in connection with the colleges established in the several states." By this resolution of the legislature the responsibility for the execution of the provisions of the Hatch act was vested in the Board of Regents of the Kansas State Agricultural College. No official action was taken by the Board of Regents prior to the passage by congress of a special appropriation bill, approved by President Harrison on February 1, 1888, from which the station received $15,000 toward the expenses of the current year.

The Board of Regents organized the Kansas station on February 8, 1888, and in a series of resolutions provided, among other things, (1) that the general executive management of the station should be under the control of a Council, consisting of the president of the College and the professors of Agriculture, Horticulture and Entomology, Chemistry, Botany and Veterinary Science; (2) that the president of the College should be ex officio chairman of the Council, and the professor of Agriculture ex officio director and general superintendent in executing the plans of the Council; (3) after detailing minutely the duties of each office, it was stated that each member of the Council should have full control of the work assigned to his department, subject to the ratification of the Council. The Council thus organized met for the first, time February 10, 1888.

The work of the station was directed by Council action during the early years, but expansion of activities created a need for changes in the organization of the station. Accordingly, a recommendation was presented to the Board of Regents, and adopted January 18, 1900, providing in part that "the experiment station shall be managed by a Council to consist of the President of the College who shall be chairman ex officio, an agriculturist, a botanist, a chemist, an entomologist and horticulturist, a veterinarian, and such others as the Board of Regents may designate. A member of the Council named by the Board shall be styled Director." J. T. Willard, chemist of the station, was appointed Director at this time.

By action of the Board of Regents in September, 1905, greater responsibilities were placed upon the directors of the station. A

1. Contribution No. 64 from the director's office.

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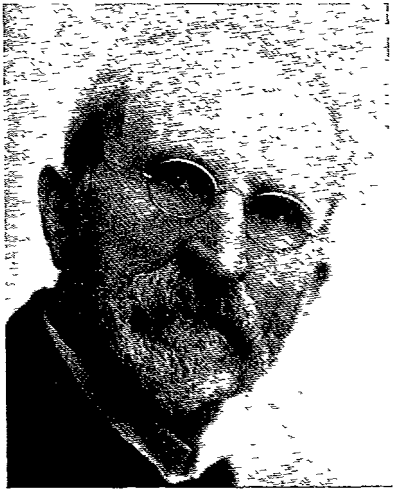
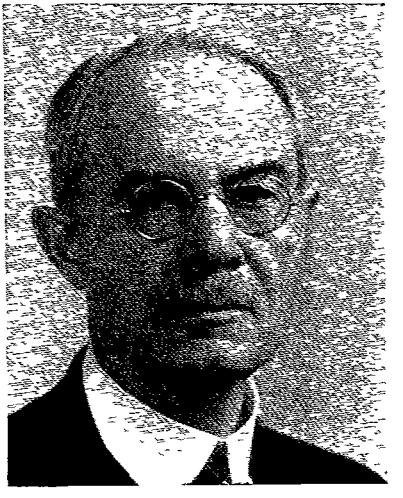


E. M. SHELTON, professor of agriculture and ex officio director of the Agricultural Experiment Station from 1888 to 1890.

J. T. WILLARD, director of the Agricultural Experiment Station from 1900 to 1906.



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CHARLES W. BURKETT director of the Agricultural Experiment Station from 1906 to 1908

E. H. WEBSTER, director of the Agri cultural Experiment Station from 1908 to 1913.

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resolution of the Board stated that "all the work of the station, whether at Manhattan, Hays, or McPherson, or elsewhere shall be under the immediate charge of the Director, and the Director shall be held responsible for the management of all work, without regard to locality."

It is significant that those who were responsible for the early work of the station realized the need for agricultural research on a statewide basis. As early as 1894 experiments on irrigation and the conservation of moisture were begun on 10 acres of land leased at Garden City, and at Oberlin. The experiments at Garden City were terminated in December of 1895, and at Oberlin in 1897. In 1896 the Board of Regents accepted from the State Board of Irrigation a lease on 40 acres of land near the city of Oakley, upon which was a well with pump and reservoir. The station was to experiment at will upon the land, its only obligation and expense being to keep a man in charge to run the engine, and to report regularly to the Board of Irrigation. This project was abandoned in 1897.

Later, outlying experimental work was undertaken by the station at the state forestry stations at Dodge City and Ogallah, and work with cereal crops at McPherson. All of this work was consolidated later with the work of the central and branch stations and work at these points discontinued.

The Fort Hays Branch Experiment Station was established in 1901 on a tract of about 3,600 acres of land, a part of the Fort Hays Military Reservation accepted by the state from the federal government for the establishment of a branch of the state normal school, an experimental station of the agricultural college, and a public park.

In 1907 cooperative work was started at this station with the Bureau of Plant Industry of the United States Department of Agriculture. Through this cooperation the station was enabled to undertake comprehensive experimental work in crop rotations and tillage practices under limited rainfall conditions. This work has been continued to the present time and has contributed much reliable information regarding moisture conservation and soil management practices that has proved practical under west-central Kansas farm conditions.

The legislature of 1907 appropriated funds with which to establish a branch station at Garden City on land provided by Finney county and leased for a period of 99 years to the station. Irrigation has been a major line of experimental work at this station.

Other branch stations were established at Tribune in 1911 and at Colby in 1914. These four branches (Hays, Garden City, Tribune, and Colby) together with 12 outlying experiment fields in eastern and southern Kansas provide the facilities that are now available for outlying experimental work.

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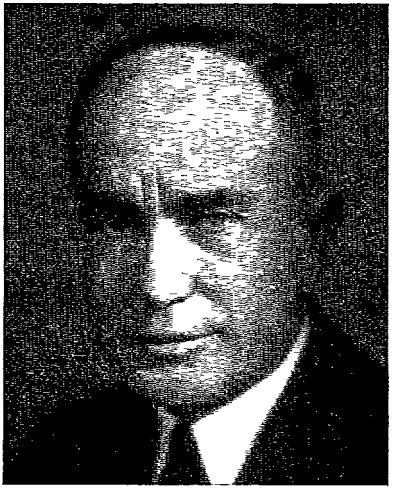
W. M. JARDINE, director of the Agricultural Experiment Station from 1913 to 1918.

F. D. FARRELL, director of the Agricultural Experiment Station from 1918 to 1925.



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FINANCIAL SUPPORT OF EXPERIMENTAL WORK

The station receives financial support from both state and federal funds. The $15,000 appropriated annually by the federal government under the Hatch act represented the sole continuing source of support for the station for many years. In 1906 congress passed the Adams act, authorizing additional federal support for fundamental research by the agricultural experiment stations. As a result of the act this station received, in increasing increments over a period of five years, additional funds until the total annual appropriation under the act reached $15,000, or a total for the two acts (Hatch and Adams) of $30,000.

In 1925 the federal congress passed the Purnell act which particularly authorized investigations in the fields of agricultural economics, rural life, and home economics. Under this act the station received gradually increasing appropriations until the year 1931. Since then the annual appropriation under this act has been $60,000.

The fourth act by the federal government authorizing support for experimental work at the stations was the Bankhead-Jones act, which became a law in 1935. Under this act the Kansas station received $37,525 for the last fiscal year. The total of all appropriations of federal funds for the support of the station under the four acts (Hatch, Adams, Purnell, and Bankhead-Jones) amounted to $127,525 for the fiscal year 1937-'38.

The first direct appropriation by the state legislature for investigational work was authorized in 1901 under an act to provide for the destruction of prairie dogs and gophers, and for experiments to that end. Under this act the Board of Regents of the State Agricultural College was duly authorized and directed to select some competent person to conduct the work. An appropriation of $5,000 was made to carry out the purpose of the act. The Board of Regents selected a member of the College staff to take charge of the experiments under the direction of the Station Council.

It was not until the station was well established through support from federal sources, however, that it received state support, except indirectly in the use of college land, buildings, laboratories and equipment. The legislature of 1903 made an appropriation of $24,900 for the current biennium for the beginning of experimental work at the Fort Hays Branch Experiment Station, authority for the establishment of which had been granted by the legislature of 1901. The legislature of 1907 increased this amount sufficiently to permit an enlargement of the scope of the work at the station. The legislature of 1907 also appropriated $1,000 "to be expended under the direction of the Board of Regents for experiments with bindweed." This money was expended chiefly for work at the Hays station.

It was not until the legislature of 1909 that the station received an appropriation from the state for the support of the work at Manhattan. Starting with an appropriation of $15,000 for that year, the station has continued to receive by direct appropriations by the

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legislature or through allotments from the general appropriation for the college, or from both, substantial amounts for the support of the work of the central station.

In 1923, at the request of the station, the legislature made an appropriation of $6,000 per annum to support work on five outlying experimental fields in southeastern Kansas. Since that time, increased appropriations for work of this character have been received until the total appropriation for the past year for the support of 12 experimental fields in eastern and southern Kansas was $21,000.

The station has received increased support from biennium to biennium from state sources until the total appropriations and allotments of state funds for the current year, including the appropriations for the branch stations, exceed the total of all amounts received from federal funds.

COÖPERATION WITH OTHER AGENCIES

It has been an established policy of the station from its inception to cooperate whenever possible with other agencies seeking to promote the welfare of agriculture. The close cooperation that has existed through the past fifty years between the station and the State Board of Agriculture was forecast in the Second Annual Report of the station, published in 1889. President George T. Fairchild, chairman of the Council of the Agricultural Experiment Station, noted in this report, "The Secretary of the State Board of Agriculture, Honorable Martin Mohler,has aided materially by giving extended circulation to several of the bulletins through reprinting them in the monthly or quarterly reports of the Board of Agriculture." This close cooperation with the State Board of Agriculture has continued to the present time. The Agricultural Experiment Station has made available to the State Board of Agriculture its facilities and personnel for analytical determinations of feeding stuffs, live stock remedies, fertilizers and dairy products. A state seed-testing laboratory has been maintained in cooperation with the board.

Coöperation, though less direct, has existed between the station and other state agencies serving agriculture, such as the Livestock Sanitary Commission in studies of livestock diseases, the Entomological Commission in insect and plant-disease control, the State Fish and Game Commission in wild-life studies, and with ether agencies. Farmers from all sections of the state have cooperated with the station in studies of problems in which they were particularly interested.

Agencies with which mutually profitable cooperative relations have existed, in addition to departments and commissions of the state of Kansas, and farmers of this state, are other state agricultural experiment stations, the United States Department of Agriculture, other agencies of the federal government, and many commercial agencies serving agriculture.

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Active cooperative work with the United States Department of Agriculture probably began at about the turn of the twentieth century. The Seventeenth Annual Report of the Experiment Station, dated 1903-'04, relates, "The Station has continued its cooperation with the Bureau of Plant Industry of the Department of Agriculture in experiments in testing and improving cereals. This work has been conducted at Halstead, in Harvey county, for a number of years."

Trials of 165 varieties of wheat and rye were conducted and reported in 1902-'03 at the Hays Branch Experiment Station in cooperation with the United States Department of Agriculture.

During the season of 1901 the experiment station at Manhattan, in cooperation with the Division of Agrostology of the United States Department of Agriculture, conducted a series of experiments in Harper county on range improvement.

Other early cooperative experiments with the Bureau of Plant Industry included rotation and tillage work for the conservation of moisture. These experiments were conducted at the Hays Branch Experiment Station.

This work has been extended to include work at the Garden City and Colby Branch Stations and has continued to the present time. Other cooperative work with the Bureau of Plant Industry relates to (1) production and breeding of small grains and corn, the study of wheat quality, the eradication of noxious weeds, and the control of cereal diseases in cooperation with the Division of Cereal Crops and Diseases; (2) alfalfa improvement, the control of alfalfa diseases, and forage-crop production in cooperation with the Division of Forage Crops and Diseases.

Work in cooperation with the Division of Soil Survey of the Bureau of Chemistry and Soils has included field work and the preparation for publication of detailed soil surveys of 22 counties in eastern Kansas, and a reconnaissance survey of the western half of the state. In cooperation with the Soil Conservation Service, a soil erosion experimental project has been maintained at the Fort Hays Branch Station, and cooperative studies have been conducted of soil erosion, sedimentation and water conservation, as well as the propagation of grass for erosion control.

The Bureau of Animal Industry has cooperated in many studies, among which are the following: Factors affecting the quality and palatability of meat and the fattening of range produced swine with the Division of Animal Husbandry, and anaplasmosis in cattle with the Division of Pathology.

In cooperation with the United States Forest Service, the work in the propagation and distribution of forest trees for planting in woodlots and shelterbelts has been carried out, as well as a survey of the forest resources of the state.

Cooperative work with the Bureau of Agricultural Economics has included studies in farm organization, farm adjustment, cost of pro-

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ducing farm products, land utilization, weather-crop relationships, and the marketing of farm products.

Cooperation with the Bureau of Agricultural Engineering has included a study of the storage of wheat under farm conditions.

Within the past three years, since the passage of the Bankhead Jones act, which made available funds for regional research laboratories, this station has cooperated with the United States Department of Agriculture and the agricultural experiment stations of the north central states in organizing and directing research at the regional soybean research laboratory at Urbana, Ill., at the regional swine-breeding laboratory of the north central states, and at the regional poultry-disease laboratory of the north central and northeastern states.

The Agricultural Experiment Station has served extensively during the past six years in cooperation with other agencies, especially the Agricultural Adjustment Administration, the Farm Security Administration, the Farm Credit Administration, and other agencies of the national recovery program. The station has supplied information to be used in formulating various portions of the programs as they relate to agriculture. Members of the staff have been consulted freely by these agencies, and in several instances have been borrowed by these agencies for brief periods of time to furnish advice and suggestions to those responsible for the programs. A number of station staff members have been granted leaves of absence and have been connected with the work of the Soil Conservation Service, the Farm Credit Administration, the Agricultural Adjustment Administration and the Farm Security Administration. In these ways the station has been able to render service of great value to the agricultural interests of the state and nation.

SOME ACHIEVEMENTS OF THE STATION DURING THE PAST FIFTY YEARS

To recount adequately the many accomplishments of the Kansas Agricultural Experiment Station during the past fifty years, since its establishment in 1888, obviously would be impossible. The record is best observed in the improved practices followed on the farms of the state that have resulted in higher living standards and superior home and farm conditions. Accepting its position as the major agricultural fact-finding agency of the state, the station has endeavored to supply helpful information to the farmers of the state in a timely manner and in such a way that it could be applied to the solution of the problems that have confronted agriculture during this period. In so doing, the station has had no small part in the accomplishments that during this period of fifty years have placed Kansas in the forefront as one of the leading agricultural states of the nation.

While it is impossible to recount in detail the accomplishments of the station during the past half century, it is possible to state the

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major objectives of the work of the station and to cite briefly examples of typical accomplishments toward the achievement of these objectives. The major objectives have been:

1. To develop facts in the field of agricultural economics that would aid farmers in the reduction of production and marketing costs, help them adjust production to demand, and to equalize taxation.
2. To develop basic information concerning the soils of Kansas, upon which to build a sound land-use program for the state.
3. To develop new and improved varieties of crop plants and to increase the efficiency of crop production. Emphasis has also been placed on the milling and baking qualities of wheat.
4. To develop improved methods of livestock feeding and management. and to secure information that would aid in the utilization of livestock products.
5. To discover methods by means of which the diseases, insects and other pests attacking crop plants might be controlled efficiently.
6. To study the diseases and pests of farm animals and to discover methods for their control.
7. To discover facts useful to the farm homemaker in order that the farm home may be more efficient, more healthful, and its environment more desirable for the farm family.

STUDIES IN AGRICULTURAL ECONOMICS

During the past fourteen years the Agricultural Experiment Station has issued monthly forecasts of the trends of the markets for agricultural products and of prices for wheat, corn, hogs, beef cattle, sheep and lambs, dairy products, poultry and eggs. These forecasts are based on exhaustive research which began several years before the first forecasts were issued. The Kansas station was a pioneer in this field. Through timely information of this character, as accurate as could be supplied from available basic information, farmers were able not only to take steps that would aid them in adjusting their production to demand, but also to market their products to better advantage than would have been possible without such timely marketing information.

Farm-management studies begun in 1915 have resulted in the reorganization of the agricultural problems of the state by type-of-farming areas and by types and sizes of farms within these areas. This work has resulted in the reorganization of the agricultural extension work so that it now is conducted by type-of-farming areas, and programs for the improvement of Kansas agriculture are based upon these areas and the sizes and types of farms within them. These studies have contributed much to the basic information required for program planning.

Studies in taxation in relation to agriculture were started in 1921. This station pioneered in this field, and the results of the studies have been widely used in Kansas and other states in improving taxation systems.

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DEVELOPING BASIC SOIL INFORMATION

Starting with the survey of Riley county, by Carter and Smith, of the Bureau of Chemistry and Soils, in 1906, the establishment of the soil-fertility plots on the station farm at Manhattan in 1909, the establishment of outlying experiment fields in 1923, and with the establishment of soils work at the four branch experiment stations, the station has developed a valuable fund of basic information concerning the soils of Kansas. These studies have been supplemented by the collection and analysis of soil samples taken from experimental plots and farms where definite systems of cropping have been practiced. The information secured in these ways provides the basic facts upon which to build a sound land-use program for the state. Such a program, when generally accepted and universally applied, will provide for the conservation of the soil resources of the state as a continuing source of wealth.

The rôle played by the reaction of the soil solution in the distribution and activity of free-living nitrogen-fixing bacteria was discovered and interpreted by the station. Also, investigations relative to the factors influencing available nitrogen and its significance as a factor in crop production in Kansas have contributed to the land-use problems of the state.

One of the earliest and most important moves toward the improved productivity of the soils of the state was the launching of the alfalfa-production program in the early days of the station. This crop proved to be well adapted to Kansas conditions and has played an important rôle in the restoration of nitrogen to the soils of the state.

An early study by the station of the ammonia, nitric, nitrate, and elemental nitrogen content of atmospheric water extending over a period of years definitely established the approximate quantity of nitrogen made available for plant growth through rain and snow.

INVESTIGATIONS IN THE PLANT INDUSTRIES

The station, in cooperation with the Bureau of Plant Industry, United States Department of Agriculture, and other stations, has made valuable contributions through the development of many new and improved varieties of field and horticultural plants, and through the development of methods that increased the efficiency of the production of these crops and improved the quality of them. Among such contributions are the following:

1. The station has developed, tested and distributed a number of varieties of crop plants that, because of resistance to disease, resistance to insects, early maturity, increased yield and other desirable qualities, have added materially to the wealth of Kansas and other states. Among the more valuable and better known of these are Kanred, Kawvale and Tenmarq wheat; Kanota oats; Flynn barley; Atlas sorgo. Kanred wheat was grown on several million acres of Kansas farm land at one time and still is a leading variety of wheat in this and several other states, and in some foreign countries. Kawrale is the most widely grown variety of wheat in eastern Kansas at this time, and Tenmarq is grown on two to three million acres in south central Kansas, Oklahoma and Texas.

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Kanota is the most widely grown variety of oats in Kansas. Flynn is a popular Kansas barley, and Atlas sorgo is the most extensively grown variety of sorghum for silage in Kansas.

2. Investigations relative to the time and method of preparing a seedbed for winter wheat have resulted in the introduction of practices, primarily early tillage, that have caused marked increases in both the quality and yield of wheat. Moisture determinations have shown such a close correlation between available moisture in the soil at seeding time and yield of wheat in western Kansas that, with definite information at hand relative to available moisture, the probability of a substantial yield can be predicted with reasonable accuracy. In eastern Kansas it has been found that there is a close correlation between the amount of available nitrogen in the soil at seeding time and the yield of wheat.

3. Methods of deferred grazing have been developed which are effective in maintaining the productivity of native Kansas pastures. The effectiveness of mowing as a means of eradicating shrubs and weeds from pastures has been proved to be associated with the food reserves in the roots of the plants.

4. Among the early problems investigated by the station was that of the sugar content of the sorghums and the possibility of using sorghums as a source of sugar. It was demonstrated that the sugar content of the sorghums could be increased in successive generations by the selection of seed from stalks shown by chemical analysis to carry higher quantities of sugar, but the difficulties of producing sugar commercially from sorghums were also shown.

5. Over a period of ten years from 1914 to 1924, the station investigated the physiology of the drought resistance of sorghums in comparison with corn. It was found that the number of roots originating from the crowns of these two types of plants and their depth of penetration in the soil were practically the same. However, the number of fibrous roots arising from the unit of length of the larger roots of the sorghums, was approximately twice the number originating from the same surf ace of the roots of the corn plant. The sorghum plant is thus better fitted for absorbing water from the soil than the corn plant. The rate of water loss per unit of surface was found to be higher for sorghums than for corn, but the leaf surface of the dwarf varieties of sorghum is only from one third to one half that of corn. Thus they were found to use less water per plant in a given time than corn. These studies show that sorghum plants withstand drought because they are efficient in absorbing water from the soil, and because the small extent of leaf surface enables the aerial parts of the sorghum plant to be continuously supplied with water even under severe climatic conditions.

6. The station pioneered in the testing of fruit and vegetable varieties in regard to their adaptation to Kansas. Apples, grapes, strawberries and plums were represented in these tests by long lists of varieties, from which the very small number of varieties now recommended for planting were in large part selected. Many species of forest trees and landscape materials have also been proved and recommended by the station in this way.

7. Experimental work conducted by the station has established facts which have profoundly affected methods of orchard soil management in Kansas. The recognition of the importance of the organic fraction of the soil, the possibilities of maintaining it through the use of cover crops, such as winter vetch, and establishing the significance of nitrogen fertilizers in the sod orchard, are among the more valuable practical contributions resulting from this study.

8. The station is in large part responsible for the greater emphasis now being placed upon quality and methods of measuring quality in wheat. A theory has been advanced for the colloidal behavior of dough whereby quality is explained as a composite of numerous characteristics, some of which, inherent in the protein structure, are influenced by variety, others by the environment of the growing plant, and still others by the storage and handling of the grain subsequent to harvest.

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INVESTIGATIONS IN THE ANIMAL INDUSTRIES

The Kansas station has pioneered in investigations of the feeding value of those crops that may be produced successfully in the light-rainfall regions of the state. These studies have centered around two major endeavors: (1) To determine the relative feeding value of the sorghums, the feed crops that are produced most successfully in the drier sections of Kansas, and (2) to develop methods of fattening livestock without the use of legume hay, since legumes suitable for hay cannot be produced economically without irrigation in the drier sections of the state and are often expensive to produce in other sections.

Sorghums have been fed experimentally to all classes of livestock. Almost every year since 1900, one or more phases of the problem have been studied through the use of feeding trials, chemical tests, physical tests and other methods. This work proved that the grain of the grain sorghums can be substituted successfully for corn in grain mixtures in the ration and that, when fed to growing calves and heifers of the dairy breeds, the results secured are practically equal to those secured from feeding corn. As silage, the sorghum crops have been shown to be equal to corn except when the corn silage carried a large amount of grain. Since the sorghum crops greatly outyield corn in tonnage per acre, these crops will produce much greater gains on an acre basis than corn when fed to beef cattle, and more milk per acre when fed to dairy cows. These discoveries undoubtedly have been an important factor in the acceptance and widespread use of the sorghum crops in Kansas.

It has been almost traditional among feeders that cattle could not be fattened satisfactorily without the use of a legume hay. It was found that the major value of a legume over a nonlegume roughage, when a protein supplement was fed, lay in its calcium content, and that calcium could be supplied in the form of the very inexpensive inorganic ground limestone. Consequently, a much cheaper, nonleguminous roughage can be substituted with equal success and much greater economy where legume roughages are difficult to grow. The significance of this discover may be summarized as follows:

A. A nonleguminous roughage plus a small amount of finely ground limestone has been found to be just as satisfactory in the cattle-feeding ration as a legume roughage.

B. Any section of the country that produces grain sorghums but no legume hay. can fatten cattle for market as satisfactorily, other things being equal as the legume-hay-producing sections.

C. This discovery has and will continue to expand the cattle-fattening industry of the country.

Some other achievements of the station that have been helpful to the livestock industry are the following:

1. The Kansas station pioneered in early work in animal production. Even before the organization of the station, the farm department had conducted feeding tests with swine and with steers. The scope of these tests was wide, and the tests were suggested by the practical needs of Kansas farmers. Factors studied were age, breeding and type of animals, exposure, and preparation of

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feeds. Digestion tests of several Kansas feeds not previously so studied were made and a rapid arithmetical method discovered for accurately calculating balanced rations.

2. The station has evolved a system of utilizing grass for fattening young steers that produces highly satisfactory beeves at a minimum cost. This consists of wintering good quality calves so as to secure a gain of 200 to 250 pounds. Grazing without other feed until August 1, and then full-feeding in a dry lot for the (90 to 100 days following, is the recommended practice.

3. A long-time study of swine-feeding problems has proved that tankage and green alfalfa hay are the most valuable supplements for grain in the winter feeding of swine.

4. Much work has been done to determine the average weight of silage at various depths in the silo as well as the capacity of silos. Tables based on these findings are commonly used throughout the state in estimating the capacity of silos, and are now generally accepted as a standard throughout the country.

5. Nutritional researches as to the vitamin requirements of swine, cattle and poultry have been pursued intensively for more than twenty years and have yielded information of inestimable value to livestock and poultry producers.

6. Studies in poultry genetics were started by the station twenty-six years ago. The early work in this field involved the use of standardbred males with mongrel females and is recognized as a classic example in flock improvement by grading. The utilization of the rate of the feathering factor as a means of sex identification at hatching, and improvement of broiler feathering in heavy breeds was initiated at this station. The first definite information on the superior vigor of first-generation hybrids in poultry was also secured at this station. In the theoretical field, the studies of inherltance of blue plumage and the mapping of the genes of the fowl have been outstanding contributions.

7. The station has made original contributions to the knowledge of the mechanics of ovulation, growth of the ovum, timing of egg formation, and effect of temperature on egg size in poultry.

8. Investigations relative to the factors influencing the sanitary quality of ice cream have resulted in changes in methods employed in the manufacture of gelatin, in the handling of ice-cream mix, and in general in plant sanitation, that have greatly improved the quality of ice cream. Many of the standards now employed as criteria of quality of ice cream are based upon these investigations.

INVESTIGATIONS OF DISEASES, INSECTS, AND OTHER PESTS INJURIOUS TO PLANTS

Entomological investigations at the college antedated the organization of the station by fifteen years, studies of the chinch bug and Hessian fly having been initiated in 1872 and continued to the present time. The time-of-planting-wheat investigations inaugurated in connection with the early Hessian fly work have resulted in an effective Hessian fly control program for Kansas.

Among other valuable practical contributions have been the first effective method for control of the large apple curculio, the heat treatment for the control of flour-mill resects, and the introduction of the “Kansas” poison-bran mash and demonstration of its large-scale practicability in the control of grasshoppers, cutworms and army worms. Many basic problems in insct biology have been solved and numerous valuable technical procedures for studying insects have been introduced. The following are of especial sig-

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nificance: (1) Discovery of the first known insect parasite of the chinch bug, (2) introduction of air-conditioning apparatus for studying insect life histories, (3) construction of an underground insectary for study of insects in their soil environment, and (4) first efforts to breed insect-resistant plants.

The station pioneered in a study of fungous diseases of farm crops and procedures to eliminate or reduce damage from them. Valuable contributions were made to the knowledge of methods of controlling many of these diseases, particularly the rust, smuts, and other diseases of cereals and truck crops.

The station began at an early date the production by breeding and selection of varieties of plants resistant to disease. Two notable varieties of wheat produced in this way were Kanred and Kawvale. Of especial practical importance in the control of truck-crop diseases has been the introduction of practices which controlled the most serious sweet- and Irish-potato diseases of the state, thereby markedly increasing both yield and quality of these crops in Kansas.

It has been established that noxious weeds, especially bindweed *(Convolvulus arvensis),* can be controlled in regions of low rainfall by the judicious use of smother crops and tillage methods. The effectiveness of sodium chlorate for the eradication of bindweed was first demonstrated by this station.

One of the first projects of the station supported by state funds was a project to investigate methods of controlling prairie dogs and pocket gophers. As a result of this early work, followed by subsequent investigations, methods have been developed for the eradication of these pests in field crops and pastures. The application of these methods in the field through the extension service has practically eradicated the prairie dog from the state, and has made notable progress in many sections in the eradication of the pocket gopher.

INVESTIGATIONS IN ANIMAL DISEASES

Through the development and introduction of modern blackleg vaccines, the station must be given credit for introducing practices that have reduced the annual estimated loss through blackleg of the calf crop of Kansas and the southwestern section of the United States from ten percent to less than one half of one percent.

The station was the first agency in Kansas to supply livestock owners with anti-hog-cholera serum. To the station is due credit for popularizing, manufacturing and distributing this valuable aid to the hog-raising industry during that period when both farmers and commercial concerns were skeptical of its value. When commercial agencies were prepared to supply high-quality products in adequate amounts at a reasonable cost, the station ceased to manufacture anti-hog-cholera serum.

The station has devoted much time to investigation of the parasites of domestic animals, especially of chickens. It has contributed

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valuable information, particularly as to the influence of age, vitamin deficiency, and strain upon resistance of chickens to tapeworm.

The station pioneered in investigations in poultry diseases and is nationally recognized for its contributions in this field and as a training ground for poultry-disease investigators. Of especial significance in this connection was the discovery of the rôle played by the incubator in disseminating pullorum disease and the introduction of control methods for this disease which have been universally adopted in hatcheries.

DISCOVERY OF FACTS OF VALUE TO HOMEMAKERS

Work to discover facts of value to the homemakers of Kansas was started in the early days of the college. An enlargement of the work in this field was made possible in 1925, with the passage of the Purnell act, when research in this field was organized as an integral part of the work of the Agricultural Experiment Station with support from Purnell funds. Valuable contributions have been made relative to the vitamin and calcium content of certain common foods. the deficiency of certain culinary devices, and the factors determining the serviceability of certain fabrics and the protection they afford the human body against sunlight, cold, and moisture.

A study, recently inaugurated, made possible by information collected by the Extension Service from Farm-Home Management Associations of the state, is proving of promise in the development of home-accounting practices and in determining the levels of family living on the farms of the state.

Research in the design and construction of farm buildings, especially the farm home, has resulted in improved plans for the use of the farm family for home construction and the modernization of the farm home. The extension of rural electrical lines and improvement in equipment adapted to the farm home have stimulated the interest of farm people in the application of these studies to the modernization and the beautification of the farm home.

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The Past Biennium

BUILDINGS CONSTRUCTED

The only building constructed during the past biennium was a beef-cattle nutrition laboratory building in 1937, at a cost of $2,500, exclusive of special equipment. The building is a one-story frame structure, 34 by 38 feet, with a small loft for storing feed. A basement, 14 by 20 feet, is located directly beneath six digestion stalls. (Figs. 1 and 2.) This arrangement facilitates the collection of

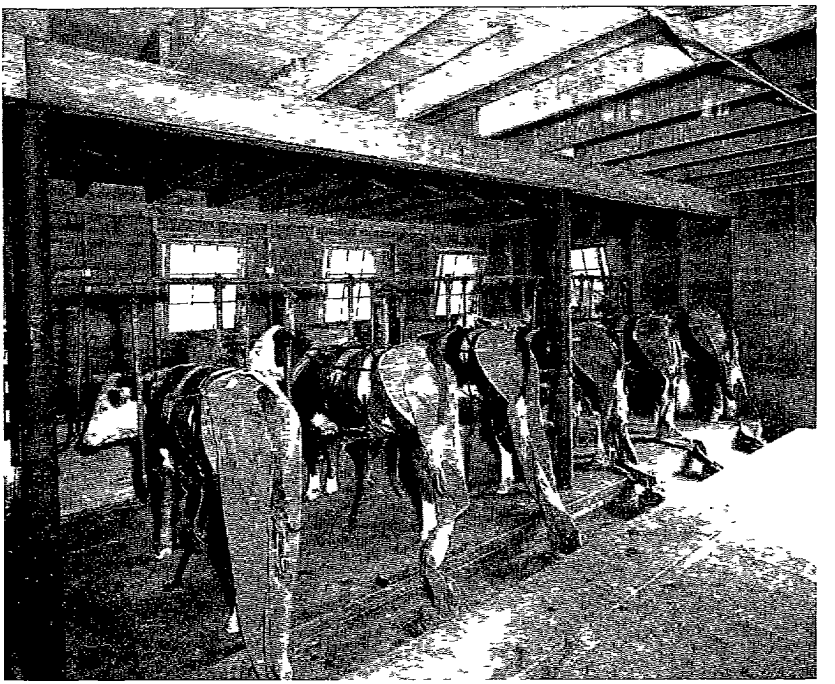

FIG 1. An interior view of the main floor of the Beef Cattle Nutrition Laboratory building, showing six steers with equipment used for the collection of urine and feces during digestion trials and mineral-balance studies.

urine and feces during digestion trials and mineral-balance studies. An electric drying oven, located in the basement. is employed in making moisture determination of feeds used in feeding trials and of feces collected in digestion trials. Stanchions and special managers are provided for feeding 12 steers individually. Six of these stalls are made in such a way that they are easily converted into the digestion stalls used in digestion and mineral-balance trials. The stalls face outward and are located in the west portion of the laboratory. The east portion of the building consists of a feed room

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approximately 12 by 15 feet, scales with a 6 by 10 deck and type registering beam, and a record room approximately 8 by 11 feet inside. A paved lot 38 by 48 feet, enclosed with a wooden fence, is located at the south side of the laboratory.

The laboratory building was designed for use in conjunction with

FIG. 2. An interior view of the basement of the Beef Cattle Nutrition Laboratory building showing the equipment used for the collection of urine and feces during digestion trials and mineral-balance studies; also, the electric oven used in making moisture determinations of feeds used in feeding trials and of feces collected in digestion trials.

technical studies of the mineral requirements of fattening cattle. These studies have involved two carefully controlled feeding trials, each with six pairs of range-breed steer calves, and two digestion and mineral-balance trials with three pairs of steer calves each. The erection of the laboratory provided modern and complete facilities for this type of work.

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PERSONNEL

The station lost, through death during the past biennium, two of its most effective research workers. Dr. H. F. Lienhardt, professor of animal pathology in the Department of Veterinary Medicine, died on November 11, 1937. He had served as animal pathologist of the station since 1919.

Dr. A. E. Aldous, professor of pasture improvement in the Department of Agronomy, died on May 5, 1938. He had directed the investigational work in pasture management since July 1, 1926. Both of these men died in the prime of life at a time when they were making most valuable contributions to the work of the station.

Resignations.— The average number of persons regularly employed on the scientific staff of the station during the biennium was 130. Fourteen members of the staff resigned during the biennium. Those resigning were:

Bruce R. Taylor, livestock investigations.
Glenn S. Fox, assistant in marketing.
H. J. Henney, in charge livestock marketing.
F. G. Parsons, assistant in cooperative experiments.
C. E. Crews, in charge of South Central Kansas Experiment Fields.
*A. M. Brunson. in charge of corn investigations.
A. C. Fay, dairy bacteriology.
J. F. Knappenberger, poultry diseases.
C. L. Lefebver, plant pathology.
Esther Bruner, clothing and textiles.
W. B. Balch, floriculture and vegitable gardening.
Rowland J. Clark. wheat and flour investigations.
J. P. Scott, animal pathology.
*F. A. Wagner, superintendent, Garden City Branch Station.

Appointments.-Twenty -five new appointments were made during the biennium. Those appointed were:

C. W. Mullen, assistant to director.
C. P. Wilson, assistant in marketing.
H. D. Hollembeak, assistant in cooperative experiments.
Clare R. Porter, assistant in charge of South Central Experiment Fields.
*R. W. Jugenheimer, in charge of corn investigations.
Kling L. Anderson, pasture improvement.
R. B. Cathcart, livestock investigations.
Catherine Mitchell, assistant in animal husbandry.
F. E, Nelson, dairy bacteriology.
G. H. Beck, dairy production.
M. J. Twiehaus, poultry disease irvestigations.
V. D. Foltz, assistant in poultry disease investigations.
*F. E. Clark, soil microbiology investigations.
*M. L. Fierke, soil microbiology investigations.
D. B. Creager, plant pathology.
J. C. Frazier, bindweed investigations.
Ralph Conrad, poultry chemistry investigations.
W. J. Peterson, animal nutrition investigations.

*In coöperation with the United States Department of Agriculture.

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Hazel Fletcher, clothing and textiles.
S. W. Decker, floriculture and vegetable gardening.
R. K. Larmour, wheat and flour investigations.
*Mark .4. Barmore, wheat investigations.
*Karl F. Finney, wheat investigations.
*Max E. McCluggage, wheat investigations.
L. M. Roderick, animal pathology.
W. W. Thompson, animal pathology.
Alvin E. Lowe, assistant in agronomy, Garden City Branch Station.
L. M. Sloan, superintendent. Garden City Branch Station.

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*In cooperation with the United States Department of Agriculture.

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SCOPE OF THE STATION WORK, JULY 1, 1936, TO JUNE 30, 1938

A list of the principal active projects carried during the biennium ending June 30, 1938, is given below, together with statements of the sources of financial support and references to the discussions included in this report:

NAME.	Project No.	Department.	Leader.	Funds.	Discussed on page—
Studies of Factors Affecting the Organization and Operation of Kansas Farms.	95	Agricultural Economics	J. A. Hodges W. H. Pine. R. J. Doll. L. F. Miller.	Purnell and State	38
Investigations in Land Tenure and Other Related Problems,	132	Agricultural Economics	H. Howe L. F. Miller.	Purnell	38
The Marketing of Kansas Grain	143	Agricultural Economics	Geo. Montgomery	Purnell	39
The Marketing of Kansas Livestock and Livestock Products,	149	Agricultural Economics	H. J. Henney Geo. Montgomery. F. L. Parsons.	Purnell	40
The Marketing of Kansas Fruits and Vegetables	177	Agricultural Economics	F. L. Parsons	Purnell	40
A Study of Factors Governing the Marketing of Dairy Products in Kansas.	185	Agricultural Economics	F. L. Parsons	Purnell	41
The Economics of the Poultry Industry in Kansas	144	Agricultural Economics	J. A. Hodges	Purnell	41
A Study of Factors Affecting the Social Well-Being of Rural People in Kansas.	195	Agricultural Economics	R. C. Hill	State	42
Soil-fertility Investigations	17	Agronomy	W. H. Metzger	Hatch	43
Influence of the Absolute Reaction of the Soil Solution Upon the Growth and Activity of Azotobacter.	128	Bacteriology	P. L. Gainey	Adams	44
Influence of Legumes and Nitrogen-fixing Organisms on the Growth of Plants and on the Nitrogen Balance.	172	Agronomy	H. E. Myers	Purnell, Hatch and State.	45
A Study of the Soil Solution as Governed by H-Ion Concentration and other Factors.	155	Chemistry	A. T. Perkins	Purnell	46

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SCOPE OF STATION WORK—CONTINUED

NAME.	Project No.	Department.	Leader.	Funds.	Discussed on page—
A Study of Some Replaceable Cations and Anions in Some Kansas Soils.	179	Chemistry	A. T. Perkins	Purnell	46
Soil and Crop Experiment Fields		Agronomy Botany. Entomology. Horticulture.	R. I. Throckmorton. L. E. Melchers. G. A. Dean. R. J. Barnett. Erwin Abmeyer.	State	47
Temperature Relations of Crop Plants.	157	Agronomy	H. H. Laude	Purnell	50
Small-grain and Sorghum Improvement	67	Agronomy	J. H. Parker	Hatch and State	51
Inheritance of Factors Affecting Quality in Wheat.	178	Agronomy Milling Industry.	J. H. Parker C. O. Swanson.	Purnell	52
Varietal Tests of Small Grains and Sorghum	129–1, 2	Agronomy	H. H. Laude	Hatch	53
Variety and Cultural Tests of Soybeans and Cowpeas	129–3	Agronomy	J. W. Zahnley	Hatch	54
Miscellaneous Legumes for Forage	129–4	Agronomy	J. W. Zahnley	Hatch	55
Corn Production and Improvement	156	Agronomy	A. M. Brunson R. W. Jugenheimer.	Purnell	55
Alfalfa Investigations in Relation to Winter Hardiness and Bacterial Wilt.	183	Agronomy	C. O. Grandfield	Purnell	56
Pasture-improvement Investigations	96	Agronomy	A. E. Aldous K. L. Anderson.	Purnell Bankhead-Jones and State.	57
Physiological Study of Bindweed in Relation to its Control.	202	Botany	J. C. Frazier E. C. Miller.	Bankhead-Jones	59
Weed Eradication	166	Agronomy	J. W. Zahnley	State	60
Cooperative Experiments with Farmers		Agronomy	A. L. Clapp	State	61

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SCOPE OF STATION WORK– CONTINUED

NAME.	Project No.	Department.	Leader.	Funds.	Discussed on page—
The Influence of the Method of Harvesting and Storing Alfalfa Hay Upon Quality.	182	Agricultural Engineering	C. K. Otis	Purnell and State	62
A Study of the Efficiency of the Combined Harvester-Thresher for Harvesting Grain Sorghums.	181	Agricultural Engineering	F. C. Fenton	Purnell	63
Factors Influencing the Quality of Wheat During Farm Storage.	204	Agricultural Engineering Milling Industry.	F. C. Fenton C. O. Swanson.	Purnell and State	63
Chemical Factors Influencing the Quality of Wheat and Flour.	60–A	Milling Industry	E. B. Working	State	64
Varietal Factors Influencing the Milling and Baking Quality of Wheat.	60–B	Milling Industry	C. O. Swanson R. J. Clark.	State	65
Tempering Factors Affecting the Quantity and Quality of Wheat Flour.	170	Milling Industry	J. E. Anderson	Purnell	65
Factors Which Influence the Colloidal Properties of Dough.	200	Milling Industry	C. O. Swanson R. J. Clark.	Bankhead-Jones	67
A Physiological Study of the Hard Winter Wheat Plant	189	Botany	E. C. Miller	Purnell and State	67
Orchard Investigations	25	Horticulture	R. J. Barnett G. A. Filinger. W. F. Pickett.	State	68
Small-fruit Investigations	26	Horticulture	G. A. Filinger W. F. Pickett.	State	70
Flower and Vegetable Investigations	27	Horticulture	S. W. Decker	State	71
Relation of Leaf Structure to Rate of Photosynthesis in Fruit Plants.	199	Horticulture	W. F. Pickett	Bankhead-Jones	72
Nutritive Requirements of Swine	38	Animal Husbandry Chemistry.	C. E. Aubel J. S. Hughes.	Adams.	73

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SCOPE OF STATION WORK—CONTINUED

NAME.	Project No.	Department.	Leader.	Funds.	Discussed on page—
Swine-feeding Investigations	110	Animal Husbandry	C. E. Aubel	State	73
Investigations in the Use of Silage for Fattening Beef Cattle,	78	Animal Husbandry	A. D. Weber	State	74
Method of Utilizing Native Pasture in Beef-cattle Feeding,	151	Animal Husbandry	C. W. McCampbell	State	75
Lamb-feeding Investigations	111	Animal Husbandry	Rufus F. Cox	State	75
Coöperative Studies in Lamb Feeding		Animal Husbandry	Rufus F. Cox F. A. Wagner.	State	76
The Effects of Inbreeding and Linebreeding on Sheep	205	Animal Husbandry	Rufus F. Cox	State	76
Field Application of Gonadotropic Hormones in Dorset Ewes.		Animal Husbandry	Rufus F. Cox	State	77
A Study of Factors Which Influence the Quality and Palatability of Meat.	165	Animal Husbandry Chemistry. Home Economics.	D. L. Mackintosh J. Lowe Hall. Eva McMillan. Martha Pittman.	Purnell and State	77
The Mineral Requirements of Fattening Cattle	203	Animal Husbandry Chemistry.	A. D. Weber J. S. Hughes.	Bankhead-Jones	78
Factors Influencing the Mineral Metabolism of Dairy Cattle.	147	Dairy Husbandry Chemistry.	W. H. Riddell H. W. Cave. J. S. Hughes. C. H. Whitnah.	Purnell and State	79
Dairy-cattle-feeding Investigations	34	Dairy Husbandry	H. W. Cave F. W. Atkeson.	State	80
Normal Growth of Dairy Cattle		Dairy Husbandry	W. H. Riddell	State	82
Calf-feeding Investigations	154	Dairy Husbandry	H. W. Cave F. W. Atkeson.	State	83

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SCOPE OF STATION WORK—CONTINUED

NAME.	Project No.	Department.	Leader.	Funds.	Discussed on page—
Dairy-manufacturing Investigations	124	Dairy Husbandry Agricultural Economics. Agricultural Engineering. Bacteriology. Chemistry.	G. H. Beck. W. J. Caulfield. H. W. Cave. V. D. Foltz. W. H. Martin. D. L. Murray. C. K. Otis. F. L. Parsons. C. H. Whitnah.	State	84
Bacteriological Study of Ice Cream	124	Bacteriology	F. E. Nelson. V. D. Foltz.	State	87
A Study of the Formation, Isolation and Properties of Milk Sugar.	190	Chemistry Dairy Husbandry.	C. H. Whitnah W. J. Caulfield.	Purnell	90
Improvement and Conservation of Farm Poultry	77–20, 23, 25,26,28,29	Poultry Husbandry	L. F. Payne D. C. Warren.	State	91
Turkey Production	77–15, 27	Poultry Husbandry	T. B. Avery	State	93
Factors Influencing the Color of Yolks of Eggs	193	Chemistry Poultry Husbandry.	J. S. Hughes L. F. Payne.	Adams and Purnell	94
The Mechanism of Egg Formation	198	Poultry Husbandry	D. C. Warren	Bankhead-Jones	95
The Chemistry of Egg Formation	198	Chemistry	R. M. Conrad	Bankhead-Jones	96
Influence of Hybridization Upon Vigor in Poultry	173	Poultry Husbandry	D. C. Warren	Purnell	97
Chromosome Mapping of the Genes of the Fowl	197	Poultry Husbandry	D. C. Warren	Bankhead-Jones	97
Studies in Inheritance and Physiology of Reproduction in Mammals.	93	Animal Husbandry	H. L. Ibsen.	State	97
Studies in the Inheritance of the Grouse Locust	72	Zoology	R. K. Nabours F. M. Stebbins.	Adams	98

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SCOPE OF STATION WORK—CONTINUED

NAME.	Project No.	Department.	Leader.	Funds.	Discussed on page—
Effect of Climate on Inheritance of the Grouse Locust	104	Zoölogy	R. K. Nabours F. M. Stebbins.	Adams	99
Bee Investigations	126	Entomology	R. L. Parker	State	99
Cereal- and Forage-crop-disease Investigations	76	Botany	L. E. Melchers	State	100
Fruit- and Vegetable-disease Investigations	130	Botany	O. H. Elmer	State	102
Resistance of Winter Wheat to Leaf Rust	171	Botany	C. O. Johnston	Purnell	103
Climate and Injurious Insect Investigations	6	Entomology	R. C. Smith	Hatch	104
Hessian Fly and Other Wheat Insects	8	Entomology	R. H. Painter H. R. Bryson.	Hatch	105
The Corn Earworm and Other Insects Injurious to Corn	9	Entomology	D. A. Wilbur H. R. Bryson.	Hatch	106
Fruit, Vegetable and Other Insects	100	Entomology	H. R. Bryson	State	107
Insects Attacking the Roots of Staple Crops	100	Entomology	H. R. Bryson	State	107
Insects Injurious to Alfalfa, Grasses and Allied Plants	115	Entomology	R. C. Smith D. A. Wilbur.	State	108
Study of the Biology and Control of Fruit and Vegetable Insects.	187	Entomology	R. L. Parker P. G. Lamerson.	Purnell and Hatch.	108
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STUDIES IN THE ECONOMICS OF AGRICULTURE

Studies in the economics of agriculture have been pursued during the past biennium along eight major lines, each of which is discussed briefly on the following pages.

Studies of Factors Affecting the Organization and Operation of Kansas Farms.— Three phases of work have been pursued during the past biennium as follows:

1. *Type of Farming and Regional Agricultural Adjustments.*— With the coöperation of the Kansas State Planning Board, a bulletin "Agricultural Resources in Kansas" has been published. A study of the bases for types of farming and type-of-farming areas has been made, covering trends in crop acreages yields and number of livestock and factors affecting these during the past 25 to 50 years; and the results of the Agricultural Adjustment Project have been evaluated in terms of this analysis. A resurvey of southwestern Kansas farms is being prepared with the cooperation of the United States Department of Agriculture to indicate changes in organization and operation since 1930 and 1931. Related to these studies has been another proceeding from the individual farm budgets, through type-of-farming areas, to the state as a whole.

2. *Factors Affecting Farm Income.*— With the coöperation of the Extension Division, the Department of Dairy Husbandry. Farm Bureau-Farm Management Associations, the Dairy Herd Improvement Association, the Kansas State Bankers' Association, and certain local banks, account records for more than 797 farms were secured. By means of multiple correlation, using these records a study was made of "Factors affecting return for management on Kansas farms." The analysis was made by years, and by type of farms; one of the most important results being the indication that the most satisfactory method is to consider farms by types.

3. *Debt Carrying Capacity of Farms.*— A study was made in collaboration with the Division of Farm Finance, Bureau of Agricultural Economics, United States Department of Agriculture, using records of the Northern Associations from 1931 to 1936, inclusive. An analysis of income, expences, debt, and carrying capacities of farms, by years, by tenure, and by type of farm, led to the conclusion that during the period under study the usual farm could not have carried a debt exceeding three times the average cash income.

(Project 95; Department of Agricultural Economics. Leaders, W. E. Grimes, J. A. Hodges, W. H. Pine, R. J. Doll, L. F. Miller; Purnell and state funds.)

Investigations in Land Tenure and Other Related Problems.— This study during the past biennium has concerned three phases of the Kansas taxation system as follows:

1. *The Assessment and Collection of Farm Real-estate Taxes.*— During this period primary emphasis has been placed on various aspects of assessment. Data concerning bona fide sales of real estate from 1913 to 1930 were secured from the State Tax Commission. With the discontinuance in 1930 of the practice of the commission of collecting tax-sales records from county officials, this source of information was closed. With the assistance of the Civil Works Administration, data on transfers for the period 1929 to 1933, inclusive, were obtained. For the three-year period, 1931 to 1933, 2,911 of these transfers were studied to ascertain the relation between assessed and sales value of the properties involved. The study demonstrated that properties of low-value-per-acre were overassessed, while properties of high-value-per-acre were underassessed throughout the state, indicating that value per acre was the important factor

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affecting the assessment ratio. In arriving at the value of land assessors tend to take an average value, placing that value on all land rather than making distinctions between grades of land, thus leading to the discrepancies of over- and underassessment.

2. *The Taxation of Mineral Resources.*— Data on the gravity and total production of oil, and the assessed value of the leasehold and equipment of each oil operator were obtained by school districts of 17 counties for the tax year 1935-'36. Production in these counties for that period amounted to 69 percent of the total Kansas production. Data assembled by the Tax Commission for the state as a whole show about the same relationship. A comparison of assessed value of oil-producing properties and income from those properties on the one hand, and the assessed value of agricultural properties and income from agriculture shows that the annual product of the oil properties is approximately equivalent to the assessed valuation of its properties (96 percent), while the annual product of agriculture is approximately one fourth the assessed value of the agricultural property. Also, oil-producing districts, benefiting from a larger assessed value, show an average tax rate of 14.47 mills in 1936 as against an average total tax rate on all farm property of 17.44 mills.

3. *The Trend of Real-estate Taxation.*— Data concerning trends of real-estate taxation from 1910 to 1935 were compiled to show the trend of taxes on farm and city properties, and to afford an analysis of the responsible factors. Some conclusions have been drawn from this study as follows:

A. Farm real-estate taxes increased from nine million dollars in 1910 to 29 millions in 1929, but declined from that date to 18 millions in 1933. Increases in 1934 and 1935 raised the levy to 20 millions, corresponding approximately to the 1919 levy. City real-estate taxes increased from five millions in 1910 to 26 millions in 1931, declined each year after to 21 millions in 1935, corresponding approximately to the 1923 level,

B. Education, roads, and miscellaneous items, including depression-fostered expenditures, were primarily responsible for the rising tax levies. Cost of government administration increased comparatively little during the period.

(Project 132; Department of Agricultural Economics. Leaders, H. Howe, L. F. Miller; Purnell fund.)

The Marketing of Kansas Grain.— Three main phases of this field of research have been followed actively during the past biennium. They are as follows:

1. *The Analysis of Trends and Fluctuations of Grain Prices.*— The analysis of trends and fluctuations of grain prices has been continued; also cyclical and seasonal movements of the price of corn, and, to a lesser extent, the prices of oats, barley and sorghums. This study of fluctuations has provided information for forecasting prices in the Kansas Agricultural Situation, and other releases dealing with price trends. Information dealing with fluctuations and affecting forces is constantly being collected.

2. *Studies of the Relation of Rainfall to Wheat Yields in Western Kansas.*— Studies of the relation of rainfall to wheat yield in western Kansas were continued during the biennium. Relationships between the precipitation for a number of different periods of the fall, and yields the following harvest have been established for 53 western and central Kansas counties, and have been used for forecasting during December the wheat yields for the following harvest. The correlation between the estimated and the actual production in these 53 counties is $+ .86 \pm .07$. In a study now in progress these 53 counties will be grouped into five areas, and other varibles such as July and August temperatures, spring rainfall and June precipitation included. Preliminary results indicate these changes will result in a still higher degree of correlation. Indications already noted are that spring rainfall is not a major factor in

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wheat yields in western Kansas. This being contrary to public opinion, it is intended to make further study of the effect of spring rainfall.

3. *The Analysis of Coöperative Elevator Records.*— In cooperation with the Extension Service and the Farmers Union Jobbing Association, the analysis of the annual audits of cooperative elevators has been continued, and financial and operating ratios calculated for about 135 coöperative elevators, for each year of the biennium. From this work valuable information concerning such criteria as operating efficiency, desirable operating margins, cost of credit extension, necessary volume of business, number of members needed, and methods of maintaining membership loyalty, has been secured and used to determine the factors contributing to the success or failure of cooperative associations

(Project 143; Department of Agricultural Economics Leader, George Montgomery; Purnell fund.)

The Marketing of Kansas Livestock and Livestock Products.— Three phases of this subject have been studied during the biennium as follows:

1. *Intra-state Marketing Structure.* — A study of 23 community auction sales was started in November, 1936, with the Coöperative Division of the Farm Credit Administration. An intensive survey of 17 auctions, a partial survey of 15 more, and a mail survey of all auctions have been completed.

2. *Cyclical Variations in Livestock Prices.*— Price analysis, and additional relationship studies have been made to locate the time of the seasonal peak and low prices. Cycle studies showing price relationships for one, two, and three-month periods, by type-of-price trend, for 15 grades and classes of livestock have been completed. Analyses of cattle and hog prices on the basis of a ten-point procedure have been prepared.

3. *Current Market Reports.*— A good part of the time devoted to research was spent in preparing and writing weekly, monthly, and annual reports on marketing livestock in Kansas, accompanied by the necessary to-date revision of the studies dealing with Kansas livestock price factors.

(Project 149; Department of Agricultural Economics. Leaders. H. J. Henney, George Montgomery, F. L. Parsons; Purnell fund.)

The Marketing of Kansas Fruits and Vegetables.— The work during the biennium on this project consisted of (1) a study of roadside marketing of Kansas horticultural products; (2) a correlation study of potato prices in Kansas, the 30 late potato-producing states, and the intermediate and early potato-producing states; (3) possibilities of profit in storage of potatoes by Kansas producers; (4) a joint study made by the Bureau of Agricultural Economics, United States Department of Agriculture, the Missouri Agricultural Experiment Station and the Kansas Agricultural Experiment Station of the fruit and vegetable market in Kansas City, Mo. The following are some pertinent observations from these studies:

A. A survey of the Kansas City, Mo., wholesale fruit and vegetable market was made in cooperation with the Missouri Experiment Station and the Bureau of Agricultural Economics of the United States Department of Agriculture to determine the adequacy of the present market, and to analyze proposals for new markets. The results indicated that the present market was unsatisfactory and inadequate in many respects; it was suggested that the market be moved to a more desirable location.

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B. There is little correlation between Kansas prices and price and production in the early and intermediate potato-producing states. Apparently prices received for Kansas potatoes are determined more by probable production and prices in the 30 late-producing states than in the other areas. Kansas ordinarily receives a better price for potatoes than 50 to 60 percent of the potato-producing states. Analysis of potato prices indicates that from the standpoint of price there is less than an even chance for the Kansas potato producer to make a profit by storing until late winter and selling at that time. Even in years when wholesale prices of all commodities advanced, the Kansas potato farmer lost by storing about as often as he gained.

Statistics on fruits and vegetables, particularly potatoes and apples will be analyzed and studied to aid in the price-forecasting service, and to acquaint growers with economic conditions in particular commodities, An intensive study of the cold-storage locker system in Kansas with particular reference to fruits and vegetables is planned.

(Project 177; Department of Agricultural Economics. Leader, F. L. Parsons; Purnell fund.)

A Study of Factors Governing the Marketing of Dairy Products in Kansas.— The work for the biennium has consisted mainly of (1) price analyses to locate the seasonal butter-price peaks and lows, and their extent; (2) a study of the factors affected ing the quantity of butter in storage; (3) compilation of statistics dealing with dairy-product plants and milk-cow numbers by counties and type-of-farming areas. The latter study is of use when assistance in locating dairy-product plants is requested. Some of the findings of the study are:

1. Daily butter prices analyzed during a five-year period showed that Saturday, Monday, and Thursday, in the order named, have a slight price advantage over Wednesday, Friday, and Tuesday.

2. The relationship between percentage seasonal changes and prices at the following seasonal peaks and lows was not of much practical value in predicting butter-price changes.

3. Kansas was ranked with other states as to yearly average prices paid farmers for butterfat. Since 1936 Kansas has ranked much higher than formerly. indicating the success of the Kansas cream-improvement work begun in 1936.

4. Milk-cow numbers varied from 19.3 cows per square mile in Area 3 in eastern Kansas to 0.9 cow per square mile in Area 12 in western Kansas. In general, for the different counties and type-of-farming areas, the trend in milk-cow numbers was down from 1919 to 1924, upward to peak numbers in 1934, and downward since 1934. At present total milk-cow numbers in the state are the lowest in the last seven years.

5. Previous years' profits from storage and butter production during the into-storage period apparently were the more important factors affecting quantity stored. The price of butter and the business situation as measured by size of industrial pay rolls also have some influence on the amount of butter stored.

(Project 185; Department of Agricultural Economics. Leader, F. L. Parsons; Purnell fund.)

The Economics of the Poultry Industry in Kansas.— In this project series of prices at Kansas City, Mo., for first eggs, heavy hens, light hens, broilers, springs and roosters, were brought up to date. Tabulations of poultry data from the Northern Association for 1935 and 1936, and from the Southern Association for 1935, in-

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cluding receipts for and home use of eggs and poultry by months, by size of flock and by type of breed kept, were made. These data were supplemented by census material on the number of chickens per farm and the production of eggs and poultry by counties and by type-of-farming areas. Farms with a high percentage of poultry receipts were compared with other types of farms in the same area. The relationships of the price of eggs, heavy hens and broilers at Kansas City with a large number of factors, such as receipts, cold-storage holdings, index of pay rolls, the wholesale commodity price index and egg-feed index, were tested. Seasonal indexes for eggs by ten-day periods were calculated, and margins between prices in Kansas City, New York and Chicago were also examined. In general, the closest relationships were obtained with prices and factors indicating demand, such as the index of pay rolls. The rapid changes in the poultry industry render the study of long series impractical unless the effects of these changes are considered. Tentative results appear to indicate or confirm former conclusions that:

1. The poultry enterprise tends to stabilize the farm business, both seasonally and from year to year.
2. The difference in results with different types of breeds varies from year to year with variations in the relative prices of poultry and eggs.
3. Efficiency increases with the size of flock for size groups included in the study.
4. Incomes on poultry farms in 1936 were fairly comparable with other types of farms in the same area and of approximately the same size.

(Project 144; Department of Agricultural Economics. J. A. Hodges, leader; Purnell fund.)

A Study of Factors Affecting the Social Well-Being of Rural People in Kansas.— The Agricultural Economics Department, in cooperation with the Division of Farm Population and Rural Life, of the Bureau of Agricultural Economics, has made a study of population changes and movements in the state.

In 1937 a questionnaire concerning farm population was sent to approximately 5,300 farm women in the state. The returns formed the basis for the report, "Summary Statement of Farm Population Changes During 1936." In 1938 the same questionnaire was sent to the same persons to secure information concerning farm population changes in 1937. Data from the returns are now being tabulated. In conjunction with the Division of Social Research of the Works Progress Administration, various aspects of the rural relief problem were studied, and the findings reported.

Data from 13 counties for the period January, 1934, to May, 1937, concerning private and public agencies providing assistance to dependents were received. From this material a report was prepared, entitled "Public and Private Relief in Rural Kansas." A youth study was made in July and August, 1936 in Inman, Mount Hope and Oxford. A preliminary report was prepared showing conditions confronting rural youth, and the effect of the depression upon rural youth.

A summary report, based on data secured in 1933 and 1934, entitled, "Comparative Characteristics of Rural Relief and Nonrelief Households in Kansas," was completed.

To indicate various social problems and maladjustments in rural relief families, several of the case histories were selected, and a report prepared en-

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titled, "Selected Case Studies of Rural Relief and Rehabilitation Families in Kansas."

In September, 1936, a survey of public assistance extended to households in the drought area was initiated in 12 Kansas counties covering a six-month period, July to December, 1936. It is anticipated that an analysis of these data will be made during the year beginning July 1, 1938.

(Project 195; Department of Agricultural Economics. Leader, R. C. Hill; state fund.)

SOIL CONSERVATION

The problem of soil conservation has continued to receive careful consideration by the station during the past biennium. The problem has been attacked primarily from the standpoint of developing a sound land-use program for Kansas. It is hoped that from facts developed from these studies a program can be built that will provide for the conservation of the soil as a continuing source of wealth for the state. A brief description of the studies under way is given in the following pages.

Soil-fertility Investigations.— The work on this project for the biennium has consisted of field, laboratory and greenhouse studies of various factors affecting the productivity of soils.

The field work, continued for 28 years, has involved studies of rotations and the use of lime, manure and commercial fertilizers on crop production on a long-time basis. Work on a smaller scale and of shorter duration has included studies of the comparative varietal response of wheat to phosphorus fertilization, the use of various types of fertilizes at various rates of application on the wheat crop, and the effects of fallowing upon stands of succeeding crops of corn, kafir, oats, soybeans and alfalfa. Laboratory and greenhouse studies have had to do with carbon and nitrogen as affected by cropping systems and soil treatments; the nature, extent and distribution of fertilizer residues in the soil of an old alfalfa fertility experiment; the effect of potash on phosphorus absorption by plants; and the effect of various crops on, and the relationship of organic matter to, the degree of aggregation of the soil.

The long-time soil-fertility experiments have continued to show results similar to those reported in the past except that there has been greater response of wheat and alfalfa, in particular, to phosphorus fertilization in recent years than formerly, Likewise, alfalfa appears to respond to liming somewhat more than in the past. A rotation containing alfalfa shows greater superiority at this time to one containing soybeans and other cropping systems not involving a legume than in the early years of these experiments. Rate-of-application studies with 16 percent superphosphate for wheat indicate that on soils of low available phosphorus content 150 to 200 pounds per acre are needed. In a fertilizer test with four various of wheat seven years results indicate that in years in which hot, dry weather developes before the plants are mature, the early maturing varieties benefit most from fertilization. In years in which conditions remain favorable up to maturity of the crop the later varieties show greatest response. Studies on the effect of fallow periods of one to three years upon stands of succeeding crops have indicated no effect upon corn, oats, kafir, or soybeans. Alfalfa stands were reduced one fourth, however, by a damping-off condition when the crop was seeded after three years of fallow.

Studies of nitrogen residual in the soil from manure treatments, varying from 1½ to 5 tons per acre per year, indicated that from 6 to 11 percent of such applied nitrogen remained in the soil after 25 years of cropping. In an alfalfa and grain-crop rotation, a green-manure crop of cowpeas incorporated into the sod along with a rock phosphate treatment once in five years left a similar residue, namely, 10 percent of the applied nitrogen. In a continuous

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wheat experiment 21 percent of the nitrogen of cowpeas turned under with rock phosphate once in three years remained in the soil. The corresponding figure for a green manure, potash and superphosphate treatment was 25 percent. A similar green-manure treatment without supplement, which did not increase wheat yields, was indicated to have left in residual form 70 percent of the incorporated nitrogen.

Studies of fertilizer residue in the soil of an old alfalfa experiment, to which fertilizer had been applied as top dressing for 27 years, showed that most of the accumulated phosphorus was retained in difficultly soluble form. The largest percentage retained in a form soluble in dilute acid was found under a rock phosphate and manure treatment. It was believed this was due to nonabsorption of the rock phosphate by the soil, although much more phosphorus was applied in this treatment than in the superphosphate treatments. Accumulated phosphorus failed to produce any appreciable effect upon the base exchange capacity of the soil. A lime and manure treatment increased the exchange capacity, apparently by the formation of new exchange complexes. Electro-dialysis reduced the exchange capacity, presumably by breaking down these new complexes. Some sodium accumulated in the soil from sodium nitrate application; and the greatest accumulation appeared to have occurred at from 1½ to 3 feet below the surface. Accumulated potassium was small in amount, and confined largely to the surface foot.

In a greenhouse and laboratory study, potash treatment by itself produced no appreciable effect on the phosphorus content of alfalfa. When applied with superphosphate, a small increase in the percentage of phosphorus in the plants was found.

Aggregate analysis studies indicated that fallowing reduced the degree of aggregation of the soil particles. Soil under corn and kafir appeared to be similar in degree of aggregation, but, when sampled in an oats stubble following the corn and kafir crops, the kafir land appeared less aggregated. It is suggested that decomposition of sorghum residues may produce some dispersing effect upon the soil. The most aggregated portion of the soil contained the most organic carbon, while the most dispersed portion was lowest in organic carbon content. Of 15 such comparisons, all showed the above relationship, and, in 12 of the 15, the differences were supported by significant odds, This is additional evidence indicating an important rôle of organic matter in soil aggregation.

The nitrogen and organic carbon studies on the old fertility plots are completed and will be discontinued for a period of about ten years, when they should be repeated.

(Project 17: Department of Agronomy. Leader. W. H. Metzger; Hatch fund.)

Influence of the Absolute Reaction of the Soil Solution Upon the Growth and Activity of Azotobacter.— The research on this project during the biennium has been concerned chiefly with (1) the nitrate nitrogen tolerance of Azotobacter under varying conditions, and (2) the nitrogen metabolizing activities of different strains of Azotobacter.

A large number of pure cultures of Azotobactm were studied qualitatively as to their tolerance of high nitrate nitrogen concentrations. All grew normally at 1,000 p. p. m. KNO_3-N or higher; two thirds grew normally at 3,000 p. p. m. or higher; approximately one third grew normally at 4,000 p. p. m. Previous observation indicated that Azotobacter could *not* tolerate high nitrate concentrations in a soil for prolonged periods of time. An entirely satisfactory explanation of the apparent, difference in behavior in soil and laboratory media, noted during the past year, is that the ability to tolerate such high nitrate concentrations in the laboratory is conditioned upon frequent transfers. Many cultures were unable to tolerate even 500 p. p. m. KNO_3-N unless transferred at frequent intervals,

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After prolonged culture at the highest concentration of KNO_3-N tolerated, all strains were tested as to their ability to grow normally on the "nitrogen free" medium. When thus tested, about one third of the strains failed to grow normally in the "nitrogen free" medium; but all grew normally in the presence of 100 p. p. m, KNO_3-N, indicating that culturing certain of the strains at high KNO_3-N concentration had induced a radical change in the nitrogen metabolism.

Quantitative studies of the nitrogen metabolized by these "abnormal" strains. both in "nitrogen free" media, and in the presence of small but increasing quantities of fixed nitrogen, led to the following tentative conclusions:

(a) Growing Azotobacter in the presence of excessive concentrations of KNO_3-N induced a radical change in the ability of certain strains to metabolize or fix atmospheric nitrogen. Other strains were apparently unaffected.

(b) The change induced is such that in a "nitrogen free" medium the organisms are unable to metabolize free atmospheric nitrogen.

(c) The failure to metabolize free atmospheric nitrogen by such cultures in a "nitrogen free" medium is in most instances not due to the loss of nitrogen-fixing ability; for, when quantities of nitrate nitrogen as small as 25 p. p. m. are added, the organisms will almost immediately begin to utilize free nitrogen. On the other hand, a few strains have been studied in which the addition of KNO_3-N to the media failed to restore nitrogen-fixing ability. Apparently there are varying degrees to which loss of ability to metabolize atmospheric nitrogen may be induced.

(d) Growing certain strains of Azotobacter under conditions where nitrogen fixation is inhibited apparently causes the organisms to cease to synthesize some constituent of the "azotase enzyme system." The cells soon become depleted of this constituent and subsequently are incapable of metabolizing free nitrogen unless they can reëlaborate the necessary enzyme system. Limited quantities of fixed nitrogen are essential and will enable the organisms to reconstruct the nitrogen-fixing enzyme systems. In other cases the alteration is more deep-seated and a normal condition is regained with difficulty, if at all.

(Project 128; Department of Bacteriology. Leader, P. L. Gainey; Adams fund.)

Influence of Legumes and Nitrogen-fixing Organisms on the Growth of Plants and on the Nitrogen Balance.— The field and laboratory work, consisting of a comparison of the relative value of several legumes as affecting the yield of corn, kafir, oats and wheat, was continued unchanged during the period.

Drought was the principal factor influencing yield. Very low coin and kafir grain yields were recorded during the period, but stover yields indicated marked differences in the effect of the various legumes on the row crops. Soybeans cut for hay and sweet clover harvested for seed resulted in the greatest forage yields, while both sweet clover and alfalfa which were growing on the soil until plowed under in preparation for the row crops resulted in very marked reductions in growth of row crops. Kafir has greatly exceeded corn in the production of forage.

Wheat and oat yields were little affected by the legumes.

The comparative effect of corn and kafir on the yield of oats and wheat the first and second year, respectively, following the row crops produced interesting results. The average yield data are shown in the following table:

	Average yield of oats, 1935-1937:		*Average yield of wheat, 1936-1937:*	
Previous legume	*After kafir*	*After corn*	*After kafir*	*After corn*
Soybeans, 1 year	36.81	39.04	23.35	24.16
Sweet clover, 1 year	43.52	41.15	26 40	26.44
Sweet clover, 2 years	45.83	44.23	28.26	27.31
Alfalfa, 2 years	44 95	42.66	26.54	26.18
Average	42.80	41.80	26.20	26.00

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Moisture and nitrate determinations on soil samples taken from the field plots, nitrogen determinations on crop samples, and the preparation of hydrogen clay to be used in greenhouse studies, constituted the laboratory work. The moisture and nitrate data on the corn and kafir plots indicated that one of the principal reasons for the corn and kafir burning so quickly after alfalfa and one year of sweet clover was the low moisture content of the soil following the plowing under of these crops.

Nitrate samples taken at oat-seeding time indicate a very marked difference in the nitrate level following kafir and corn. In the kafir plots the quantity of nitrate is about one half that of the corn plot. By wheat-seeding time this difference has largely disappeared.

(Project 172; Department of Agronomy. Leader, H. E. Myers; Purnell, Hatch, and state funds.)

A Study of the Soil Solution as Governed by H-Ion Concentration and Other Factors.— The work of the biennium on this project has been devoted to studies of the effects of fertilizer and lime treatments on certain soil particles from the fertility plots of Ohio, New Jersey and Kansas, as separated and fractionated by size and specific gravity. The soils were limed so as to change the average pH value from about 5.7 to approximately 6.5.

The results obtained are not conclusive, as they are confined mostly to the coarser particles, but they indicate that liming increases the percentage of the larger particles at the expense of the smaller particles, and that liming also tends to increase the percentage of the heavier minerals at the expense of the lighter minerals. This observation is important, since the light minerals in general possess base exchange capacity to a much greater degree than the heavy minerals.

(Project 15.5: Department of Chemistry. Leader, A. T. Perkins; Purnell fund.)

A Study of Some Replaceable Cations and Anions in Some Kansas Soils.— The major work of the biennium continued the study of the variation in the reaction and phosphorus volubility of soils. Aerations of systems of $CaCO_3$ and H_3PO_4 were studied. The CO_2 removed was determined quantitatively by absorption on ascarite. The speed with which equilibrium is reached (phosphorus volubility) has also been studied. The order of adding $CaC0_3$ and $CaH_4(PO_4)_2$ to a soil has been varied, and the effects studied. Different periods of time of shaking the various combinations have also been studied. Some of the results are:

1. The retention of CO_2 in $CaCO_3$, phosphate, soil systems tends to lower the pH values of the filtrates.
2. A definite amount of aeration establishes equilibrium, the pH value of the system rising until equilibrium is reached.
3. The amount of phosphorus remaining in solution decreases as aeration progresses until equilibrium is reached.
4. A soil saturated with calcium was prepared and a systematic varition of $CaCO_3$ and $CaH_4(PO_4)_2$ treatments has been made. The amounts and order of addition especially have been varied. The results indicate that when $CaCO_3$ is added to a soil before $CaH_4(PO_4)_2$ is added, the phosphorus will remain more soluble than when the order is reversed. Pots have been set up in the greenhouse to test the ability of wheat plants to take up more or less

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phosphorus in accord with the phosphorus volubility studies made in the laboratory.

(Project 179; Department of Chemistry. Leader, A. T. Perkins; Purnell fund.)

Soil and Crop Experiment Fields.— Experiments in soil management and crop production were conducted at four groups of outlying fields during the past biennium. The work conducted on each of these groups of fields is briefly described below.

Southeastern Kansas Experiment Fields.— The experimental results obtained during the past biennium in alfalfa fertility work showed an average increase on the two fields for the two years of 1.14 tons of hay from the use of lime, 1.88 tons of hay from the use of lime and manure, and 2.10 tons from the use of lime, manure and superphosphate. In the use of lime and superphosphate at varying rates, there was an increase of only 0.14 tons of alfalfa from the use of 300 instead of 150 pounds of superphosphate. There was only a slight difference in the average yields from the use of one ton of lime and 300 pounds of superphosphate, three tons of lime and 150 pounds of superphosphate, and three tons of lime and 300 pounds of superphosphate. In the alfalfa variety tests Ladak was the highest yielding variety during the biennium, with Kansas 308 a close second.

Corn was a failure at Moran in 1936, but fairly satisfactory yields were obtained at Columbus during both years. On the fertility plots the highest yield of corn was secured from the use of lime, manure and phosphorus, with an average increase from this treatment of 10.4 bushels per acre. The highest yielding variety of corn at Moran in 1937 was Yellow Selection 1, which produced 46.6 bushels per acre, only 0.3 of a bushel more than was produced by Pride of Saline.

Linota and Redwing continued to be the highest-yielding varieties of flax. Redwing produced an average of 9.9 bushels per acre during the biennium, while Linota and Bison produced average yields of 8.4 and 7.5 bushels per acre, respectively. The 40-pound rate of seeding flax has been superior to heavier or highter rates of seeding; and early March has been the most satisfactory time for seeding the crop. The highest yields were secured when flax was planted on spring-disked or fall-plowed soybean land.

Yields of Atlas forage were materially increased by the use of a legume in the rotation, and by the use of manure and phosphorus. Atlas produced 27.4 bushels of grain per acre on the no-legume plot and 47.2 bushels on the legume, lime, manure and phosphorus plot. In the sorghum variety test, Kansas orange and Atlas each produced an average of 7.65 tons of forage per acre, but the former produced 20.4 bushels of grain per acre to the latter's 22.7 bushels.

In the soybean variety test, A. ,K., Hongkong, Virginia Selection and Laredo continued to be the highest-yielding varieties for both seed and hay purposes.

The highest average yield of wheat 40.2 bushels per acre, was produced on the plot receiving lime, manure and superphosphate. The plot receiving no treatment in the rotation produced an average yield of 19.8 bushels per acre. Clarkan produced the highest average yield of wheat in the variety test, with Kawvale second, Blackhull third and Tenmarq fourth.

Studies were conducted both years with winter barley. Southeastern Kansas barley produced an average of 29.6 bushels of grain per acre, followed closely by south-central Kansas barley with a yield of 29.3 bushels per acre Missoury Early Beardless barley produced an average of 22.9 bushels of gram per acre.

(Department of Agronomy. Leaders, R. I. Throckmorton and F. E. Davidson; state fund.)

South-central Kansas Experiment Fields.— The application of superphosphate and sodium nitrate on wheat has had no significant effect on the yield. The response to superphosphate was greater on continuous wheat than wheat in

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rotation with other crops. An increase of five bushels to the acre was shown on the superphosphate plot.

In general, crops have shown considerable response in yield where a source of nitrogen was supplied. This response was significant on manured plots and plots including a legume in the rotation. The application of $NaNO_3$ has increased the yield of oats to some extent, but not above the yield of plots where the soil had been manured before kafir in the rotation.

Sweet clover sown in the springs of 1936 and 1937 was killed by the continued hot, dry weather throughout the summers. Fall-seeded sweet clover failed in the winter. because of weather conditions preventing the formation of a good seedbed. Alfalfa seeding in the fall of 1936 was a failure because of insufficient moisture. However, an excellent stand of alfalfa varieties was secured at both fields in the fall of 1937. Sweet clover responded well to lime, especially on the Kingman field.

Potatoes showed a significant response to superphosphate and sodium nitrate. Mulching with straw reduced the yield of potatoes 40 percent. The value of certified potato seed proved exceptionally high by yielding 45 percent more than the noncertified seed.

Wheat planted about the first of October has produced an average of two bushels per acre more than seed sown the first part of September, the middle of October, or later. Tenmarq wheat combined more desirable factors with its high-yielding ability than any other wheat grown in the test, and is very well adapted for production in this section.

Flax yields were only fair in 1936, producing an average of 4.5 bushels per acre. Good yields were obtained in 1937. Linota has shown up the best for the biennium. Bison has done well, but has shown low resistance to low temperatures. Seeding at the rate of 40 pounds per acre has produced maximum yields.

Ladak alfalfa has done well, especially at the Kingman field, Higher yields have been obtained from the Kansas Common than from other varietis of alfalfa at the Wichita field for the two years.

Brome grass has given the most desirable results of the grass varieties grown. Plots sown in 1933 maintained a fair stand during the hot, dry summers. Crested wheat grass has not shown the ability to maintain its stand that Brome has. Alfalfa seeded with Brome has increased the forage yield 40 percent and prevented a sod-bound condition that develops when Brome is seeded alone.

(Department of Agronomy. Leaders. R. I. Throckmorton and C. R. Porter; state fund.)

Southwestern Kansas Experiment Fields.— Extremely unfavorable weather conditions during the two years resulted in very low yields of all crops. Total precipitation for 1936 was 14.96 inches and for 1937, 12.71 inches. While soil blowing was a serious problem through southwestern Kansas, little or no wind erosion occurred on the experiment fields.

Summer fallowing as a method of crop production proved its worth in 1937. Wheat on fallow land produced 16.1 bushels per acre. while that on continuously cropped land was a complete failure. The average grain yield of 24 varieties of sorghums grown on summer-fallowed land, 6.6 bushels per acre, was more than double that of the same varieties grown on wheat ground. 2.7 bushels per acre. The yield of forage was nearly doubled on fallow. The yields of the best five varieties of sorghums were as follows:

Variety	*Yield in bushels per acre*	
	On fallow	*After wheat*
Club	20.5	8.7
Kalo	10.6	1.2
Dwarf Yellow milo	10.1	3.7
Tricker	9.7	0 0
Western Blackhull	9.4	6.5

Basin listing as a method of seedbed preparation and seeding of sorghums was superior to ordinary listing and planting. The average yield of duplicate

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plots with ordinary listing was 1,252 pounds of forage per acre compared with an average of 2,624 pounds per acre on the duplicate basin listed plots.

(Department of Agronomy. Leaders, R. I. Throckmorton and A. B. Erhart; state fund.)

Northeastern Kansas Experiment Fields.— Experiments with phosphorus in the potato rotation did not give consistent results during the two years. Commercial fertilizers increased yield of potatoes, but the increases were not significant except when both nitrogen and phosphorus were used. Green-manure crops in the rotation were a total failure because of light rainfall. Attempts to grow the green-manure crops apparently lowered the moisture content of the soil because the untreated plots gave higher yields.

Yields of potatoes increased, and the percentage of the total crop grading No. 1 decreased as the rate of planting was increased. In 1936, when many potatoes rotted in the ground, only half as many potatoes rotted where the 16-bushel rate of planting was used as with the 8- and 12-bushel rates, indicating that the heavier vine growth on the 16-bushel plots afforded more protection against heat.

Planting four inches deep increased the yield over the two-inch depth by 23 and 15 bushels for the two years, In the 1936 season 40 percent of the potatoes rotted on the plots where the depth of planting was only two inches, and 21 percent where the depth of planting was four inches.

A comparison of ridged and level culture indicated that the ridging is of importance only when the potatoes are planted shallow. The 1½-ounce seed piece gave the greatest return above cost of seed per acre in 1936, and the one-half-ounce piece in 1937.

Straw mulch had an adverse effect on potato yields during the biennium because of an outbreak of scab in the strawed plots. The total yield, however, was increased by the use of the mulch.

Cobbler continued to be the highest-yielding variety, although Warba yielded well, and outyielded the Cobbler variety in 1937.

Yields of alfalfa were increased one half where lime and manure were applied, two thirds by the application of lime and phosphorus, and doubled by the application of lime, manure and phosphorus. Oat yields were increased an average of 13 bushels per acre where manure was used in the rotation, and 17.5 bushels per acre where phosphorus was used. A change in the outline of the project permitted the use of phosphorus on wheat for the first time in the fall of 1936, and resulted in increases of 11 to 12 bushels per acre. A noticeable increase in test weight also was secured. Lime or manure did not give a marked increase in yield of wheat.

Kawvale, Kanred, Tenmarq and Clarkan continued to be the leading wheat varietues in yield. Winter barley winterkilled severely during both years of the biennium, Linota flax yielded 10.2 and 15.4 bushels per acre, respecively, for the two years. Kanota and Fulghum × Markton were the high-yielding oat varieties. Only forage yields were obtained from the sorghum varieties. Kansas Orange yielded slightly higher than Atlas, and both varieties were far above all others in yields of forage.

Only one cutting of alfalfa was obtained from the alfalfa varieties in each of the two years. In general, Kansas 308, Kansas Common, Grimm and Ladak were the better yielders. Brome grass, timothy and bluegrass were the only grasses able to survive 1936 and 1937. Application of phosphorus to bluegrass resulted in only a slight increase in yield, but the yield was trebled where both phosphosrus and nitrogen were applied.

Young apple trees mulched with straw made the best growth, as measured by girth increases, but trees intercropped with corn maintained a more desirable shape, resulting from the windbreak effect of the corn. The soil moisture supply was greater and more constant under the straw mulch than under the other systems of soil management.

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Bearing trees in straw mulch made more growth, yielded higher and produced larger but less well-colored fruit than trees under the other systems of soil management. Soil moisture was more plentiful and constant under the straw than elsewhere.

The use of sulphate of ammonia in an old apple orchard had little effect where the trees were cultivated, but increased the growth and yields somewhat on the trees growing in the bluegrass sod.

The different methods of soil management had a marked effect on the coloration of fruits. The percentages of under-color apples for the two years were: bluegrass sod, 16 and 3 percent; straw mulch, 23 and 29 percent; sod and fertilizer, 35 and 9 percent; cultivation and vetch, 43 and 18 percent; cultivation and fertilizer, 52 and 15 percent.

Yield from lightly pruned trees was better than that from moderately pruned trees. which in turn was better than from heavily pruned trees, but the largest and best-colored fruit came from the heavily pruned trees.

Liquid lime-sulphur gave almost complete control of scab, but caused the greatest amount of spray injury. Dry lime-sulphur gave good control, but also caused some injury. Flotation sulphur was the most effective of the milder forms of sulphur. Dry lime-sulphur in the prebloom sprays, followed by the milder forms of sulphur in the after-bloom sprays, gave good control of scab and caused very little spray injury.

At the Wathena field, with the exception of the straw mulch and variety tests. the results secured from the strawberries were of little significance. During the winter of 1936-'37, 50 percent of the unmulched plants winterkilled while only 5 percent of the mulched plants were injured.

Spraying with a l-percent summer oil solution under 150 pounds pressure for the control of red spiders on raspberries was not effective in controlling this pest; the number was reduced more than 90 percent. however. with an increased pressure of 500 pounds.

(Departments of Agronomy, Horticulture, Botany and Entomology. Leaders, R. I. Throckmorton, R. J. Barnett, L. E. Melchers, G. A. Dean, and Erwin Abmeyer; state fund.)

INVESTIGATIONS IN THE PLANT INDUSTRIES

The work of the station during the past two years relating to the problems of plant improvement and production is summarized briefly on the following pages.

Temperature Relations of Crop Plants.— The work on this project the past biennium concerned chiefly (1) the rate of loss in cold resistance of varieties of wheat after the start of spring growth; and (2) the relation of nutrient level to cold resistance of winter wheat.

In the experiment on changes, in cold resistance of wheat during the winter-spring transition, several varieties were tested, including Harvest Queen and Kanred. which had been studied previously. The results verified the earlier indication in showing that Harvest Queen lost cold resistance slowly during the transition period whereas Kanred lost resistance rapidly. In the present tests transition changes in Clarkan took place even more slowly than in Harvest Queen. Kawvale exhibited somewhat the characteristics of Harvest Queen and Clarkan, but to a lesser degree. The survival of clarkan in the hardened condition was 15 percent less than Kanred and 18 percent more than Kanred after five days in the greenhouse. The survival of hardened plants of Kawvale was 10 percent less than Kanred. but after the plants had grown for five days in the greenhouse. the difference was slightly in favor of Kawvale; and, after 10 days Kawvale Survived 7 percent better than Kan-

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red. The relatively hardy condition of Clarkan, Harvest Queen and Kawvale after spring growth started indicated that they may be superior in resistance to spring freezes.

The relation of soil nutrients to cold resistance of wheat was investigated Kanred wheat was grown indoors in pots filled with soil prepared so as to represent six different nutrient conditions. Four of these conditions were obtained with a soil of low fertility from an eroded part of the agronomy farm. One group of pots was filled with untreated soil, while to the other three groups were added one, two, and three units of superphosphate, respectively. The other two nutrient conditions were obtained with a fertile soil from a bottomland field on the farm. One group of pots was filled with untreated soil and to the other group three units of superphosphate were added.

During the winter when the plants were in the hardened condition, they were artificially frozen. Twelve repetitions of the freezing test gave essentially the same results. The greatest amount of freezing injury to the wheat was observed in the low-fertility, untreated soil; slightly less in that receiving one unit of phosphate; considerably less where two units of phosphate were applied; and the least injury with three units of phosphate. The wheat grown in the high-fertility soil was injured about the same in the untreated as in the treated pots, and relatively little in either condition. The injury was about the same in the low-fertility soil, treated with three units of phosphate, as in the fertile soil.

The results indicate that the use of fertilizers on nutrient-deficient soil may be expected to increase the winter resistance of wheat.

Further study of the relation between the nutrient levels of the soil and the cold resistance of wheat is contemplated to determine whether the differences in resistance are due to the physiological condition of the protoplasm as a result of the plants having been grown in different nutrient conditions, or to the greater capacity of the plants to recover in soils at the higher nutrient levels.

(Project 157; Department of Agronomy. Leader, H. H. Laude; Purnell fund.)

Small Grain and Sorghum Improvement.— This project has been continued with the coöperation of the Bureau of Plant Industry, United States Department of Agriculture, and of the departments of Botany, Entomology and Milling Industry, and has been concerned with plant-breeding work on winter wheat, spring oats. barley, and grain and forage sorghums,

Winter Wheat.— Selections of Kawvale × Tenmark, and of Oro × Tenmarq (bunt resistant) were promoted from nursery rows to field plots. Average nursery yields of these hybrids, and of standard varities, are as follows;

Kansas No.	*C. I. No.*	*Variety*	*Three-year (1935-1937) Average Yield*
2727	11750	Kawvale × Tenmarq	39.6
2723	11669	Kawvale × Tenmarq	39.2
2728	11672	Oro × Tenmarq	38.9
2729	11673	Oro × Tenmarq	36.3
2593	8180	Kawvale	36.2
514	6936	Tenmarq	35.8
343	6251	Blackhull	30.9
570	1558	Turkey	29.5
317	6471	Fulcaster	28.7

Selections of Cheyenne × Tenmarq, Early Blackhull × Tenmarq (earliness) and crosses of Hope and Marquillo on winter wheats (resistance to stem rust) and several other crosses, appear promising in the nursery. In a winter-wheat nursery at the Colby Branch Station special attention has been given to winter hardiness. A soft, red winter-wheat nursery is grown at Columbus, in southeastern Kansas.

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Oats Breeding— A fifteen-acre field of Fulghum × Markton, Kansas 6138, is being grown at the agronomy farm for seed increase and probable distribution to farmers in 1939. Agronomic data on this hybrid variety, compared with Kanota Kansas 839, as tested in the nursery for seven years, 1931-1937, are here given.

C. I. No.	Variety	Plant height, inches	Date head, May	Smut, pct. 1933-1937, inoc. seed	Bushels per acre	Test weight pounds, six years*
3327	Fulghum × Markton	32	25	0.5	58.4	29.8
5179	Kanota	29	28	25.9	50.2	28.3

* 1934 omitted.

This Fulghum × Markton selection is susceptible to stem rust and to crown rust. It has been crossed with Richland (resistance to stem rust), Victoria (resistance to crown rust), and with Victoria × Richland (resistance to both rusts). Large numbers of selections of these composite crosses are now being tested in the rust nursery.

Barley Breeding.— Flyun, an early, smooth awn variety, continues to do well on farms in western Kansas. Selections of Atlas (California) × Vaughn produced high yields and appear promising in nurseries at Hays and Colby.

Sorghums.— A selection of Atlas × Early Sumac (an early Atlas for western Kansas) appears promising at Hays and Colby. Selections of Greely × Weskan (earliness, clean white seed) appear promising at Tribune and Hays. Selections of kafir × darso are ready for plot tests at Darlow, Kan. Selections of Atlas × (Red Amber × Feterita) and of the backcross (Spur feterita × Blackhull kafir) × Blackhull, are among the more promising smut-resistant types being tested in the sorghum breeding nursery at Manhattan.

(Project 67; Department of Agronomy. Leader, John H. Parker; Hatch and state funds.)

Inheritance of Factors Affecting Quality in Wheat.— Chief attention has been given to the wheat-meal-fermentation-time test and its value in plant breeding. Until recently wheat breeders have had no simple method by which an indication of the baking quality of wheats in the early stages of development could be obtained. A physical test termed the doughball, or wheat-meal-fermentation-time test, originated in England, has been used in quality testing of varieties and hybrid lines of wheat in Germany, the United States and several other countries. In 1931, 1934, 1935, 1936 and 1937, wheat varieties and hybrid selections from coöperative wheat variety tests on Kansas farms, field-plot variety tests on branch experiment stations and regional experimental fields, wheat variety plots at the agronomy farm, Manhattan, and the wheat-breeding nursery at Manhattan, were tested for "time."

The test is based on the time that a dough mass takes to break down in water. The longer it takes for the dough mass to break down, the stronger the wheat is considered to be. In order to determine the "time" of a large number of varieties grown each year, wheat samples from several sources were obtained. The following data on the varieties grown in the cooperative wheat variety tests on farms in Kansas for five years show that the test in general separated strong, semistrong, and weak wheats.

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Variety	*Five-years-average "Time" in minutes*
Tenmarq	132
Turkey	91
Blackhull	85
Kanred	79
Kawvale	75
Early Blackhull	72
Clarkan	52
Harvest Queen	45
Fulcaster	43

A large number of Varieties, pedigree selections and advanced hybrids grown in the cereal breeding nursery have been tested. The varieties Tenmarq, Cheyenne, Oro, Kanocks, Lin Calel, and Danne selections C24-10 and C7R10 have long "time." Turkey, Kanred, Blackhull, Early Blackhull, Quivira, Minturki, Kawvale and Iobred have medium "time." Superhard Blackhull, Kanhull, Chiefkan, Danne selection H68B, Nebraska 28 and Mutant (Akron 7) are hard wheat varieties having a short "time."

Since the "time" of varieties, selections and advanced hybrids remains in a given range from year to year, the greatest value of the "time test" probably lies in its use to the plant breeder. In the segregating of progency of such crosses, as for example Early Blackhull × Tenmarq, only those lines baring a "time" in the same range as that of the parent having the most desirable quality should be selected. In such crosses the plant breeder can be relatively sure as to the inherent quality of the strains selected, as any strain having "time" in the range of the poor-quality parent would in all likelihood have the quality of the poor-quality parent, and vice versa. A few lines baring "time" exceeding the limits of either parent, probably caused by transgressive segregation, were obtained in most of the crosses tested. These lines probably have different quality than either parent.

Correlations of the "time test" have been made with other tests of wheat quality, such as the protein test, dough development curves the baking test. In three years, using more than 100 strains each year, no significant correlations were obtained between the "time test" and the percentage of protein in the wheat. Preliminary studies of the "time" of varieties, for which recording dough mixer curves are available, indicate that significant correlation exists between the "time" and the curve type. Limited studies indicate no correlation between "time" and loaf volume.

(Project 178; Departments of Agronomy and Milling Industry Leaders, John H. Parker, C. O. Swanson; Purnell fund.)

Varietal Tests of Small Grains and Sorghum.— The work done on this project during the biennium included variety tests of winter wheat, winter barley, oats, flax and sorghum, adaptation tests of spring barley and spring wheat, and date of seeding-variety tests of winter wheat. Attention was given to possible relationships between environmental conditions, growth responses, and yield. In a cooperative plan with the United States Department of Agriculture additional equipment was installed for the measuring of environmental factors associated with plant growth and yield.

The elimination of nonwinter, hardy segregates and hybrid populations by natural selection was demonstrated. Seed of Oro × Federation F2, obtained from the experiment station at Pendleton, Ore., was planted at Manhattan in the fall of 1933. In successive seasons seed of the preceding crop was planted. Winterkilling the first year was 35 percent; the second, 10 percent; and the third, a trace. Seed of this cross harvested at Pendleton in 1934 was planted in the fall of 1936 at Manhattan for comparison with that harvested here in 1936. The winterkilling of the plot planted with the Pendleton seed was 48 percent; with the Manhattan seed, 1 percent.

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Among the varieties of wheat tested, Turkey Selection, C. I. 10,094. Kansas 2719, made an unusually good record, having yielded more than Kanred, Turkey, Tenmarq, and Cheyenne in each of the three years it has been tested. Several new varieties of wheat were introduced into the test the second year of the biennium. Kawvale × Tenmarq. Kansas 2723 and 2727, made the highest yields in 1937, averaging 52.1 and 50.7 bushels, respectively, compared with 42.4 for Tenmarq, 45.6 for Blackhull, 43.2 for Kanred, and 41.5 for Turkey. Two selections from the cross Oro × Tenmarq also did particularly well, Kansas 2728 averaging 45 bushels; and 2729, 48.2 bushels.

In 1937 yields was positively associated with number of heads per area within varieties of wheat, but among varieties this relationship was only slight.

Fulghum × Markton, Kansas 6138, oats, of particular interest because of smut resistance, averaged slightly higher in yield than Kanota during the four years it has been tested, the difference being 1.4 bushels.

In sorghum variety studies it was observed that approximately one half of the total dry weight of the plant in forage varieties such as Atlas, Kansas Orange and Leoti Red was composed of stem, whereas in grain varieties, such as Western Blackhull kafir, Darso and Ajax, the stem comprised only one fourth of the weight of the plant.

(Project 129, 1-2; Department of Agronomy. Leader, H. H. Laude; Hatch fund.)

Variety and Cultural Tests of Soybeans and Cowpeas.— The work on this project has included tests of 18 varieties, 16 selections and 28 introductions of soybeans; and of 16 varieties of cowpeas and two of tepary beans. Tests of different methods and rates of planting were made also. Drought, high temperatures during the bloom period, and grasshoppers affected the crop adversely both seasons, and the yields were below normal.

The extreme range of yield of seed of soybean varieties was 4.68 to 16.43 bushels in 1936, and 5.41 to 14.96 in 1937; and 1,708 to 2,861, and 1,128 to 2,633 pounds of air-dry hay. Conditions in both yearn seemed to favor the earlier varieties; Pinpu, Illini, Kansas Selection 83, and Kansas Selection 85 ranked first in seed production. All of these are earlier than A. K. and Hongkong, the recommended varieties. Laredo, normally first in hay production, fell to seventh place in 1936, and to fourth place in 1937. The conditions of abnormal rainfall distribution must be considered in evaluating data for the recommendation of varieties.

The yield of cowpeas ranged from 1,228 to 2,631 pounds of hay per acre, and 0.28 to 4.4 bushels of seed. Victor, New Era. Holstein and Progressive White are consistently among the high producers. During the adverse seasonal conditions of the biennium, cowpeas have produced less hay than soybeans, and less than one fourth as much seed.

Tepary beans have excelled cowpeas in yield of both hay and seed. The seed yield of the light-yellow variety has been approximately double that of the highest-yielding cowpea. In 1937 the yield of that variety was 2,889 pounds of hay per acre, which exceeded even the highest-producing soybean. The yield of seed was 8.38 bushels, a little more than half that of the highest soybean yield.

Soybeans planted with a corn planter at the rate of 14.6 pounds per acre produced the highest yield of seed in both years. There was no significant difference in yield of hay by the different rates of planting, which included rates of 14.6, 19, 26, and 32 pounds per acre. Planted with a grain drill in 7-inch rows, 70 pounds per acre produced the highest yield of both hay and seed in 1936, while the 46-pound rate produced most hay, and the 86-pound rate most seed in 1937. There is no apparent advantage in planting with a grain drill, and the hay produced is somewhat less.

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(Project 129-3; Department of Agronomy. Leader, J. W. Zahnley; Hatch fund.)

Miscellaneous Legumes for Forage.— The work of the biennium on this project has consisted of a study of growth characteristics of a large number of varieties, and of variety tests. In 1936 plantings of seven varieties of legumes were made, both with a nurse crop and alone to determine the effect of the nurse crop upon survival of the different varieties.

In 1936 all varieties were largely defoliated by the variegated cutworm, and a large proportion of the bark eaten from the stems. It was necessary to harvest the entire planting for seed in order to avoid losing some of the varieties. In 1937 the growth was more satisfactory, although damaged both by variegated cutworms and grasshoppers. The cutworms climbed to the tops of the plants and ate leaves and fine stems, particularly the flower racemes, thus interfering with seed production. The white-blossom varieties as a group were damaged least. Ohio Evergreen, a white-blossom strain from the Ohio station, produced the heaviest vegetative growth in the second year, followed by Madrid White, Downs, Chantlands, and another strain of Madrid white. in order. These are all late varieties and coarser and more stemmy than the Madrid Yellow varieties.

The detrimental effect of a nurse crop for sweet clover was clearly shown in plantings made in the spring of 1937. Data obtained on April 18, 1938, showed a higher percentage of survival in every case where there was no nurse crop. This was consistent on duplicate plots of each of the seven varieties. The average survival of all varieties without a nurse crop was 57 percent. and with a nurse crop of oats, 25 percent.

(Project 129-4; Department of Agronomy. Leader, J. W. Zahnley; Hatch fund.)

Corn Production and Improvement.— The production of superior dent and popcorn hybrids from inbred lines has been continued as the primary objective of this project during the past biennium, conducted in cooperation with the Bureau of Plant Industry, United States Department of Agriculture. Agronomic experiments to determine the best time and method of planting corn, and the optimum rate of planting have been continued. Other phases given attention include studies of insect resistance in corn, heat tolerance in corn, and the effect of one, two or three doses of the Y factor on the amounts of the different pigments in the endosperm of corn. The corn project was greatly handicapped during 1936 by the continuation of the drought. Although all plots of varieties and hybrids were almost complete failures in 1936 from the standpoint of grain production, pronounced differences in drought injury were evident and valuable information concerning drought tolerance of inbred lines and hybrids was obtained. Weather conditions in 1937, although better, were again below normal for corn production. Corn was almost a complete failure in the western third of the state; yields were poor in the central counties and spotted in eastern Kansas. The southeastern corner of the state was the most favored section, where fair to good yields predominated.

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In the "time and method of planting" experiment at Manhattan, plantings after May 1 yielded less than those to and including that date. The average yield for all the plots was 25.6 bushels per acre. Yields were a little erratic in the "rate of planting" test, but were highest for the 16-inch and 24-inch spacings. The thickest planting produced the highest tonnage of dry stover and the lowest yield of grain. The 4-inch spacing yielded 15 bushels per acre, while the 16- and 24-inch spacings yielded nearly 50 bushels per acre. In the variety comparison at Manhattan, Pride of Saline yielded 53.9 bushels per acre, while Phillips County Yellow was clearly unadapted, yielding only 19.4 bushels per acre.

Because of the drought, seed stocks had diminished to the extent that many of the lines were on the verge of extinction. A piece of new equipment acquired during the year was a Skinner System, for overhead irrigation of a small nursery. As a result, stocks of selfed lines and single crosses are now in better shape.

Thirty-two top crosses and 97 double crosses were tested in replicated plots. Yields per acre ranged from 13.4 bushels to 61.3 bushels. Kansas HY30 was easily the highest-yielding top cross in the local test. The highest-yielding hybrid produced 61.3 bushels per acre in comparison with 50.1 bushels for open-pollinated Pride of Saline. Eightly-nine white single crosses, 179 yellow single crosses, 234 yellow double crosses, and 92 popcorn single crosses were made.

The popcorn-variety test was limited to two varieties, South American and Supergold, which are the chief varieties now grown commercially in this region. Supergold was superior in popping expansion, and greatly superior in yield and eating quality. Little consistency in differences could be noted in the popping expansion or eating quality of the corn produced under different methods of fertilization.

A study of heat and drought tolerance in maize showed that both physiological and genetical factors are involved in the drought relationship of plants.

A few of the major items for future consideration are:

1. Further testing of Yellow Selection 1, and, if sufficiently promising, its ultimate distribution;
2. Testing of a large number of experimental hybrids;
3. Testing of the "out-of-state" commercial hybrids being sold to Kansas farmers;
4. Studies of the nature and inheritance of corn smut and Diplodia stalk rot;
5. Continued drought-resistance studies.

(Project 156; Department of Agronomy. Leaders, A. M. Brunson and R. W. Jugenheimer; Purnell fund.)

Alfalfa Investigations in Relation to Winter Hardiness and Bacterial Wilt.— Particular attention has been given to the study of five phases of the problem of cold resistance to bacterial wilt in alfalfa.

1. *Correlation of Storage of Organic Food Reserves in Alfalfa Roots with Other Physiological Processes Affecting Cold Resistance.—* Laboratory and field data obtained during 1936 and 1937 trace the cold-hardening processes of the alfalfa plant. The dry weight of the crown buds gives an indication of the time, rate and extent of their development. On September 2, the average dry weight of crown buds from eight replications of 100 root samples was less than one gram. From this date on there was a gradual increase in dry weight until the last of October; and, from the twenty-third of October to January 1, there was very little change. The March 12 samples showed a decrease in dry weight from the January 1 sampling, caused by the start of spring growth.

The amount of moisture in plant material and the form in which it is retained has a direct relation to cold resistance. The determination of total

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moisture, and the percentage of the total moisture that is bound water, correlate closely with the seasonal development of cold resistance. From September 2 to October 23, as the total moisture increased, there was a decrease in the percentage of bound water. However, the percentage of total water increased faster than the bound water decreased, as this change occurred during the period in which the crown buds were making their most rapid development. From October 23 to January 1 there was a decrease in the percentage of total water from 87 percent to 73 percent, and, of this total water on October 23, 72 percent was bound water, and, on January 1, 90 percent. The free or easily frozen water was reduced from 27 to 10 percent, an indication of hardening.

2. *Methods of Promoting the Production and Viability of Alfalfa Seed.*— Seed-setting studies were made, using the temperature and humidity control cabinet. The maximum set of seed pods was obtained at temperatures ranging from 70 to 95 degrees F. Above 100 degrees F. the number of pods decreased very rapidly. The number of seeds per pod was not affected by either the temperature or humidity within the temperature range for pod forming, and not to any appreciable extent by the humidity, regardless of the temperature. Flower buds and young shoots will stand higher temperatures after a few hours of daylight hardening than when subjected to the same temperature immediately following a dark period.

Studies with moisture control indicate that if the plants are held in a low-moisture condition for a short period just previous to budding, the number of flowers will be approximately the same as at optimum moisture conditions, and the percentage of flowers setting pods will be increased as well as the number of seeds per pod.

3. *Alfalfa Breeding and Improvement.*— During 1937, 12 strains of alfalfa were grown at Garden City for seed increase. Seed yields ranged from one to five pounds. The wilt nursery in 1937 consisted of 180 individual plant selections made from isolated seed blocks at Garden City in 1936. By plant selection made from isolated block, wilt resistance of 50 to 65 percent in different lines has been developed in a strain of Kansas Common from an original resistance of approximately 20 percent.

4. *Adaptation of Domestic and Foreign Species and Strains of Alfalfa to Different Environments.*— Nursery-row and plot work has been discontinued as in the past. Although the drought of the past few years made it impossible to obtain reliable yield data, the observational data concerning wilt resistance continue to show the superior resistance of the Turkestans over all other strains, also their higher susceptibility to leaf and stem diseases.

5. *Selection and Hybridization for Improvement of Alfalfa.*— After several years of careful selection and testing, a few selected lines of Kansas Common show a high resistance to bacterial wilt, at the came time maintaining other desirable characters of the Kansas Common. Lines are also being selected from Kaw and other Turkestans with the aim of retaining the wilt-resistant characteristic and developing resistance to leaf and stem diseases.

(Project 183; Department of Agronomy. Leader, C. O. Grandfield; Purnell fund.)

Pasture-improvement Investigations.— During the past biennium investigations were conducted on eight phases of this project as follows:

1. *The Management of Livestock on Bluestem Pastures.*— The drought of 1936 and continued dry weather in 1937 were factors preventing the bluestem grasses from making normal recovery from the 1934 drought except where protection from grazing was practiced. Comparative studies on protected areas, in contrast to those grazed season-long, have shown that the tall grasses tend to be eliminated by continuous grazing and replaced by short grasses and weeds.

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2. *Effect of Burning on Bluestem Pastures.*— Owing to the extreme drought none of the experimental plots have been burned during the past two seasons. Density studies have been continued on the old burning plots however, and still show the effect of burning done in 1934 and previously. All the burned plots show decreased yields as compared with the unburned check plots, with the greatest decrease in the fall-burned areas, and the least decrease in the late spring-burned areas. It is planned to resume these burning investigations this season, and to study the effect of burning on run-off and erosion. Two plots have been established on a 7-percent slope, and at present the run-off on nonburned land is being studied in preparation for future burning studies.

3. *Eradication of Undesirable Plants from Pastures.*— This work has largely been discontinued during the drought. Mowing of brush has further substantiated the observation that the most efficient time of mowing is at the point of lowest root reserves. The investigations in southeast Kansas to determine the best method of eliminating annual, weedy grasses, which have invaded the pastures largely as a result of the drought, show that the use of various tame grasses is very effective in controlling little barley and the weedy bromes. When more than a half-stand of the tame grass was obtained.

4. *Effect of Frequency, Height and Time of Harvesting on Yield and Succession of Pasture Vegetation.*— The clipping has not been continued since the drought, but the effects of previously clippings can still be observed. Quadrats clipped most frequently show the greatest injury. Early clipping was also found to be injurious.

5. *Effect of Fertilizers on Yield and Succession of Pasture Vegetation.*— Fertilizer treatments, discontinued during the drought. Have been resumed in 1938. The treatments being used are: Nitrogen ($NaNO_3$) 200 lbs., 3 applicationa yearly; nitrogen ($NaNO_3$) 100 lbs., 1 application yearly; nitrogen ($NaNO_3$) 100 lbs. yearly with 200 lbs, superphosphate on alternate years; $NaNO_3$, 100 lbs., with 200 lbs. superphosphate and 25 lbs. potash on alternate years; superphosphate 200 lbs., alternate years; lime, 1 ton per acre, every eight years; manure. 3 tons per acre. alternate years; lime. 1 ton every eight years with 200 lbs. superphosphate on alternate years. Quadrats on plots treated with nitrogen at the rate of 200 lbs. of $NaNO_3$ and manure show less injury from the past drought than the other fertilized or untreated plots.

6. *Grass and Forage-crop Nursery.*— This nursery includes observation plots and rows of a number of *grasses* and pasture legumes, many sent from foreign countries for observation and testing. Foreign grasses giving promise of real value are: *Agropyron semi-costatum, Spodiopogon sibericus,* and *Andropogon intermedius-caucasium.* It also includes increase blocks of crested wheat grass and of *Agropyron semi-costatum,* as well as a number of blocks of tame grasses and grass mixtures. The value of cereals for temporary pasture has been investigated in the nursery. The highest yields for fall and spring pasture were obtained from winter rye, with winter wheat second, and winter barley third. Winter barley cannot be depended upon to stand the winter, and oats, while making good fall pasture, was killed by early December freezes The investigations will be continued during the coming year.

7. *Grass-breeding* Nursery.— The 1936 nursery contained approximately 14,000 individual grass plants of which 6,000 were big bluestem *(Andropogon furcalus),* and the rest included such grasses as switch *(Panicum virgatum),* Indian *(Sorghastrum nutans)* side oat grama *(Boutelowa curtipundula),* blue, grama *(B. gracilis).* A number of brome-grass selections were planted in the fall of that year.

From the 1936 bluestem nursery a number of the most desirable plants were selfed. Progeny from both the selfed and open pollinated portions of the plant make up the 1937 nursery, or third generation. Detailed study of these plants substantiated the evidence from their parents; variations are heritable, and selection even in open-pollinated lines is a successful method of improvement; both big and little bluestem can be selfed successfully. There is a reduction in seed set, but the seeds produced are viable and capable of becom-

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ing thrifty plants. There is some evidence that selfing does not appreciably affect the vigor of growth, but further investigations are needed.

8. *Coöperative Pasture Experiments.*— Coöperative pasture experiments were continued in four places in eastern Kansas to obtain information on the best methods of reseeding farm pastures that have been depleted by overgrazing and drought, or a combination of these factors. The cooperative work with the Fort Hays Branch Station and the Soil Conservation Service on the effect of grazing on run-off and erosion was continued at the Phillips pasture near Hays, Kan. Selection, adaptation, and breeding work have also been started at Hays.

A cooperative grazing experiment was started with the Department of Dairy Husbandry to determine the palatability, yield, and carrying capacity of various tame grasses and mixtures. Result to date indicate that a mixture of brome, orchard, meadow fescue, and alfalfa is probably the most palatable, and will pasture more head per acre, while crested wheat grass gives the highest yield.

(Project 96; Department of Agronomy. Leaders, A. E. Aldous and K. L. Anderson; Purnell, Bankhead-Jones and state funds.)

Physiological Study of Bindweed in Relation to Its Control. —The work of this project during the past biennium consisted of studies of (1) the general nature and growth of the bindweed plant; (2) the effect of plowing on this plant; (3) the seasonal variation in the place and extent, of reserve storage in older plants undisturbed by cultivation, older plants in cultivated land, and year-old undisturbed plants; and (4) of seed viability and the effect of depth of planting on the rate of germination of seed.

1. *Nature and Development of the Bindweed Plant.*— The nature of the plant undisturbed by cultivation is as follows: The germinating seed gives rise to a deeply-penetrating taproot bearing a well-developed shoot. Along this taproot in its earlier stages of development are many lateral roots. Some of these grow into well-developed horizontal roots which extend some 14 to 30 inches and then turn downward in a broad, sweeping turn to develop into a deeply penetrating taproot. At the general region of downturning of this horizontal root, lateral roots arise, Some of these persist as hair roots, but a few develop into horizontal roots which extend 12 to 24 inches and then bend downward to form a deeply penetrating taproot. The subterranean part of the plant extends laterally from the taproot by the several horizontal roots grow ing out radially from this common center. The surface growth of the plant is observed as a circular patch of bindweed.

2. *Modification of the Bindweed Plant by Cultivation.*— Agronomists have advanced the criticism that cultivation methods such as plowing and deep cultivation may modify the physical nature of the bindweed plant. The criticism is pertinent; hence, to obtain evidence of the nature and extent of this modification, a small area of one-year-old plants grown from seed was plowed in the fall of 1937 to a uniform depth of six inches with a 16-inch sulkey plow. The plant parts exposed as each furrow was turned were labeled with a permanent label. Excavations will be made in the fall of 1938.

3. *Seasonal Variations in Place and Extent of Reserve Storage.*— A well-established stand of old, undisturbed bindweed was located and the plants so removed that the plant body could be divided into 13 divisions. Fifteen-gram samples were secured of each plant, division at bimonthly periods. These are being analyzed for total N, protein N, reducing and nonreducing sugers, starches, and hemicellulose to give the place and extent of storage of these various reserve fractions; also the changes occurring in the same for an eight months' period of 1937.

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4. *Seed Viability.*— Twenty-four hundred selected bind-weed seeds were planted in a well-drained loam soil in October, 1936. Plantings were made at the rate of 50 seeds per square yard, all seeds four inches apart. Depth of planting was ½, 1, 1½, 2, 2½, 3, 3½, and 4 inches. The percentage of germination of the entire planting was about 12 percent. It was much higher than the average in the plots with seeds planted 1½ inches or less, about average in the plots planted two inches deep and much lower in those planted below two inches,

On November 10, 1936, 160 seeds were selected, scarified by nicking the seed coats slightly with a three-cornered file, and planted at a uniform depth of one inch in a good loam soil. Only one of the 160 seeds germinated.

(Project 202; Department of Botany. Leaders, J. C. Frazier, E. C. Miller; Bankhead-Jones fund.)

Weed Eradication.— The work on this project during the biennium has been concerned with the use of chemicals for field bindweed control. Comparisons were made of the relative values of dry and spray applications; Atlacide and sodium chlorate; acid arsenicals, sodium thiocyanate, and acidulated sodium chlorate; repeated treatments of sodium chlorate and a single heavy application. A study was made of the seasonal trends of root reserves.

Dry sodium chlorate has compared more favorably with the spray method during the last two years than in earlier tests. The dry treatments gave as good results as the spray method in 1937, but in 1936 it was significantly inferior. The new Atlacide has not been so effective in killing bindweed as sodium chlorate where equal quantities of the two chemicals were used. Acid arsenicals have shown some promise for bindweed control, but have been less effective than sodium chlorate. Where about three times as many gallons of the acid arsenical spray solution as would be required with sodium chlorate were used, the results were still inferior to those obtained with sodium chlorate. Sodium thiocyanate has proved to be practically worthless for killing bindweed. Acidulated sodium chlorate apparently has no advantage over sodium chlorate to which no acid has been added.

There is apparently little advantage of repeated light treatments with sodium chlorate over single heavy applications, evenly distributed.

Samples for determination of root reserves were collected every two weeks during the growing season. Analyses of these samples show that the low point in root reserves for the years 1936 and 1937 occurred approximately September 15. In both years there was a distinct rise in total carbohydrates during October.

Further study of the use of dry sodium chlorate in comparison with spray treatments is contemplated for 1938; and two herbicides new on the market, called triox and pentox, will be compared with sodium chlorate as to efficiency. Continuation of the study of the trends of root reserves is desirable because of the fluctuations from season to season, and the apparent influence of growing conditions.

(Project 166; Department of Agronomy. Leader, J. W. Zahnley; state fund.)

Cooperative Experiments with Farmers.— During the last biennium, 1,439 experiments were conducted in coöperation with county agents, vocational teachers and farmers in 99 counties, as shown on the accompanying map. (Fig. 3.)

The number of wheat variety tests has been increased slightly in eastern Kansas in recent years in order to secure additional information on the adapta-

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tion of Tenmarq, Kawvale and Clarkan wheat varieties. Small-grain fertility tests were located in central and eastern Kansas. Corn- and sorghum-variety tests were distributed over the entire state; corn, however, is stressed in eastern Kansas and sorghum in western Kansas. Grass, alfalfa and sweet clover tests were located in various sections of the state, but comparatively few yield records were secured because of poor stands due to drought. Red clover-variety tests were established in the spring of 1937 and 1938 in order to secure information on the relative value of imported and home-grown strains of red clover. Oat-variety tests, which had been discontinued in 1934-'35, were again established to study the relative value of Kanota and a new early-maturing, smut-resistant selection from a Fulghum × Markton cross

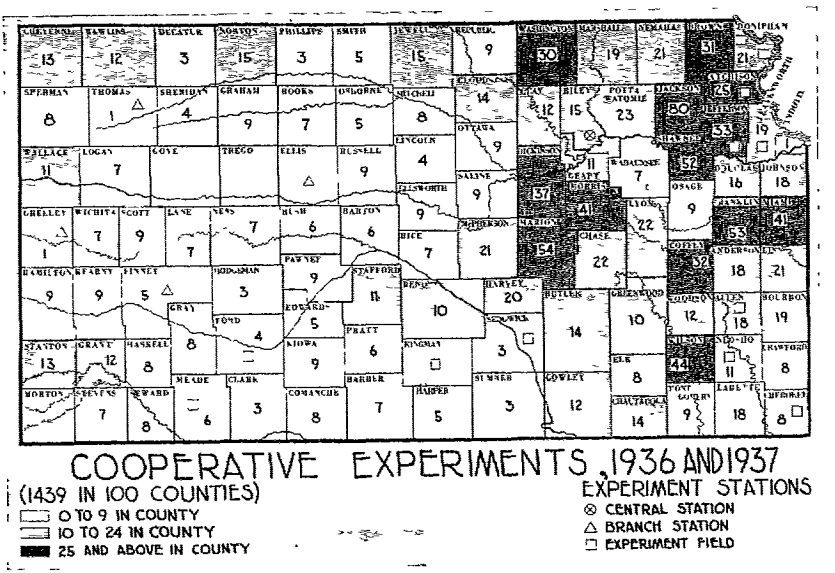

FIG. 3. Location of experimental work conducted during the biennium.

The first artichoke variety test was established in the state in the spring of 1937. In the spring of 1938, two hand-planted, replicated, corn-variety tests were established in eastern Kansas to make possible a more detailed comparison of open-pollinated varieties of corn and corn hybrids. It is proposed to expand this work next year should the need for testing corn hybrids increase as is expected.

Wheat Varieties.— Compamble yields of wheat were secured from 49 wheat variety tests in 1936, and 63 in 1937. Tenmarq made the highest yield in both years in central Kansas. In 173 tests, located in south-central Kansas during the last nine years, Tenmarq has averaged 23.1 bushels per acre, Turkey 21.4, Blackhull 21.1, and Kanred 21.0. Three early maturing varieties, Early Blackhull, Quivira, and Kanred × Hard Federation, were all outyielded by Tenmarq both years. In western Kansas Early Blackhull made the highest yield in 1936, and Tenmarq in 1937. Clarkan is the highest-yielding soft wheat in eastern Kansas.

Fertility Tests with Wheat.— Superphosphate may be used profitably in growing wheat and oats on many soils in eastern and central Kansas. In 11 replicated tests conducted in 1936, 80 pounds of 45-percent phosphate per acre

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increased the yield of wheat as much as 10.6 bushels per acre; and in nine replicated tests in 1937 the increases varied from 2.9 to 11.4 bushels per acre, depending upon the location of the test.

Eighty pounds of 45-percent phosphate per acre on 20 tests conducted in 1936 and 1937 increased the yield of wheat an average of 5.9 bushels per acre. An application of approximately half as much increased the yield only 3.5 bushels per acre in the same tests.

Oat Variety.— A limited number of tests during the last two years indicates that a new oat variety selected from a Fulghum × Markton cross, No. 6183, is slightly superior to Kanota in yield and test weight. In five tests conducted in 1937, Fulghum × Markton made an average yield of 37.7 bushels per acre and test weight of 28.6 pounds per bushel. Kanota in the same tests made an average yield of 36 bushels per acre with a test weight of 27.8 pounds per bushel. Fulghum × Markton, No. 6183, is resistant to smut.

Sorghum Varieties.— Three sorghum varieties, Club, Early Kalo, and Colby, were approved for distribution in 1938. In coöperative tests for several years, Club has made a higher average grain yield than Blackhull in all parts of the state except the northwest section. Early Kalo, an early-maturing grain sorghum, has proved to be adapted to all of the state except where chinch-bug damage is a limiting factor. Colby is early in maturity, has a short stalk and an attractive milo-type grain, In coöperative tests since 1934, Colby has been one of the high-yielding varieties in northwestern Kansas.

Sweet Clover Varieties.— Coöperative tests since 1934 have indicated that Madrid Yellow, No. 27474, is superior in yield to Common Yellow and furnishes better-quality forage than Common White sweet clover. Seed of Madrid Yellow is being increased for distribution.

Effect of Bindweed on Small Grains.— Bindweed reduced the yield of small grains as indicated by yield data secured during the last four years. In 76 tests located on farms in central Kansas, wheat on bindweed-free land made an average yield of 20.3 bushels per acre, 4.9 bushels or 31 percent more than an adjacent bindweed-infested land. On 16 farms oats on bindweed-free land made an average yield of 43.5 bushels per acre, 14.3 bushels or 50 percent more than on infested land.

The work of securing yields of small grain on bindweed-infested and free land will be discontinued as a purely cooperative experiment project because this information is now being secured in cooperation with the Kansas State Board of Agriculture.

(Department of Agronomy. Leader, A. L. Clapp; state fund.)

The Influence of the Method of Harvesting and Storing Alfalfa Hay Upon Quality.— The aim of the work of the biennium was to ascertain whether or not the quality of alfalfa hay is affected by the method of harvesting and storing.

Heating in storage was studied in connection with the experimental hay. and a study of ventilation in chopped hay started. However, a very small quantity of hay was put up for experimental purposes because of the crop failure in 1937. The hay has not been removed from storage at this date, but it is felt that any results obtained will not be representative of farm storage conditions.

If suitable hay crops are available, the lines of attack for the 1938 season will be the effect of method of storing alfalfa on quality and palatability High, medium and low initial moisture contents will be used and carotene content, market quality and palatability of the final product will be investigated for each of the three methods of storing: baled from windrow, stored in bulk in a hay shed, and chopped into a snow fence bin protected from moisture on top only.

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(Project 182; Department of Agricultural Engineering. Leader, C. K. Otis; Purnell and state funds.)

A Study of the Efficiency of the Combined Harvester-Thresher for Harvesting Grain Sorghums.— Work on this project has been delayed because of the almost complete failure of grain sorghums during the biennium. It seems unnecessary to make additional studies on the use of the combine for the harvesting of grain sorghums. With relatively simple, practical adjustments this machine can be used successfully for most of the types of grain sorghums grown in western Kansas.

The problem of securing grain with low enough moisture content for safe storage is a difficult one if the combine harvester is used. This will be especially true in seasons when rainfall is normal. Accordingly, much of the future work will be devoted to the problem of storage and drying of the grain after it has been harvested.

(Project 181; Department of Agricultural Engineering. Leader, F. C. Fenton; Purnell fund.)

Factors Influencing the Quality of Wheat During Farm Storage.— The work on this project during the past two years, in coöperation with the Bureau of Agricultural Engineering and Agricultural Economics, United States Department of Agriculture, and the Fort Hays Branch Station, has been a comparison of the effects of initial moisture content of wheat on quality when stored in plain metal bins, small underground metal bins, metal bins sealed underground; metal (steel), concrete and wood bins. In addition. tests of the value of different types of ventilation and of absorbent materials were made. The investigations were carried on at the Fort Hays Branch Station where approximately 5,000 bushels of wheat were stored each year in experimental bins. Results of the 1936 season were of little value because of the initial dryness of the wheat. Results of the 1937 season, while not conclusive, were significant.

Metal, Wood and Concrete Construction.— The moisture content of the wheat at time of storage in the three types of bin averaged 14.56 percent and varied only to the extent of 0.35 percent. Heating during the period of storage was approximately the same in all types, the range being from 15 to 17 degrees, The least damage to the wheat occurred in the wood bin; and temperature was lowest in the steel bins. Germination loss was least in steel bins, and greatest in concrete bins. Rancidity tests were not conclusive.

Underground Bins.— More germination loss was found in wheat in underground bins, but less rancidity. There was no heating in the underground bins with an initial moisture content of 15 percent. In both the sealed and the unsealed underground metal bins, germination loss increased with increase of initial moisture content; the percentage of loss was less in the sealed bin.

Ventilation.— Ventilation tests proved that effective air movement reduces moisture content in grain carrying approximately 15.5 percent initial moisture. Of the different types of ventilation, bottom ventilation was of the least value, The greatest heating, largest loss of germination, and increase of rancidity attended the use of bottom ventilation.

Absorbent Materials in Bins.— Absorbent materials tested (straw, peat moss in sacks, and lime-sulphate) did not reduce the moisture content, prevent heat or damage the wheat to any great extent. High rancidity was found when

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peat moss was introduced. The use of chemicals to inhibit the growth of moulds also appears to have little merit.

Plans for 1938 contemplate additional work on the value of ventilation by natural and mechanical means, with emphasis on a more practical farm set-up for mechanical ventilation than was used in 1937. Two underground cisterns in the nature of pit silos are being constructed for wheat storage. They will make possible an expansion of the underground storage investigations.

In 1937 milling and baking tests were made on seven samples, which represented the wheat when put into the bins. and 17 samples taken at the close of the experiment. Besides recording-dough-mixer curves, gas-production and retention curves were made on the flour produced from these samples of wheat.

The milling studies consisted of testing samples of wheat taken from the storage bins, and an investigation of factors which may affect quality of wheat during storage. The average test weight of the samples at the close of the experiment was 1.5 points less than at the start, probably due mostly to the roughened condition of the bran coat. In one of the lime-sulphur bins the decrease in test weight was 4.0 points. The average flour yield of the samples taken at the close was 1.3 percent higher than the average of those taken at the start. This higher yield was accompanied by 0.036 percent lower ash in the straight flour, indicating that the mechanical milling qualities had not been injured by the conditions of storage.

Two types of factors were studied that affect wheat quality, (1) diastatic activity, and (2) production of heat in wheat with various moisture contents. The factors affecting diastatic activity studies are: (a) method of preparing the sample; (b) variations in diastatic activity in different parts of the wheat kernel; (c) the fineness or degree of pulverization of the wheat. It is generally known that the diastatic activity of commercially milled flour is not the same as that of flour milled on an experimental mill. In a commercial mill the rolls are warm because of continuous operation. The result of these experiments indicates that it is not the higher temperature itself which causes the higher diastatic activity, but that the mechanical effects of warm rolls on the starch granules are different from those of cool rolls.

In measuring heat production, the wheat was held in a thermos bottle through which air was drawn slowly to supply the oxygen for respiration. The problem of preventing heat loss during the experiment was solved by keeping the bottle in a water bath with an automatic temperature lag of 0.05 degrees C. In wheat of 18 and 20 percent moisture, the heating was fairly rapid up to about 52 degrees C. Above this point no reliable data were obtained because of the difficulty of maintaining adiabatic conditions so high above the room temperatures. The wheat had zero viability at the end of the trials, but there was no evidence of mould growth, contrary to most experiments of this type, except in small spots where accidental leakage of water occurred. This indicates that the heat was produced mainly by the respiration of the wheat.

Wheat having 16 percent moisture was subjected also to heat measurements for a period of six weeks. There was very little temperature change for the first two weeks; after that there was a gradual rise to 45 degrees C. There was some possibility of heat loss in these experiments.

(Project 204; Departments of Agricultural Engineering and Milling Industry. Leaders, F. C. Fenton and C. O. Swanson; Purnell and state funds.)

Chemical Factors Influencing the Quality of Wheat and Flour.— The object of this study has been to determine the effects of the removal from flour of the fatty substances, and the subsequent replacement of known fats and phosphatides, upon the mixing curves and baking characteristics.

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Lecithin was prepared from freshly milled flour, and was found to be entirely normal in characteristic, in contrast to the "lecithin" extracted by identical procedure from flour which had been stored for six months at laboratory temperatures. The latter could not be dispersed in water and was scarcely swelled by it, but treatment with alcoholic potash in amount calculated to combine with fatty acid, followed by drying and solution in ether, restored the abnormal preparation to the usual characteristics of plant lecithin.

Over a period of four months at 25 degrees C., no significant increase was observed over the normal slow respiration rate of the flour. The temperature was then increased to 35 degress C., and within three weeks two of the four samples started respiration increase, soon reaching several hundred time the normal rate. After the rise starts, it may require about a week to reach the maximum rate, which lasts several days, and then it usually falls off for about two weeks to approximately the original respiration rate, which then apparently continues without much change for more than a year. However, two samples were observed in which the high respiration rate continued for more than four months and was stopped only after the flour had been removed from the apparatus for a microscopic examination to assure the absence of any insect life. The ensuing aeration apparently stopped the rapid respiration.

Measurement of oxidation-reduction potentials directly in dough is planned in an attempt to study the oxidation requirements of different flours and to clarify the relationship of different oxidizing and reducing agents, and what appears to be an oxidizing effect of fermentation.

(Project 60-.A; Department of Milling Industry. Leader, E. B. Working; state fund.)

Varietal Factors Influencing the Milling and Baking Quality of Wheat.— During the biennium 200 samples of wheat, including both Hard Red Winter and Hard Red Spring varieties, were subjected to the wheat meal time fermentation test, diastatic activity, and baking tests. The protein, moisture and ash contents of the varieties were also determined.

Chiefkan, a beardless hard red winter wheat aroused the greatest interest during this period, but was found to be inferior in certain baking characteristic and is therefore of doubtful commercial value. In comparison with Turkey. Chiefkan rates as follows:

Superior	*Eaual*	*Interior*
Test weight	Water absorption	Dough-development time
Flour yield	Height of dough	Resistance to breakdown
Protein of wheat	Mixer curve	Specific loaf volume
Protein of flour		Bread score
Water absorption		Doughball time
Fermentation time		

Tests made by other agencies confirmed the conclusion that Chiefkan was undesirable from the point of baking value.

(Project 60-B; Department of Milling Industry. Leaders. C. O. Swanson and R. J. Clark; state fund.)

Tempering Factors Affecting the Quantity and Quality of Wheat Flour.— The work during the biennium has consisted of five types of study, dealing with the effects of tempering on milling behavior and flour quality. A study was made of the physical changes that take place in wheat during tempering, measured by changes in electrical conductivity, moisture content of mill stock,

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heat of hydration of wetted wheat, and the amount and rate of swelling of tempered wheat.

The study of the influence of the period of tempering, and of the moisture content of the grain during the tempering process, on the quality of flour obtained was undertaken. These effects were measured by dough-mixer curves, gas production and retention curves, granulation studies on the flour, and determination of, maltose values. A study was made of the influence of tempering on the milling behavior of the grain. These effects were measured by the amount of flour obtained from wheats treated under different tempering conditions, by the yield of total products, and by the amounts of feed obtained.

The rate of absorption of water vapor by different varieties of wheat was tested. This was measured by the amounts of water absorbed in atmospheres of 90 to 96 percent relative humidity. Affinity for water seems to be associated with protein content and hardness of the wheat. These investigations may serve as a guide to the amount of water to be added in tempering. A study was made also of the Bühler experimental mill: To adapt the flow of the mill to the milling of hard winter wheat; to establish a comparison between this mill's results and those obtained by milling the same wheats in commercial mills.

Electrical conductivity measurements show that the most rapid changes in the state of the mater added in tempering takes place three to five hours after the water is added to the wheat. Moisture determinations made on break stocks, middlings and break flour indicate that the greater part of the water added in tempering, which is absorbed by the endosperm, is absorbed during the first three hours; after that the moisture content of the endosperm in tempered wheat increases very slowly for as long as 24 hours. Measurements on the rate of hydration show that about three hours are required for hydration to become complete. The specific heat, or calories of heat liberated per gram of water, decreases when increasing amounts of water are added to the grain. Measurement of the swelling which takes place when hard winter wheat is tempered indicates that the volume may increase as much as S percent. The rate of swelling is more rapid at higher temperatures and proportional to the amount of moisture added.

Moisture content of the wheat during tempering and the length of time of conditioning for milling appear to have marked effects on the gluten quality of the flour. Recording dough-mixer-curves, used to measure those influences of time used in tempering, indicate that increasing the moisture content of the grain during tempering will in some cases compensate for several hours of tempering time. On the hard w-inter wheats tested. 30 hours of tempering time produced the largest increase in the amplitude in the dough-mixer curves when wheats were tempered to 15, 17 and 19 percent moisture. This range extends above and below the moisture content used in tempering this class of wheats, indicating that the characteristics of the flour may be influenced by the method of tempering. Gas production of the flour is only slightly influenced. Granulation of flour depends primarily on the physical characteristics inherent in each wheat, but may be influenced by the method of tempering. Maltose values for hard winter wheat flours milled from the 1937 crop showed a decrease when the wheat was tempered for longer than 30 hours and above 17 percent moisture.

Measurements of the influences of tempering on the milling behavior of wheat as measured by flour yield, relative quantities of feed and of total products, indicate that each variety has its optimum moisture content for tempering; hence, each wheat must be tempered according to its characteristics

Tests of rate of water vapor absorption show that Quivira wheat is a more rapid absorbent than either Turkey or Tenmarq, when treated under identical conditions of humidity. Turkey and Tenmarq absorb moisture at nearly the same rate. Other kinds of wheats tested show that in relative humidities of 90 to 96 percent, and when the moisture content of the grain is near 10 percent, water is absorbed at the rate of about 1 percent in ten minutes.

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(Project 170; Department of Milling Industry. Leader, J. E. Anderson; Purnell fund.)

Factors which Influence the Colloidal Properties of Dough. — Three problems have received special emphasis during the biennium: The correlation of the dough-mixer-curve characteristics with actual baking results; the method of determining water absorption to obtain the best consistency of dough; the use of gas-production and retention curves in measuring baking quality.

Dough-mixer curves were regularly made on flour from all varieties milled and baked, providing much material for the study of correlation of curve characteristic with baking value. Baking was done by the checkerboard sponge method, in units of 36 loaves. One checkerboard is required for each of the variables. The recording dough mixer was used to mix the dough so as to obtain an accurate record of the amount of mixing required along with other treatments to produce the optimum loaf.

The use of the supercentrifuge as a method of determining absorption of water by flour has now given way to the use of a small mechanical mixer. This method uses 20 grams of flour for each trial, and three trials are necessary. In the first trial 10 c.c. of water, or less than necessary, are added to the 20 grams of flour. More water is added by syringe as the need is observed. established fairly closely the amount of absorption. In the second trial small excess is added. By these two trials and observations and previous experience. the correct figure is established. which is then confirmed by a third trial.

An instrument for recording automatically the rate of gas production and retention was used for the first time this year on the wheat varieties.

Previous testing has established that as a rule, and in a normal season. the recording-dough-mixer curves will be characteristic of individual varieties. The tests of the 1936 crop showed that in certain seasons the curves may very greatly from those usually characteristic of any variety. In certain parts of the state the wheat had been damaged by the unusually hot and dry weather and the curves were very far from normal.

When the dough-mixer curves were first used in testing, it was supposed that the peak of the curve represented the end of the mixing time. Later work has shown that the distance from the start to the peak of the curve represents the sum of all the mechanical punishments the dough is to receive in baking, such in mixing, dividing, rounding, molding and stretching during fermentation.

The end of the mixing time any flour should receive must be determined by observation during mixing. There are three definite stages in the mixing which can he observed: (1) The “clean-up” or point of incorporation of all the dough ingredients; (2) the smoothing of the dough. caused by the arrangement of the gluten particles into parallel patterns: and (3) the “let down,” when the dough begins to cling to the bottom of the bowl. The second stage represents the end of the mixing time. Dough in the third stage will recover on standing and may be made into a satisfactory loaf in experimental baking.

After the mixing has proceeded to the top of the curve. the dough begins to break. It loses its elasticity, probably doe to the fact that the gluten strands become too attenuated. The break apparently occurs when these elongated gluten particles begin to separate. The duration curve of the peak stage varies greatly in the different varieties. The rounded peak curves are preferred to those with a sharper peak.

(Project 200; Department of Milling Industry. Leaders, C. O. Swanson and R. J. Clark; Bankhead-Jones fund.)

A Physiological Study of the Hard Winter Wheat Plant.— The function of the awns of cereals has been for a long time a topic

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of interest. In some regions these organs are apparently necessary for the maximum yield, while in other sections they seemingly have little or no effect in this regard. On that account it was though advisable to study the physiology of the awns of wheat.

The experimental work has included a field study of the effect of awn removal on the yield of grain as expressed in dry weight, number of grains, and volume of grain; and a greenhouse study of the effect of awn removal upon the rate of transpiration of the heads. Seven varieties of wheat were grown in the field. The hard wheats were represented by Kanred × Hard Federation, Tenmarq, Kanred, Turkey, and Early Blackhull; the semihard varieties by Kawvale, and the soft wheats by Fulcaster. In the greenhouse the variety Puss 52 × Federation was used because it matures in a relatively shorter time under such conditions than the above-mentioned varieties.

The heads were de-awned by clipping them with shears before flowering, at flowering, and one and two weeks after flowering. The de-awning of each variety at these stages involved both partial and total removal of the awns In partial de-awning the awns were removed from one side of the head. Thus there were eight sets of experiments for each variety.

Before the heads had emerged, 300 culms were selected and tagged in pairs for each set of experiments for each variety. One half of the plants was marked with one type of tag for de-awning and the other half of the culms was marked with another type of tag to serve as a check. In this manner approximately 16800 culms were tagged. At the proper stage of develpoment the heads in any particular set mere de-awned. At harvest in nearly all cases, approximately 125 de-awned heads and the same number of controls were collected for each set. Thus approximately 14,000 heads were harvested each year.

De-awning always caused a decrease in the yield of grain. This decrease was always the greatest when the de-awning was performed before blooming and the least when so treated two weeks after flowering had occurred.

During 1936 and 1937, 108 one-hour determinations of the transpiration of awned and de-awned heads were made, using a modification of the Freeman method. It was found that the transpiration of the spike was decreased approximately 40 percent by the removal of the awns Although the total amount of transpiration for an awned or de-awned spike varied according to the stage of growth, the amount of transpiration attributable to the awns remained nearly constant until just preceding maturity. The awns of wheat are very active in the transpiration of the spike although they do not ordinarily transpire more than 1 to 5 percent of the total amount of water lost from the plant.

(Project 189; Department of Botany. Leader, E. C. Miller; Purnell and state funds.)

Orchard Investigations.—The work of this project is conducted under four phases as follows:

1. *Spraying.*— Apples, cherries, peaches and brambles were sprayed experimentally during the biennium. Both seasons were so hot and dry that practically no diseases were found on tree fruits. No data were collected concerning the different fungicides on tree fruits.

Anthracnose of raspberries was controlled very satisfactorily. A dormant spray consisting of liquid lime-sulphur, 1 to 20, and one summer spray consisting of liquid lime-sulphur, 1½ to 50, were applied. The latter was applied when the young canes were about six inches high.

Among the insecticides used in various combinations to study their effectiveness in controlling the codling moth without leaving too much objectionable residue on the fruit were lead arsenate, calcium arsenate. Kalo, Raleigh's Dip, Superla oil, Dendrol, Tar'O Flakes and Orthol Spreader. Due to the adverse

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weather conditions, the apples remained so small that the arsenical residue was very high even where lead or calcium arsenate was used only a part of the season.

Lime, zinc sulphate-lime and "Magnetic" catalytic sulphur were compared in their ability to protect peach leaves from arsenical injury when sprayed with lead arsenate. The zinc sulphate-lime combination afforded the most protection. "Magnetic" catalytic sulphur next, and lime the least protection.

Chemically-treated codling-moth bands were used in the apple orchard as a supplementary control. A rather high percentage of adults emerged from the bands during the latter part of each summer, indicating that the bands lose much of their insecticidal property during dry, hot summer weather.

Many trees of various species have been weakened by the series of dry seasons and were subject to flat-headed borers. Serious damage to many trees has resulted from these insects so a series of plots of seedling apple trees were treated to determine the value of different washes, etc., in controlling the borers. The following materials were applied to one-year-old apple seedlings: Grafting wax, linseed oil, "Tremco" tree compound, paradichlorobenzene, 1 part to 4 parts of parafine, water emulsion of asphalt, sulfonated oil, water glass, 2 ounces paradichlorobenzene and 1 pint of Dendrol to 1 pint of water, "Pel-ant." "Kid-Blight," parchment paper wrapping. burlap wrapping; and, as a check, no treatment.

All the washes or paints caused some damage to the young trees, and killed many. Wrappings with paper or burlap proved most effective in preventing borer damage and did not injure the trees.

2. *Methods of Pruning Fruit Trees*-— No new work was started during the biennium. Further observations were made on the cherry trees pruned by three methods: Open center; modified central leader, light heading back of lateral branches; modified central leader,, severe heading back of lateral branches. None of these methods is entirely satisfactory. Some trees in each block show weak, damaged crotches, in part due to winter injury. No comparative yield records were obtained, as late spring frosts seriously damaged the crop both seasons.

3. *Orchard Soil-management Experiments.*— All experimental work on this subproject: relative to the growing of cover crops and the use of chemical fertilizers in the apple orchard, has been handicapped during the past biennium because of the adverse climatic conditions. Almost all of the Winesap, Stayman. Grimes, Livland, Delicious, Gano, Blacktwig. King David, and Rails trees of bearing age died. A few of the York, Wealthy, Jonathan, and Rome trees survived in a severely weakened condition. The varieties in the first group set heavy crops of apples in 1935 and 1936, a condition which probably enabled the dry, hot seasons to cause more damage to the trees than where no fruit or light crops existed.

Soil-moisture and nitrate-nitrogen determinations were made on nine dates between May 5 and September 1, 1936. The average moisture content was 15.3, 15.3, and 14.5 percent for the first, second and third foot samples, respectively. The calculated wilting coefficient for the first foot was 15.5 percent, and for the second and third foot levels, 15.3 percent. The field capacity of the soil was found to be slightly over 31 percent. The average nitrate content was between 85 to 90 parts per million for the top first, second, and third foot samples.

The use of nitrogenous fertilizer applied in the spring, fall, or both seasons in the York block, has been discontinued because of the death of most of the trees.

4. *Testing New and Promising Varieties of Tree Fruits.*— As in the past, new varieties of tree fruits have been set in the test plots, given good orchard care, and records have been made of the vegetative development and fruit production at frequent intervals.

The period has been characterized by such abnormal climatic conditions that both the planting of new varieties and the growth and fruit-bearing of those already under test have been much hampered. Twenty-one trees died;

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eight varieties are entirely missing (aside from the Burbank plums), and no variety produced normal mature fruit during the summers of 1936 and 1937. Compared with the loss of bearing trees in the same orchard, this list of lost varieties is small, probably because these trees are younger, were bearing but little fruit. and are, in part at least, on deeper soil.

The last of the 24 plum varieties originated by Luther Burbank and supplied under number for testing by the Stark Brothers nursery has been removed. They all proved either winter-tender or bloomed so early that the blossoms were annually destroyed by spring frosts. All trees of the St. Medard cherry were killed by the drought.

Work on layered apple trees was completed during the biennium. Several hundred own-rooted trees of varieties adapted to Kansas were produced by this method. Three crops of rooted shoots were harvested. The mother trees were so weakened that their retention for a fourth crop did not seem practical. Trees propagated in this way are now planted in the station orchard.

(Project 25; Department of Horticulture. Leaders, R. J. Barnett, G. A. Filinger and W. F. Pickett; state fund.)

Small-fruit Investigations.— Some progress has been made in the investigation of the factors affecting the growth of different varieties of small fruits despite the extremely hot and dry seasons of 1936 and 1937. The work has been carried on under two subprojects: Strawberries, brambles and groselles; and grapes.

1. *Strawberries, Brambles and Groselles.*— The late summer season of 1936 was unfavorable for setting of runner plants; hence, the renovated Blakemore plot set. only a few plants and the 1937 crop was light. Aroma and Premier planted in the early spring of 1936 set runner plants early and produced fair crops in 1937. Dorsett, Fairfax, Progressive and Rockhill produced only sample fruits. Dunlap was planted in 1937 and is being harvested now.

Brambles grown were Black Pearl and Cumberland black raspberries. Chief and Latham red raspberries, Eldorado blackberry, Young and Boysenberry dewberries and Columbian and F-117 (North Dakota) purple cane raspberries.

The brambles made only fair growth during 1936, and practically all unprotected canes winterkilled to the ground during the 1936-'37 winter. During 1937 the cane growth was again good. A fair crop will be harvested this. season. Since red raspberries and purple raspberries so frequently winterkill, several methods of protecting them were tried during the biennium. Weather records were kept during both winters.

The results of the 1936-'37 protection experiments were as follows:

Variety	*Treatment*	*Linear cane, inches*	*Cane killed, inches*	*Canes killed, percent*
Chief	Soil covered	9386	158	1.70
Latham	Soil covered	9384	376	3.80
Chief	Nursery wax[1]	5661	879	15.5
Latham	Nursery wax[2]	4344	432	9.9
Chief	No treatment	3798	851	22.3
Latham	No treatment	5451	619	11.3

1. Sprayed in the fall with Dowax.
2. Sprayed in the fall with L1949 wax (a Standard Oil product).

Unprotected Young dewberries killed back about 25 percent, and Boysenberry killed back about 33 percent during the 1936-'37 winter. Soil-protected dewberries were alive to the very tips.

Gooseberry varieties being tasted are Houghton, Glendale and Pixwell. Sample fruit was obtained from Houghton and Glendale in 1937. A slatted snow fence placed along the south side of the gooseberries afforded sufficient protection from hot wind and sun and snow to save Glendale gooseberry plants, The unprotected plants died. Unprotected Houghton gooseberries also were severely damaged.

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Currant varieties planted were Cherry, Fay, Wilder and Perfection. The Fay and Perfection-were not replanted after the summer of 1936 killed all the currants.

2. *Grapes.*— The failure of crops to mature properly prevented the successful accomplishment of the fruit-production experiments during 1936 and 1937. A fairly heavy crop of fruit set on the vines, and the inhibiting effect of the hot, dry summer on the functioning of the plants, and the injury to fruit and foliage from the intense insolation were the distinct causes of this condition. Moreover, the severe hailstorm of September 8.1936, destroyed all the remaining fruit and foliage of that year.

During 1936 the influence of shading and watering on photosynthesis in Concord leaves was studied. The foliage on the plot which was half shaded with ordinary lath and watered accumulated only half as much dry matter per unit of area as the plot which was watered but not shaded. The foliage on the plot which was neither shaded nor watered gained twice as much in total dry matter per unit of area as the plot which was shaded but not watered. All photosynthetic values, however, were exceedingly low, and the differences were not great. The daily variations in the water content of leaves on the irrigated and shaded plots were not significant.

On one occasion, the plot which was shaded and watered lost 1.34 grams of total dry matter per square meter of leaf area between six o'clock in the morning and two in the afternoon. Undoubtedly carbohydrate manufacture was at a standstill, and respiration and translocation accounted for the loss. The leaves on the plot which was watered but not shaded gained more in dry weight when the temperatures were 90 and 92 degrees F. than when the maximum temperatures were 105, 108 and 110 degrees,

(Project 26; Department of Horticulture. Leaders, G. A. Filinger and W. F. Pickett; state fund.)

Flower and Vegetable Investigations.— Progress has been slight on the studies of enzymatic activities, chemical changes and respiration of the asparagus roots treated to break the rest period, due to the extremely dry weather resulting in the production of weak plants.

Most varieties of beans and tomatoes failed to produce during the hot, dry months of 1936 and 1937. Varieties that have proved best in arid sections are being tested. Bison and 216C (red) of North Dakota, are promising tomato varieties. Vegetable variety and adaptability tests during the dry seasons have shown clearly the need for an expansion of activity in this field. Three selections, large fruited red varieties, from the tomato breeding work are being tested in the greenhouse along with ten commercial varieties. Two seedlings outyielded all other varieties tested in the garden during the season of 1937.

The electrically and wood-heated hotbed trials in cooperation with the Department of Agricultural Engineering were completed with the publication of Station Circular 183, "Hotbeds for Kansas."

Irrigation of farm vegetable gardens in cooperation with the Department of Agricultural Engineering and the State Committee on Electricity in Relation to Agriculture was started during the spring of 1938. Four plots, 45 by 100 feet, are included in the farm-garden study. One of these plots is being irrigated with an overhead or spray system of irrigation, one by subirrigation, a third by the furrow system of irrigation; and a fourth is without irrigation. Two additional plots of like size are included to give information with regard to potatoes and tomatoes under furrow and overhead irrigation.

The farm garden plots are to be planted as a complete farm garden. Data will be collected upon cost of installation and maintenance of equipment, cost of application of water, amount of water used, the yields and quality of vegetables produced, and the period of time over which quality produce is available to the producer.

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(Project 27; Department of Horticulture. Leader, S. W. Decker; state fund.)

Relation of Leaf Structure to Rate of Photosynthesis in Fruit Plants.— The object of this project is to determine if leaf structure, as measured by the extent of the intercellula space in the mesophyll, partially governs the rate of photosynthesis by influencing the diffusive and absorptive capacity of the foliage leaves.

Twelve two-year-old Wealthy and twelve two-year-old York apple trees were grown for five months in the greenhouse. The increase in total dry matter of the trees between planting and digging was used as an index of the photosynthetic activity of the foliage. In addition, quantitative determinations of chlorophyll a plus b were made from 10-gram (fresh weight) samples of the foliage of each of the 24 trees.

The Wealthy trees made less gain in total dry matter per tree, but made a significantly greater gain per unit of leaf area than York. The intercellular space in the Wealthy is more extensive and possesses the greater total internally exposed surface. The two varieties contain practically the same amount of chlorophyll a plus *b* per unit area, the York having slightly the greater amount.

Chemical analyses show that the total carbohydrate content and ash content of the foliage, expressed as percentages on the dry-weight basis are nearly the same for the two varieties. Likewise, the shoot systems of the two varieties are similar in composition, and the same condition was found in the two root systems.

A possible explanation for the more efficient photosynthetic activity of the Wealthy leaves is that the chlorophyll in the Wealthy foliage had a greater amount of available carbon dioxide in the mesophyll cells, due to the greater extent of the internally exposed surface.

Fifteen two-year-old trees of each of the York and Wealthy varieties were grown in the orchard during the season of 1937. The mean gain in total dry matter per square meter of leaf area for the Wealthy trees was 612.06 ± 17.15 grams, and 374.53 ± 9.58 for the York trees.

Several varieties of grapes were used in an experiment designed to determine which variety has the greatest photosynthetic activity when measured by the dry-weight increment method. Campbell Early was the most active, with Niagara second. and Moore and Diamond third, No anatomical studies of grape foliage were made.

(Project 199; Department of Horticulture. Leader, W. F. Pickett; Bankhead-Jones fund.)

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PART II

INVESTIGATIONS IN THE ANIMAL INDUSTRIES

The following pages contain a brief report of the work that the Agricultural Experiment Station has done during the past biennium on problems relating to the livestock industry.

Nutritive Requirements of Swine.— The work during the biennium has consisted of a study of the phosphorus requirements of pigs in the absence of vitamin D. In both years three groups of four pigs weighing 48 pounds each were fed individually the same ration for six months, each group, however, receiving a different level of phosphorus without exposure to sunlight and without cod-liver oil. The calcium content of the ration for all lots was 0.8 percent. During the second year an additional lot of three pigs, receiving the same level of phosphorus as one of the other groups,, but given also cod-liver oil and exposed to sunlight, was maintained as a check lot. The results of the experiment indicate that the use of 0.5 percent of phosphorus is approximately the desirable amount to be used when the calcium is at the 0.8 percent level, and in the absence of vitamin D.

Previous experiments at this station have shown that the minimum requirement of phosphorus for growing pigs is between 0.27 and 0.30 percent of the ration when the calcium level is about 0.8 percent, and when all other ingredients of an adequate diet, including vitamin D, are supplied.

The results of the first year showed that the pigs in the first lot (0.3 percent phosphorus) and lot 3 (0.75 percent phosphorus) developed weak bones and became rickety, accompanied by poor utilization of feed and a small daily gain. The pigs in the second lot (0.5 percent phosphorus) made good daily gains, had strong appetites and bones, and were without rickets.

The second year's test showed again that the pigs of the second lot developed normally in bone and body gains, and compared very favorably with the pigs in the check lot that had been receiving the ration with adequate amounts of phosphorus and vitamin D. The pigs in the first and third lots became rickety, with weak bones, but made fairly good body gains.

One of the observations made in connection with the blood analyses was that the increase in the phosphatase of the blood was the first indication of phosphorus deficiency.

(Project 38; Departments of Animal Husbandry and Chemistry. Leaders, C. E. Aubel, J. S. Hughes; Adams fund.)

Swine-feeding Investigations.— Particular attention has been devoted during the biennium to three phases of this project as follows: (1) A study of the comparative value of corn and blackstrap molasses as swine-fattening feeds in dry lot; (2) a study of the comparative value of tankage and expeller process soybean oil meal with and without minerals as protein supplements for pigs on alfalfa pasture; and (3) a study of the relative value of soybeans and soybean products as protein supplements to grain in swine-feeding rations during the winter.

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Comparisons have been made of the records of pigs fed on (1) shelled corn, tankage and alfalfa hay; (2) the same plus one, two, and three pounds of molasses per pig each day; (3) alfalfa pasture, shelled corn, and tankage as protein supplement; (4) alfalfa, corn, and equal parts of tankage and soybean oil meal supplement; (5) alfalfa, corn and soybean oil meal plus minerals; (6) alfalfa, corn and soybean oil meal without minerals; (7) alfalfa hay, shelled corn, tankage; (8) same Plus soybeans; (9) alfalfa hay, corn, and expeller process soybean oil meal and minerals; (10) alfalfa hay, corn, and solvent process soybean oil meal and minerals; and (11) alfalfa hay, corn, solvent process soybean oil meal without minerals. Some significant findings are here noted.

1. The average daily gain was lower in the lots that received molasses than in the lots that did not receive it. In this test 100 pounds of molasses saved seven pounds of corn with the pigs that received 11.5 percent of their ration as molasses, 18.1 pounds of corn with those that received 20.3 percent, and 27.1 pounds with those that received 29.4.

2. Tankage, compared with soybean oil meal fed alone, with minerals, or mixed with tankage in equal parts, as a protein supplement for fattening pigs on alfalfa pasture, produced more rapid daily gains and better finish. Soybean oil meal alone did not prove to bean efficient protein supplement. The cheapest gains were made by the lot receiving tankage with soybean oil meal. Soybean oil meal and minerals produced slightly more expensive gains, followed by tankage alone, with soybean oil meal alone the most expensive.

3. The largest daily gains, 1.52 pounds per day, were made by the pigs receiving alfalfa hay, corn, expeller process soybean oil meal and minerals. Moreover, this lot registered the lowest feed consumption and the cheapest gains.

4. It has been concluded that the most desirable ration includes minerals with the soybeans and soybean meal.

(Project 110; Department of Animal Husbandry. Leader. C. E. Aubel; state fund.)

Investigations in the Use of Silage for Fattening Beef Cattle.— Active study has been made during the biennium of the relative value of linseed oil meal and cottonseed meal as a supplement to silage in winter rations for heifers, of the value of silage as roughage and molasses as a concentrate, and of the effects of different methods of processing Atlas sorgo upon returns from silage fed to stock cattle.

Groups of heifers fed on rations including cottonseed meal, wheat straw and cottonseed meal, and linseed oil meal, showed no significant differences in gain. In order to get the heifers to consume small amounts of wheat straw, it was necessary to decrease the amount of silage fed, approximately five pounds for each pound of wheat straw fed.

Two lots of four steer calves each, and one lot of three yearling steers, were fed a basal ration of silage, cottonseed meal, and ground limestone. In addition to the basal feeds, ground shelled corn was full fed to one lot of calves and cane molasses to the yearlings and the other lot of calves. During the 108-day feeding period the steer calves consumed 11.46 pounds of cane molasses per head daily. The yearling steers consumed 14.85 pounds of cane molasses. and the check lot of steer calves ate 11.49 pounds of ground shelled corn per head daily. Each 100 pounds of corn produced 172 pounds of gain when fed to steer calves, but only 11.5 pounds of gain when fed to yearling steers The calves fed molasses drank 10.3 gallons of water per head daily during this period, while the calves fed corn drank only 5.4 gallons per head daily. Bad scouring among the steers fed molasses was undoubtedly due to the high ash content of the cane molasses. This trouble was to some extent overcome by feeding a small amount of wheat straw.

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Four lots of ten choice steer calves each were fed the following average daily rations from November 23, 1937, to April 22, 1938:

Lot 1.— Normal Atlas silage (grain in silage not ground), 30 pounds; cottonseed meal, one pound,

Lot 2.— Special Atlas silage (grain in silage finely ground), 30 pounds; cottonseed meal, one pound.

Lot 3.— Stover silage (no grain in silage), 30 pounds; cottonseed meal, one pound.

Lot 4.— Stover silage. 26.8 pounds; ground Atlas heads, 2.6 pounds. and one pound of cottonseed meal.

At the close of the 150-day period of feeding, the gains per ton of silage were as follows: Lot 1, 91 pounds; Lot 2, 108 pounds; Lot 3. 73 pounds; and Lot 4. 114 pounds.

(Project 78; Department of AnimaI Husbandry. Leader, A. D. Weber; state fund.)

Method of Utilizing Native Pasture in Beef-cattle Feeding.— The work of the current biennium has been a continuation of the study of the relative values of full feeding yearling steers on bluestem grass for 60 days after August 1, and then for 40 days in a dry lot; of full feeding for 100 days in a dry lot after August 1; and of the effects of different methods of discontinuance of the winter allowance of grain for yearling steers. Results from three tests show that rate of gain, total gain, and cost of gain will be about the same by either method, but that full feeding for the entire 100 days induces a better general appearance, attracting a higher selling price. Results indicate that, there is no advantage to be derived from discontinuing gradually the winter allowance of grain when yearling steers handled in accordance with this general plan go to grass.

Definite conclusions have been drawn from a study of methods of utilizing grass in fattening yearling steers for market that has been carried on for 12 years. These conclusions are:

1. The best method consists of wintering well, grazing 90 days, and then full feeding 100 days in a dry lot.

2. The next best method consists of wintering well, grazing 90 days, and then full feeding up to 60 days on grass and then not less than 40 days in a dry lot, To be successful either plan requires: Good quality steer calves, 200 to 250 pounds of gain during the wintering phase, 90 to 100 pounds during the grazing phase, and 250 to 275 pounds during the full-feeding phase.

(Project 151; Department of Animal Husbandry. Leader, C. W. McCampbell; state fund.)

Lamb-feeding Investigations.— Two phases of this work have been studied during the biennium: the effects of various protein supplements for growing ewe lambs, and the relative merits of different methods of feeding silage to growing ewe lambs.

Three lots of 15 purebred ewe lambs each were fed rations containing cottonseed meal, linseed meal and skim-milk powder, respectively. The lambs fed skim-milk powder ate approximately 7 percent more straw than those eating the other supplements, and made larger gains. This suppliment being the most costly, however, gains made using it were the most expensive. The lambs fed cottonseed meal made greater and considerably more economical gains than those fed linseed meal. The tests indicated that. provided the added costs of

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gains can be justified, skim-milk powder can be used to advantage when faster than normal growth is desired.

Three lots of 12 ewe lambs each were fed the following rations: Lot 1, grain mixture, cottonseed meal, silage; Lot 2, grain mixture, cottonseed meal, silage and ground limestone; Lot 3, grain mixture, cottonseed meal, Silage and alfalfa. The lambs receiving silage and alfalfa hay gained more than those in either of the other lots. The lambs fed silage and ground limestone made nearly as much gain as those fed silage and alfalfa, but those fed silage as the only roughage made decidedly less gain than the others.

(Project 111; Department of Animal Husbandry. Leader, R. F. Cox; state fund.)

Cooperative Studies in Lamb Feeding.— The work done under this project at the Garden City Branch Station during the past biennium has consisted of a number of tests of various sorghum grain and roughage feeds, as well as methods of feeding fattening lambs. In the 1936-1937 feeding season, 270 western lambs were fed, and during the 1937-1938 season, 518. The following are the principal results secured:

(1936-1937)

1. Wheatland milo produced somewhat larger and more economical gains in this experiment than either dwarf yellow milo or Sumac grain. Dwarf yellow milo grain was slightly superior to Sumac grain in producing satisfactory gains and market finish.

2. Lambs fed by the deferred grain-feeding system made almost identically the same rate of gain, but with greater economy, than those fed a full grain feed from the start.

3. Ground Sumac stover produced slightly larger gains than ground milo stover. Both roughages were full fed. The lambs fed Sumac stover ate approximately 50 percent more than those receiving milo stover. This resulted in a decidedly larger feed cost per pound of gain for the Sumac-fed lambs.

4. Lambing down sorghum crops appears to be an expensive and wasteful practice where the grain yield of the crop is sufficient to warrant harvesting.

(1937-1938)

1. Advantages for the deferred grain-feeding system were a little more pronounced for heavy lambs than for medium- or light-weight lambs. There was little difference in the way medium and light lambs responded to this system of feeding. The average daily gain for the three lots full fed from the beginning was 0.29 pounds. The average for the three lots fed by the deferred system was 0.28 pounds, revealing no significant difference in this respect. This conforms to the results of previous tests of these methods. The average cost per ewt. of grain for the three full-fed lots was $6.03, and the deferred fed lots, $5.99. Previous tests have shown much greater advantage in this respect for the deferred grain system.

2. The rate of gain of the heavy, medium and light lambs was in the order listed, but the difference was small. The cost of gains was lowest for medium lambs, and next lowest for light lambs, but with little difference.

3. Gains favored milo fodder as roughage slightly over Sumac fodder, and ground Sumac fodder produced more gain than a combination of Sumac fodder and Sumac silage. Sumac silage did not equal either of the two above.

(Department of Animal Husbandry. Leader, R. F. Cox; state fund.)

The Effects of Inbreeding and Line Breeding on Body Type, Rate of Growth, Breeding Performance and Other Characteristics of Sheep.— This is a new project formally started in July of 1937, the objects of which are as follows:

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(1) To develop breeding animals of outstanding merit and to fix a greater degree of homozygosity; (2) to attempt to limit or eliminate, through careful selection, the deteriorating effects commonly associated with the practice of inbreeding; (3) to fix more definitely some of the desirable characteristics of purebred sheep; (4) to obtain more definite information regarding the advisability of line breeding in sheep. The work done on this project to date has been confined to Shropshire and Rambouillet sheep. Twenty-six body measurements have been made on each of 66 male and female breeding animals. Various degrees of inbreeding have been done and the offspring are to be compared with noninbred offspring of the same breeding animals or blood lines. However, the nature of the work is such that considerable time will be needed to secure definite results.

(Project 205; Department of Animal Husbandry. Leader, R. F. Cox; state fund.)

Field Application of Gonadotropin Hormones in Dorset Ewes.— The chief object of this project is to alter the estral cycle in Dorset ewes in order to increase the frequency of fall lambing.

Twenty-two ewes were divided into two lots, equal in number, age and other individual characteristics. Attention was given also to their past records in regard to fall or spring lambing. The ewes in the experimental group were inoculated with 5 c.c. each of standardized mare serum containing gonadotropin hormones. The rejection was repeated in 17 days. The control group was allowed to run with the experimental lot, and both groups received the same feeds and management.

The following observations were made as to the breeding and lambing performance of the two lots of ewes:

1. Among the 11 head of ewes receiving hormone injections, estrum and breeding occurred one or more times early enough for the production of fall lambs in eight head.
2. None of the 11 ewes in the control lot bred until fall.
3. Only two of the 22 ewes actually produced fall lambs. Both of these ewes had received the hormones.

(Department of Animal Husbandry. Leader, R. F. Cox; state fund.)

A Study of Factors Which Influence the Quality and Palatability of Meat.— Observations made at this station several years ago seemed to indicate that a ration low in phosphorus might influence the keeping qualities and palatability of beef. A study of this possibility has been undertaken during the biennium.

In 1936-1937 eight steers were fed by the Mitchell paired feeding method, one member of each pair receiving six to seven grams of phosphorus a day, the other receiving 15 grams per day. Two pairs were slaughtered after 35 weeks, and the other two pairs after 48 weeks. Sixteen rib roasts, consisting of eight paired cuts obtained from the animals fed on different levels of phosphorus were cooked to an internal temperature of 135 degrees F. The roasts were scored by the palatability committee. No marked differences were noted. Conclusions from the 1936-1937 experiments are questionable because of unforeseen accidents to two of the steers. The tests will be repeated in 1938-1939.

In 1937-1938 eight steers were fed a basal ration of corn, cottonseed and corn silage; in addition, one member of each pair received one-tenth pound of ground limestone per day. Since the Ca/P ratio was approximately 1 in Lot 1, 2 in Lot 2; and, since a ratio of 1.25 to 2.50 is considered the optimum for steers, it was not expected that much difference would result from the two rations. The results of the 1937-1938 experiments are as follows:

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Color of Beef Muscle.— The two lots averaged nearly the same in muscle hemoglobin, although as much as 50 percent cross variation occurred between lots. No trends in oxidation potential or pH were evident.

Color and Physical Constants of Fat.— Although analyses of adipose tissue are as yet incomplete, the samples present striking similarity in physical properties, with the exception of one interesting pair. Of this pair the adipose tissue of the low-calcium individual was the hardest of all eight samples. The sample of its high-calcium mate was the softest, stickiest, and gummiest of all, even though it contained only about half as much moisture.

Tenderness.— A variation in the collagen and elastin technique was tried in order to include a study of the relation of other protein fractions to tenderness. Although collagen did not show significant difference between lots, shear on cooked rib eye correlated well with it in individual variations, but to a lesser degree with coarse insoluble coagulum, and least with totally insoluble coagulum. Electrical resistance of the fresh rib eye showed a tendency to decrease with decreasing shear values on the cooked rib eye.

Keeping Quality.— Ripening performance was nearly the same in both lots for a 28-day period. Shrinkage loss was more uniform and slightly lower in the lot receiving the limestone supplement. Electrical resistance declined ma ternally along with mechanical shear. In most cases the coarse insoluble coagulum decreased; however, collagen exhibited an anomalous increase which seems to lack explanation, unless caused by a difference in dissection. Little change occurred in pH. Oxidation potentials became distinctly more negative during ripening, and were most negative in Lot 2.

Eight paired beef rib roasts were cooked and scored. No marked differences were noted either in the desirability of the cooked meats produced on the two rations, or between ripened and unripened cuts.

Degree of Finish.— Ether extract of rib eye was higher in Lot 2 (limestone supplement).

Jurciness.— The quantity of press fluid from the raw rib eye was more uniform and slightly higher in the high-calcium lot.

Permeability and Water-holding Capacity.— Analyses of press fluid and adipose tissue are yet incomplete. However, inorganic calcium in press fluid was slightly higher in the low-calcium group total; rib eye calcium was lower in this group. Inorganic phosphorus in press fluid was higher in the high-calcium group with the exception of one individual which possessed also an abnormally high phosphatase activity.

(Project 165; Departments of Animal Husbandry, Chemistry, and Home Economics. Leaders, D. L. Mackintosh, J. Lowe Hall, Eva McMillan, and Martha Pittman; Purnell and state funds.)

The Mineral Requirements of Fattening Cattle.— The work of the biennium on this project has been a study of the calcium and phosphorus requirements of fattening cattle, and of the effects of calcium and phosphorus upon beef production.

During 1936-1937 six pairs of steer calves were used in an attempt to determine the reason for larger gains obtained in experiments by the addition of calcium carbonate to a fattening ration composed of corn, cottonseed meal and silage. In addition to the basal feeds, one member of each pair received one-tenth pound of finely ground limestone daily.

The steers were weighed at 14-day intervals. The blood of each steer was analyzed monthly for calcium inorganic phosphorus, and haemoglobin. Digestion trials and mineral balances were run on three pairs of steers during the period June 22 to July 2, 1937. Records of water consumption for all pairs were kept from August 19 to August 28, 1937. Four pairs were slaughtered at the conclusion of the experiment, having been fed 249 days. Meat samples were secured, and a study of meat quality made. Bones were kept for chemical and physical examination.

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In four of the six pairs the steer fed the calcium supplement gained an average of 39 pounds more than his mate.

Blood analyses showed no differences within the pairs with reference to calcium and phosphorus. The average for the 11 determinations for the group receiving the calcium supplement was 11.6 milligrams calcium, and 9.5 milligrams phosphorus per 100 c. c. of blood serum, while the values for the other group were 11.6 and 9.4 milligrams for calcium and phosphorus, respectively. These values were within the average normal range for steers of this age.

At the end of the experiment the average number of grams of haemoglobin per 100 c. c. of blood was 13.3 for the steers receiving the calcium supplement, and 15.5 for the others.

In the balance trial the three steers receiving the calcium supplement were all in positive calcium and phosphorus balance, the average amounts stored during the ten days' trial being 141 grams of calcium and 16.5 grams of phosphorus. One of the other three steers was in negative calcium balance and the remaining two in negative phosphorus balance. The average balances of these three were 12 grams calcium and 0.5 gram phosphorus. No significant difference was observed in the coefficients of digestibility.

The three steers receiving no calcium supplement drank an average of 279.7 kilograms of water during the ten days, while their mates drank only 159.2 kilograms, which is normal for steers of this weight. Water consumption of the six pairs was checked later, and, while the differences were not so striking, in five of the six pairs the one receiving no calcium supplement drank more than his mate. The average water consumption of those receiving the calcium supplement was 200.6 kilograms, while their mates consumed 227.7 kilograms. It was the opinion of the observers that the steers which did not receive the limestone, and which had abnormal water metabolism as shown by excess drinking and urination, were more irritable than their mates. This difference in irritability is in accord with the generally accepted view that increased calcium content of the body tissues decreases irritability, and with the well-known fact that overhydration of the tissues tends to cause irritability.

Breaking strength determinations of the bones indicated stronger bones for the steers receiving the calcium supplement. Chemical analyses of these bones have not been completed.

It is planned to repeat this test during 1938-1939, giving special attention to water metabolism and irritability.

(Project 203; Departments of Animal Husbandry and Chemistry. Leaders, A. D. Weber and J. S. Hughes; Bankhead-Jones fund.)

Factors Influencing the Mineral Metabolism of Dairy Cattle.— A study, begun in 1934, of the deficiencies of prairie hay in the dairy ration was continued. Eighteen Holstein heifers, divided into equal lots, received the following rations:

Lot 1. prairie hay and grain mixture (equal parts white corn, bran and cottonseed meal); Lot 2. prairie hay, same grain mixture and ground limestone; Lot 3, prairie hay, same grain mixture and silage. Twelve mineral balance trials were run with cows in full milk flow and at the close of lactation during the biennium.

At three years of age the average growth, as measured by weight, and by height at withers, was greater in Lot 3 than in either of the other lots. The average of each lot was above the Eckles standard for weight and height for cows of comparable age. The reproduction record, as indicated by the health and vigor of the calf at birth, and condition of the placenta, was decidedly better for Lot 3. In this lot seven of eight calvings were considered normal, in Lot 1 only three of nine calvings, and in Lot 2 but five of twelve. This benefit from the silage in the ration did not appear to affect the breeding performance masmuch as the number of services per conception was almost identical for each group.

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The addition of silage to the prairie hay ration showed a beneficial result when measured in terms of the average milk and butterfat yield for each lot.

The nine heifers (three from each lot) tested before calving were found to be in positive balance for both calcium and phosphorus. The results of the balance trials on cows in full milk flow showed the six cows tested in Lots 2 and 3 to be in negative calcium balance. In Lot 2, receiving calcium supplement, two cows were in positive, and one in negative calcium balance. The last series of trials run, when the cows were near the close of lactation, showed both cows tested in Lot 1 in negative calcium balance, while in Lot 2 one of the two cows tested showed a negative calcium balance, and the other positive. The one cow tested in Lot 3 showed a positive calcium balance. The calcium and phosphorus content of the blood was normal in all animals throughout the experiment. The blood hemoglobin was also normal, except during the period of extreme heat in the summer of 1936.

A study was also made of the vitamin C metabolism of the dairy cow. Three cows on winter feed were changed to all the green rye they would consume, and vitamin C determinations made on the blood, urine and milk of these cows. The fate of vitamin C in the rumen was also studied in a cow with a rumen fistula. The rumen contents contained lees than one tenth the vitamin C of grass eaten 12 hours earlier. The average of vitamin C in blood more than doubled within 12 hours after green feed was supplied. The average output of vitamin C in urine increased over fivefold within 60 hours after green feed was first consumed. The season of the year. the individuality and breed of cow, and the stage of lactation were found to be the more important factors causing variation in the vitamin C content of milk from cows in the station dairy herd.

(Project 147; Department of Dairy Husbandry and Chemistry. Leaders, W. H. Riddell, H. W. Cave, J. S. Hughes, and C. H. Whitnah; Purnell and state funds.)

Dairy Cattle Feeding Investigations.— The investigations conducted under this project during the past biennium have consisted of seven phases, as follows:

1. *Straw as a Feed for Dairy Cows.*— Ten cows, in two balanced groups, were fed for three 40-day periods, Group 1 receiving alfalfa hay ad libitum, Group 2 receiving ad libitum, a synthetic hay made of wheat straw 62 parts, cottonseed meal 28 parts, molasses 10 parts. In addition, all received a 12-percent total protein grain mixture made up of 570 pounds of yellow corn chop, 400 pounds of wheat bran and 1 percent each of steamed bone meal, ground limestone and salt. At the start of each new period the roughages for each group were reversed.

The synthetic hay was not relished by the cows as much as alfalfa hay, and consumption was somewhat less. Body weight was maintained about the same with the straw mixture as with the alfalfa hay. Group 1. starting on alfalfa hay, produced only 81.5 percent as much 4-percent fat-corrected milk during the straw period as during the alfalfa periods. However, Group 2. starting on straw, produced on the average 97.5 percent as much 4-percent fat-corrected milk as during the alfalfa period.

2. *Straw for Wintering Dairy Heifers.*— Twelve heifers, divided into three groups, were fed for 150 days on rations containing straw. Group 1 received three pounds of silage per 100 pounds body weight and, ad libitum, synthetic hay with a protein content of 10.6 percent, made up of straw, molasses and cottonseed meal. Group 2 received ad libitum a synthetic hay containing 5.94 percent protein composed of the same ingredients. Group 3 was fed straw ad libitum and one pound of cottonseed meal per head each day. Group 1 consumed its allotment of silage, but the maximum consumption of hay was only 12 to 13 pounds per heifers. Group 2 consumed a maximum of 13 to 20 pounds of hay per heifer, and Group 3 consumed a maximum of 14 to 15

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pounds of straw per heifer. The only group which came through the trial in satisfactory condition was Group 1. These heifers made an average gain of 105 pounds, which was considerably below normal. Group 2 lost an average of 41 pounds per head, and Group 3 lost 89 pounds per head. The gains in height at the withers of Groups 1, 2, and 3, were 6.5, 4.6, and 3.1 centimeters, respectively, all gains being below normal.

Although the straw rations especially were quite low in carotene, there was no external evidence of vitamin A deficiency in the heifers. A great deal of irregularity in oestrum was noted, and more than normal breeding trouble was experienced.

3. *Paintability and Yield of Various Perennial Pasture Plants.*— Eleven strips, 20 by 402 feet, were planted in the fall of 1936 with different kinds or combinations of grasses. An additional strip was left at the end of each plot and allowed to grow for the purpose of obtaining samples for yield and carotene content. The yields from the various strips were as follows:

Plot No.	Pasture plant used	Pounds of seed sown	Yield in Pounds: Unpastured area June 1, '37	Unpastured area July 3, '37	Pastured area July 12, 37
1.	Korean lespedeza	3 2	....	. ..	..
2.	Sweet clover	3.2	...	..	....
3.	Korean lespedeza	0.8	2.329	2.172	1.357
	Meadow fescue	0.8	....	....	.. .
	Orchard grass	1.2	. ..	....	. .
	Brome grass	1.6	....	....	..
4.	Alfalfa	0.8	2,405	3,688	1,816
	Brome grass	2.8	....	....	.. .
5.	Crested wheat grass	3.6	3,247	3,758	4,276
6.	Timothy	3.6	2,185	1,692	1,409
7.	Redtop	3.6	1,779	2,468	2,004
8.	Kentucky blue	3.6	2,033	2,229	2,990
9.	Meadow fescue	3.6	1,940	1,533	1,906
10.	Orchard grass	3.6	....	. ..	...
11.	Brome grass	3.6	....	....	1,943

In the opinion of those making the observation on palatability, the ranking of the strips would be as follows, in order of preference: Nos. 4, 11, 8, 3, 6, 10, 9, 7, 5. Very little crested wheat grass was eaten, which may have been caused by its comparative maturity at the time of pasturage.

The carotene content of most grasses reached a maximum early in June. The legumes averaged highest in carotene content, and crested wheat grass averaged lowest. With individual grasses the maximum content in many cases was eight to ten times that of the minimum. The highest value observed was 60.6 mg. of carotene per 100 grams of dried grass from Plot 3 on June 18, 1937, while the lowest was 2.86 mg. secured on grass from Plot 6 on July 8, 1937.

4. *Carrying Capacity of Temporary Pastures and Response to Grazing.*— Four one-acre pasture plots were sown as follows:

Fall, 1936	Fall, 1937
1. Sudan grass (sown spring, 1937)	Winter wheat and lespedeza
2. Winter rye and vetch	Winter rye and vetch
3. Winter rye	Winter rye
4. Winter wheat	Winter rye

From one to three cows, depending upon the amount of plant growth, were kept on the pastures. No fall pasturage was obtained from the plots in 1937. During the 1936-1937 pasture season the plots furnished the following pasturage: Wheat, 103.5 cow days; rye, 113 cow days; rye and vetch, 113 cow days. Production and feed consumption other than pasturage were as follows:

	Production, pounds: Milk	Fat	Feed consumption, pounds: Hay	Grain
Wheat	2,822 3	112.34	279	242 6
Rye	2,650.5	136.18	274	316.0
Rye and vetch	2,822 0	127.41	291	346.8

5. *Palatability of Temporary Pasture Crops.*— A field of approximately five acres was sowed in the fall of 1937 with common winter rye, Abruzzi rye,

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winter barley, soft winter wheat and hard winter wheat, about one acre to each. The winter barley completely winterkilled, so this crop was replaced by spring-sown oats, which could not then be included in the relative palatability tests. A group of ten cows was placed on the pasture when the Abruzzi rye was about eight inches high, the common rye six inches, and the wheats five to six inches in height; and daily observations were made for 307 cow days as to the preference. The cows showed a distinct preference for the Abruzzi rye and, when driven to the other plots, returned to graze the Abruzzi rye. Hard winter wheat, soft winter wheat, and common rye followed in order of preference.

6. *Carotene Content of Posture Plants.*— Thirteen pasture plants were studied for a determination of their carotene contents at various stages of growth, and at regular intervals during pasture season. These plants included rye, wheat, barley, big bluestem, little bluestem, local brome, Canadian brome, Dakota brome, orchard grass, bluegrass, redtop, buffalo grass and alfalfa. All showed with rather wide variations a relatively high carotene value in early summer. During the hot months of midsummer carotene content tended to decrease markedly. After the fall rains most of the plants reestablished carotene content similar to early summer values.

Some studies were also made of the utilization of carotene in green rye by dairy cows, when the daily intake was excessive. Of the carotene ingested daily an average of 0.086 percent was recovered daily as carotene in the butter and an average of 0.154 percent as vitamin A, or a total of 0.24 percent in terms of international units. The data seem to indicate that when the carotene intake is excessive the ratio of carotene to vitamin A in the butter, at least with Holstein and Ayrshire cows, becomes rather constant at about one to two.

7. *Rotation versus Season-long Grazing.*— A six-acre field was sowed in the fall of 1936 with permanent pasture grasses as follows, per acre: Alfalfa, four pounds; meadow fescue, four pounds; orchard grass, six pounds; brome grass. eight pounds. The field was divided into three two-acre plots, the center plot being grazed continuously during the pasture season by two cows. Four cows were started on one of the end plots, and at 14-day intervals were changed to the other end plot. Besides pasture the cows received grain according to a given schedule. Three-tenths pound of grain was fed for each pound of milk above base, the bases being, Jersey 10 pounds, Guernsey 12 pounds, Ayrshire 14 pounds, and Holstein 16 pounds. During the last few days on pasture the cows were fed an average of 45 pounds each of alfalfa hay.

In spite of the dry spring and early summer of 1937 the continuous and the rotational grazed plots furnished 59 cow days of pasture. When the cows were taken from the pastures on July 10, the gross was badly dried, but the rotational grazed areas, especially the one on slightly lower ground, seemed in better condition than the continuously grazed plot. After July 1 the grass became short and dry, and it was noticed that the cows were failing in milk flow.

The average milk production per cow on the continuously grazed pasture was 1,431.3 pounds as compared with 2,158.7 pounck on the rotational grazed pasture.

(Project 34; Department of Dairy Husbandry. Leaders, H. W. Cave. F. W. Atkeson; state fund.)

Normal Growth of Dairy Cattle.— The height at withers and the weight of all calves in the station dairy herd have been determined at monthly intervals to 24 months of age. Data, collected over a period of fifteen years, are available and have been reported in tabular form in Morrison's Feeds and Feeding, 20th edition, and in the Proceedings of the American Dairy Science Association.

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(Department of Dairy Husbandry. Leader, W. H. Riddell; state fund.)

Calf-feeding Investigation.— The work on this project has been concerned during the past two years principally with the value of skim milk, cod-liver oil concentrate, commercial calf starters and prairie hay as feed for calves.

Use of cod-liver Oil Concentrate with Skim Milk Fed Calves.— Two groups of four calves each were fed during an eight months' observation period, group 1 receiving 5 c. c. of a commercial cod-liver oil concentrate from birth, group 2 receiving 10 c. c. of the concentrate. All calves received colostrum from the mother for three days, after which they were changed abruptly to skim milk. As soon as they would consume it, they were allowed alfalfa hay and a grain mixture. Grain was limited to three pounds, and skim milk to 15 pounds daily per calf, but hay was fed ad libitum. Body weights were secured at 10-day intervals and height at withers monthly. The percentage of normal growth for group 1 was 95.5 at six months, and 87.5 at eight months; for group 2, 96.6 and 91.8 percent. The percentage of normal height for group 1 was 94.7 percent at six months and 102.1 percent at eight months; for group 2, 98.0 and 99.5 percent, respectively.

Use of Cod-liver Oil Concentrate with Calves Fed Remade Skim Milk.— After the colostrum period six calves were placed on remade skim milk (1 pound of powder to 9 pounds of water) which they received for six weeks. In addition, each calf received 10 c. c. daily of a commercial cod-liver oil concentrate. A grain mixture consisting of equal parts of corn, oats, bran and skim-milk powder was fed to a maximum of three pounds per calf daily. Alfalfa hay was given ad libitum.

The calves in this trial did not progress as satisfactorily as did those fed normal skim milk. Digestive disturbance was experienced, and two calves died. Growth of the remaining calves has been below normal.

Use of a Commercial Calf Starter in Raising Calves.— A group of five Ayrshire bull calves has been fed a calf starter and a limited amount of whole milk and alfalfa hay, all feeds being given according to the directions of the manufacturer of the calf starter. Whole milk was fed for three to four weeks, during which time every attempt was made to encourage consumption of the calf starter.

The calves have been on experiment only two months, so no conclusions can be drawn. They have grown fairly well, but have eaten little but the calf starter, and appear to have no appetite for hay, which has caused a light-bodied appearance. Practically no digestive disturbance has been observed.

Prairie Hay Rations for Calves.— Eight calves, divided into two groups of four each, were fed for a six months' period. All received prairie hay at will and a grain mixture consisting of equal parts of white corn and wheat bran. The grain allowance at no time exceeded two pounds per calf daily. Each calf received its mother's milk for three days, and mixed whole milk until two weeks of age, after which it was gradually changed to skim milk. The calves in Group 1 received whole and later skim milk from cows fed only prairie hay as roughage. Group 2 received whole and skim milk from cows fed silage in addition to prairie hay. The skim milk fed each calf at no time exceeded 12 pounds daily.

The amounts of nutrients consumed by groups 1 and 2 were approximately the same. Since all calves used were Ayrshire-Holstein crossbreds, it is not possible to make a direct comparison of growth with the standard growth curves. The average gain in body weight for groups 1 and 2 was 226 and 232 pounds, respectively, and the gain in height of withers 22 and 23 centimeters, respectively. These gains approximate the normal gains made by purebred Ayrshires in the Kansas State College herd and are somewhat below the normal gain for Holsteins. Only one calf had digestive trouble, and that was

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of short duration. Carotene determinations on the hay used indicated that the calves received sufficient vitamin A, and at the end of the trial tests for night blindness gave no evidence of defective sight.

(Project 154; Department of Dairy Husbandary. Leaders, H. W. Cave, F. W. Atkeson; state fund.)

Dairy-manufacturing Investigations.—Twelve phases of this project were active during the past biennium, each of which is reported as follows:

1. *The Composition of Milk.*— This work was started in the fall of 1936 for the purpose of establishing the normal limits of variation for several milk constituents, and to establish possible relationships between these constituents. Fat, total solids, and chloride determinations are being made by the Department of Dairy Husbandry, determinations of the other constituents involved in this study by the Chemistry Department. Three-day composite samples from each cow in the station dairy herd are being analyzed once a month for one complete lactation period.

2. *The Effect of Various Feeds and Feeding Practices on the Flavor of Milk.*— A study has been made of the following pasturages on the flavor and odor of milk: fall growth of wheat and rye, spring growth of wheat and rye, rye and vetch. The duration of a trial was usually 12 days, during which time groups of cows were removed from the pasture at intervals ranging from one to five hours before milking. Samples of the afternoon milk for individual cows were taken and examined on the following morning for the presence of off flavors and odors. Group samples were examined before and after aeration. During the trial made in the spring of 1938 the cows were allowed to graze on the pastures day and night, and were removed only at milking time. Samples of the night and morning milk were examined for off flavor and odor.

The time of removal from the pasture seemed to exert a greater influence on flavor and odor than any other factor. The removal of the cows at least four hours before milking greatly minimized, or entirely eliminated, the off flavors and odors. Rye proved to be more offensive than wheat in the production of flavor and odor defects. The season of the year did not have any marked effect on occurrence of the flavor and odor defects. Aeration of the milk did not result in any noticeable improvement. The off flavor was much more pronounced in the p. m. than in the a. m. milking.

3. *A Study of Oxidized Flavor in Raw Milk in Relation to Certain Milk Constituents.*— The study of oxidized flavors in milk has had widespread interest in recent years. Its sporadic occurrence among dairies attempting to produce high-quality milk has offered a serious problem, especially during the winter months. Even though many precautionary measures are now being taken during processing to prevent the action of agents which might catalyze oxidation of milk, this off flavor still occurs in some milk. The production of milk which is not susceptible to oxidation may be a possible solution of the problem. Therefore, it seemed desirable to study the raw milk from individual cows in an effort to determine the possible relationship of certain milk constituents to the oxidation process.

Samples of morning milk from the four breeds of dairy cows in the station herd were collected on three consecutive days during the months of December to May, inclusive. The milk was examined while fresh and again after three days' storage at 45 degrees F. for the presence of off flavors. Vitamin C tests were also made on the fresh and stored milk. The amounts of lecithin in the milk were determined by testing samples taken at various internals, and the amounts of carotene were estimated from color determinations made on the milk fat.

Oxidized flavor occurred in 11 percent of 1,134 samples of milk. It occurred in 6 to 7 percent of 480 samples of Jersey and Guernsey milk, and in 16 to 17 percent of 445 samples of Ayrshire and Holstein milk. No relation was found

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between either the natural amount of vitamin C in milk or the amount of vitamin C lost during storage, and the development of oxidized flavor. No relation was found between frequency of occurrence of oxidized flavor and the amount of lecithin or the amount of phosphatase in the milk. Carotene supplements fed at the rats of 600 and 206 mgms. of carotene per head each day to cow producing an oxidized flavored milk resulted in a disappearance of this off flavor.

4. *The Use of the Phosphatase Test in Determining the Efficiency of Pasteurization.*— At present three modifications of the original Kay and Graham test are being used in the United States in addition to the original test which came from England. The modified tests are the Gilereas and Davis test, the New York City Field test, and the Scharer Laboratory test. During the past year work has been in progress dealing with the use of one or more of the modified tests as a measure of pasteurization efficiency with milk and ice cream mixes.

In the case of milk, two pasteurization procedures have been studied in relation to the inactivation or destruction of phosphatase; namely, the holding process (30 minutes at 142 degrees F.) and the short-time, high-temperature process (15 seconds at 160 degrees F.). Factors studied in connection with the holding process of pasteurization included: (1) Pasteurization temperature, (2) holding time, and (3) admixture of raw milk in varying amounts to a properly pasteurized sample.

In the work thus far the destruction or inactivation of phosphatase in ice cream has been studied with respect to the possible influence of the following factors: (1) Ingredients, (2) vanilla flavors, (3) pasteurization temperature and holding time, (4) processing, (5) admixture of raw products in varying amounts to a properly pasteurized sample of mix, and (6) storage of the frozen ice cream.

A reduction in the pasteurization temperature, 142 to 140 degrees F., was detected in each of a series of 10 trials by the Gilcreas and Davis and the New York City Field tests.

The effect of shortening the holding time from 30 to 20 minutes, when the milk was pasteurized at 142 degrees F., was detected in every case by both of the above-mentioned phosphatase tests. The results obtained establish the fact that modern commercial pasteurization equipment designed for short-time, high-temperature pasteurization is capable of consistently turning out milk which will give negative results with the phosphatase tests.

Sugar was found to exert a protective action against the inactivation of phosphatase during the pasteurization of ice cream mixes to the extent that mixes pasteurized at 142 and 145 degrees F. for 30 minutes, gave positive results with the Gilcreas and Davis and the New York City Field tests. Similar mixes without sugar pasteurized at these temperatures were negative. Pasteurization at 150 degrees F. for 30 minutes yielded negative results in all cases irrespective of the presence of sugar. None of the other ingredients commonly used in ice cream mixes were found to have any significant influence on the inactivation of phosphatase when pasteurized at 150 degrees F. for 30 minutes.

The precision of the different tests in detecting added raw milk or cream in a pasteurized sample of mix was found to be as follows: Gilcreas and Davis test detected a minimum of 0.2 percent of raw milk and cream; the Scharer Laboratory test, 0.5 percent; and the New York City Field test, 1 percent. The Scharer Laboratory test was not well adapted for use with ice cream, due to difficulty experienced in filtering the samples and obtaining clear filtrates.

5. *Comparison of the Minnesota and Babcock Tests for Butterfat in Milk or Cream.*— The Minnesota test has been used extensively to measure the butterfat content of buttermilk and ice cream. More recently its use has been recommended for the testing of other dairy products, including whole milk and cream. The present investigation was planned to compare the results obtained with these tests when applied to milk and cream samples.

A total of 180 milk samples has been tested to date by these two methods. Of this number, 50 contained no preservative; 57 were preserved with formalin,

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51 with potassium bichromate; and the remaining 22 contained corrosive sublimate. A total of 102 comparisons of the two tests has been made, using cream samples.

These preliminary data indicate that the Minnesota test yields results slightly lower than the Babcock test on milk samples. The results of the two tests appear to agree rather closely on cream samples.

6. *Cream Quality.*— Renewed interest in the general subject of cream improvement has been shown in all parts of the country as a result of the Federal Food and Drug Administration's efforts to improve the quality of butter. During the past biennium studies have been conducted dealing with three different phases of this problem. One phase dealt with the rate and type of deterioration in cream as influenced by the time and temperature of storage. Split samples of cream were held at several storage temperatures. The grade, pH, titratable acidity, formol acidity and changes in the bacteriological flora were measured daily. This study, conducted in cooperation with the Department of Bacteriology, has been completed and the data published.

An attempt was made to determine the relative merits of some of the more commonly used methods of cooling cream, including (1) placing cans of cream in a refrigerator, (2) partially submerging the cans in water, (3) allowing water to flow over the outside of the can, (4) using a spray, and (5) using evaporation. In addition, the effectiveness of the evaporation method of cooling sweet and sour cream through a wide range of atmospheric temperatures and humidities was determined.

A study was made of the influence of three different procedures of cleaning and sterilizing cream separation on the flavor and keeping quality of the resulting cream when held at different storage temperatures. The procedures of cleaning and sterilizing the separators compared in this study were (1) the Rogers method, consisting of submerging the separator parts after use in a 5-percent tri-sodium phosphate solution to which was added 0.25 percent sodium chromate; (2) separator washed and steam sterilized after each usage; (3) separator left dirty overnight before use.

Split batches of whole milk were separated through the three separators. Each separator was adjusted to deliver cream testing approximately 35 percent fat. Each of the three lots of cream was divided into three portions and stored in glass fruit jars at 60, 70 and 80 degrees F., respectively. The cream thus stored was graded daily, the flavor defects noted, and the time required for the cream to change from first to second grade recorded. Acidity and formol acidity determinations were also made daily.

7. *A Study of the Color Variations in Creamery Butter.*— With the cooperation of the United States Department of Agriculture butter samples were collected from the terminal markets of New York, Chicago, Minneapolis, and San Francisco; and cream and butter samples were secured in Hutchinson. Manhattan, Concordia, Topeka, Coffeyville, Sabetha, Garden City and Norton. The cream samples, collected in order to determine the natural color of the butter before any butter coloring substance had been added, were churned and analyzed for color, along with the butter samples. In determining color intensity a clear ether fat solution was compared with a standard potassium bichromate solution in a Kletter calorimeter.

Color intensity is much higher in the spring and fall than it is in the summer and winter seasons. This seasonal variation is to be expected since pastures are at their best in the spring and fall seasons. Although Kansas produces most of its butter for eastern markets, the color intersity is somewhat higher than most of the butter marketed in Chicago and New York. From a study of the individual creameries in Kansas, it would appear that some of these creameries produce butter which might be discriminated against from the standpoint of excessive coloring. However, butter produced by Kansas creameries does not seem to fluctuate as much in color from season to season as the butter marketed on the western markets; nor is it so highly colored in the spring.

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8. *Effect of Starter Distillate upon the Flavor of Butter.*— Diacetyl in the form of distillate was obtained by steam distillation of starters. The diacetyl was added to sweet cream immediately before pasteurization, just after pasteurization, followed by 24 hours ageing just prior to churning, and just prior to churning. The diacetyl was also added directly to the butter at the time of working. The ratios at which the diacetyl was added to the butter, or to the cream in equivalents, were: 1/50,000, 1/100,000, 1/200,000, 1/300,000, 1/400,000, 1/500.000. Two controls, one with nothing added and one with 5-percent added starter, were used. Each sample of butter was divided into two parts, one stored at 45 degrees F. and the other at 0 degrees F. Each sample was scored when fresh and at the end of 30, 45 and 60 days of storage.

Storage temperature had more influence on the keeping quality than did the amount of diacetyl added. Butter containing one part of diacetyl to 400,000 parts butter had the poorest keeping quality. There was very little difference in the score of the various samples of butter stored at a given temperature.

9. *The Cold Storage of Butter.*— The main reason for the storage of butter, as revealed by this study, was the desire to sell during seasons of low production. The length of the storage period was determined in most cases by price and supply available. Approximately 75 percent of the Kansas butter is shipped to Chicago and New York markets, with the remaining 25 percent sold locally. In most instances the butter was stored at the local creamery or in a local warehouse. The average amount of deterioration in quality was reported to be approximately one-half point in score.

10. *The Use of Parafilm in Packaging Loaf Cheese.*— Four lots of cheddar cheese were made into approximately 60 five-pound-loaf cheeses. One half of each lot of curd was bandaged, paraffined and ripened in the conventional manner, the other half sealed and ripened in Parafilm. Comparisons were made between the two methods of packaging when stored for a period of six months at a temperature of approximately 50 degrees F. and a relative humidity of 75 percent.

The amount of mold growth which occurred on the surface of the cheese was the most important factor influencing the net weight of usable cheese when Parafilm was used. In the case of the paraffined cheese the trim loss was affected by the thickness of the rind and the amount of drying which occurred at the surface. The trim loss averaged 6.54 percent at 60 days, 5.91 percent at 90 days, and 10.43 percent at the end of 180 days storage for the cheese ripened in the conventional manner. Trim losses for the cheese ripened in Parafilm averaged 4.74 percent at 60 days, 2.55 percent at 90 days, and 6.56 percent after 180 days of storage.

11. *Power Requirements for Freezing Ice Cream.*— Some difficulty has been experienced in attempting to freeze and whip heavy, viscous ice cream mixes in a 40-quart, direct expansion freezer equipped with a three-horsepower motor. Excessive heating of the motor, reduced dasher speed and blown fuses were frequently encountered, especially when an attempt was made to draw ice cream from the freezer at 24 degrees F. or less. Factors that have been studied include the various sizes of motors, size of pulley, effect of shutting off the refrigerant at various temperatures, varying the percentage and kind of stabilizer, effect of egg yolk in the mixes upon the power requirements for the freezer and the quality of the ice cream. The study and the results have been published.

(Project 124; Departments of Dairy Husbandry, Agricultural Engineering. Bacteriology and Chemistry. Leaders, G. H. Beck, W. J. Caulfield, H. W. Cave, V. D. Foltz, W. H. Martin, D. L. Murray, C. K. Otis, F. L. Parsons, and C. H. Whitnah; state fund.)

Bacteriological Study of Ice Cream.— Five phases of this project which have been given special attention during the biennium are here reported briefly.

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1. *Survey of Kansas Ice Cream.* —The survey of Kansas ice cream has been conducted for four years on a state-wide basis. In 1936 a total of 260 samples representing practically all of the manufacturers of ice cream in Kansas were analyzed. The distribution of standard plate counts of bacteria in the 260 samples is as follows:

Range of counts per ml. of sample	*Number of samples*	*Percentage of samples*
Less than 10,000	6	2.31
10,000 to 49,999	44	16.92
50,000 to 99,999	36	13.55
100,000 to 499,999	80	30.77
500,000 to 999,999	34	13.08
1,000,000 to 10,000,000	44	16.92
10,000,000 and over	16	6.15

Since the most widely accepted bacterial standard for ice cream of a satisfactory sanitary quality is 100,000 per ml., it is evident that only about one third of the product sold in Kansas at the time these samples were taken could have met this standard. If the number of bacteria per ml. of sample is accepted as a basis for judging quality, there was little difference between the years 1934, 1935, and 1936, but in 1937 there was a distinctly larger number of samples in the low-count group.

The average bacterial counts on dextrose agar were one and one-half times those on saccharose agar and two times higher than those on plain agar.

The distribution of weights of the 260 samples of Kansas ice cream. calculated to a basis of pounds per gallon, follows:

	Factory filled	*Dipped samples*	*All samples*
Lowest	3.39	3.61	3.39
Highest	7.70	8.27	8.27
Average	4.75	6.21	4.97
Median	4.63	6.43	4.71

The wide variation in weights of ice cream sold in pint and quart packages suggests very strongly the need for a weight standard for Kansas ice cream.

The survey figures have been presented to the manufacturers each year and directions given as to methods of improving quality.

2. *Development of Organisms Found in Ice Cream on Tryptone-glucose - skim milk agar.* —An appreciable increase in count of organisms was obtained with the new tryptone-glucose-skim milk agar, compared with the milk agar. This increase in count has been used as an argument for the adoption of the new medium for routine use in the grading of milk and milk products. If this increase in count were due to the growth of organisms of either economic or public-health significance, their enumeration would be of considerable importance. The organisms which develop on tryptone-glucose-skim milk agar, and which either do not develop or which grow very poorly on standard milk agar, were studied in order to determine their possible significance to the dairy industry.

A series of 125 organisms which grow fairly well on tryptone-glucose-skim milk agar, but poorly, if at all, on standard milk agar, has been isolated from a number of ice cream samples. Many of these are Gram-positive cocci and bacilli, but some Gram-negative organisms are also included in the group, Studies of the taxonomic relationships of these organisms and of their characteristics which may be of importance to the dairy industry are in progress. In the case of several samples, the cultures obtained from tryptone-glucose-skim milk agar plates which showed several times more colonies than did plates of the same dilution poured with standard milk agar, almost all grew satisfactorily on standard milk agar, once growth had been initiated on the tryptone-glucose-skim milk agar, Indications are that this agar permits some organisms which have been weakened by pasteurization to initiate growth when they will not grow on standard milk agar under the same conditions. This may explain the increase in the bacterial count of pasteurized products frequently observed with the tryptone-glucose-skim milk when compared with standard agar.

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3. *Prevalence of Escherichia-Aerobacter Organisms in Kansas Ice Cream.*— of 51 ice cream samples examined for the presence of organisms of the Escherichia-Aerobacter group, 40 yielded positive presumptive tests for these organisms in amounts of 1 ml. or less of melted sample, using brilliant green lactose peptone bile broth as the medium for the test. Of these presumptives, 37 were confirmable. Eighty-seven strains were isolated and characterized. Aerobacter cultures were 54 in number and constituted 62 percent of the total number; 26 cultures, or 30 percent, belonged to the genus Escharichia; and six cultures, or 7 percent, were Citrobacter species. All of the cultures were destroyed by pasteurization at 143.5 degrees F. for 30 minutes when placed in sterile skim milk, but 12 cultures of the genus *Escherichia* survived when sterile ice cream mix was used as the medium. These results again demonstrate that higher temperatures must be used to obtain adequate pasteurization of ice cream mix than can be used for the pasteurization of market milk.

On a series of 24 samples, 16 of which gave confinable tests for organisms of the *Escherichia-Aerobacter* group, phosphatase tests for the efficiency of pasteurization were made by the Department of Dairy Husbandry by means of the New York City Field test. Four samples were positive to both tests indicating that possibly the organisms were present because of inefficient pasteurization. Twelve samples were negative to the phosphatase test, but still contained organisms of the Escherichia-Aerobacter group, indicating, apparently, that the mix was contaminated following pasteurization, or that some unusually resistant species were present.

Experiments on a semicommercial scale to determine the comparative temperatures of destruction of phosphatase enzyme and of death of the Escherichia-Aerobacter organisms are now under way. If the phosphatase enzyme and the bacteria in question are destroyed at about the same temperature, a combination of the phosphatase test and the test for members of the *Escherichia-Aerobacter* group should not only show whether or not pasteurization has been adequate, but should indicate also something of the sanitary condition of the plant.

A negative phosphatase and a positive preemptive test would indicate satisfactory pasteurization followed by contamination from equipment due to insanitary conditions.

4. *Media for the Determination of Proteolytic Organisms in Dairy Products.*— Standardization of methods for the determination of proteolytic organisms is necessary before accurate evaluation of the part which they play in the deterioration of dairy products will be possible. Five media have been studied comparatively for their suitability in determining the numbers of proteolytic organisms in dairy products. Standard milk agar plus 5-percent sterile skim milk, beef infusion agar plus 5-percent sterile skim milk, and tryptone-glucose-skim-milk agar containing 5-percent skim milk, gave the highest counts, with little difference except that the last named gave more clearly defined and more easily countable colonies, both before and after flooding with the various precipitating agents. Frazier and Rupp casein agar and Frazier gelatin agar showed neither as many proteolytic colonies nor as high total counts as the other three media and seemed to be unsatisfactory for quantitative work. Differences in the abilities of pure cultures to bring about detectable proteolysis on the various media were demonstrated, proteolysis on one medium not indicating necessarily a similar condition on another medium. Three precipitating agents, tannic acid, dilute hydrochloric acid and acid mercuric chloride, were compared as aids for counting. Tannic acid was the least satisfactory. tending to cause clouding around almost all proteolytic colonies. Dilute hydrochloric acid was relatively satisfactory. In no case did the treatment of the plate with precipitating agent result in an appreciable change in the count of proteolytic organisms.

5. *Studies on Resazurin as an Indicator of the Quality of Milk.*— Within the past two years the dye resazurin has been recommended highly as superior to methylene blue for the determination of the quality of market milk. The

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greater rapidity of the test with the new dye and the fact that it is supposed to detect milk from physiologically abnormal udders have been advanced as the principal advantages of its use.

Results obtained on several hundred samples of aseptically drawn milk from individual quarters of the udder indicate a definite tendency for milk to cause at least some change in the color of resazurin during a one-hour incubation period when the leucocyte count is above 500,000 per ml. There is apparently no demonstrable relationship between the shedding of mastitis streptococci, as determined either by the Hotis test or by microscopic examination of an incubated sample, and the change in color of resazurin during an hour of incubation. Because of this latter characteristic, the dye could not be used as an indicator of some types of mastitis.

Examination of various commercial lots of resazurin has shown that there are marked differences between the products of different manufacturers, only two of the four samples examined to date being suitable for milk-control work. There are pronounced differences in tinctorial abilities and in the sequences of the changes of color.

(Project 124; Department of Bacteriology. Leaders, F. E. Nelson, V. D. Foltz; state fund.)

A Study of the Formation, Isolation and Properties of Milk Sugar.— The work for the biennium has consisted of three phases.

1. *Tests of the Need of Milk Sugar for Cerebroside Formation.*— Small though consistent correlations of learning ability in rats with the amounts of galactosides and other lipids in their brains have been reported. Reasons for the lack of closer correlations have been sought in the relation of learning ability and emotional stability to the mineral content of the brain. The preparation of a ration freer from galactose than heretofore available has been found necessary to enable further work on the relation of cerebral galactosides or of ovarian function to lactose or galactose in the ration.

The relations of brain minerals to learning ability and emotional stability have been more striking than the relation of brain lipids to learning ability. The outstanding relation found has been the negative correlation between the amount of sodium in the brain and learning ability or emotional stability. A positive correlation has been obtained between potassium and learning ability.

2. *Production and Study of Riboflavin.*— A study of the radiations in riboflavin and milk, and the relation of these variations to variations in other milk constituents, has been made in conjunction with the Department of Home Economics. The work on flavin has been undertaken in the study of factors affecting the vitamin C content of milk. This study of vitamin C relationships has involved continued comparison of prairie hay fed Holstein cows with cows of similar age and breed on the regular herd ration; and a comparison of cows from four dairy breeds fed wheat-straw roughage for periods of six weeks with similar cows on the regular herd ration.

Seven tons of whey have been concentrated to make d-ribose available for laboratory studies. The lowest wholesale cost of this sugar has been $6.50 per gram; the sugar being produced in the laboratory has cost less than $3 per gram. This cost could probably be reduced to one half or one third that amount if the demand justified the installation of suitably arranged equipment. Two hundred to three hundred grams of ribose may be expected from seven tons of whey. This would represent 40 times the amount of ribose present as riboflavin in the whey.

A rapid method for the determination of riboflavin in milk has been developed. Distinct differences in the flavin content of milk have been found in different breeds of cows. Milk from Ayrshire cows was lowest in riboflavin content, with that of Holsteins. Guernseys and Jerseys, respectively, higher. Very little difference was found in the flavin content of milks produced from different winter rations; and the change from winter rations to pasture exerted little influence.

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Variations in the flavin content of milk were most closely associated with the fat content. Irregularities in this association were allied to irregularities in the relation of flavin to lecithin and to phosphata. These observations indicate that flavin may have a rôle in the synthesis of butterfat.

3. *Carotene Metabolism of Cattle.*— The most surprising result of the study of the carotene metabolism of cattle was the large loss found in the feces at low levels of carotene intake. The total carotene loss was less at the lower levels of intake, but the ratio of loss to intake was higher when young animals had been on the poor ration for five months.

(Project 190; Departments of Chemistry and Dairy Husbandry. Leaders, C. H. Whitnah and W. J. Caulfield; Purnell fund.)

Improvement and Conservation of Farm Poultry.— Seven phases of this project, dealing with chickens, have been carried on during the past two years.

1. *The Relation of Hatching Date to Income from Eggs.*— Twelve hundred Leghorn chicks were hatched at four-week intervals, beginning February 12 and ending May 7, reared under uniform conditions, and 100 pullets from each hatch segregated for study. The four lots were kept in a long laying house for 52 weeks from 20 weeks of age. The eggs were gathered daily, graded, and the paying price at a local packing house for each grade was used to arrive at the market value of eggs from the different lots. The results for each lot are given below. (Table I.)

TABLE I. — PRODTION AND INCOME AS RELATED TO HATCHING DATE

	First hatch.	Second hatch.	Third hatch.	Fourth hatch.
Feed consumed per bird, lbs.	77.4	78.9	74.3	76.6
Egg production, average per bird	177	160	161	184
Hatchability of fertile eggs	76.4	78.5	82.6	80.3
Number dozen eggs production per lot	1,064.7	963.4	883.8	1,078.3
Number dozen eggs sold	1,058.3	957	871.8	1,070.7
Difference in dozens	6.4	6.4	12	7.6
Value of eggs sold per lot	$214.78	$194.91	$176.51	$202.61
Cost of grain and mash	$85.29	$107.93	$96.41	$85.82
Difference	$129.49	$86.98	$80.10	$116.79
Average number of hens for year	72.3	71.4	68.5	68.6
Income per hen above feed cost	$1.79	$1.22	$1.17	$1.70
Average annual income, two years	$1.43	$1 02	$1.20	$1.46

2. *A Comparison of Dehydrated Alfalfa and Immature Oat-plant Meal.*— Twelve hundred White Leghorn chicks were hatched early in April of 1936 and reared on the same ration-under uniform range condition to 20 weeks of age, at which time 95 pullets were placed in each of four lots in a laying house. All mature pullets received essentially the same basal ration except for vitamin A, which was supplied from two sources, alfalfa and grass meal. Lot 1 received 10 percent dehydrated alfalfa leaf meal in the basal ration, while Lots 2, 3, and 4 received 10, 15, and 20 percent, respectively, of dehydrated oat-plant meal in the basal ration. A chemical analysis showed the fourth cutting of alfalfa meal contained 23.4 percent protein, while the grass meal contained 28.5 per-

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cent protein. The meal in the ration which analyzed 55 percent protein was reduced in the last three lots as the grass meal was increased to make the protein level in each lot practically equal. Shelled white corn and wheat were hopper fed for scratch grain.

There were no marked differences in the results. Egg production in Lot 4 was probably significantly less than production in the other lots, while the matchability in Lot 1, which received alfalfa meal, was slightly less than in the lots which received grass meal.

3. *The Relative Value* of *Alfalfa and Young Cultivated Cereal Grasses in Poultry* Nutrition.— Twelve hundred White Leghorn chicks were hatched early in April, 1937, and reared on "clean ground' with oat and sudan grass pasturage. In addition to a grain and mash ration, young grass of the above varieties was cut before jointing and fed daily by the soiling method during the growing period, one to twenty-four weeks of age. Another lot of chicks from the same stock was reared in confinement to eight weeks of age, after which they were reared to maturity on a good alfalfa range. These were designated as controls. At 24 weeks of age three lots of 100 pullets each from the grass range were transferred to Lots 1.2. and 3 in a long laying house, and 100 pullets from the alfalfa range were placed in Lot 4. A basal ration was prepared for all lots which contained approximately the same amount of protein for each lot after the supplements of greenmelk, tender grass or grass silage, and condensed milk were added. In addition to the basal ration, Lot 1 received three pounds of greenmelk daily. Lot 2 four pounds of finely chopped young, tender oat or sudan grass when available, after which oat-plant silage was fed during the winter months, and Lots 3 and 4 received three pounds of condensed buttermilk from the same source as that used to prepare the greenmelk. These last two lots also received 5 percent of dehydrated alfalfa leaf meal in the mash feed as a source of vitamin A. Shelled yellow corn and wheat were fed in open hoppers as scratch grain. The vitamin A units in 100 pounds of feed were calculated for each lot to be: Lot 1, 867,150; Lot 2, 906,750; Lots 3 and 4, 710,040 each.

It was observed when the pullets were brought in from their respective ranges that those reared on the grass showed much more yellow pigment in the beak and shanks than those reared on alfalfa Since the first year's work on this phase is not completed, results for the first 32 weeks in the laying house are given here:

	Lot 1	*Lot 2*	*Lot 3*	*Lot 4*
Feed consumed per bird, pounds	51.90	51.00	47.00	48.80
Average egg production per bird	114.00	108.00	98.00	99.00
Unit profit above feed cost	$0.32	$0.47	$0.32	$0.29
Hatchability, percentage	66.00	64.00	62.00	71.00
Mortality, percentage	30.00	28.00	34.00	59.00

4. *Grass Silage for* Poultry.— Since alfalfa meal loses its carotene rather rapidly when stored in the usual way, an attempt has been made to preserve this precursor of vitamin A by cutting young oat plants and storing this material with molasses and water in pit silos. The oats was mowed and put through an ensilage cutter. The finely chopped grass was mixed with molasses and water at the rate of 60 pounds of each per ton of green feed, and tightly tramped in two pit silos.

The weight of green oats cut on 1.4 acres and placed in the two silos was 9,250 pounds. The oats which reached a peak in carotene content of 43.66 mg./100 on May 3 had declined to 24 mg./100 by May 17, when cut and stored. The moisture content of the green oats as cut was 83.3 percent, and of the green oats plus molasses and water as stored, 86.5 percent. This gave a dry weight per ton of oats as stored of 270 pounds.

The silage was fed to birds in Lot 2. The birds appeared to relish it. From 4 to 9 percent of the birds in this lot produced olive colored egg yolk commonly termed "grass eggs" on the market. The cause for this has not been determined.

For convenience the silage was transferred from the pits to 50-gallon wood and metal barrels where the air was pressed out.. It kept satisfactorily in

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the barrels. The amount put into each barrel was 470 pounds. Hatchability for the season among two flocks of White Leghorn hens, mated with the same males, was 77.4 percent for the no-silage pen, and 78.7 percent for the group receiving silage.

5. *The Stability of Carotene in Dehydrated Alfalfa and oat-plant Meal.*— One 100-pound bag each of dehydrated alfalfa-leaf meal and dehydrated oat-plant meal produced on the same type of soil near Lawrence, Kan., was prepared in October, 1936, shipped to Manhattan and stored in the attic of a nutrition building. Samples were taken about once a month by extending a grain sampler down each side and in the center of the bag.

After one year's storage in a dry room the alfalfa-leaf meal contained 81,600 units of vitamin A per pound, while the oat-plant meal contained 63,600 units per pound. The loss of carotene content of the two samples for the year was 66.4 and 79.4 percent, respectively.

6. *Effect* of *Dubbing on Sex Hormones.*— The object of this work has been to determine (1) the differences in the size of testes from dubbed and normal Leghorn cockerels, (2) the change, if any, in hormone secretion from the two groups of males, (3) changes in interstitial tissue of the testes of the two groups.

Seventy-five early hatched Leghorn cockerels were used in 1936, and the same number in 1937. Each year 15 were caponized, 30 were dubbed (comb and wattles removed with a shear close to the head), and 30 were retained as normal. The birds were killed and body weight, comb weight, comb volume and weight of testes were recorded. The second year, testes were removed and fixed for sectioning from two representative dubbed and normal males each month until the binds were judged to be mature, or about eight months of age. The study on the section was made in order to follow the progression in spermatogenesis, as well as the development of the tubules, the amount of interstitial tissue, and the changes in the weight. The testes of the males remaining at the termination of the project were extracted for the androgenic factor.

The average weight of the testes of the dubbed males at maturity was 16.26 grams, while the weight of the normals for the same period averaged 10.18 grams. A study of the sectioned testes revealed no difference in time as to spermatogenesis or development of tubules, or the amount of interstitial tissue. Therefore the dubbed birds with testes much larger in size probably have no greater breeding capacity than normal males.

7. *Factors Influencing Feathering in Rhode Island Reds.*— In this study the degree of feathering found in seven- rind eight-weeks-old Rhode Island Reds was considered. Both physiological and genetic factors were investigated, By selection it was possible to establish strains which differed with respect to feathering conditions

The major genetic factors involved showed evidence that well-feathering is dominant over poor-feathering. The genetic differences segregated by selection seemed not to involve sex-linked factors. In general, selection for better feathering in the genetically late-feathering strain was less effective than utilization of the existing sex-linked early-feathering factor.

Lowered brooding temperatures and higher humidity in the brooding room. each seemed to stimulate better feathering. Variations in the grain content of the diet had only a slight influence. Iodine feeding and thyroxin injections each seemed to have stimulating effect on feathering.

(Project 77-20, 23, 25, 26, 28 and 29; Department of Poultry Husbandry. Leaders, L. F. Payne and D. C. Warren; state fund.)

Turkey Production.— Two phases of this project have been active during the biennium.

1. *Growth Comparisons of Bronze and Narragansett Turkeys.*— The objects of these studies completed in the fall of 1936 were to compare the growth rates of the two breeds of turkeys, and to determine the pounds of feed re-

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quired to produce a pound of gain. The experiment was begun with 110 Narragansett poults, and 995 Bronze poults hatched May 19, 1936. Birds received the same balanced ration and were weighed individually at four-week intervals until they were 24 weeks of age. Feed consumed for each period was recorded.

The average weights at 24 weeks were as follows:

Narragansett females 10.3 pounds.	Bronze females 10.1 pounds.
Narragansett males 15.4 pounds.	Bronze males 15.1 pounds.

Total mash and grain consumed per bird for the 24-week period was 49.01 pounds for the Bronze turkeys and 49.16 pounds for the Narragansetts.

2. *Relation of Altitude and Temperature to Feathering.*— Another study was made to compare the rate of feathering in Kansas at a low altitude and relatively high fall temperatures with rate of feathering in L-tab at a high altitude and relatively low fail temperatures, and to study the rôle of green grass in the diet. The experiment was begun with 149 Bronze poults which were hatched during the last week in April of 1937 from eggs received from a meat-producing strain of turkeys in eastern Oregon. The Poultry Department of the Utah State College received poults from the same source and at the same time. The rations fed the Kansas and Utah flocks differed only slightly. Weekly feed and poult weights were taken throughout the Kansas experiment, which ended when the birds were 28 weeks old.

When one week old the poults were given finely chopped, tender young oat plants daily in addition to the grain ration. This was continued until the poults were six weeks old and removed to the range. They were allowed to range on young, tender Sudan grass for the balance of the experiment. Finally, chopped Sudan grass was fed also each morning.

When the poults were six weeks old, records of individual weights, average length of feathers, and average number of pin feathers in the region of the pectoral feather tract, the back, and the tail of each bird were taken. This was continued at weekly intervals until the completion of the experiment. A comparison of the results obtained would indicate that altitude and climate had little, if any, effect on feather maturity in Bronze turkeys.

(Project 77-15, 27; Department of Poultry Husbandry. Leader, T. B. Avery; state fund.)

Factors Influencing the Color of Yolks of Eggs.— During the first year of the biennium, a study was made of the metabolism of some of the more common carotenoid pigments in the pure form. During the second year a study was made of the utilization of carotene and xanthophyll of oat silage and dehydrated oats. The work included three phases as follows:

1. *Metabolism of Carotenoid Pigments in the Pure Form.*— Thirty-two White Leghorn hens, which had been kept on a feed low in carotenoid pigments until egg yolks of a uniformly light color were produced were fed the following purified pigments: carotene, cryptoxanthin, zeaxanthin, lute in, and esters of cryptoxanthin, and zeaxanthin. An amount of material containing approximately one milligram of each of these pigments was placed in the crop of each hen daily for seven days. All the eggs laid during the seven days and those laid 14 days after discontinuing the pigment were kept for analysis. All the yolks from each hen were pooled separately and analyzed for petroleum phasic and alcohol phasic pigments.

The results indicated that the pigments of the petroleum phasic fractions do not find their way into the egg yolk when fed in the pure form. The alcohol phasic fractions, however, are deposited in the yolk. In accord with previously published results, a higher percentage of zeaxanthin is deposited than leaf xanthophyll (lutein).

2. *Metabolism of the Pigments of Oat Plant, Molasses Silage and the Dehydrated Oats.*— Three lots of eight hens were used in this study. The hens

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were kept on a basal ration low in carotenoid pigments until the egg yolks were of a uniformly light color. Then each of the hens in Lot 1 was fed orally 30 grams of oat-plant silage each day for seven days. Those in Lot 2 received orally 10 grams of dehydrated oats per day, or an amount which was calculated to provide approximately as much carotene and xanthophyll as was available for the oat-silage group. Lot 3 was continued on the basal ration as a control group. All the eggs laid during the feeding period and 14 days following were pooled for analysis. The results are given below:

	Silage	*Dehydrated oats*
Mgs. of pigment in material fed:[1]		
Cryptoxanthin and Carotene	23.3	30.1
Xanthophyll	44.1	46.4
Mgs. of pigment in yolks in excess of amount in controls:[2]		
Cryptoxanthin and Carotene	0 389	0.343
Xanthophyll	2.6	2 82
Percentage of pigments deposited in yolks:		
Cryptoxanthin and Carotene	1.67	1.10
Xanthophyll	5.9	6.0

1. The silage contained 11.12 mg./100 of carotene and 21.03 mg./100 of xanthophyll. The dehydrated oats contained 43 mg./100 of carotene and 66.34 mg./100 of xanthophyll.

2. The control hens in Lot 3 on the basal ration deposited no cryptoxanthin and carotene and 0.45 mg./100 of xanthophyll in them yolks.

It would appear that the hen is able to utilize the carotenoid pigments with equal efficiency from either of the plant sources.

3. *Utilization of the Carotenoids of Greenmenlk, Fresh Oats and Oat-plant Silage, and Dehydrated Alfalfa.*— Four lots of 100 White Leghorn hens were fed a ration which was identical in every respect except for the main source of carotenoid pigments. Lot 1 received greenmelk; Lot 2 received fresh oat plants during the fall and spring, and during the winter, oat-plant silage; Lots 3 and 4 received dehydrated alfalfa. At the first of Marc, April and May eggs from each lot were pooled for analysis.

The lot receiving oat-plant silage deposited the greatest amount of total carotenoid pigments in the egg.

(Project 193; Departments of Chemistry and Poultry Husbandry. Leaders, J. S. Hughes and L. F. Payne; Adams and Purnell funds.)

The Mechanism of Egg Formation.— Three phases of this project have been active during the biennium.

1. *Growth of the Avian Ovum.*— Growth of the hen's ovum has been studied with injections of Sudan III into the blood stream at regular intervals of 12 and 24 hours. The dye marked the yolk in concentric bands. The final period of rapid growth covered the last seven to ten days before ovulation. When measured in units of the radius, the growth declined rapidly during the last seven days before ovulation. At the beginning of the period of rapid growth, the secretion of yolk, when measured by weight, increased until the third day before ovulation when the amount began to decrease. Last year's report indicated that little yolk was secreted in the last eight hours before ovulation. Recent, more critical data show that yolk secretion occurs within the last hour before ovulation, but that the rate gradually decreases.

No close correlation was found between size variation and rate of ovum growth, or ovulation rate and rate of ovum growth. Differences in growth rate did not seem to be responsible for the segregation of laying into clutches. Feeding of excessive amounts of fat made a slight but significant increase in the growth rate of the ovum, indicating that the amount of available fat probably has some influence on the rate of yolk secretion.

2. *Influence of Environmental Temperatures on Egg-size Variations.*— The collection of data from 12 different localities extending from the Philippine Islands to Scotland is now complete and ready for publication. The material used includes data from localities in 10 to 55 degrees north latitude. The

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final results indicate that temperatures of above 70 degrees F. adversely affect egg size. The usual summer decline in egg size encountered in the latitude of central and southern United States is not found in eggs produced in more northern latitudes. Where high temperatures do not interfere, a pullet's egg increases in size throughout the entire first year.

3. *Influence of Environmental Temperature on Shell Thickness.*— This phase of the study was conducted under controlled temperature conditions. A number of experiments have been carried out where the same group of laying birds have been subjected to various ranges of temperatures. In each experiment the thickness of the egg shells was measured and the influence of periods of high and low temperatures on the mean daily shell thickness was noted. Repeated experiments demonstrated that there was a prompt thinning of the shells when birds were subjected to temperatures of about 90 degrees F. The poor shell texture frequently encountered toward the end of the laying year, may be the result of the deleterious effects of high temperatures.

(Project 198; Department of Poultry Husbandry. Leader, D. C. Warren; Bankhead-Jones fund.)

The Chemistry of Egg Formation.— Three studies have been in progress during the biennium.

1. *Yolk Growth.*— The studies of yolk growth by injections of Sudan III have *been* continued. The formation of double-yolked eggs was studied by this method, and it was found that these are caused in some cases by the simultaneous development of two ova, and in others by the simultaneous rupture of two follicles in different stages of development. It has been found that the white and yellow layers of yolk described by Riddle in 1911 and 1916. and by others before him, represent irregular deposition of the yellow pigments of the yolk due to irregular ingestion of these in the feed. They apparently are not caused by a fundamental change in the metabolism of the follicle, nor associated with large variations in growth rate, as he suggested.

2. *The Formation of the Outer and the Inner Thin Whites.*— The formation of the outer thin white was studied by determining the composition of the fluid increment to the egg white during the time the egg is in the uterus, and by studying the rate of distribution of this material within the egg. It was found that the outer thin white is formed simply by the extraction of the soluble proteins from the thick white.

The chemical and mechanical changes responsible for the formation of the inner thin white from gelatinous white were also investigated. It was found that by the time the egg reaches the uterus there is a very thin layer of semi-fluid white around the yolk, so that it can turn within the gel envelope. In the uterus no chemical changes seem to take place in the formation of inner thin white. The formation of this inner thin (fluid) white is due to the rotation of the egg in the uterus. This action wraps the mucin fibers of the gel around the yolk, forming the chalaziferous layer of white, and the chalazae extending towards the ends of the egg. They removal of the mucin liquefies several cuble centimeters of gel around the yolk, forming the inner thin white,

3. *Calcium Content of the Blood of Hens.*— It was found in experiments that raising the temperature from 70 to 90 degrees F. caused a 40-percent low ering of the calcium content of the blood. It has frequently been observed that the blood calciums of a group of hens will tend to fluctuate together. This is probably a partial explanation.

Some work has been done to determine the endocrine control which causes these fluctuations, but so far without results The relation of temperature to calcium metabolism is being studied further.

(Project 198; Department of Chemistry. Leader, R. M. Conrad; Bankhead-Jones fund.)

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Influence of Hybridization Upon Vigor in Poultry.— Hybirds from various crosses have been compared to purebreds with regard to various criteria of vigor. The greatest emphasis has been placed upon White Leghorn × Black Minorca and White Leghorn × Rhode Island Red crosses. The Black Minorca × White Leghorn cross is of particular interest because it produces one of the few hybrids laying a white egg.

Both of the reciprocal crosses between White Leghorns and Black Minorcas grew slightly better than the pure Leghorns. Mortality was low in all lots The Minorca × Leghorn hybrids laid slightly better than the purebred Leghorns, producing an average of 200 eggs to the latter's 192. The Rhode Island Red × White Leghorn hybrids grew for the first eight weeks as well or better than either of the pure breeds involved. The mortality was very low among the hybrid chicks, although it was rather high in the pure Rhode Island Reds. The average annual egg production of the pure Rhode Island Reds was 209; the pure Leghorns, 197; the cross of the Rhode Island Red male by Leghorn female, 201; and the Leghorn male by the Rhode Island Red female hybrid, 224. The results here agree with earlier data to show that egg production is slightly better in hybrids resulting from the cross of Leghorn males with the heavier breed females.

(Project 173; Department of Poultry Husbandry. Leader, D. C. Warren; Purnell fund.)

Chromosome Mapping of the Genes of the Fowl.— In the work of this project during the biennium emphasis has been placed on two recently established linkage groups, the crest-dominant white frizzling group, and the silkie-flightless group. Numerous other tests for linkage have been made, particularly with recessive white, which has been tested with all known linkage groups as well as with all independently segregating characters. The accumulated data indicate strongly that a recessive factor, fray, also belongs to the crest-dominant white-frizzling linkage group.

The exact location has not been established, but fray seems rather widely separated from each of the three known genes on this chromosome. Although linkage of fray is rather loose, the data involving large numbers are consistent in indicating some degree of linkage. There is also evidence for naked-nack belonging to the silkie-flightless group. Here again linkage is rather loose and the exact location of the gene is not established. In studies of these two linkage groups many data have been accumulated for a comparison of the percentage of crossing over in the two sexes. For various map distances studied the crossing over percentages in females and males were as follows: 13.4 and 13.1, 31.5 and 27.4, 20.1 and 19.3, respectively. Although very similar in the two sexes, the percentage of crossing over in females is consistently higher than in males.

The new character duplo was shown to be independent of crest, dominant white, naked-neck, pea comb, and rose comb.

(Project 197; Department of Poultry Husbandry. Leader, D. C. Warren; Bankhead-Jones fund.)

Studies in Inheritance and Physiology of Reproduction in Mammals.— A brief description of the two phases of this project that have been actively pursued during this biennium are given below.

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1. *Inheritance in Guinea Pigs.*— During the past year many more animals have been produced in the conformation and size inheritance experiment with guinea pigs. Most of these consist of Fa animals and of backcrosses of both the P1 show and nonshow animals with those of the F1 generation. Many of the F1 generation have reached maturity. Based on evidence obtained from them and from the production of more P1 animals, there is good reason for believing that the small size of the nonshow animals is due to one or more completely dominent genes. The evidence for the complete dominance is furnished by the fact that many of the F1 animals are fully as large as their show-type parent. Since all of the F1 animals are not large, this furnished proof that the P1 generation as a whole is not homozygous for its dominant size gene or genes. During the coming year it is proposed to make rather extensive tests of animals belonging to the vrious generations in regard to their ability to utilize their feed in the making of gains.

Another case of linkage has been found in guinea pigs. The genes linked are those for salmon-eye *(sm)* and for black *(B).* The experiment is still in progress, but the results, as they stand at present, are 129 noncrossovers and 83 crossovers. The deviation from a 1:1 ratio is 23 ± 4.91, and the percentage of crossing over is approximately 39. The gene for salmon-eye *(sm)* has also been shown to be independently inherited so far as four other genes are concerned. These are extension *(E),* color *(C),* agouti *(A),* and rough *(R).*

2. *Inheritance in Cattle.*— A fairly complete study has been made of the relation of pigmentation to color inheritance in cattle. Some progress has been made with a similar study of guinea pigs and will be continued. It is proposed to examine horse hairs for the same purpose. Accumulation of data with regard to various modifiers of white spotting in cattle continues.

(Project 93; Department of Animal Husbandry. Leader, H. L. Ibsen; state fund.)

Studies in the Inheritance of the Grouse Locust. — The principal complexes of patterns, deformities, the lethal and X-ray induced translocations in *Apottetix eurycephalus* were destroyed by the extreme heat and complications of the summer of 1936. This was a severe loss, as these combinations were the product of many years of effort. However, a grant-in-aid of $350 from the American Academy of Arts and Sciences made possible the collection in Mexico of a large number of specimens carrying the genes previously used and some new ones. During the past year linkage groups, etc., have been built up until several of the former ones have been restored.

The breeding of *Tettigidea parvipennis* and *T. P. pennata,* a species of grouse locusts found both in the north and south, has been continued. The long winged, flying form is from the south, while the northern variety is short winged and unable to fly. A previous report that the two lengths of wings make a Mendelian pair, and that short is dominant, has been confirmed. A lethal linked with the dominant short wings has also been found.

A new species, not yet identified, from Santiago, Mexico, has six genes for color patterns which appear to form a closely linked group. Another species from Vera Cruz, Mexico, Apotettix mexicanus, which does not crossbreed with *A. eurycephalus,* appears to have the genes for the same patterns as occur in the latter, in about the same groups.

Progress has been made in the analyses of the genes for color patterns in *Paratettix texanus.* Attention has been devoted mainly to the recessive specked femora of the jumping legs, and in turn to the recessive modifier,

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which completely inhibits it. Another modifier of specked femora has been discovered, but its effect has not yet been demonstrated definitely.

(Project 72; Department of Zoölogy. Leaders, R. K. Nabours, F. M. Stebbins; Adams fund.)

Effect of Climate on Inheritance of the Grouse Locust.— The X-rayed material was killed by the extreme heat of the summer of 1936. Collection of new specimens was made possible by a grant-in-aid of $350 from the American Academy of Arts and Sciences. These specimens, secured in Mexico, are now ready for further X-raying and experimentation.

The National Research Council has provided an X-ray tube, and a dosimeter.

(Project 104; Department of Zoölogy. Leaders, R. K. Nabours and F. M. Stebbins; Adams fund.)

Bee Investigations.— The work on this project has been seriously hampered by the dryness and high temperatures of the summers of 1936 and 1937. These weather conditions had a decided effect upon honeybee biology and field activities. Many colonies ceased brood rearing. Honey which was produced was of unusually heavy body. All colonies were fed sugar sirup through the latter part of the summer, fall of 1936, and again in the springs of 1937 and 1938 to maintain this apiary. The wet May of 1938 brought about favorable plant-growth conditions of white clover and yellow sweet clover, and colonies gained slightly in weight during the first days in June, 1938.

Feeding Substitutes for Pollen.— The colonies were fed sugar sirup as the carbohydrate food, and, as substitutes for pollen (protein), six combinations of protein feed in 1936, and three in 1937, were given. The colonies were confined to a wire screen cage and did not have free access to pollen in the field. Powdered egg yolk was the only substitute capable of sustaining brood rearing. A colony which was fed this food was able to rear three generations of honeybees, but the number of adult bees reared in this manner was not great enough to maintain good colony strength.

Effect of Aromatic Oils on Bee Behavior.— Requeening, or the introduction of queens and uniting of colonies by sprinkling the bees thoroughly with a dilute solution of oil of peppermint or oil of wintergreen was successful with weak colonies. During no honey flow, when strong colonies are united by this method, the queen is usually killed by the bees. The strength of the solution used was 10 drops to 1 quart of water in the case of oil of peppermint, and 20 drops to 1 quart of water with oil of wintergreen. During 1937 synthetic oil of wintergreen (methyl salicilate) was used as a means of introducing immediately queens to nuclei and uniting nuclei, and of adding a few combs of bees to weak colonies. The dilution of the solution used was 25 drops to 1 pint of water. The treatments were 90 percent successful.

Simplification of Queen Rearing Practices.— It has been customary in the grafting of larvae to queen cells to moisten the cups with royal jelly just before the grafting. To test this method, dry cell cups and royal jelly treated cell cups were given to starting and finishing colonies. The use of the dry queen cell cups indicated that they were slightly better than the royal jelly

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treated cups, with 54 percent of the queens reared in comparison with 49 percent reared by the royal jelly method.

(Project 126; Department of Entomology. Leader, R. L. Parker: state fund.)

DISEASES, INSECTS, AND OTHER PESTS INJURIOUS TO PLANTS

The results of some of the more important work in the control of diseases, insects and other pests injurious to plants are given on the following pages.

Cereal and Forage Crop Disease Investigations.— The phases of this project dealing with wheat flag smut and wheat foot rot diseases were conducted in cooperation with the Division of Cereal Cropsand Diseases, Bureau of Plant Industry, United States Department of Agriculture. The flag smut studies were under the supervision of A. G. Johnson, and the wheat foot rot investigations herein reported are by H. Fellow and C. H. Ficke.

1. *Sorghum Disease Investigations.*— Studies of the milo disease have been continued. Resistant selections of the susceptible varieties, Dwarf Yellow milo (Finney mile), Wheatland, Beaver, and Day milo are being made at Garden City; and resistant selections made at Manhattan of Day Milo. Darso, and Two Foot milo are being tested for agronomic qualities. The greenhouse seedling testing method is one which will be used in connection with seed certification of all the resistant selections of miles when these selections are finally approved by the Kansas Crop Improvement Association. It is a definite means of distinguishing the resistant selections from the ordinary susceotible variety. Experiments in the greenhouse show that naturally infested soils kept dry lor a period of five years still retain their infective power.

Four years' data on the effect of kernel sorghum smuts, *Spacelotheca sorghi* and *S. cruenta,* on the normal development of the host indicated that certain morphologic changes were more pronounced in the case of *S. cruenta. Spacelotheca sorghi* infection did not reduce the height of plants materially, but reduced the diameter of the stalk 18 percent, and the leaf width 16 percent. *Spacelotheca cruenta* has a marked effect on the height, causing reduction of from 10 to 40 percent, with an average on all varieties tested of 20 percent. The diameter of stalks was reduced 38 and 27 percent, and a reduction in leaf width of 33 and 23 percent, respectively, for physiologic races 1 and 2. With these reductions from the normal, it would seem that less tonnage of fodder might be expected from plants attacked by both of these smuts, especially *S. cruenta.* Other morphologic abnormalities noted on certain varieties attacked by *S. cruenta* included fewer nodes above ground; somewhat shorter internodes in some instances; larger number of tillers, especially in certain varieties of sorghum; and pronounced proliferation of the spikelets, which appeared to be an asexual reproduction of small plants from tissues that normally give rise to the glumes and sexual organs of the spikelet. Studies on sorghum kernel smut infection showed that soil temperature and soil moisture were interdependent factors, and that medium to low soil temperature and moisture were conducive to maximum infection, heavy infection ocurred at any temperature below 75 degrees F. which allowed seed to germinate; in fact, low soil temperatures were consistently associated with high smut infection. Sorghum kernel smuts, *Spacelotheca sorghi* and *S. cruenta* may be effectively controlled by New Improved Ceresan, but increased dosages of this dust will result in seed injury.

2. *Wheat Disease In Investigations.*— Preliminary studies on the effect of bunt infection on the winter hardiness of four varieties of winter wheat in-

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dicate that bunt-infected plants are more susceptible to winter injury than bunt-free plants. Oro × Tenmarq and (Kanred × Hard Federation) × Oro are bunt-resistant hybrids that have been produced and tested sufficiently to seem promising.

Studies on take-all foot rot of wheat, *Ophiobolus graminus,* show that infested soil kept at a warm temperature retained fewer organisms than soil kept cool. Minimum retention occurred in soil kept warm, moist and loose; and maximum retention occurred when cool, compact and moist. High moisture in soils favored increased severity of disease. Infection in the seedling stage of wheat persisted throughout the life of a plant, becoming worse even with the source of inoculum removed.

Spring varieties as a group were slightly less susceptible than winter varieties, but no variety of wheat has been found that is resistant. Several varieties of wheat are resistant to the dry-land foot-rot disease, however, and further studies are in progress.

There is little difference between the amount of disease produced on plants grown in well and poorly aerated soils. The efficiency of water is nearly twice as great in healthy plants as in diseased plants. Infested soil retains its infecting power in the greenhouse over a period of seven years.

* The incorporation of certain organic matter in foot-rot infected soils has resulted in control. A comparative study is being made of the numbers of kinds of microorganisms in such soils, their relationships to each other, to the wheat plant, to *Ophiobolus graminis,* and to infection of the wheat plant by *Ophiobolus.* The microflora of infested soil has been changed qualitatively and quantitatively by various soil amendments, and growth substances produced by certain of the common soil fungi have been found to influence markedly the development of *ophiobolus,* Both inhibitory and stimulatory substances have been produced by fungi in pure culture, the effect of any specific instance being conditioned by the organism used and the chemical composition of its nutritional substrate.

Wheat flag smut studies have been continued. It is now fully established that Kawvale and Clarkan are resistant and could be used in areas where this disease is troublesome. Also, a resistant selection of Harvest Queen may be available for those desiring to continue growing Harvest Queen. There seems little likelihood that *Urocystis tritici* (flag smut) will become established in the hard winter wheat area of Kansas because of the marked resistance shown by all hard winter wheat varieties tested.

3. *Oat-disease Investigation.*— Oat smut collections obtained from county agents and other sources were tested on differential oat varieties during 1936, and 10 physiologic races were identified. This work indicated that the smut flora of the state is continually changing, and that different races of the smuts of oats are entering the state and apparently able to attack heavily the Fulghum type of oats.

Kansas has produced in the hybrid Markton × Fulghum an oat that is smut resistant, but by no means immune. It has the necessary agronomic qualities and is not susceptible to the various races of oat smut that are common in Kansas at the present time.

4. *Alfalfa Disease Investigations.*— A study is being made of the cause of the black stem disease. It is necessary to combine bacterial wilt resistance in alfalfa with resistance to some of the common and distinctive leaf spots and the black stem disease, if progress is to be made.

5. *Cereal Disease Nursery and Uniform Bunt Nurseries.*— These were grown as in past years and serve to show the reactions of varieties, selections and promising hybrids of wheat and oats to the common wheat and oat diseases, as the smuts, rusts, powdery mildew, black chaff disease and Septoria leaf blotch. A uniform bunt nursery at Manhattan yielded valuable information on bunt. Some of the promising Kansas varieties and hybrids show not only

* Work conducted by C. M. Slagg

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resistance to but in Kansas, but also in other uniform bunt nurseries in the United States. The Kansas, Markton × Fulghum hybrid showed considerable resistance wherever planted in the uniform smut nurseries in the various states.

(Project 76; Department of Botany. Leader, L. E. Melchers; state fund.)

***Fruit and Vegetable Disease* Investigations.—** Studies were continued during the biennium on methods of controlling potato and sweet-potato diseases, and on the development of mosaic-resistant varieties of slicing and small pickle-type cucumbers. Investigations were begun on methods for preventing the anthracnose disease of black raspberries.

Studies of high concentrations of HgCl2 applied as instantaneous dips for controlling potato Rhizoctonia were again made. Dip treatments at concentrations of 6, 12, 15, 18, 24, and 30 ounces of HgCl2 to 25 gallons of water containing HCl at concentrations of one half, 1 and 2 percent indicated: (1) The concentration of 30 ounces to 2.5 gallons provides good control, but causes injury to the potato plant; (2) dip treatments at the standard concentration of 6 ounces to 25 gallons, while causing a reduction in Rhizoctonia, does not control the disease; (3) dip treatment in a solution of approximately 18 ounces of HgCl2 to 25 gallons of water apparently causes no more plant injury and is as effective for controlling Rhizoctonia as is the standard ten-minute treatment in a concentration of 6 ounces of HgCI2 to 25 gallons of water acidulated with 1 percent of HCl.

Dip treatments in various organic mercury compounds did not control Rhizoctonia as well and were followed by lower yields than was the case following dip treatments at even the lowest HgCl2 concentration used.

Very little Rhizoctonia persisted over winter from previous years in Kansas potato fields. Rhizoctonia-free potatoes planted on 20 different farms in the Kansas valley showed infection on only 3 percent of the plants. This indicates that in Kansas the Rhizoctonia organism cannot remain alive in the soil during seasons when the soil is dry during the summer and fall. Tests in 1936 in three fields where a fall crop of potatoes had been grown from July to November, 1935, resulted in 15, 18 and 59 percent of the plants becoming infected with soil-carried Rhizoctonia. During the arid summer and fall months the organism in these fields was able to remain alive in the tissues of the infected potato plants.

Tests made to find the comparative effect on the potato plant of treatments before and after the cutting of the seed piece indicated that injury occurs when the treatment is made to cut seed. Injury was indicated by delayed emergence and by reduced yields.

Black raspberry anthracnose control tests were made in 1936 and in 1937. Applications of lime-sulphur made when the plants were still dormant gave the best control. The following results were obtained.

	Percentage of Control	
	1936	*1937*
Canes sprayed when dormant	83.05	94.93
Canes first sprayed when new canes 6″-12″ tall	43.75	70.31
Canes first sprayed just before blooming	31.00	19.05
Unsprayed canes	16.72	14.95

Applications of Bordeaux and other copper fungicides as dormant sprays were ineffective for preventing raspberry anthracnose infections in both 1936 and 1937.

The mosaic-resistant cucumber breeding work has been continued. A slicer-type cucumber hybrid has remained free from common cucumber mosaic virus for three generations, but became infected with yellow cucumber mosaic

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virus. Yellow cucumber mosaic virus killed American variety cucumbers, but caused no apparent injury to the hybrid.

(Project 130; Department of Botany. Leader, O. H. Elmer; state fund.)

Resistance of Winter Wheat to Leaf Rust.— This project, conducted in cooperation with the Bureau of Plant Industry, United States Department of Agriculture, has consisted of six phases as follows:

1. *Studies on the Reaction of Varieties, Selections, and Hybrids of Winter Wheats to Leaf Rust in the Rust Nursery.*— None of the commercial varieties of true hard red winter wheat exhibited strong resistance to leaf rust in the rust nursery. Kawvale, a semihard variety, continued to exhibit marked resistance, however. Among the soft red winter varieties strong resistance was shown by certain selections of Mediterranean, Fultz, and Fulcaster. A high degree of resistance also was shown by promising selections from the crosses Kawvale × Tenmarq, Oro × Tenmarq, Hope × Kawvale, Mediterranean × Hope, and Hard Federation × Kawvale.

The rust nursery contained 2,246 winter and 380 spring wheats in 1936, and 2,816 winter and 450 spring strains in 1937. Among the winter wheats there were 1,295 hybrid selections in 1936, and 2,097 were hybrids in 1937.

2. *Tests of Varieties, Selections, Introductions, and Hybrid Lines of Wheat with Pure Physiologic Races of Rust in the Greenhouse.*— Greenhouse tests were used to supplement nursery studies and to furnish information on the sources of rust resistance. Many varieties, promising new hybrid selections. and foreign introductions were tested with pure cultures of the physiologic races most abundant in the western Mississippi Valley. These tests have been found valuable as a rapid method of determining the resistance of hybrid material.

3. *Breeding for Resistance to Rust and Studies on Its Inheritance.*— The necessity for stronger resistance to leaf rust and some degree of stem rust resistance in the winter wheats of Kansas and adjacent states resulted in the use of several spring wheats in crosses with winter selections during the past. biennium. The spring varieties, Hope, H-44, Marquillo, Thatcher, Renown, Apex and Mindum, were used as sources of stem rust resistance. These and a few stem rust resistant winter selections from the Mediterranean × Hope Hope × Kawvale, and Hope × Hussar crosses, were crossed with promising winter wheat varieties and hybrid selections. This resulted in many compound hybrid lines involving three or four varieties of wheat. Numerous crosses were made with promising leaf rust resistant selections of Kawvale × Tenmarq or Oro × Tenmarq as one parent and some stem rust resistant wheat as the other. All crosses were made in the greenhouse and all F1 and parental plants were tested with pure physiologic races of leaf rust.

4. *Physiologic Specialization.*— Physiologic race determinations were made on numerous collections of rust made in the western Mississippi Valley in 1936 and 1937. Race 9 was the most widely distributed and abundant race in both years, while race 15 was second in distribution and prevalence. Other important races were 3, 5, and 31. The information indicates that winter wheats bred for resistance to leaf rust should have strong resistance at least to races 9 and 15.

5. *Studies on the Oversummering, Overvintering, and Epidemiology of Leaf Rust in Kansas* — Very little oversummering or overwintering of leaf rust occurred in Kansas during the biennium. Isolated infections established during the fall became inactive in November and disappeared in January of both years. In the spring, leaf rust infection appeared first in southern counties and moved gradually northward. Heavy infections were late in their development in 1937, but very early in 1938, The heaviest infections developed in the eastern half of the state.

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6. *The Effect of Rust Infection the Yield, Kernel Weight and Protein Content of Winter Wheat.*— Combined infections of leaf rust and stem rust on three varieties of wheat grown in replicated plots gave the following average percent reductions in yield during the last two years: Turkey (Cheyenne in 1937) 34.9, Tenmarq 24.1, and Quivira 19.3. The average weight per 1,000 kernels was reduced by rust infection 21.3, 12.3, and 6.9 percent and the average protein content of the grain was reduced 9.9, 9.1, and 5.5 percent, respectively, in the rusted plots, Rust was reduced in the control plots by dusting or spraying with sulphur.

In a separate experiment conducted in 1937, two lines each from two crosses were tested. In each cross the two lines were equally susceptible to stem rust, but one was resistant to leaf rust-while the other was susceptible. The yields of the leaf rust susceptible lines were 19.8 and 21.4 percent lower than those of the resistant lines. Leaf rust infection resulted in reductions of 10.1 and 28.3 percent in the weight per thousand kernels. In one cross leaf rust reduced the protein content of the grain only 0.08 percent, but in the other caused a lose of 13.1 percent.

(Project 171; Department of Botany. Leader, C. O. Johnston; Purnell fund.)

Climate and Injurious Insect Investigations.— The work of the biennium consisted of (1) preparing and publishing the annual injurious insect population of the state summaries; (2) soil surface temperature studies with reference to outdoor lethal temperatures for some common farm pests; (3) surve: of insect outbreaks from 1860 to date, with prior and attendant climatic conditions; and (4) study of the climatic aspects of current insect pests.

The weather during 1936 was characterized by marked drought in the spring and summer up to the latter part of August with record-breaking high temperatures from early June to the latter part of August. The following insects occurred in outbreak numbers during 1936: Grasshoppers (an unprecedented outbreak with widespread damage), blister beetles and wood borers. The following insects and those mentioned above mere more plentiful than in 193.5: Common ants, cattle lice, chinch bugs, codling moths, crickets, cucumber beetles, onion plant bugs, rose curculios, squash bugs, strawberry leaf rollers, wheat stem maggots, and webworms. Those less plentiful than in 1935 were biting flies on livestock, houseflies, termites, false wireworms, wireworms and white grubs. Those scarce or without consequence during the year were aphids, horseflies, box-elder bugs, cankerworms, cutworms, chinch bugs, cucumber beetles, Hessian fly, mange mites, screwworms, mosquitoes, wheat-straw worms and grain weevils.

In general, 1937 was a record-breaking drought year with an abnormally hot summer, and with winter months below normal temperature. The years rainfall was deficient throughout Kansas except in a few counties in the southeast part of the state. It was a year of more than usual insect population and damage. The following insects occurred in outbreak during 1937: Elm leaf aphid, army worms, blister beetles, wood borers, cabbage curculio, black crickets, pale western cutworm, variegated cutworm, biting flies, grasshoppers, leaf hoppers, onion plant bug, red bud leaf folder, tarnished plant bug, walnut datana, garden webworm, false wireworm and wheat white grub. The following insects were also more plentiful in 1937 than in 1936: Formica ant, pea aphid, cabbage aphid, rusty plum aphid, radish aphid, wheat head army worm, fall army worm, box-elder bug, cabbage looper, curculio, carrot beetle, cloverleaf weevil, cotton cutworm, dingy cutworm, clover root curculio, crambid moths, diamond back moth, eight-spotted forester, forage looper, grain weevil, corn-ear worm, false chinch bug, green clover worm, unbricated snout beetle, screwworm flies, mites on wheat, clover and grasshoppers, negro bugs, red

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spider mites, onion plant bug, seed corn maggot, wild cherry sphinx, squash bug, tentiform leaf miner, wheat sawfly, white grubs, and wireworms.

Apple curculio, cankerworm, chinch bug, Colorado potato beetle, army cutworm, flea beetle, Hessian fly and rose slug were scarce or nearly absent during 1937. Cattle grubs, corn billbugs, chinch bugs, rose slugs and strawberry leaf rollers were less plentiful than in 1936. Yellow ants, mound-budding prairie ants, wood borers, corn-ear worm, army cutworms, feltia cutworms, grasshopper, termites, thrips and scale insects had about the same population as in 1936.

The study of the mosquitoes found in Kansas, with especial reference to Riley county, was started in the fall of 1935. Most of the collecting was done in the summer of 1936, from the latter part of May to the latter part of September. Mosquitoes were found breeding only in artificial receptacles. Twenty species were found to occur in Kansas, eight of which are being reported for the first time in this state. There are 10 pestiferous species, four malarial, and six that are not troublesome. *Aedes Vexans* Meig., and *Psorophora ciliata* Fab, are the most common and widespread of the pestiferous group, Anopheles punctipennis Say of the malarial group.

Experimental attempts to inoculate termite colonies with parasitic fungus (*Empusa* sp.) have been made with laboratory colonies and controls. The problem was being approached by inoculation of intestinal contents in specially prepared cells, and by the inoculation of colonies in prepared jars of approximately 1,500 termites in each colony. Observation haveshown that the spores of the fungus will grow on the termite's body, but no live termite has been observed with spores developing. Colonies thus inoculated have revealed dead individuals with mycelial growths. The soldiers were the first to succumb to the fungus. Some three dozen colonies in glass jars were inoculated, but, none succumbed to the parasitic fungus inoculated.

The box-elder bug, known chiefly as a household pest in Kansas, flourished up to about 1932, when the species began a severe decline in numbers because of the drought to 1934, when it became practically nonexistent for two years. The numbers began to increase in 1936, and the overwintering bugs again became troublesome during the winter of 1937. The insect requires from 50 to 78 days for its growth from egg to adult. The egg undergoes an incubation period of approximately two weeks. The nymphs molt six times and the total average time for the molts is two months.

The nymphs spend a greater part of their lives in weeds, grasses, and under accumulations of old leaves. This insect was observed feeding on 23 known plants as well as on several unidentified ones, but chiefly on weeds and grasses and maple seed on the ground.

The best methods of control appear to be prevention by removal of cover, the application of hot water or kerosene to the overwintering adults, and drenching the nymphs with cold water.

(Project 6; Department of Entomology. Leader, R. C. Smith; Hatch fund.)

Hessian Fly and Other Wheat Insects.—The insects that have been studied) under this project during the biennium are the Hessian fly, the wheat-straw worm, mites, and white grubs. Methods of combatting these damaging insects have been tested.

The Hessian fly population has been at a low level in Kansas but apparently is budding up through the spring of 1938. Less than a half dozen of infested plants were found near Manhattan in the fall of 1937. The life history of the fly was followed in a field southwest of Junction City, where an infestation took place in the fall of 1937 with a great increase the following spring. Studies were begun on the relation of the fly larva to wheat plants of different varieties, with especial reference to *(a)* the maturity: of the leaf sheath on which larvae can begin to feed, *(b)* relation of the size of the larvae to the

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number of individuals feeding on a single tiller, and *(c)* the time at which the feeding of the larvae begins to affect the growth of the plant.

Studies have been made of the relation of variety of wheat and depth of planting to infestation by the first generation of the wheat straw worm *Harmolita grandis.* With a light infestation some differences were found between the resistances of various varieties of wheat. In all samples shallow-planted wheat had a lower infestation than that planted deeper. No great difference was found in the degree of infestation of spring and winter wheat by the second generation, except that varieties of the species Triticum turgidum had lower degrees of infestation than common wheats or durums.

Heavy infestations of mites in 1937, and of leaf-feeding sawflies both years, have offered a good opportunity for study. Partial life histories of three species of mites, the sawfly and at least one parasite of the latter have been obtained.

Seed treatment studies were continued during the past year in an effort to determine a safe and satisfactory method of treating seed wheat to protect it from injury caused by the attacks of false wireworms.

Rearing investigations conducted with white grubs taken in wheat plots showed that *Phyllophaga crassissima, Phyllophaga rubiginosa,* and *Phyllophaga lan-ceolata* were three species responsible for the devastation of over 475,000 acres of wheat in south central Kansas, the latter species being more numerous and destructive than were the other two, Further study of the distribution records indicates that it has extended its damage with the aid of consecutive dry seasons, increased wheat acreage and decreased rowed-crop area. The facts obtained indicate that a crop rotation is necessary to keep this insect under control.

(Project 8; Department of Entomology. Leaders, R. H. Painter and H. R. Bryson; Hatch fund.)

The Corn-ear Worm and Other Insects Injurious to Corn.— This project has consisted of a study of the insects that damage corn, and of various means to combat these insects.

Tests were made during the summer of 1937 on sweet corn at the insectary to determine the tolerance of the corn plant to lead arsenate and paris green for use in the control of the garden webworm on corn. No significant injury to corn plants occurred when these insecticides were used at the rate of four pounds to 50 gallons of water.

Preliminary tests of grasshopper baits using cane pulp as a substitute for bran showed that cane was as satisfactory as bran. Coarsely ground cane did not distribute so evenly as finely ground cane or bran.

A machine was designed and constructed to be dragged over grasshopper egg beck in order to crush the young hoppers shortly after hatching. The machine consisted of a fire-foot length of four-inch gas pipe riding on a two and one-half foot runner of angle iron. On the front of the pipe was a sheet-metal shield. Window weights, loosely attached to the gas pipe, followed closely any uneven surface of the ground. The machine was tested in the control of cutworms at the college farm, and proved effectively.

With funds made available by the National Youth Administration a study was undertaken to determine the effect of different seed treatments upon seed corn. Twenty different materials were used in treating seed corn to protect it from the attack of wireworms and seed-corn maggots. Both dipping and soaking methods were employed, No satisfactory materials were found.

Ecological studies of white grub infestations in the cornfield showed a concentration around the roots of the corn plants. Study of these insect in a sorghum plot adjacent to the corn showed a population of 10 to 12 larvae to each plant, among which was *Phyllophaga rubiginosa.* The sorghum plant can withstand a greater population without injury than the corn plant.

(Project 9; Department of Entomology. Leaders, D. A. Wilbur, H. R. Bryson; Hatch fund.)

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Fruit, Vegetable and Other insects.— The work of this project during the past two years has been the study of cankerworm emergence, the biology of the redbud leaf folder, and of the redbud aphis.

Cankerworms were at an extremely low population in 1937. The first fall cankerworm female was trapped December 26, 1936, and the first spring cankerworm female, March 8, 1937. The greatest number of female moths trapped on any one tree was 82 fall and 20 spring, or a total of 102 females. In 1938 they increased slightly in number. The first fall cankerworm female was trapped December 26, 1937, but the bulk of the emergence began the second week in March, 1938. The greatest number of female moths on any one tree in one day was 138 spring cankerworms found on March 17, 1938. The greatest number of females trapped on any one tree was 93 fall and 118 spring, or a total of 211 females.

Biological studies of the redbud leaf folder *(Gelechia* cercerisella Cham.) have been continued. The egg has been found and the life history recorded except for the incubation period. The first generation began during the last week in May of 1937 and continued to July 20, the partial third generation overlapping the second. Parasitism was evident in the second generation. and, during a rainy period, a fungus developed on the larvae, killing all of the material under study. Identified parasites reared in 1936 were as follows; *Haltichella* sp., *Idechthis gelechiae* (Ashm.), *Levcodesmia* n. sp., *Macrocentrus ancylivorous* Rohwer. *Tetrastichus caerulescens* Ashm., and *Xenostemum ornigus* Mues.

Populations are confined to infested trees or groups of trees; and the insect does not spread rapidly. Damage to trees, caused by the second generation, was severe during July and August, 1937.

The redbud aphis *(Aphis pauneepae* Hottes) was first discovered in Kansas in 1934 on the redbud above the soil. In September, 1936, it was found on the roots of the plant, attended by the ant *Crematogaster missouriensis.* The aphis was again observed in the spring of 1938 on the plant above the soil in the characteristic position on the under side of small branches.

(Project 13; Department of Entomology. Leader, R. L. Parker: Hatch fund.)

Insects Attacking the Roots of Staple Crops.— Plans were made the past biennium to complete the studies begun in 1927 on a series of plots treated with soil insecticides. Because of the dry soil conditions which prevailed during the growing seasons of the past three years satisfactory data could not be secured on the effect of these treatments upon the soil and subsequent plant growth. Variations in the growth and development, of plants were less marked during the dry summers of 1934, 1935 and 1936 than in years of plentiful soil moisture.

Investigations concerning the effect of soil insecticides upon the soil and subsequent plant growth showed very little effect upon the plants and upon the soil three years after treatment. This fact substantiates the data of previous tests which indicated that about three years were required for the treatment to lose its deleterious effect upon the soil and growing plank.

The application of arsenate of lead at the rate of 14 ounces to each 100 square feet of soil surface, worked into the soil to a depth of four inches and placed in flower pots, into each of which had been placed one white grub, failed to kill the grubs. The fact that these grubs were exposed to this treatment for three weeks without apparent injury would indicate some tolerance of the insect to the treatment.

Attempts to rear subterranean insects were again unsuccessful to some extent, due to the prevalence of high temperature and low humidity in the field

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insectary. Larvae of *Eleodes opaca* Say were very little affected by high temperatures.

Ecological studies made in the spring of 1938 indicated an abundance of Brood A beetles of *Phyllphaga* spp. *Phyllophaga crassissima* and *Phyllophaga rubiginosa* were the most numerous at lights.

Further observations and records were made on the habits of carrot beetles. Garden crops and flowers in western Kansas were attacked severely during the summer of 1937. Cosmos, marigolds, beets, carrots and strawberry plants were the most subject to attack.

(Project 100; Department of Entomology. Leader, H. R. Bryson; state fund.)

Insects Injurious to Alfalfa, Grasses and Allied Plants.— Two subprojects have been given attention during the biennium: (1) the study of insects that injure alfalfa, clover and allied plants; (2) the study of insects that affect prairie, blue, orchard and brome grasses. Some results of these studies are here reported.

Epsom salts as a substitute for arsenicals in grasshopper baits was tested at the recommended and at twice the recommended strength. It proved to be of no value.

The life history of the wing mite of grasshoppers, *Eutrombidium locustarum*, was traced. The mites feed on grasshopper eggs from early spring to fall. They enter the soil by dropping from the wings during the summer, feed for a short time on grasshopper eggs and other foods, and transform to adults which overwinter.

The chief insect enemies of bindweed were found to be the morning glory leaf miner tortoise beetles, flea beetles and a plume moth. Their control of this weed is largely nullified by heavy parasitism.

The tarnished plant and field plant bugs were reared from egg to the adult stage. The importance of these bugs in killing young plants and causing flowers and buds of alfalfa to drop, thereby reducing seed production, was fully demonstrated.

A summary of the insect population of the families Chloropidae, Cicadellidae and Acrididae on native prairie, Kentucky bluegrass, orchard and brome grass areas for the years 1933 to 1937 is as follows:

	1933	*1934*	*1935*	*1936*	*1937*	*Total*
Chloropidae	4,400	972	5,166	1,788	725	13,051
Cicadellidae	26,117	31,942	31,004	9,191	10,586	108,840
Acrididae	3,426	2,255	587	2,503	2,475	11,246

Nearly 6,000 Hymenoptera secured in the collections from 1933 to 1937 were sorted, pinned, labeled, identified as to family, and, in many cases, as to species.

(Project 115; Department of Entomology. Leaders, R. C. Smith and D. A. Wilbur; state fund.)

Study of the Biology and Control of Fruit and Vegetable Insects.— The chief activity of this project has been the study of the biology, of the strawberry leaf roller, *Ancylis comptana* Froel., and of various methods of control. The life history and habits of this insect have been studied and control measures have been synchronized with them. The biological fact which is most significant in the control of the larvae is that the larvae hatch and go to the underside of the leaves and remain under thin webbing for about seven days before rolling the leaves. Organic sprays or dusts should be applied to the plants in this interval in order to attack the larvae effectively.

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Of 30 insecticides tested, the organic combinations which were applied gave the best control for the first brood as well as for the second and third broods, Nicotine sulphate or pyrethrum extract in combination with summer oil emulsion sprays, applied three times at five-day intervals during the period of nonrolling of the leaves by the larvae, gave the best result. Pyrethrum and rotenone dusts applied at these same time intervals gave good control of the insect. Cryolites, or lead arsenate summer oil emulsion combination sprays. gave good control for the second and third broods of this insect on old and new plantations. These late summer spray applications should be made at ten-day intervals to keep the population of the leaf roller low.

Of the hymenopterous parasites collected, *Crematus cookii* Weed far outnumbered all others, indicating that it is the most beneficial of the parasites. *Macrocentrus ancylivorous* Rohwer, introduced in 1935, was not found. This indicates that this parasite of the strawberry leaf roller and the oriental fruit moth could not adapt itself to the high temperatures and drought conditions of the past few years. Nemorilla *floralis* Fallen, a dipterous parasite, was numerous.

(Project 187; Department of Entomology. Leaders, R. L. Parker and P. G. Lamerson; Purnell and Hatch funds.)

A Study of the Control of the Codling Moth in Northeast Kansas.— Codling moth control tests have been carried on in the Blair experimental orchard in Doniphan county the past two years. In 1936 fourteen, and in 1937 thirteen combinations of insecticides were used. As is usual in dry seasons, lead arsenate without sticker or spreader ranked high in control among the insecticides used in the tests.

Each of the insecticides was sprayed on a separate row of 10 trees. In 1936 all of the plots were given a calyx spray of astringent lead arsenate except one which was the nonastringent lead arsenate plot. The best results were obtained from the following sprays:

Treatment *Pounds per 100 gallons of spray material*	*Percentage of clean fruit*
1936:	
Lead arsenate (non-astringent), 4	84.3
Lead arsenate, 4 + 1 qt. Grandpa's Wonder Pine Tar soap + 1 qt. Verdol	83.3
Lead arsenate, 4 + 1 qt. Verdol	82.0
Lead arsenate, 4 + 1 qt. Rawleigh Dip and Disinfectant	80.0
1937:	
Lead arsenate, 4 + 1 qt. Verdol + 1 qt. Grandpa's Wonder Pine Tar soap	90.6
Lead arsenate, 4	90.1
Lead arsenate, 4 + 1 qt. Nat. Oil Prod. Co. neutral soluble fish oil	87.7
Lead arsenate (Latimer), 4 + ½ gal. Petrocide	87.4
Lead arsenate, 4 + 1 qt. Verdol	85.2

Ortho nicotine plus Ortbol K Ready Mix oil, lead arsenate plus soybean flour, lead arsenate, lead arsenate plus Nat, Oil Prod, Co. neutral soluble fish oil, calcium arsenate plus lime and Verdol, and phenothiazine with and without soybean flour and at three different dosages, were the inferior insecticides used in 1936.

Lead arsenate plus kerosene and Grandpa's Wonder Pine Tar soap, lead arsenate (astringent) + Verdol, basic zinc arsenate plus Orthol K Ready Mix oil, Ortho nicotine plus Orthol K Ready Mix oil, lead arsenate plus lime, safe calcium arsenate plus lime and lead arsenate (astringent) were the inferior insecticides used in 1937.

Nonastringent lead arsenate, with and without summer oil emulsion, proved to be a better insecticide for the control of the codling moth than the other arsenates or organic insecticides used in this experimental work.

(Project N. E. 9; Department of Entomology. Leaders, R. L. Parker and P. G. Lamerson; state fund.)

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The Resistance of Crop Plants to Insect Attack.— The work of the project has been concerned primarily with the development of wheat resistant to the Hessian fly, and the transference of the resistance of the spring wheat, Marquillo, to wheats of winter growth habit. Studies have been made of differential infestation of other crop-plant varieties by a number of insects as opportunities were available.

1. *Resistance to Hessian Fly in Wheat.*— Nurseries of more than 1,000 strains of wheat varieties and hybrids have been studied each year. An infestation was secured at Manhattan in the fail of 1936 only, but heavy infestations were present in the other nursery at Springfield, Mo., both fall and spring. Major emphasis was given to hybrids involving the fly-resistant spring wheat Marquillo. In the fall of 1936, of 326 F5 hybrids between Marquillo and susceptible winter wheats, 72 percent were within the range of the infestation of the resistant parent. This is the result of three generations of selection primarily for resistance to fly. Most of these 326 hybrids also have been selected for resistance to stem and leaf rust, and a few appear to be resistant to jointworm and bunt. All are of winter habit and a few may approach the winter hardiness of such winter wheat as Tenmarq. After further selection in the spring of 1937 over 600 F6 hybrid selections were promoted to the Agronomy Nursery for yield and other agronomic tests.

Infestation of F1 hybrids between various fly-resistant spring wheats and commercial winter wheats gave indications that more than one group of genetic factors might be involved. With some resistant parents, resistance appeared to be dominant, with others recessive.

Among winter-wheat varieties dissected for study of infestation, there is a general agreement with past performances in the areas where these were tested in 1936-'37. At Manhattan some hybrids involving Kawvale and Honor inherited the resistance of their respective parents to fly of this region.

Tests of spring wheats planted at Springfield, Mo., indicate the following possible sources of wheat genes for resistance to the eastern type of fly: Marquillo, Marvel, certain selections of Illinois 1, and of wheats from Uruguay. Certain other promising strains are now undergoing a second test.

2. *Corn-ear Worm and Hybrid Corn.*— Additional data were secured in 1937 on the resistance of various corn hybrids to corn-ear worm, and the accumulated data of more than 10 years' tests were partially summarized.

3. *Resistance to Injury by Grasshoppers in Cam Plants.*— In the summer of 1936 observations were made of differences in injury by grasshoppers to different varieties of crop plants, especially corn, sorghum and alfalfa. Data were secured on all hybrids grown in the corn nursery. These indicate that strains of corn derived from the older Kansas varieties were injured less by grasshoppers than those derived from corn of states farther east. These observations were summarized and published. Some individual corn plants which were less injured by grasshoppers in 1936 are the source of plants which were selfed last year and planted for a test this year should grasshoppers be sufficiently abundant.

(Project 164; Departments of Entomology and Agronomy. Leaders, R. H. Painter and J. H. Parker; Purnell fund.)

Physiology of Reproduction and of Hibernation in Mammals.— The work of this project during the biennium has concerned chiefly five phases.

1. *Relation of the Adrenal Glands* of *Chickens to Their Gonads.*— Continued work has shown that the removal of the adrenal glands in chickens causes the gonads to decrease to only a small fraction of their original size. The

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combs, wattles and plumage change to those of capons. The part the pituitary may play in the mechanism of this reaction is being studied at present.

2. *Relation of the Pituitary Gland to Reproduction in Chickens.*— Commercial extracts of anterior pituitary and of pregnancy urine have been injected into young chickens and the effect studied. Although the gonads of the injected birds were not appreciably heavier than their controls, histological studies of the tissues revealed much stimulation of the developing egg follicles. The pregnancy urine extract was not so effective as the anterior pituitary.

3. *Effect of Hibernation on the Blood in Ground Squirrels.*— The work done indicated that there was a slight reduction in the number of red blood cells when the animal went into hibernation, but there was no further reduction upon continued hibernation.

4. *Effect of Male Hormone Upon the Developing Ovaries of Chickens.*— The injection of chemically pure male hormone into developing female chickens does not appreciably affect the developing ovaries, even though the secondary sexual characteristics become those of normal males.

5. *Relation of Male Hormone to the Development of the Femoral Pores and Color Markings in Collared Lizards.*— The injection of the male hormone, testosterone propionate in oil, had no effect on the femoral pores of collared lizards. Femoral pores developed in castrate male lizards.

(Project 191; Department of Zoölogy. Leader, E. H. Herrick; Purnell fund.)

DISEASES OF FARM ANIMALS

Some of the more important features of the work of the station during the past biennium relating to animal diseases and parasites are discussed below.

Miscellaneous Animal Disease Investigations.— Laboratory examinations of diseased animal tissues and fluids have been carried on as in the past, approximately 29,238 such examinations being made during the biennium. Phases that have received special study are Equine Encephalomyelitis, incidence, physiology and chemotherapy of the Strongylidae of horses, and the hydrogen ion concentration of the fluid content of the alimentary canal of the horse.

1. *Hydrogen Ion Concentration of the Fluid Content of the Alimentary Canal of the Horse.*— A quinhydrone pH indicator was used to determine the hydrogen ion concentration of fluid samples from the alimentary canal of the horse. These samples became available within 14 minutes after the death of the animals. The hydrogen ion concentrations of the several fluid samples were approximately as follows:

Number of samples	*Organ*	*pH Concentration*
108	Stomach	0. —7.63
71	Duodenum	6.48—8.04
71	Jejunum	6 87—7.97
71	Ileum	7.35—7.89
190	Cecum	6.02—7.79
150	Large colon	6.15—8.0
21	Rectum	5.39—7.13

2. *Equine Encephalomyelitis.*— A disease commonly referred to as sleeping sickness in horses affected so many of the animals in the middle west in the fall of 1937 that it was decided to investigate the causative factor and the method of spread. A virus reported by former investigator as being the cause of this disease was isolated from a field case destroyed early in the

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moribund stage, and was successfully cultivated on chick tissue and on the chorioallantoic membranes of the developing chick. Several guinea pigs and three horses succumbed upon intracranial inoculation with this virus.

Two dozen assassin bugs, *Sinae diadema,* were captured on the vegetation of a pasture where a field case was being treated and were emulsified in physiological saline and passed through an "N" candle filter. The filtrate was then injected intracranially into guinea pigs and rabbits. The guinea pig succumbed in 40 days and the rabbit in three. A streptococcus similar to that reported by Rosenou of the Mayo clinic was isolated from these animals.

Two armored "wheel" bugs were obtained, emulsified and filtered in the same manner as the above-named insects. The filtrate of these bugs following intracranial inoculation in a guinea pig and rabbit caused the death of the guinea pig in three days, and that of the rabbit in 41 days. A streptococcus was recovered from the brain of the guinea pig and a staphylococcus from the rabbit's brain.

3. *Investigations on the Incidence, Physiology and Chemotherapy of the Strongylidae of Equines*— The most common member of the Strongylidae. *Strongylus vulgaris,* was found in 84 percent of the caeca examined. Sixty-three percent had infestations estimated at less than 100 worms; 17.5 percent had less than massive but over 100; 3.5 percent had massive infestations, so heavy that it was impossible to touch the end of the finger to any part of the tip six inches of the caecum without touching one of the parasites concerned.

Worthy of note is the fact that in this series there were few heavy infestations with other members of this family. This tends to confirm Foster's report of lack of age resistance to this parasite, since the vast majority of the animals examined were very aged.

If a medium can be developed that will preserve 98 percent of the parasites for 48 hours, it is planned to expose them to varying strength solutions of copper salts so as to obtain an efficient worm poison, and, by analysis of the data, establish a principle of anthelmentic action.

(Project 102; Department of Veterinary Medicine. Leaders, J. H. Whitlock, E. E. Leasure, C. H. Kitselman, C. C. Morrill, W. W. Thompson; state fund.)

Abortion Disease Investigations.— Notable progress has been made this biennium in eradicating Bang's disease in the state herds. Eight herds are entirely free from the disease; the disease is well under control in five others; and in only-one herd is it still a matter of grave concern. An intensive effort will be made to eradicate the disease in this herd this year.

The Kansas rapid-test method antigen has been developed to the point of exceptional stability and dependability. Check tested repeatedly by the federal authorities at the Beltsville Laboratory, a 100-percent factor of agreement has been demonstrated.

During the first year of the biennium a study of the pH value of the blood of reacting and nonreacting cattle was made. In ninety-five percent of the cattle studied, the reactors were found to be more alkaline than nonreactors. An average increase of 0.2 pH was found in these animals.

The results of the experiments with vaccination as a means of controlling Bang's abortion disease showed that 12.5 percent of the cows infected as calves were susceptible to Bang's disease as compared to 25 percent of the cows not exposed to or infected with the disease until sexually mature.

A valuable and much-needed service is being rendered livestock owners in the routine testing of blood samples mailed or brought to the laboratory. The number of requests for this service has increased steadily.

(Project 135; Department of Veterinary Medicine. Leader, C. H. Kitselman; state fund.)

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Anaplasmosis Investigations.— Studies of this disease of cattle have included field studies of outbreaks, with reference to type and number of cattle affected, methods of handling and treatment, and routine examinations of cows that have been carriers from one to nine years, particularly with regard to blood analyses, methods of transmission, etc.

The medicinal treatment used by practicing veterinarians continues to be sodium cacodylate, although it is now given intravenously with dextrose. The administration of drugs to cure acute anaplasmosis in cows, produced experimentally in the research laboratories, has given negative results.

Colloidal iodine, iron hematoxylin, Giemsa's stain and Fuadin were administered to recovered or carrier cattle. The results were negative as evidenced by the fact that susceptible cattle, later inoculated with blood from these treated carriers, contracted anaplasmosis after the usual incubation period.

Colloidal iodine, Fuadin, Acaprin, sulfanilimide (5-percent solution) and dextrose to which was added sodium cacodylate were used, but failed to alter the course of the disease in eight cattle suffering from it in an acute form.

These data show conclusively, when compared to those obtained from untreated cattle, that these drugs did not alter the course of the disease.

A mild type of anaplasmosis was produced experimentally in a ten-months-old calf. The temperature, pulse, and respiration of the calf remained practically normal, but there was some reduction in the total number of red blood cells.

One cow was proven a carrier for the ninth consecutive year. The incubation period of infection following the administration of 30 c. c. of carrier blood from the above animal into susceptible cow has ranged between 23 and 28 days.

Two cows that have been carriers since 1934 were subjected at intervals for a period of one year to injections of 90 to 200 c. c. of blood obtained from six different cows suffering from acute anaplasmosis. Serum has been prepared from these cows for immunological studies in anaplasmosis.

(Project 180; Department of Veterinary Medicine. Leader, H. Farley; state fund.)

Feeder-cattle Disease Investigations.— The work on this project during the biennium has consisted of field and laboratory studies of diseases of cattle, including mineral deficiencies, ensilage poisoning, blistering disease, shipping fever, wheat poisoning, and pink eye (keratitis). Apparent scarcity of most diseases during this period has made possible a more thorough study of keratitis. Some of the more significant findings are here reported.

The disease spreads readily through herds of cattle maintained under barn lot and pasture conditions. It is not, however, transmitted to susceptible calves held together in fly-proof stalls, even though they are caused to eat and drink from the same receptacles. When one eye of an animal is experimentally infected, the virus will not involve the other eye unless caused to do so by direct application.

Calves that have been experimentally infected in one eye and then allowed to recover do not show resistance to experimental infection of the opposite eye. Apparently there is very little, if any, attire immunity produced in this dis ease. Diseased calves held in semidarkened stalls recover from the disease within three to four weeks without treatment, provided that the cornea has not become extensively involved or ulcerated.

Lacrimal secretions from diseased calves, when applied to the eyes of susceptible calves, have been noted to produce keratitis after an incubation period of 3 to 18 days. Filtrates prepared with filters of V and N porosity from these

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eye secretions failed to produce keratitis in 20 attempts, involving six different cattle. Several forms of bacteria have been isolated from diseased eyes. Intracellular forms (within epithelial cells) are readily demonstrable on smears, but isolation and cultivation are difficult. This infective material (lacrimal secretions) has proved virulent for susceptible calves four months after initial onset of the disease.

(Project 194; Department of Veterinary Medicine. Leader, H. Farley; state fund.)

Poultry Disease Investigations.— The work of this project has consisted of seven phases which are described briefly below.

1. *General Observations and Studies of Poultry Diseases.*— The routine procedure for the examination and study of the various cases of diseases among chickens and other birds presented from the field has not been changed. During the biennium 3.924 diseased chickens were examined and more than 1.500 letters concerning poultry diseases were received at the laboratory. Many persons, with and without specimens, visited the laboratory seeking information and advice concerning the control of poultry diseases In addition, other services were rendered as listed:

Feed samples tested for poisoning	28
Miscellaneous examinations	40
Cultures of bacteria sent to other laboratories	25
Blood samples tested	1,579
Doses of pox virus distributed	14,385
Doses of *S. pullorum* antigen distributed	16,175
Doses of laryngotracheitis vaccine	186
Doses of autogenous bacterin supplied	256

2. *Avian Tuberculosis in the Domestic Fowl.*— Additional data have been gathered to supplement those already collected on the distribution of the lesions of avian tuberculosis in the domestic fowl. Of 56 tuberculous birds examined during the biennium lesions were found as indicated below:

Organ	*Percentage showing lesions*
Liver	100
Spleen	75
Intestine	65
Bone marrow	35
Gizzard	15
Lungs	8.3
Subcutaneous tissue	8.3
Skeletal muscle	8.3

In general, proper management has produced satisfactory results in controlling this disease.

3. *Studies on Protozoan Parasites of Poultry.*— During the summer of 1936 a great increase in the number of outbreaks of a disease caused by a species of the flagellated protozoan, *Trichomonas,* was noted in chickens and turkeys.

The lesions produced by the parasite in birds depends upon the location of the infection. The greater number of cases were found to affect the upper digestive tract, the upper and lower esophagus, crop and proventriculus. Lesions were also present on the posterior portion of the mouth and on the tongue. When lesions were found in this area, they were of a grayish and yellowish color, conical tumorlike granulations deeply embedded in the mucosa. The early lesions appeared as spoutlike elevations in the center of a round depressed area of ulceration. Such lesions were not found on the surface of the proventriculus, but this organ was covered with a thick semigelatinous exudate.

The lesions in most cases were so extensive as to occlude the proventriculus and result in a distention of the crop with a fetid mass of decomposed food. The majority of affected birds show-cd a pendulous crop filled with putrid fluid containing enormous numbers of trichomonades.

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Lesions may also be found in the lower digestive tract; namely, the small intestine, caeca, and large intestines, whether associated with or without the lesions of the upper digestive tract. Friability of the intestine, distention with gas and small area of hemorrhage were found in these cases. Chickens usually showed only the lesions of the lower digestive tract, while turkeys showed lesions of the entire tract. This may be attributable to a difference in the species of causative organisms.

Diagnosis of the condition may be made by the finding of the lesions described, and confirmed by observing the flagellated parasite upon microscopic examination. In many instances a field diagnosis can be made by removal of some of the crop material and noting the very putrid odor.

Therapeutic measures seem to be of little value, and sick birds seldom recover. However, in over 50 percent of the outbreaks which occurred in the last season losses were quickly checked by the use of copper sulphate in the drinking water, 1 to 5,000 parts; this must be used as the sole source of drinking water for an indefinite period. Sanitary measures are advised; those instituted for the control of blackhead, a very similar disease, are satisfactory.

Recovered binds may act as carriers of the Trichomonad, and must be considered potential sources of danger to poults of the next season. One artificially inoculated poult has been a healthy carrier of the infection for 13 weeks and is still of healthy appearance. Chicks become infected easily, but soon lose the infection, in many cases without apparent injury.

A study of the protozoan parasite is now under way, the purpose being to determine whether or not methods of feeding prior to, and during the infections, are factors in the prevention and control of the disease.

4. *Study of Selenium poisoning of Chickens.*— A limited number of trials were conducted to determine the susceptibility of chickens to selenium poisoning. A salt of selenium, sodium selenite, was used, and it was found that birds had no difficulty in withstanding a dose of sodium selenite in the sole source of drinking water at a rate of 200 p.p.m. over a period of 10 days.

5. *Anatomical Studies of the Respiratory Tract of the Chicken.*— Studies of that portion of the respiratory system located in the heads of chickens was undertaken to determine the significance of some of the pathological changes which characterize so-called roup of birds. It was found that the chicken has but one sinus on each side of the head. This sinus is located anterior and inferior to the eye, and is named the infraorbital sinus. The only communication between the sinus and the nasal chambers is a very small opening on the extreme dorsal medial border. It is evident that with an inflammation of the mucous lining of this sinus and with the presence of pus-producing organisms. an exudate will be formed and collected in this pocket. The character of the pus formed as a result of infection in chickens is also a factor in that it is thick. Without a natural opening at the lower part of the sinus for drainage, there is no possible chance for escape of this material; and its presence increases the irritation of the part with the subsequent increase in its production. The accumulation finally in some instances exerts pressure enough to close the eye.

The only method of treatment is to incise the affected sinus from the lateral side, making the incision in front of and, below the eye, over the highest point of the swelling. The collected material can be expressed and the sinus flushed with some mild antiseptic solution.

6. *Study of Fowl Paralysis.*— The investigations of fowl paralysis have continued to some degree this year. The opinion held is that this is one of the manifestation of the so-called “leucosis” complex and is undoubtedly a tumor Although little success has been had here in filtering the agent of this condition, it has been reported as a virus from other stations. According to observations, the incubation period varies greatly from a few days to many months. This makes it difficult to study experimentally.

During the past biennium 543 birds with a recognizable form of leucosis were received, and of these 272 exhibited tumorlike involutions of the nervous system, indicating that this form of the disease accounts for about half of those

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exammed. It is quite possible, also, that numerous birds were so slightly injured by the disease as to exhibit no macroscopic lesions whatever.

7. *Studies on the Paratyphoid Infections in Birds.*— There appear to be several groups of bacteria among the Salmonella and closely related bacteria. These have been under investigation for three years, and progress has been made in identifying them. In this survey over 1,300 cultures belonging to these groups of bacteria have been isolated and studied.

(Project 85; Department of Bacteriology. Leaders, L. D. Bushnell and N. J. Twiehaus; state fund.)

Parasitological Investigations.— During the past biennium the work on this project has consisted of studies of (1) the life cycle of the tapeworm *Raillietina cesticillus* (Molin); (2) the importance of the housefly in transmitting the chicken tapeworm *Choanotaenia infundibulum* (Bloch); (3) effects of tapeworms on chickens; and (4) identification of flukes from dogs and bitterns.

The life history of the chicken cestode *Raillietina cesticillus* (Molin) has been restudied and physiological experiments involving 300 chickens and 570 beetles have given much new information. Most of the gravid proglottids are voided by the chickens in the afternoon and evening. This periodicity in shedding proglottids is thought to be associated with feeding and digestion in the chicken, and with absorption and assimilation in the tapeworm.

Observations on the motility of the gravid proglottids showed that: detached gravid proglottids are very motile in the intestine; while warm they remain motile for some time after leaving the host; the proglottids migrate to the outside of the fecal mass in which they are evacuated; one warm proglottid moved eight inches upon moist filter paper; they are not tropistically activated by light, heat or gravity.

The onchosphere stage of *R. cesticillus* can be distinguished from onchospheres of other species of fowl tapeworms by two funnel-like structures in the membranes which surround the hexacanth embryo.

Two genera, *Chlaenius* and *Anisodactylus,* and 12 species of ground beetles *(carbidae),* which previously have not been reported, can act as intermediate hosts for the fowl tapeworm *R. cesticillus.* These beetles are as follows: *Pterostichus (Eumolops) torvus* Lec., *Pterostichus (Abacidus) permundus* Say, *Pterostichus (Anaferonia)* sp. near *constrictus* Say following Casey, *Amara (Percosia) obesa* Say, *Amara (Curtonotus) laticollis* Lec., *Amara (Celia) muscula* Say, *Amara (Amara) fallax* Lec., *Amara (Amara) basillaris* Say, *Anisotarsus subvirens* Say., *Chlaenius tomentosus* (Say), *Anisodactylus (Triplectrus) rusticus* Say, *Harpalus pennsylvanicus* Degeer.

As many as 626 cysticercoids were produced by one beetle which had been fed four proglottids. The size of the cysticercoids is partly dependent upon the number of cysticercoids in a beetle and upon the species of beetle. Cysticercoids usually develop into adult tapeworms in about two weeks, although tapeworms with gravid proglottids were produced in 11 days after the fowl had swallowed cysticercoids.

Techniques were developed which facilitated the infection of beetles with onchospheres, the rearing of infected beetles, and the feeding of the fully developed cysticercoids to chickens, thus making possible critical studies of host-parasite relationships.

The discovery that so many beetles could serve as intermediate hosts of the chicken tapeworm *Raillietina cesticillus* raised the question of the importance of houseflies as intermediate hosts of the tapewarm *Choanotaenia infundibulum.* Studies made by exposing chickens to houseflies having access to tapeworm proglottids and eggs, and by precluding the entrance of beetles to the chickens, showed that 15 of 20 chickens so exposed became infested with the tapeworm *Ch. infundibulum.* Houseflies, on being dissected, had the tapeworm larvae (cysticercoids) in their body cavities. The evidence showed

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that houseflies are very important intermediate hosts of *Ch. infundibulum* and may possibly serve also as an intermediate host for *R. cesticillus* (Molin). The cysticercoid has been redescribed and adequately illustrated.

Preliminary tests of the effects of tapeworms on chickens have been begun. While very deleterious effects have appeared in some of the parasitized chickens, the numbers of cases are too few to be conclusive. Among the effects noted have been loss of weight, legs and combs pale, feathers rough, eyes brighter than controls, behavior sluggish, appetite good. Post-mortem examinations showed pathological effects only in the intestines which were somewhat congested. All of these symptoms were lacking in the control chickens.

The fluke *Metorchis albidus* from an Eskimo Husky dog, examined post-mortem at Los Angeles, Cal., was reported for the first time in North America. The specimens were taken from the bile duct. The record increases the size range of these flukes.

A new species of fluke from the cloaca of an American bittern taken at Manhattan is described as *Prosthogonimus folliculus* Reid and Freeman.

(Project 79; Department of Zoölogy. Leader, J. E. Ackert; Adams funds.)

Resistance of Chickens to Parasitism.— The work during the biennium has concerned the following phases of the project: (1) the comparative resistance of two strains of White Leghorn chickens to the nematode *Ascaridia lineata* (Schneider); (2) age resistance of chickens to the large roundworm *A. lineata;* (3) nutrition of *A. lineata;* (4) age resistance of chickens to tapeworms; (5) susceptibility of mature chickens to tapeworm infection.

1. In a series of experiments carried out through three generations of chickens the results showed that it would be possible to establish a strain of White Leghorn chickens that is very resistant to the development of the large roundworm *Ascaridia lineata* (Schneider). The results also indicated that a susceptible strain of White Leghorn chickens could be established.

2. Further evidence of age resistance of chickens to the nematode *Ascaridia lineata* has been secured by giving groups of chickens of different ages the same numbers of infective eggs of the nematode. For example, from White Minorca chicks 33 days old, an average of 7.47 worms was collected as compared with an average of 1.19 worms from chickens 65 days old. In size, the worms from the 33-day chicks averaged 20.4 mm. in length as compared with a length of 17.71 mm. from the 65-day-old chickens.

One of the factors in the greater resistance of the older chickens to the worms appears to be the larger number of goblet cells in the intestinal epitheliums. Histological examinations show that goblet cells in the villi of chickens 124 days old are markedly more numerous than are those in chicks two days of age. By making ten counts each of serial microscopic sections through intestinal villi, the numbers of goblet cells (which supply the intestinal mucus) increased with the age of the chickens as follows: two-day chick, 14 goblet cells; five day, 26 cells; 26 day, 41 cells; 40 day, 48 cells; 51 day, 60 cells; 48 day, 90 cells; and 124 day chickens, 91 goblet cells. As the older chickens have fewer worms, and as an increased amount of mucus makes it more difficult for the worms to maintain their position in the chicken intestine, it appears that one of the factors in the increased resistance of older chickens to the nematode *Ascaridia lineata* (Schneider) is the larger number of goblet cells in the intestinal epithelium. This appears to be the first observation of goblet cells being more numerous in older than in younger animals.

3. Little is known of the food of *Ascaridia lineata,* Ackert, in 1923, found that young worms, 10 to 17 days of age, buried their anterior ends in the wall of the chicken intestine. To ascertain if these worms are tissue feeders, growing worms were removed from the intestine of one chicken, washed in saline

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solution, measured and introduced into the body cavity of another chicken. After an interval of a few days, the chicken was killed and the inserted worms were examined for growth and vigor. Of a total of 142 live *A. lineata* transferred to the body cavities of 31 chickens, 81 of the namatodes were recovered; of these only 16 worms remained viable; these lived only from one to four days. Nearly all of the worms recovered were phagocytized, encapsulated or walled off by some portion of the fowl's body. The worms were unable to thrive outside the lumen of the intestine.

The results of this experiment furnished an explanation of the method by which worms occasionally get into a hen's egg. It had been thought that the worm entered the upper portion of the oviduct from the body cavity through the infundibulum, since Stewart found that ascaris larvae migrated from the host's intestine and Ackert found that ascaridia larvae occasionally migrate into the chicken's body cavity. As no larva or worm was able to live more than four days in the body cavity of the chicken, it would thus be impossible for a larva to grow to maturity in the body cavity of the hen. The path of migration of worms in hens' eggs thus must have been from the small intestine to the large intestine through the cloaca and into the oviduct. It is known that adult ascaridia are constantly being eliminated from the intestine of the chicken. Worms which retain considerable vitality would be able at the cloaca to migrate into the lower end of the oviduct and find their way up to where they would be enclosed within the egg-shell membrane.

In a series of experiments extending over two years, the food of this fowl nematode was studied by parasitizing a group of chickens with *Ascaridia lineata eggs*, then separating the group into two lots of chickens: one lot to be nourished only by intramuscular injections of glucose solution, the other to be fed normally. After a period both lots of chickens were killed and the parasites collected, counted and measured. The results from 96 chickens showed that the worms thrived better in normally fed chickens than in those nourished only by glucose injections. The average number of worms from the glucose-injected group was 4.27 as compared with an average of 7.44 worms from the naturally fed group. As to length, those from the injected group averaged 4.46 mm. and the worms from the controls 17.47 mm. Furthermore the *A. lineata* from the controls made normal growth, while those from the glucose-injected chickens made but little growth. The lowered incidence of infestation and the smaller size of the worms in the injected group appear to have been due to starvation from lack of host ingesta.

4. While age resistance of animals to nematodes has been recorded several times, such resistance of chickens to tapeworms was unknown until the present work was done. In a series of experiments in which infestive cysticeroids of the tapeworm Raillietina cesticillus were administered to growing chickens of different ages, results were obtained which demonstrated age resistance to this tapeworm. Fifteen chickens, 20 to 51 days of age, parasitized with approximately 50 cysticercoids had an average of 4.87 tapeworms per bird, whereas 27 fowls, 71 to 150 days old, had an average of 3.22 worms per bird, a difference of 1.65 tapeworms, which was five times the probable error and therefore considered significant. Instead of length of tapeworms, the number of proglottids was used as the factor of comparison of size of cestodes. The 15 chickens, 20 to 51 days of age, had an average of 94.91 proglottids as compared with an average of 79.3 proglottids for the 27 chickens of the older group. This difference of 15.61 proglottids was 4.19 times its probable error, also a significant difference. These results demonstrate that chickens (White Leghorns) approximately 2½ to 5 months of age may be markedly more resistant to the viability and growth of the cestode *R. cesticillus* than are younger fowls (about one to two months of age) from the same flock.

5. While it was known that mature chickens may be infested with tapeworms, it was uncertain when the infections were acquired. That is, a young chicken, after becoming infested, might retain its worms for months or years. Of six mature chickens raised in confinement, four were fed cysticercoids (larval tapeworms), and two were kept as controls. In from 12 to 85 days the four chickens were examined. All of them had become infested. The num-

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bers of worms per chicken ranged from four to fifty. Both control chickens were negative. These results show that mature chickens may acquire infestations of the tapeworm *R. cesticillus.* This appears to be the first carefully controlled experiment in which mature chickens have been infected with cysticercoids.

(Project 169; Department of Zoölogy. Leader, J. E. Ackert; Purnell fund.)

STUDIES IN HOME ECONOMICS

Several lines of investigational work that have for their purpose the development and improvement of the rural home have been conducted during the past biennium. Brief statements of the work done follow.

Vitamin Content of Food in Relation to Human Nutrition. — The vitamin A value of the colostrum and milk of four cows was determined on 24-hour composites taken on the first, second, fourth, seventh, fourteenth and twenty-sixth days of lactation. The single feeding method of Sherman and Todhunter was used. Vitamin G (riboflavin) values were determined on the milk and colostrum of four cows by the method of Bourquin and Sherman. These were made on 24-hour composites of the first, seventh and thirtieth days of lactation.

The influence of pasture on the vitamin G content of milk was also studied on groups of Holstein and Jersey cows in September, 1936, at the end of an abnormally dry summer, and again after access to good fall pasture. Similar determinations were also made on composite collections for groups of Holsteins, Jerseys and Guernseys the following spring before and after access to pasture.

Values were also secured for the milk of cows maintained in dry lot for over two years without green feed.

The secretion of the first and second day were found richest in total vitamin A value, with 25 to 28 International units program for two cows freshening on pasture, and 16 to 20.1 units for two cows maintained on winter ration. After the seventh day of lactation there was little change in vitamin A value, and the milk was found to contain approximately two International units per gram.

Colostrum was found to contain more than two to three times as much vitamin G as the thirtieth-day milk from the same cow. The vitamin G value of milk from individual cows at the end of the first month of lactation was estimated to be about two micrograms per gram, or 1.950 micrograms per quart.

The average riboflavin value for all samples of milk tested was 2.1 micrograms, the range being 1.6 to 2.8.

Statistical analysis of all values representing before and after pasture feeding showed no significant difference between those periods.

(Project 158; Departments of Home Economics and Dairy Husbandry. Leaders, B. L. Kunerth and W. R. Ridden; Purnell fund.)

An Investigation of the Effect Upon the Animal Body of Varying the Amount of Vitamins in the Diet.— The work of the biennium has consisted of observations on: (1) The effect of reproduction in guinea pigs of a limited amount of vitamin C in the diet; (2) the abortions of pregnant animals when put on the limited

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amount of vitamin C; and (3) the effect of this diet on the teeth and bones of these animals.

The minimum amount of vitamin C necessary to prevent scurvy is not sufficient for normal reproduction. Abortions occur in every case when less than 3 ml. of orange juice, or its equivalent, per 300 grams body weight are fed with a diet devoid of vitamin C, although pregnancies had proceeded for as long as three weeks before the animals were put on the experimental diet. No pregnancies were secured when this diet was used before copulation.

The ovaries and the uteri of guinea pigs are being studied to determine whether the failure to reproduce and the production of abortions are correlated in any way with the histological structure of these organs.

The comparison of the vitamin C deficient animals with normal animals showed that there was no increase in the number of atretic follicles in the scorbutic animals or in those which received only a limited amount of vitamin C. There were no large normal follicles present in the ovaries of the scorbutic animals, and their ovaries had a larger number of small cysts than the others. Endometrial hyperplasia has been observed in the uteri of guinea pigs on vitamin C deficient diet. Following injections of corpora lutea extract, pseudopregnancy occurred. The injections are being continued using varying amounts and varying lengths of time for injection. Injections of antuitrin are also being made on pregnant animals on a vitamin C limited diet.

In guinea pigs fed on the Sherman-LaMer-Campbell vitamin C free diet without supplement the bone at the base of the cheek teeth and along the edge of the alveolar area was resorbed. This resorption occurred without respect to the age of the animal. Four weeks on the diet were sufficient to produce a considerable amount of resorption. The addition of 3 ml. of orange juice per 300 grams body weight gave almost complete protection against resorption. Guinea pigs fed the vitamin C free diet supplemented with greens ad libitum, those on the adequate Ibsen diet, and embryos of mothers on the Ibsen diet, had firm and strong jaw bones. Experiments are being carried on to determine whether vitamin C added to the diet after resorption has been produced will bring about a recovery from this condition.

(Project 188; Departments of Home Economics and Zoölogy. Leaders, M. M. Kramer and M. T. Harman; Purnell fund.)

The Nutritional Status of College Women as Related to Their Dietary Habits.— Five types of data are being collected in this project: anthropometric measurements, basal metabolism records, blood pictures, records of intake and utilization of foods, and trends in dietary habits. Compilation of these data was begun in 1936-'37 with freshmen, but, as it is desirable to have all the data concerning development over a period of four years, little of the work can now be considered complete.

Food records for one week of 228 freshmen women eating a freely chosen diet have been tabulated to determine the frequency of occurrence of certain foods in the diet. The results are given below.

SUMMARY OF TRENDS IN FOOD CONSUMED DURING ONE WEEK BY 228 FRESHMEN WOMEN

Food	*Trend*	*Percentage* 1936-'37	1937-'38
Meat, fish or poultry	Food most often served more than once a day,	83	84
Eggs	Most often entirely omitted	28	25
Whole-grain products	Never eaten	17	16
Coffee, tea, Coca-Cola	Used more than once a day	25	19
Milk	Approximately one pint daily standard	49	54
Green or yellow vegetables	More than one serving daily	53	67
Citrus fruit or tomato	More than one serving daily	34	33

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(Project 201; Department of Home Economics. Leaders, Bernice Kunerth and Martha Pittman; Purnell fund.)

A Study of Factors Affecting the Service Qualities of Certain Textile Fabrics.— Research has been carried on during the biennium covering three phases of this project.

1. *Methods of Measuring the Absorptive Qualities of Certain Fabrics.*— The amount of absorption of Turkish toweling of double- and single-loop construction was first measured by the method reported by Stevenson and Lindsay. This method consists of allowing a sample of fabric of known size and weight to absorb the maximum amount of water from the surface of a moist, porous porcelain disk. Much time is consumed in securing the readings because of the two-hour intervals between weighings necessary for constant weight. Two or three weighings may be needed before the weight of the fabric becomes constant.

A new method requiring less time was devised. It consists of allowing water to drop from a burette onto a sample of the fabric, of known dimensions and weight, until a drop of water comes through. A factor representing the absorption capacity of the fabric by both methods was calculated by multiplying the number of cubic centimeters of water that the material held by the specific gravity of water, and dividing by the weight of the sample in grams.

This method gave results that indicated slightly higher absorptivity than is found by the porous porcelain disk method. Since in each case, however, the results were uniformly higher, it would seem that this method might be satisfactorily used to compare the absorptivity of a number of fabrics.

2. *A Study of Service Qualities of Fabrics as Affected by Laundering.*— Lengths from six brands of unbleached and bleached sheetings were laundered 20 times in an electric washing machine. The temperature and hardness of the water and the concentration of the soap solution were the same for all launderings. A neutral soap flake, Ivory, was used for all but one test, in which Oxydol was used. Before each laundering lengths of brown sheetings were treated with bleaching agents. These treatments were continued until the unbleached sheetings had attained the whiteness of commercially bleached fabric of the same brand, the whiteness being measured with a Bausch and Lomb Color Analyzer. Six applications of Clorox and nine of bleaching powder were necessary.

Analysis of the data obtained indicated that unbleached fabrics were stronger than the commercially bleached fabrics after laundering. Unbleached fabrics which were bleached and laundered 20 times had approximately the same breaking strength as the commercially bleached fabrics after 20 launderings. In general, unbleached fabrics laundered with Ivory flakes were strongest; Oxydol caused greater tendering than Ivory flakes. Bleaching powder (Javelle water) caused still greater loss, and Clorox the maximum loss in breaking strength.

3. *A Comparison of the Effects of Laundering Silks with Various Soap Flokes.*— Eight samples each of white pure dye, tin weighted, and lead weighted silks were laundered 10 times in a launderometer. Four were soiled; then a clean and a soiled sample were laundered in distilled water or in solutions of Chipso, Ivory or Dreft in distilled water. Breaking strength, thread count, shrinkage and color were measured before and after laundering; and the amount of residue deposited by the different detergents was determined.

Dreft, which cost the most per ounce, was the cheapest in that less was required to produce a permanent suds. In general, the samples laundered in Dreft had a slightly higher breaking strength than those laundered with soap and showed less shrinkage.

Dreft removed the greatest amount of soil from the weighted silk; Ivory soap was most effective with the unweighted silks. Chipso and Ivory showed the greatest deposit of residue of the detergents studied.

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In appearance the material laundered with Dreft compared favorably with the one laundered in distilled water. Ivory flakes produced a harsh, chalky white fabric, and the mild chip a harsh yellow fabric.

(Project 161; Department of Home Economics. Leaders, K. Hess, Esther Nelson and Hazel Fletcher; Purnell fund.)

A Study of Factors Affecting the Expenditures for Family Living of Kansas Farm Families.— To date the work on this project has consisted chiefly of securing data from account books kept by cooperators in the Farm Bureau-Farm and Home Management Associations, and of summarizing and tabulating these data. In this work the Department of Agricultural Economics has supplied information concerning the farm incomes secured on the coöperating farms. A preliminary report is planned for the coming year.

In addition, data have been obtained from matched farm and home account books kept by a number of clients of the Farm Security Administration. The data from these books have not been analyzed, but it is expected that they will be analyzed during the coming year.

(Project 196; Departments of Home Economics and Agricultural Economics. Leaders, M. A. Gunselman, W. E. Grimes; Purnell fund.)

BRANCH EXPERIMENT STATIONS

The work of the central station at Manhattan is supplemented by work at, four branch experiment stations all in the western part of the state, located at Hays, Garden City, Colby, and Tribune. The work at each of these stations is closely correlated with that of the central station, but planned and conducted with particular reference to local conditions. At all of these stations, with the exception of Tribune, cooperative assistance is obtained for the investigation of tillage and rotation problems from the Division of Dry-Land Agriculture, Bureau of Plant Industry, United States Department of Agriculture. In addition, coöperative assistance is obtained at the Fort Hays branch station from the following agencies of the United States Department of Agriculture: Forest Service with the production and distribution of trees; Soil Conservation Service with moisture conservation and erosion problems; Divisions of Cereal Crops and Diseases and Forage Crops and Diseases of the Bureau of Plant Industry with weed, cereal, and forage-crop problems; and Bureau of Agricultural Engineering with wheat-storage problems.

The experimental and demonstrational work at these branch stations has been maintained on a high plane during the past biennium. Each station has presented the results of its work to the public through meetings, field days, demonstrations, bulletins, press reports, and other publications. A brief description of the work conducted and of the results secured is given in the following pages.

FORT HAYS BRANCH EXPERIMENT STATION

The Fort Hays Branch Experiment Station, consisting of an area of 3,440 acres, was established on the old Fort Hays Military Reservation by legislative enactment in 1901. Approximately 2,000 acres

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are under cultivation. The remainder is pasture, campus, feed lots, and roads. The station is equipped to conduct experimental work with soils, crops, livestock, forestry, and horticulture. Brief statements about the more important projects follow:

Dry-land Agriculture.— The tillage and crop rotation investigations consist largely of a continuation of experiments in methods of production of the principal crops adapted to this area.

The investigations include: The use of numerous methods of seedbed preparation in continuous cropping for wheat; alternate cropping with fallow; rotation of crops, using various combinations; alfalfa and brome grass as sod crops in rotation; the use of commercial fertilizers, green-manure crops and barnyard manure; various widths of row spacing for the production of row crops in rotation; the effect upon the crop resulting from stover of the previous crops being left on the ground; the effect of the use of different tillage machines when used for the first operation in preparing the seedbed for wheat; the effect of the various methods and amounts of tillage during a period of fallow; the effect of deep tillage by means of plowing, chiseling and dynamiting; the deposition of nitrates in the soil as effected by different methods of seedbed preparation; the effect of tillage methods and of crop rotations on the protein content of wheat; a study of soil moisture as influenced by different tillage methods, and the relationship between yields and soil moisture; the depth and distance to which sorghum plants in rows use moisture; the depth and rapidity of penetration by rain water and amount of water lost from the surface by evaporation; and the effect of basin farming machinery and the diking of small areas on water storage in the soil.

In addition to the tillage and rotation work a small area is devoted to the pasturing of wheat on fallow and manured fallow to determine possible means of controlling wheat-plant growth in order to obtain maximum yields.

Meteorological observations, including maximum and minimum temperatures, wind velocity, humidity, precipitation and evaporation from a free water surface, have been continued on this project since 1907. Through the coöperation of the United States Weather Bureau a standard evaporation tank was installed in 1937 to enable a comparison of readings from the standard type and the dry-land type under the same conditions to determine the extent of correlations between the readings. Significant correlation would be valuable in evaluating data from the long-time record of evaporation from a free water surface which has already been accumulated.

The season of 1936 was one of those rare years when winter wheat matured a normal crop despite the fact that the subsoil was dry at seeding time and precipitation between seeding time and maturity was below normal. Barley and oats also made good yields, but a dry, hot summer caused almost complete grain failure of row crops on cropped land, and near failure on fallowed land.

Owing to extreme drought in 1937 only wheat on fallow produced satisfactory yields. All crops on cropped land failed to develop grain, and stover yields were light. It was another year in which seasonal precipitation was insufficient to produce grain crops. This emphasized the need of having some portion of the farm fallowed each year to insure some crop income and to assist in stabilizing crop production. (A. L. Hallsted, in charge.)

Cereal Investigations.— The object of these investigations is to test sorghum, winter wheat, winter and spring barley, oats, corn, flax and broomcorn, and to determine the best varieties for ultimate distribution. Improvement by plant-breeding methods is extensively conducted for sorghum and to a lesser degree for spring barley.

The mid-early varieties of wheat are the best adapted to central Kansas from the standpoint of yield. During the eight years from 1930 to 1937, representing both favorable and unfavorable seasons, the average yield of Early Blackhull was 23.8. Tenmarq 24.6, Blackhull 24.5. Kanred 23.1 and Kharkof 20.8 bushels. These are listed in order of maturity.

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The optimum date for seeding winter wheat in the Hays territory is from September 25 to October 5. An early maturing variety of wheat seeded late has followed the same trend in yield as a late-maturing wheat seeded late, indicating that date of planting has a greater influence on yield than varietal differences in the length of growing season.

Further progress has been made in isolating stiff-strained, smooth-awned selections of barley from the cross Atlas × Vaughn along with high yield.

Work with spring oats has been limited at the Fort Hays station to varietal testing and to such selections in the nursery as have been of promise at other stations. A Fulghum selection grown under Hays Cereal No. 713 continues to rank highest in yield at this station.

Improvement of both grain and forage sorghums by hybridization is being continued. An early, white seeded forage sorghum is sought for the northern sorghum belt. Selections from the cross Atlas × Early Sumac to meet this requirement have been advanced to increase plots.

Leoti Red x Club in the F_3 generation has given a number of promising lines. Progenies of this cross have shown resistance to red-leaf blotching. Tillerless plants were observed and isolated in the F_3 generation and are to be tested for further utility. Dwarf types suited to combine methods of harvesting have also been isolated from the above cross.

A large number of lines from Club × Day and Club × (Backcross) have been isolated as suited to combine methods of harvesting. Many of these lines were subject to a malady designated as weak neck, which causes the heads to lodge. Investigation has shown that the malady is inherited and that the problem of selecting dwarf sorghums must take into consideration susceptibility to weak neck.

Since the last biennium, Early kalo and Club kafir have been approved for distribution to farmers from the Hays station.

The pasturing of winter wheat on a commercial field of the station is being continued to determine the factors involved in successfully grazing winter wheat, the gain per acre which can be expected, and the effect of grazing upon the yield of the wheat crop. Successful grazing of winter wheat without injury to the grain yield seems to be conditioned upon a high amount of stored moisture in the seedbed at seeding time and upon an abundance of available nitrates in the soil for quick recovery. The grazing of winter wheat requires 25 percent higher rate of seeding than when intended for grain production only, and earlier seeding. Best grazing is obtained on fallowed land and should begin in late November and continue until late March or early April, depending upon season and locality. A sufficient number of animals to keep the wheat *grazed* uniformly, but not too severely, is desirable. Under extremely wet conditions the livestock should be removed to prevent damage to the crop. The dry-feed consumption of cattle when grazing on a good growth of winter wheat was reduced from 75 to 80 percent.

Gains at this station on good wheat pasture have been produced at costs of from $2 to $2.50 per hundred pounds, compared with costs of about $7 when sorghum silage and a protein supplement were used.

Palatability experiments with sorghums as fodder feed during the winters of 1936, 1937, and 1938 indicate that sweet sorghums, such as Atlas, Kansas Orange and Leoti Red, were the most palatable. The kafirs of the grain group proved next best, and milo and feterita or derivatives of these varieties were the least acceptable. However, hegari, which has sweet stalks and is classed as a grain sorghum, was as palatable as the forage group. Amount of rainfall, cultural methods used, date of harvesting, along with varietal differences, influenced the factors concerned in palatability. (A. F. Swanson, in charge.)

Forage-crops Investigations.— The object of these investigations is to test and develop improved strains and methods of establishing or producing sweet clover, alfalfa and grasses. More and more the major attention has been directed to selecting and testing domestic and imported grasses, perfecting methods of harvesting and threshing and establishing them on a practical

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basis, and studying the effects of drought and grazing on native grasses on different types of soil.

Results from these investigations indicate that certain native grasses may be satisfactorily reestablished on cultivated land, Spreading the mature hay of blue grama with a manure spreader over land prepared as it should be for wheat and packing or disking it in gives surer and better stands than drilling the seed. Good stands have been secured from January to June, but spreading during April and May appears to be the most satisfactory. Protecting a portion of the native pasture from July to October not only allows for the production of a blue grama hay (seed) crop but improves the vegetative cover.

Buffalo grass, as previously reported, can best be established by sods dropped on the surface of deeply cultivated land and pressed into the soil with a weighted packer. When transplanted by this method at wide intervals, the nucleus of a buffalo grass pasture can be secured on a practical basis. After transplanting and packing the soil is in good condition for drilling blue grama or western wheat grass which will supply some immediate pasturage and protective cover while the wide-spaced buffalo sods are spreading. Indications are that spreading mature hay of blue grama over these sods would result in even quicker and better stands with more immediate pasturage and with an ultimate buffalo-grama balance that would be more desirable than either alone.

Of the several strains of sweet clover included in nursery and variety tests. Madrid Yellow and Madrid White have shown the most promise. Seed of Madrid Yellow will soon be available for distribution. (Leon E. Wenger, in charge.)

Soil Erosion and Water Conservation Investigations.— These investigations have constituted largely, during the past two years, a continuation of work previously begun. The careful and detailed measuring of soil and water losses has been continued on all established terraced and unterraced water sheds with the exception of the 30-acre Y-terrace watershed, which was discontinued in 1937 because of drainage difficulties. Soil and water loss and soil moisture penetration studies have been made on approximately 70 carefully controlled terraced and unterraced areas having different degrees of slope, different types and spacings of terraces, and subjected to various tillage and cropping systems.

Results secured from a series of very intense soil moisture samplings conducted on wheat land, grass land, and fallow, throughout the summer of 1937 indicated that in general rains of less than one-half inch, falling during the hot season, were lost from the soil before they had penetrated to a depth of six inches.

Results of the work in general show that contour tillage, regardless of the tool used, is important in conserving water, with a consequent result of increasing crop yields and decreasing soil losses. It has also been definitely indicated that under general farming conditions the terrace may serve two definite purposes, as a guide to contouring, and as insurance against gulleying of slopes during heavy rains. (F. G. Ackerman, in charge.)

State Forest Nursery.— Distribution of nursery stock has increased considerably over previous years despite drought, heat, grasshoppers and crop failures. The continued interest is due in part to heavy losses of ornamental and windbreak plantings made within the state before the last decade. Some of the older plantings about the station have been lost through continued drought and attack by insects and diseases. The number of ornamental trees and shrubs sold in the spring of 1937 was 13,420 units, going to 57 counties. In the spring of 1938, 17,035 units were distributed to 55 counties. In the forest seedling service 122,845 units were distributed to 63 counties in 1937, and in 1938, 150,997 forest-tree seedlings were distributed in 64 counties.

The untried varieties of plums planted in 1931 at the terraced farm orchard have been weak on exposed sites, and many are dead. Sweet cherries and Duke types have not been satisfactory. The cherry planting on terraced land throve through severe drought and bore a heavy crop in 1937. The 1938 crop was fairly light due to freezing and hail damage after the fruits were well set.

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A tomato variety test was started in 1937 to find varieties which may be planted in the western part of the state and which will produce satisfactory yields in dry seasons when setting of fruit is difficult. The first test included 30 varieties, which were furnished, in part, by the Cheyenne Horticultural Field Station, Cheyenne, Wyo., which is coöperating in the test. The 1938 test was less successful due to late freezes and hail damage.

Sixty-nine new species of plants from the Foreign Plant Introduction Division of the Bureau of Plant Industry were planted in 1937 and 1938, and fourteen untried species of shrubs were added to the list of plants on trial. A testing block of iris containing 88 varieties was started in 1931 and in the spring of 1938, 71 varieties remain in vigorous growing condition with all plants bloomng. Hardiness of the iris is indicated by the fact that the iris block has survived several years of severe drought and grasshopper attacks without serious loss, and has grown entirely without irrigation. (F. P. Eshbaugh, in charge.)

Bindweed-control Investigations.— This work has been under way since July 1, 1935, on a 130-acre tract of land adjoining the station and leased from the Fort Hays Kansas State College. Investigations were based largely on four main points of attack: (1) Clean cultivation, including time of beginning, frequency and depth of cultivation experiments; (2) competitive cropping in combination with clean cultivation, including experiments with fall-planted wheat and rye, summer annual crops and biennial and perennial crops; (3) herbicides, including experiments comparing different chemicals and different dates, rates and methods of applying sodium chlorate; and (4) fundamental studies of the seasonal trend of food reserves in bindweed roots and of the trend of root reserves immediately after cultivation. Other minor experiments under way were: (1) the effect of bindweed on the yield of different field crops; (2) the amount and duration of the residual effect of chlorate in the soil on the yield of different crops; (3) the relation of different crop rotations to the reinfestation of the land from bindweed seedlings; (4) the relation of size and age of bindweed patches to the difficulty of eradicating with chlorate and with cultivation; (5) the rate of lateral spread of bindweed patches; and (6) methods of follow-up treatment after chlorate applications.

The most significant results were those secured with the clean-cultivation method. On the average 15 cultivations were required to eradicate bindweed when it was allowed to grow above the ground eight days each time; 19 were required when the bindweed was allowed to grow four days each time; and 26 were necessary when it was cultivated the first day of emergence. The 12- and 16-day top-growth intervals between cultivation gave no additional saving in number of operations required for complete eradication, and eradication was not always complete after two years of treatment. The 20-day top-growth interval did not eradicate bindweed.

Late April and May proved to be the best time for beginning the clean-cultivation treatment. There was little advantage from starting cultivation after harvest in the dry seasons of 1936 and 1937. No advantage was found for cultivating deeper than necessary to cut off all plants well below the surface and to facilitate subsequent operations.

Sweet sorghum and sudan grass proved to be effective smother crops for bindweed. Results indicated that they should be preceded by a full year of fallow in western Kansas. Millet was not a satisfactory smother crop. Wheat and rye were promising as competitive crops where preceded by a full season of fallow.

Sodium chlorate and mixtures consisting largely of sodium chlorate were the only chemicals which gave satisfactory eradication results. The dry and spray methods of applying sodium chlorate averaged about equally effective. September and August proved to be the best time for applying sodium chlorate. Rates of 2½ to 4 pounds per square rod were as effective as heavier rates, and more effective than lighter rates. (F. L. Timmons, in charge.)

Beef-cattle Feeding Investigations.— The beef-cattle feeding investigations for the biennium have been concerned with the comparative value of eight protein supplements fed with sweet-sorghum silage to calves and to

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yearlings in Wintering rations. Alfalfa hay and seven manufactured feeds varying in protein content from 15.5 to 60 percent were used. The manufactured feeds were cottonseed meal, linseed meal, soybean oil meal, peanut oil meal, corn gluten meal, tankage and wheat bran.

The results from three successive yearn of feeding these eight protein supplements to calves have been evaluated and appear in the Annual Roundup Report of April 30, 1938. The experiments with the same supplements fed to yearlings have one more year to run and will be summarized in the 1939 Annual Roundup Report.

Probably the most significant fact deduced from these feeding experiments with calves was that any one of the protein supplements was eaten readily and made more satisfactory gains when fed in a wintering ration with sweet-sorghum silage, which in each year was made from immature drought-stricken sweet sorghum.

Each year wheat bran fed at the rate of three pounds per head daily produced more gain than ground alfalfa hay fed at the rate of four pounds per head daily, and each produced more gain than any of the remaining six protein supplements fed at the rate of one pound per head daily. Tankage and peanut oil meal made the lowest gains. Despite the fact that the average price of wheat bran and of ground alfalfa hay was abnormally high during the period of these feeding experiments, compared to the price of the other protein supplements fed, the cost of gain was lowest in the lots fed wheat bran and nearly as low as any in the lots fed ground alfalfa hay.

The wintering cost and the cost per hundred pounds of weight gain were considerably greater in the case of yearlings than in the case of calves. (L. C. Aicher and C. W. McCampbell, in charge.)

Pure-seed Distribution.— The 1936 season proved disastrous from the standpoint of sorghum-seed production, all sorghums failing to make grain, due to severe drought. However, the winter wheat crop on summer-fallowed land yielded an average of 32.5 bushels per acre, provided a good quality of seed wheat which was widely distributed. Seed sales for 1936-'37 embraced 103 orders distributed to 25 counties of Kansas and 10 states, and included 171,870 pounds of Tenmarq wheat, 94,124 pounds of Kanred wheat, 35,521 pounds of alfalfa seed, and 10,445 pounds of Flynn barley. No sorghum seed was carried over from the previous year. and none was produced in the fall of 1936.

The season of 1937 was favorable from the standpoint of wheat production on fallow, and a small crop of sorghum seed was also produced. Sales began early, but not many sales in large quantities have been made. All the Atlas, Club, and Early kalo seed available for distribution has been sold. Sales of Tenmarq seed last fall reached the total of 364,425 pounds, and 15,190 pounds of Kanred were distributed.

The alfalfa seed crop amounted to only 4,380 pounds, but it was sold at twenty-five cents per pound, a new high for alfalfa seed from this station. Sorghum-seed sales amounted to 59,491 pounds. The large Tenmarq distribution and the availability of sorghum seed increased the number of orders to 677 for the 1937-'38 season, reaching 79 counties in Kansas, and 17 states.

The spring of 1938 marks the first release to Kansas farmers of the new Club kafir and the Early kalo, two new sorghum varieties selected and developed at this station. It is anticipated that the Club kafir will largely replace Western Blackhull. The Early kalo is a kafir-milo hybrid which, because of its earliness. is especially adapted as an early grain sorghum crop for north central and northwestern Kansas. The Early kalo is not a combine type. (L. C. Aicher. in charge.)

Machinery Improvement.— The season of 1936 marked the demonstration of the first successful damming attachment for listers. This attachment was developed at this station and demonstrated to farmers in 32 counties in western Kansas during 1936. Over 850 blueprints of damming attachments have been sold and distributed in Kansas and many western states since the equipment was first demonstrated. Basin listing has proven of real value in areas where torrential rains occur; and, if the furrows are run on contour and the

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dams made as high as the lister furrows, rain up to three and a half inches can be held successfully in the basins without run-off. On all land carrying over 2-percent slope, basin listing should be done on contour to prevent erosion and water losses. Attachments for leveling off basin-listed ground have also been perfected and blueprints made available. (L. C. Aicher, in charge.)

Agricultural Engineering and Milling Industry.— Investigation of factors influencing the quality of wheat during storage have been undertaken in cooperation with the Bureaus of Agricultural Engineering and of Agricultural Economics of the United States Department of Agriculture, and the Departments of Agricultural Engineering and Milling Industry of the Kansas State College. (See Project 204, p. 63.)

A series of metal and wooden bins of various sizes and a concrete bin have been used to store wheat of varying percentages of moisture content. (L. C. Aicher, in charge.)

GARDEN CITY BRANCH EXPERIMENT STATION

The Garden City Branch Experiment Station contains 420 acres of upland soil, and is located five miles northeast of Garden City. At the last session of the state legislature a fund of $5,000 was provided for the purchase of new land at the Garden City Experiment Station. With a portion of this fund 100 acres of land lying to the west of the original 320 acres was purchased in the spring of 1937. All of the 100 acres purchased was planted to sorghums and a good crop was produced on half of it, which was irrigated. An increase in funds by the last session of the legislature made it possible to add an assistant agronomist to the technical staff. The experimental work is divided into two main projects: Dry-land Agriculture, and Irrigation Agriculture. In addition, lambs are fed experimentally each winter.

Dry-land Agriculture.— The Division of Dry-land Agriculture, United States Department of Agriculture, is cooperating with the station. Studies of various seedbed preparations for wheat and sorghums, crop rotation, value of green manures and barnyard manures, and soil moisture have been continued.

A new project, called the "Basin Lister Project," was started in the spring of 1938. This was located on what was virgin sod, but drought and soil blowing the past three years killed the grass.

The precipitation for 1936 and 1937 was considerably below normal. The totals were 13.01 and 8.03 respectively. Due to the lack of sufficient moisture at wheat-seeding time in 1935, the 1936 wheat crop was a failure. The 1936 crop of sorghums was very small, only a small yield being harvested from a few of the milo-on-fallow plots and from the wide row milo plots. The only sorghum plots to produce grain were milo rows 11 and 16.5 feet apart and feterita planted with the lister. Milo in 4-foot rows produced the highest yield. The wheat yield in 1937 was small, averaging a little more than four bushels.

The work on unirrigated land included variety tests of corn, sorghums and small grains and date-of-planting experiments with those crops. Yields in 1936 and 1937 were poor except for sorghum varieties planted after two year. of fallow, some of which yielded over 40 bushels of grain to the acre in 1937 No small-grain varieties were planted in the fall of 1937 because of the severe drought. Moisture penetration on fallow was sufficient to assure a fair crop, but the surface was too dry. (F. A. Wagner, A. E. Lowe and H. J. Haas, in charge.)

Irrigation Agriculture.— The availability of irrigation water as needed makes this station the most suitable in the state for alfalfa seed increase work with new strains and selections. In 1936 eight such plots, each approximately one-fourth acre in size, were grown on the station. In 1937 eight plots were again grown on the station, and four plots on the farm of a coöperator near

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Holcomb. In the spring of 1938 the number was increased to 12 on the station, with 10 plots on farms of coöperators. A good set of seed was obtained in 1936 on all plots, and in most of the plots in 1937. A severe outbreak of grasshoppers, combined with jack-rabbit injury and extreme drought, caused several of the plots to fail to set seed in 1937.

Variety test work with alfalfa was discontinued because of poor stand due to soil drifting onto the plots. The three pasture grass mixtures, which involved eight varieties of cultivated grass pasture, were abandoned for experimental purposes, as drifting soil had covered the grass so deeply that all were dead except a poor stand of brome grass. This does well under irrigation in the spring and fall, but growth is light during the hot weather even though the soil is kept well saturated with moisture. The stand in a field of alfalfa was also severely thinned by drifting soil. The surviving plants have formed a new crown on each branch about six inches above the old crown.

Native grass plants, started in the greenhouse at Manhattan, were planted in the field in 1937. Included in this project were plants of buffalo, blue grama, side oats grama, little bluestem, big bluestem and sandhill bluestem *(Andropogon hallii)*. A few plants each of *Spodiopogen sibericus* and *S. cotulifer* were also set. Probably because they are of northern origin, all of the latter were dead by the fall of 1937, and all but a few of the *S. sibericus* were dead, even though the project was irrigated in 1937.

Shoot, crown and root disease of milo is another problem that has received intensive study in cooperation with the Division of Cereal Crops and Diseases, United States Department of Agriculture. The problem originated at this station in 1926. Since that time the scope of the work has increased rapidly until during the past four seasons it has become the major problem under irrigation. A reconnaissance survey made of the irrigated district north and west of Garden City, in the Arkansas Valley in the fall of 1937, indicated that the disease is becoming widely scattered through this area. Resistant strains of Dwarf Yellow milo. Wheatland, Beaver, Day, Sooner and Kafir × milo selection 27317, have been obtained by selection at this station. One of the resistant strains of Dwarf Yellow milo has been named Finney and has been approved for distribution to farmers. (F. A. Wagner and A. E. Lowe, in charge.)

Lamb-feeding Investigations.— Experiments in methods of feeding lambs have been continued during the biennium. Results indicated that sorghum, grain and roughage, with the addition of ground limestone, are satisfactory substitutes for alfalfa whenever the price differential justifies their use. Comparison between the milo and Sumac roughages failed to show any considerable difference for fattening lambs. Comparisons of the grains of Dwarf Yellow milo, Wheatland, kafir and Sumac showed little difference in gains. Lambs full fed on Sumac grain for the full-feeding period of 110 to 120 days showed no ill effects. Deferring grain feeding for 30 days at the beginning of the period had no significant effect on the total gains made by the lambs compared with full feeding of grain from the start, and did produce cheaper gains.

A more complete report of these investigations is contained in *Coöperative Studies in Lamb Feeding,* page 76. (F. A. Wagner and R. F. Cox, in charge.)

COLBY BRANCH EXPERIMENT STATION

The Colby Branch Experiment Station consists of 274 acres of land located on the west edge of Colby, Thomas county. The work of the station is divided into three major projects: dry-land agriculture investigations, crop adaptations, and dairy-herd improvement. Minor projects include variety tests of fruits, shrubs and trees.

Dry-land Agriculture.— The experimental work in cultural methods and soil management studies with the Division of Dry-land Agriculture of the United States Department of Agriculture were continued with the addition of

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12 plots during the biennium. In these plots the effects of the use of the damming lister will be studied.

A continuation of the drought was experienced and the yields of all plots and crops were below average during the period. Yields from crops grown upon summer-fallowed land were lower than expected because of failure to receive sufficient moisture in the subsoil. (J. B. Kuska, in charge.)

Crop Adaptation.— Studies in varieties of the various field crops-were conducted throughout the biennium. Because of the severity of the drought even the most resistant sorts were unable to return a profitable yield. No grain was produced in 1936, and yields of all grains were light in 1937.

A new variety of grain sorghum, "Colby milo," was distributed from the station during the spring of 1937. This variety is a cross between Early White milo and Dwarf Yellow milo that was made at the Woodward, Okla., Experiment Station, and developed at the Colby station. This variety is early maturing, has a stiff stalk that resists lodging, yields well, and is adapted to harvest with the combine harvester thresher.

Fruit trees planted in the orchard block in the spring of 1938 consisted of varieties of apples, pears, plums and apricots. The project is being carried on in cooperation with the Horticultural Field Station of Cheyenne, Wyo. (E. H. Coles, in charge.)

Dairy Herd Improvement.— The dairy herd improvement work of breeding a herd of grade cattle by use of purebred sires was continued. The average production of the 16 cows in 1936 was 8,461 pounds of milk and 327.6 pounds of butterfat; and in 1937, 8,596 pounds of milk and 343.85 pounds of butterfat. Feed conditions were poor during both years of the biennium and only a partial ration of ensilage was available. (E. H. Coles, in charge.)

TRIBUNE BRANCH EXPERIMENT STATION

The Tribune Branch Experiment Station consists of 110 acres located in Greeley county, near the town of Tribune. The results secured on this land apply to the high-plains area extending from the Smoky Hill river to the Arkansas river. The work is planned to study variety response, seedbed preparation and date of seeding of the principal adapted crops: wheat, oats, barley, corn and sorghums. Studies are also made of the adaptation of various varieties of legumes, grasses, garden crops, flowers and trees.

Climatic conditions were severe during the biennium; yet there was some improvement over 1934 and 1935. The total precipitation during 1936 was 10.14 inches, 6.13 inches below normal. In 1937 the precipitation was 4.17 inches below normal. During the two-year period only 12 rains of more than one-half inch occurred, Temperatures were higher than normal during the period. In 1936 there were 33 days and in 1937, 23 days with temperatures above 100 degrees. In average years there are five to six days with temperatures above 100 degrees. However, the precipitation in 1937 was timely, and a good feed crop and some grain were produced.

No wheat yields were secured in 1936. In 1937 wheat planted September 15 made a slightly higher yield than that planted September 1 or October 1. Over a 12-year period there has been very little difference in the yield of wheat planted on these three dates. There is no significant difference in the yield of wheat planted with a common or a furrow drill in 1937, or over a 12-year period. The yields of Kanred, Blackhull and Tenmarq were all within one tenth of a bushel in 1937, and the average for all three varieties over a nine-year period was within nine tenths of a bushel. These three varieties have made a slightly higher yield than Turkey and a slightly lower yield than Early Blackhull over a nine-year period.

No spring small-gain yields were secured in 1936 or 1937 because of drought. Flynn has made a higher yield than any other barley variety over

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an eight-year period. Seeding barley with a common or a furrow drill made very little difference in the yield. Kanota oats average 10 bushels per acre over a 13-year period when seeded with a common drill, and 11.9 bushels when seeded with a furrow drill. Kanota and Brunker oats have each made an average yield of 10.4 bushels per acre over a 14-year period.

No corn grain yields were secured in 1936 or 1937, Cassel White has made higher yields than any other variety over a 21-year period. May 1 to, May 15 has proved to be the best time to plant corn. Over a 14-year period corn planted in rows 42 inches apart made an average yield of 10 bushel per acre; in 84-inch rows, 10.1 bushels; plant two rows and skip one, 10.8 bushels.

Sorghum planted on June 5 made a higher forage yield than that planted May 20. Leoti Red sorgo made an average yield of 5,054 pounds of cured forage per acre over a ten-year period when planted on June 5, and 4,055 pounds when planted on May 20. Greeley has made the highest grain-sorghum yield over the last ten years.

The damming lister was used for the first time in planting sorghums on the station in 1937. The green weight of sorghum forage planted on fallow with a damming lister was 7,462 pounds per acre and when planted without the damming attachment, 6.415 pounds. Sorghum planted on cropped land with a damming lister produced 1,876 pounds per acre more green forage than when planted with a common lister.

A new project was started in 1936 to compare the amount of pasture from Sudan grass and winter wheat when planted on summer-fallowed land. In 1936, 4.4 acres of Sudan grass furnished 192 animal days of pasture, and wheat furnished no pasture. In 1937. 4,4 acres of Sudan grass and wheat each produced 225 animal days of pasture when planted on fallowed land.

Work at the station has shown that many early, hardy flowers can be successfully produced if they are given proper care and attention. Flowers grown successfully include: bush balsam, bachelor buttons, dianthus, California poppies, larkspur and zinnias.

One of the best features of the garden project during the last two years has been the use of burlap wind protection on the south side of tomato vines. This protection aided greatly in producing good crops of tomatoes in both 1936 and 1937. (T. B. Stinson, in charge.)

STATION PUBLICATIONS

The results of investigations by the Agricultural Experiment Station are reported in four series of publications: Biennial reports, technical bulletins, bulletins, and circulars.

Biennial Reports.— At the close of each biennium a report is made giving a brief survey of all the work of the station. It consists primarily of progress reports on the various projects actively pursued during the biennium.

Technical Bulletins.— Reports of detailed scientific investigations, too technical for the average reader, but of value to the investigational and technically trained reader, are published as technical bulletins. Three such bulletins were issued during the biennium.

General Bulletins.— The reports of specific investigations for popular distribution are published as bulletins. The material is presented in such a manner as to be readily understood by the average reader. Three bulletins were printed during the biennium.

Circulars.— Brief popular reports of experimental results and popular discussions on various agricultural problems are published as circulars. Thirteen circulars were published during the biennium.

The following are the regular station publications issued during the biennium, listed by series and showing the title, size of edition, and the number of pages:

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BIENNIAL REPORT

No.	Title	Edition	Pages	Total pages
	Eighth Biennial Report of the Director	1,750	144	252,000
	TECHNICAL BULLETINS			
42	The Relationship Between the Internal Structure and Photosynthetic Behavior of Apple Leaves	2,000	58	116,000
43	Nitrogen—The Major Cause in the Production of Spotted Wheat Fields	2,500	58	145,000
44	Physiologic and Genetic Studies of Crooked Keels in Chickens	1,500	32	48,000
	GENERAL BULLETINS			
275	Sheep Production in Kansas	15,000	72	1,080,000
276	Turkey Production in Kansas	12,000	95	1,140,000
277	Swine Production in Kansas	15,000	74	1,110,000
	CIRCULARS			
179	Information Regarding Recent Publications	15,000	2	30,000
180	Evaporation and Spray Systems of Cooling Cream	17,000	16	272,000
181	Home Vegetable Gardening in Kansas	15,000	45	675,000
182	Information Regarding Requests for Publications	2,000	3	6,000
183	Hotbeds for Kansas	10,000	29	290,000
184	House Plants and Their Care	15,000	16	240,000
185	Liming Kansas Soils	15,000	26	390,000
186	Tax Delinquency on Farm Real Estate in Kansas, 1928 to 1933	10,000	12	120,000
187	Swine Feeding Investigations, 1926 to 1930	7,500	15	112,500
188	Swine Feeding Investigations, 1930 to 1935	7,500	26	195,000
189	Information Regarding Recent Publications	14,000	4	56,000
190	Publications Available from the Agricultural Experiment Station	2,000	4	8,000
191	Flax Production in Kansas	15,000	14	210,000

SOME INFORMATION REGARDING EACH PUBLICATION ISSUED

BIENNIAL REPORT

Eighth Biennial Report of the Director: For the Biennium July 1, 1934 to June 30, 1936.— This biennial report outlines the scope of the work of the Agricultural Experiment Station for the period. Brief summaries of the results on some projects are given and brief progress reports made on the others. The annual financial statements and a list of the publications of the station and of contributions to other scientific publications by members of the station staff are included. (By L. E. Call, Director. Agricultural Experiment Station. 144 pages; 2 figures; 5 tables.)

TECHNICAL BULLETINS

Technical Bulletin 42: The Relationship Between the Internal Structure and Photosynthetic Behavior of Apple Leaves.— Anatomical studies of several varieties of apple leaves revealed that Livland and Wealthy leaves have a greater amount of intercellular space per unit of area than certain other varieties, notably York. Livland leaves rank high in their rate of photosynthetic activity, and York leaves under comparable environmental conditions show a much lower rate. The rank of other varieties studied as to photosynthetic activity is similar to a ranking based on the extent of the intercellular space.

From the evidence presented, the anatomical characteristics of apple leaves as expressed by measurements of the intercellular spaces may be a factor, in addition to those previously recognized, which influences photosynthetic activity. This characteristic probably exerts its influence by governing the diffusive capacity of the leaves and determining the extent of the moist surface of the mesophyll cell walls bounding the intercellular space. (By W. F. Pickett, Department of Horticulture. 58 pages; 7 figures; 23 tables.)

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Technical Bulletin 43: Nitrogen— The Major Cause in the Production of Spotted Wheat Fields.— This bulletin reports the results of studies of both soil and plant characters of naturally occurring and induced spots in Kansas wheat fields during the period 1929 to 1934. The total and the available nitrogen content of the soil, the nitrifying capacity of the soil, the nitrogen in the plant material, and the similarity of spots produced by the addition of nitrogenous fertilizers or animal urine to those occurring in the fields show that such spots are the result of an increased nitrogen supply to the plant. (By P. L. Gainey. Department of Bacteriology. M. C. Sewell, formerly. Department of Agronomy, and H. E. Myers, Department of Agronomy. 58 pages; 5 figures; 23 tables.)

Technical Bulletin 44: Physiologic and Genetic Studies of Crooked Keels in Chickens.— Studies of the crooked-keel condition in poultry were conducted on White Leghorn chickens during the period 1926 to 1934. After five years of selection the incidence of the deformity was increased from 40 to 80 percent in the female progeny of the crooked-keel strain, whereas mass selection failed to alter the genetic constitution of the straight-keel strain. With the exception of one year, the incidence of the deformity in the latter strain was never greater than six percent. Crosses between the two strains after the sixth year (1932) and the eighth year (1934) of selection resulted in progeny in which the incidence of the deformity was intermediate between that of the two strains crossed. Reciprocal matings of the two selected strains indicated that sex-linked factors were not involved. The back crosses to crooked keeled strain males gave a higher percentage of crooked keeled offspring than the back crosses to straight-keeled strain males. The failure, after six generations of selection, to establish strains homozygous for the factors controlling the growth of a straight keel in chicks would indicate that the mode of inheritance cannot be explained on a single factor basis. The tendency to develop crooked keels probably has its basis in a defective calcium-phosphorus metabolism, since decidedly less ash was found in the breast bones of the crooked-keel chickens. The blood picture of straight- and crooked-keeled chicks on adequate and rachitic diets was not significantly different.

Experiments were conducted to show the interaction of heredity and environment (roosting conditions). The chicks' resistance to the deforming tendency of perches is inherent, but the degree of resistance is conditioned by the roosting conditions imposed upon them. Early roosting encourages the expression of the deformity. Sharp perches tend to exert the same influence. Under practical conditions, in strains where the tendency to develop crooked keels is prevalent, selection against the tendency should be exercised. The prevention of roosting too early in life and the provision of wide roosting poles will also materially aid in controlling the tendency. (By D. C. Warren; Department of Poultry Husbandry. 32 pages; 3 figures; 15 tables.)

BULLETLNS

Bulletin 275: Sheep Production in Kansas.— This bulletin presents the general sheep situation and discusses Kansas as a sheep state, and the qualities desirable in a sheep man. Types and breeds of sheep are described with illustrations. Care and management from fold to market are explained. Discussion includes pasture crops, shelter and equipment, handling and feeding. (By H. E. Reed, Department of Animal Husbandry. 72 pages; 39 figures.)

Bulletin 276: Turkey Production in Kansas.— The introduction discusses the adaptability of Kansas to turkey raising; trends of the industry in Kaneas; practices used by growers. Further discussion covers selection of breeding stock, deformed breast bones, mating practices, management of breeding stock, incubation, brooding, feeding and range management including nutrition studies, growth and feed consumption. Marketing discussion includes finishing killing, dressing, packing, price trends. An improvement programs is suggested. A page refers to “turkens,” Final pages treat of a few diseases of turkeys and their control. (By H. M. Scott, Department of Poultry Husbandry. 96 pages; 45 figures; 32 tables.)

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Bulletin 277: Swine Production in Kansas.— This bulletin describes the swine situation in general, and shows the adaptability of the state to swine raising. It also describes types and breeds of swine and methods of choosing a breed. A discussion is included of the principles of feeding the utilization of feed, the components of an adequate diet, and of the different concentrates and protein supplements for hogs. Consideration is given to the care and management of boars and brood sows, and young pigs from farrowing until marketing, with notes on weaning, castration, and the care of orphan pigs. Pasture crops and methods of feeding on pasture are suggested. Ideal and practical types of shelter and equipment are discussed. Especial reference is made to sanitation. (By C. E. Aubel, Department of Animal Husbandry. 74 pages; 52 figures; 2 tables.)

CIRCULARS

Circular 179: Information Regarding Recent Publications.— This *circular* contains brief statements of the nature and content of the following publications of general interest: Bulletins 272, 273, and 274; Circulars 176, 177, and 178. (Office of Director. 2 pages.)

Circular 180: Evaporation and Spray Methods of Cooling Cream.— This circular consists of a comparison, as a result of experiments made under controlled conditions, of the wet sack or evaporation method and the spray method of cooling cream. Atmospheric temperatures, humidity, air circulation and agitation of the cream affected efficiency of both these methods. In the absence of more satisfactory methods these two have some merit. (By W. H. Martin. W. J. Caulfield, and A. C. Fay; Departments of Dairy Husbandry and Bacteriology. 16 pages; 1 figure; 14 tables.)

Circular 181: Home Vegetable Gardening in Kansas.— This is a publication for farmers and truck growers with especial emphasis on home gardening. Among the topics discussed are: Garden plans, classification of vegetables, soil preparation, fertilizers, soil-improvement crops, variety list, rate and date of planting. Attention is green to the special cultural requirements of the home garden, and methods of controlling the various garden insects and diseases are cited. (By Walter B. Balch. Department of Horticulture. 48 pages; 17 figures; 4 tables.)

Circular 182: Information Regarding Requests.— This circular gives instructions for ordering publications from the station, and a list of the publications of the station of which a sufficient quantity is available for general distribution. (Office of Director. 3 pages.)

Circular 183: Hotbeds for Kansas.— This circular gives all the necessary information for the construction and use of hotbeds. Plans for the use of flue heating and electrical heating are included. The care of the plants from the sowing of the seed to transplanting is adequately handled. (By Walter B. Balch and F. C. Fenton; Departments of Horticulture and Agricultural Engineering. 32 pages; 18 figures; 2 tables.)

Circular 184: House Plants and Their Care.— This circular contains an exposition of the culture of house plants. Propagation and potting of plants, resting plants. care of frozen plants, and disease and insect control are among the topics included. The circular also gives a list of plants for inside and outside window boxes. (By Walter B. Balch, Department of Horticulture. 16 pages; 5 figures; 1 table.)

Circular 185: Liming Kansas Soils.— This circular is concerned with the value of liming in raising crops on certain Kansas soils. It explains the effect of form, qualty, and fineness on value of lime, gives the proper method of application, and lists the crops that need lime. It also includes the results of field tests over a period of years. (By H. E. Myers, A. L. Clapp. and F. E. Davidson; Department of Agronomy. 26 pages; 12 figures; 10 tables)

Circular 186: Farm Tax Delinquency in Kansas, 1928 to 1933— This study of tax delinquency, "taxes due and unpaid on the date when a penalty was legally applied or an interest charge began," indicates the extent of such de-

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linquency for the period 1928 to 1933. Statistics of delinquency are given for the four major sections of Kansas, and by type-of-farming area; the long-term tax delinquency situation is described; and a general explanation of the types and causes of delinquency is given. (By Harold Howe; Department of Agricultural Economic. 12 pages; 3 figures; 12 tables.)

Circular 187: Swine-feeding Investigations, 1926 to 1930.— The observations and conclusions are given for three swine-feeding tests: (1) Relative value of various protein supplements and protein supplementary mixtures; (2) Corn versus Atlas sorgo; (3) Alfalfa pasture feeding versus dry-lot feeding for fattening spring pigs. (By C. E. Aubel and M. A. Alexander; Department of Animal Husbandry. 16 pages; 11 tables,)

Circular 188: Swine-feeding Investigations, 1930 to 1935.— This circular reports the results of and conclusions from six swine-feeding tests. The tests were concerned with (1) the relative value of various protein supplements and protein supplimentary mixture; (2) corn versus wheat for fattening hogs; (3) desirability of restricting tankage in the ration of fattening pigs when self-fed corn; (4) alfalfa pasture feeding versus dry-lot feeding for fattening spring pigs; (5) separation of the grain; (6) soiling alfalfa for fattening pigs. (By C. E. Aubel and W. E. Connell; Department of Animal Husbandry. 26 pages; 20 tables.)

Circular 189: Information Regarding Recent Publications.— This circular gives brief statements regarding the content of the following publications of the station: Bulletins 275 and 276 and Circulars 180 to 189. (Office of Director. 4 pages.)

Circular 190: Publications Available.— This circular gives the numbers of all publications, as well as the titles, that are available in quantities sufficient to warrant listing. (Office of Director. 4 pages.)

Circular 291: Flax Production in Kansas.— This circular presents experimental data relative to flax varieties and flax production. It contains information on the characteristics and adaptation of several different varieties of flax, the place of flax in the cropping system, methods of seedbed preparation, and rate and date of seeding. (By F. E. Davidson and H. H. Laude; Department of Agronomy. 14 pages; 2 figures; 11 tables.)

PUBLICATIONS BY DEPARTMENTS

The following table contains a list, classified by departments, of the regular publications of the Agricultural Experiment Station, and also the technical articles contributed to scientific journals by members of the station staff:

LIST OF PUBLICATIONS BY DEPARTMENTS

Department of Agricultural Economics

Serial No.	*Year of Issue*	*Title, author, and publication*
94	1937	Tax Delinquency on Farm Real Estate in Kansas, 1928-1933. Harold Harold. Kan. Agr. Expt. Sta. Circ. 186:1-12.
95	1937	The Power Problem as It Affects the Farm Business as a Whole. J. A. Hodges. Jour. Farm Econ. 19:487-492.
96	1937	Price Interrelationships as a Basis for Appraising Price Trends. H. J. Henney. Jour. Farm Econ. 19:886-891.
97	1938	Goals in Conservation Policy. W. E. Grimes. Jour. Farm Econ. 20.247-254.

Department of Agricultural Engineering

Serial No.	*Year of issue*	*Title, author, and publication*
70	1937	A Humidity and Temperature Control Cabinet for Growing Plants. C. O. Grandfield and F. J. Zink. Jour. Agr. Research, 54:503-508.
. . .	1937	Comparative Tests of Fuels in Low-compression Tractors. E. L. Barger. Agr. Engin. 18:311-314.
71	1937	Hotbeds for Kansas. W. B. Balch and F. C. Fenton. Kan. Agr. Expt. Sta. Circ. 183:-1-29.

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Serial No.	*Year of issue*	*Title, author, and publication*
72	1937	Power Requirements for Freezing Ice Cream. W. J. Caulfield, C. K. Otis and W. H. Martin Jour. Dairy Sei 20:645-655.
. . .	1938	Distillate as a Tractor Fuel. E. L. Barger. Agr. Engin. 19:67-70
73	1938	Power, Fuel and Time Requirements of Contour Farming. E. L. Barger. Agr. Engin. 19:153-157.
. . .	1938	Wiring the Farmstead. F. C. Fenton and H. E. Stover. Kan. Ext. Bul. 63:1-52. (revised).

Department of Agronomy

Serial No.	*Year of issue*	*Title, author. and publication*
245	1937	The Resistance of Sorghums to the Chinch Bug. R. O. Snelling, W. M. Osborn, R. H. Painter, and J. H. Parker. U. S. Dept. Agr. Tech. Bul. 585:1-.56.
249	1937	Liming Kansas Soils. H. E. Myers and A. L. Clapp. Kan. Agr. Expt. Sta. Circ. 185:1-26.
250	1937	Nitrogen-The Major Cause in the Production of Spotted Wheat Fields, P. L. Gamey, M. C. Sewell, and H. E. Myers Kan. Agr. Expt. St. Tech Bul. 43:1-58.
257	1937	Cold Resistance of Winter Wheat, Rye, Barley, and Oats in Transition from Dormancy to Active Growth. H. H. Laude. Jour. Agr. Research, 54:899-917.
259	1936	A Method for Studying Resistance to Drought Injury in Inbred Lines of Maize. J. W. Hunter, H. H. Laude, and A. M. Brunson. Jour. Amer. Soc. Agron. 28:694-698.
260	1936	The Stem Rust Epidemic of 1935 in Kansas. C. O. Johnston, L. E. Melchers, H. H. Laude, and J. H. Parker. Plant Disease Reporter Supplement, 92:19-30.
261	1937	Inheritance of Resistance to Pythium Root Rot in Sorghum. D. H. Bowman, J. H. Martin, L. E. Melchers, and J. H. Parker. Jour. Agr. Research, 55:105-115.
262	1937	A Humidity and Temperature Control Cabinet for Growing Plants. C. O. Grandfield and F. J. Zink. Jour. Agr. Research, 54:503-
263	1937	Comparison of the Gold Resistance of Varieties of Winter Wheat in Transition from Dormancy to Active Growth. H. H. Laude. Jour. Agr. Research, 54:919-926.
264	1936	The Influence of Superphosphate and Light Lime Applications Alone and in Combination on the Composition of Sweet Clover. H. E. Myers and W. H. Metzger. Jour. Amer. Soc. Agron. 28:976-984.
265	1936	Economic Value of Kansas Native Grasses. A. E. Aldous. Grasses in Kansas- 55:12-23.
266	1937	Sod Treatments as Safeguards Against Drought. R. I. Throckmorton. Kan. State Bd. Agr. Quart. Rpt. 56:61-69.
267	1937	Observations on the Carotene Content of Some Typical Pasture Plants. F. W. Atkeson, W. J. Peterson, and A. E. Aldous. Jour. Dairy Sci. 20:557-562.
268	1937	Monoecious Bufialo Grass. Kling Anderson and A. E. Aldous. Jour. Amer. Son. Agron. 29:709-710.
269	1937	Soil Erosion by Wind. R. I. Throckmorton and L. L. Compton. Kan. State Bd. Agr. Quart. Rpt. 56 (224-A):1-87.
270	1938	Extension of Alfalfa Roots into Subsoil Dried by a Previous Crop. W. H. Metzger and C. O. Grandfield. Jour. Amer. Soc. Agron. 30:80. *(Note.)*
271	1938	Management of Kansas Bluestem Pastures. A. E. Aldous. Jour. Amer. Soc. Agron. 30:244-253.
272	1938	Differential Feeding of Grasshoppers on Corn and Sorghums. A. M. Brunson and R. H. Painter. Jour. Amer. Soc. Agron. 30:334-346.
273	1938	Restoration of Bluestem Pastures. A. E. Aldous Kan. State. Bd. Agr. Quart. Rpt. 57:51-58.
275	1938	Do We Properly Appreciate the Sorghums? H. H. Laude. Kan. State. Bd. Agr. Quart. Rpt. 57:25-36.
278	1938	Flax Production in Kansas. F. E. Davidson and H. H. Laude. Kan. Agr. Expt. Sta. Circ. 191:1-14.

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Department of Animal Husbandry

Serial No.	*Year of issue*	*Title, author, and publication*
119	1936	Reproductive Capacity of Female Rats as Affected by Kinds of Carbohydrates in the Ration. C. H. Whitnah and Ralph Bogart. Jour. Agr, Research, 53 :527-532.
120	1936	Fat as a Factor in Palatability of Beef. D. L. Mackintosh and J. Lowe Hall. Trans. Kan. Acad. Sci. 39:53-58.
123	1937	The Reiation of Hair and Skin Pigmentation to Color Inheritance in Cattle, with Some Notes on Guinea Pig Hair Pigmentation. Ralph Bogart and H. L. Ibsen. Jour. Genetic (England). 35:-
124	1936	Some Observations Pertaining to Tenderness of Meat. D. L. Mackintosh, J. L. Hall, and Gladys E. Vai. Amer. Soc. Anim. Prod. Proc. 1936, pp. 285-289.
126	1937	Sheep Production in Kansas. R. F. Cox. Kan. Agr. Expt. Sta. Bul. 275:1-72.
127	1937	Swine Feeding Investigation, 1926 to 1930. C. E. Aubel and M. A. Alexander. Kan. Agr. Expt. Sta. Circ. 187:1-26.
128	1937	Swine Feeding Investigations, 1930 to 1935. C. E. Aubel and W. E. Connell. Kan. Agr. Expt. Sta. Circ. 188.1-26.
129	1938	Swine Production in Kansas. C. E. Aubel. Kan. Agr. Expt. Sta. Bul. 277,1-74.
130	1937	The Effect on Growing Pigs of Rations Containing Different Levels of Phosphorus in the Absence of Vitamin D. C. E. Aubel and J. S. Hughes. Amer. Soc. Anim. Prod. Proc. 1937, pp. 334-340.
131	1937	Recent Developments in Lamb Feeding. R. F. Cox and F. A. Wagner. Amer. Soc. Anim. Prod. Proc. 1937, pp. 149-152.
. . .	1938	Beef Cattle Investigations, 1937-'38, Fort Hays Branch Experiment Station. C. W McCampbell and L. C. Aicher. 26th Ann. Rpt. Beef Cattle Investigations, 1937-'38, Fort Hays Branch Expt. Sta.
133	1938	Livestock Programs for Kansas. C. W. McCampbell. Kan. State Bd. Agr. Quart. Rpt. 57:59-71.

Department of Bacteriology

Serial	*Year of issue*	*Title, author, and publication*
163	1937	Nitrogen —The Major Cause in the Production of Spotted Wheat Fields. P. L. Gamey, M. C. Sewall, and H. E. Myers. Kan. Agr. Expt. Sta. Tech. Bul. 43:1-58.
167	1936	Total Nitrogen as a Factor Influencing Nitrate Accumulation in Soils. P. L. Gamey. Soil Sci. 42:157-163.
168	1936	The Evaporation and Spray Systems of Cooling Cream. W. H. Martin, W. J. Caulfield, A. C. Fay. Kan. Agr. Expt. St. Circ. 180:1-16.
169	1937	The Limitations of Significance of Some of the Methods of Analyzing Ice Cream. "B.W. Hammer, Panegyric." Collegiate Press, Inc., pp. 185-192.
170	1936	The Tolerance of Nitrate by Pure Cultures of Azotobacter. P. L. Gainey, Soil Sci. 42:445-459.
171	1938	Detection of Mastitis by the Brom-Thymol-Blue Test, Leucocyte Chum, and the Microscopic Examination of Incubated Samples of Milk. A. C. Fay, H. W. Cave, and F. W. Atkeson. Cornell Vet. 28:40-50.
. . .	1938	The Composition of Milk as Affected by Mastitis. C. H. Whitnah, W. J. Caulfield, A. C. Fay, and V. D. Foltz. Internat'l Assoc. Milk Dealers Proc. Prod. Sec. 30:19-27. Milk Plant Mo. 11:61 (1937).
172	1937	The Effect of Temperature and Time of Storage of Cream on the Rate and Type of Deterioration. W. H. Martin, A. C. Fay, and W. J. Caulfield. Jour. Dairy Sci. 20:667-678,
173	1938	Comparison of Tryptone-Glucose-Skim Milk and Standard Nutrient Agars as Media for Determining the Total Bacterial Count in Ice Cream. V. D. Foltz and W. H. Martin. Jour. Dairy Sci. 21:289-294.

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Department of Botany

Serial No.	*Year of issue*	*Title, author, and publication*
353	1937	Pythium Root Rot of Milo. Charlotte Elliot, L. E. Melchers, C. L. Lefebvre, and F. A. Wagner, Jour. Agr. Research. 54:797-834.
354	1938	Interrelation of Take-all Lesions on the Crowns, Culms and Roots of Wheat Plants. Hurley Fellows. Phytopathology, 28:191-195.
355	1936	Kansas Botanical Notes, 1935. Frank C. Gates. Trans. Kan. Acad. Sci. 39:85-87.
356	1936	Kansas Mycological Notes, 1935. C. L. Lefebvre and C. O. Johnston. Trans. Kan. Acad. Sci. 39:95-101.
358	1936	Nitrogen Utilization by Ophiobolus Graminis. Hurley Fellows. Jour. Agr. Research. 53:765-769.
359	1937	Inheritance of Resistance to Pythium Root Rot in Sorghum. D. H. Bowman, J. H. Martin, L. E. Melchers and J. H. Parker. Jour. Agr. Research. 55:105-115.
360	1936	A Preserve Unhampered by Man. Frank C. Gates. Trans. Kan. Acad. Sci. 39:89-93.
361	1936	The Stem Rust Epidemic of 1935 in Kansas. C. O. Johnston, L. E. Melchers, H. H. Laude, and J. H. Parker. Plant Disease Reporter Supplement, 92:19-30.
363	1937	Seed Treatment for Grain Smuts. C. L. Lefebvre and J. O. Miller. Kan. Ext. Circ. 127:1-8.
364	1938	Grasses in Kansas. Frank C. Gates. Kan. State Bd. Agr. Rpt. 55:1-349.
365	1938	A Quarter Century (1912-'36) of Meteorological Data, Douglas Lake, Michigan. Frank C. Gates. Papers Mich. Acad. Sci., Arts, and Letters, 23:551-562.
366	1937	Kansas Mycological Notes, 1936. C. O. Johnston, C. L. Lefebvre and E. D. Hansing. Trans. Kan. Acad. Sci. 40:69-74.
368	1937	A Polygamous Spirogyra. Margaret A. Newcomb. Trans. Kan. Acad. Sci. 40:83-87.
369	1938	The Influence of Environmental Conditions at Planting Time on Sorghum Kernel Smut Infection. L. E. Melchers and E. D. Hansing. Amer. Jour. Bot. 25:17-28.
370	1937	Kansas Botanical Notes, 1936. Frank C. Gates. Trans. Kan. Acad. Sci. 40:67-68.
372	1937	Reaction of Certain Varieties of Wheat to Infections of Powdery Mildew at Manhattan, Kansas, 1932-1935. C. O. Johnston, Hurley Fellows, and L. E. Melchers. Plant Dis, Reporter, 21:201-211.
373	1936	A Revision of the Numbers Assigned to Physiologic Races of the Leaf Rust of Wheat, Puccinia triticina Eriks. H. B. Humphrey, C. O. Johnston, and R. M. Caldwell, Mimeographed Report, U. S. Dept, Agr., Div. Cereal Crops and Diseases, pp. 1-14.
374	1937	A Histological Study of Stalk-breaking in Maize. James w. Hunter and Nora E. Dalbey. Amer. Jour. Bot. 24:492-494.
375	1938	Observations on the Loose Kernel Smut of Johnson Grass. C. O. Johnston, C. L. Lefebvre, and E. D. Hansing. Phytopathology, 28:151-152.
376	1936	Suggestions Regarding Preparation of Manuscripts for Publication in the Transactions of the Kansas Academy of Science. F. C. Gates. Trans. Kan. Acad. Sci. 39:399-405.
377	1938	Layering in Black Spruce (Picea mariana (Mill.) BSP.). F. C. Gates. Amer. Midland Nat, 19:589-594.

Department of Chemistry

Serial No.	*Year of issue*	*Title, author, and publication*
195	1936	Sulfur in Eggs. H. K. Marlow and H. H. King. Poultry Sci. 15:377-380.
196	1936	The Change in Concentration of Ovoglobulin in Egg White During Egg Formation. J. S. Hughes and H. M. Scott. Poultry Sci. 15:349-351.
201	1936	The Relationship Between Brain Lipids and Learning Ability of White Rats. O. W. Alm and C. H. Whitnab. Jour. Genetic Psychology, 49:389-403.
203	1936	The Effect of Calcium Ions and Reaction Upon the Solubility of Phosphorus. E. J. Benne, A. T. Perkins, and H. H. King. Soil Sci. 42:29-38.

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Serial No.	*Year of issue*	*Title, author, publication*
204-a.	1936	The Location of the Antienzyme in Egg White. J. S. Hughes, H. M. Scott, and J. Anteleyes. Indus. and Engin. Chem. (Analytical Edition) 8:310-311.
205	1937	Augmentation of Nitrogen to the Egg White after the Formation of the Shell Membranes in the Fowl. H. M. Scott, J. S. Hughes, and D. C. Warren. Poultry Sci. 16.53-61.
206	1936	Reproductive Capacity of Female Rats as Affected by Kinds of Carbohydrates in the Ration. C. H. Whitnah and Ralph Bogart. Jour. Agr. Research, 53:527 532.
207	1936	Fat as a Factor in Palatability of Beef. D. L. Mackintosh and J. Lowe Hall. Trans. Kan. Acad. Sci. 39:5358.
210	1936	Base Exchange in Soil Separates and Soil Fractions (Sand and Silt). H. H. King and A. T. Perkins. Soil Sci. 42:323-326.
211	1937	Variations in the Vitamin C Content of Milk. C. H. Whitnah and W. H. Riddell. Jour. Dairy Sci. 20:9-14.
212	1937	Determination of Carotene in Forage: A. Modification of the Guilbert Method. W. J. Peterson, J. S. Hughes, and H. F. Freeman. Indus. and Engin. Chem. (Analytical Edition) 9:71-72.
213	1937	Fluctuations of Calcium and Inorganic Phosphorus in the Blood of the Laying Hen During a Single Egg Cycle. J. G. Feinberg, J. S. Hughes, and H. M. Scott. Poultry Sci. 16:132-134.
214	1937	The Relation of the Carotenoid Pigment of Feed to the Carotenoid Pigments of Egg Yolks. J. S. Hughes and L. F. Payne. Poultry Sci. 16:135-138.
215	1937	Replaceable Base Determinations by Electro-Migration. H. H. King, M. J. Caldwell, and A. T. Perkins. Soil Sci. 43:311-316.
216	1936	Some Observations Pertaining to Tenderness of Beef. D. L. Mackintosh, J. L. Hall, and Gladys Vail. Amer Soc. Anim. Prod. Proc. 1936, pp. 285-289.
220	1937	Recovery of Carotene and Vitamin A in Butter When CowsWhere Fed Unlimited Quantities of Green Rye. F. W. Atkeson, J. S. Hughes, Bernice L. Kunerth, W. J. Peterson, and Martha M. Kramer. Jour. Nutrition. 14:62-629.
221	1937	Observations on the Carotene Content of Some Typical Pasture Plants. F. W. Atkeson, W. J. Peterson, and A. E. Aldous. Jour. Dairy Sci. 20:557-562.
222	1937	Biological Assay of Milk with Lactoflavin as a Standard for Vitamin G. Bernice L. Kunerth, Martha M. Kramer, Sister Regina Marie Dickman, and C. H. Whitnah. Trans. Kan. Acad. Sci. 40:-297-299.
223	1937	A Rapid Method for the Determination of Lactoflavin in Milk C. H. Whitnah, M. M. Kramer, and B. L. Kunerth. Jour. Amer. Chem. Soc. 59:1153-1154.
225	1938	The Formation of the Chalazae and Inner Thin White in the Hen's Egg. R. M. Conrad and R. E. Phillips. Poultry Sci. 17:143-146
226	1937	The Effect on Growing Pigs of Rations Containing Different Levels of Phosphorus in the Absence of Vitamin D. C. E. Aubel and J. S. Hughes. Amer. and Soc. Anim. Prod. Proc. 1937. pp. 334-340.
227	1937	Comparative Analyses of Molasses. A. T. Perkins and J. F. Merrill. Trans. Kan. Acad. Sci. 40:131.133.
229	1937	Humidity and Specific Gravity of Soil Particles. A. T. Perkins, LeRoy Horne, and H. H. King. Trans, Kan Acad. Sci. 40:127-129.
230	1936	The Composition of Milk as Affected by Mastitis. C. H. Whitnah, W. J. Caulfield, A. C. Fay, and V. D. Foltz, Internat'l Assoc, Milk Dealers Proc. Prod. Sec. 30:19-27 Milk Plant Mo. 11:61 (1937).

Department of Dairy Husbandry

Serial No.	*Year of issue*	*Title, author, and publication*
107	1936	The Evaporation and Spray Systems of Cooling Cream. W. H. Martin, W. J. Caulfield, and A. C. Fay. Kan. Agr. Expt. Sta. Circ. 180:1-16.
108	1937	Variations in the Vitamin C Content of Milk. C. H. Whitnah and W. H. Ridden. Jour. Dairy Sci. 20:9-14.
109	1937	Vitamin A Activity of Butters Determined by Various Methods. Sister M. Etbelburg Leuschem, B. L. Kunerth, M. M. Kramer, and W. H. Riddell. Jour. Nutrition, 14:247-259.

Historical Document
Kansas Agricultural Experiment Station

Serial No.	Year of issue	*Title, author, and publication*
110	1937	Recovery of Carotene and Vitamin A in Butter When Cows Were Fed Unlimited Quantities of Green Rye. F. W. Atkeson, J. S. Hughes, B. L. Kunerth, W. J. Peterson, and M. M. Kramer. Jour. Nutrition, 14:621-629.
111	1937	Observations on the Carotene Content of Some Typical Pasture Plants. F. W. Atkeson, W. J. Peterson, and A. E. Aldous. Jour. Dairy Sci. 20 557-562.
112	1937	Power Requirements for Freezing Ice Cream. W. J. Caulfield, C. K. Otis, and M. H. Martin. Jour. Dairy Sci. 20:645-655.
113	1938	The Vitamin A Value of Colostrum and Milk of Four Cows Determined by the Single-feeding Method. M. M. Kramer, M. D. Bair, B. L. Kunerth, and W. H. Riddell. Jour. Agr. Research, 50:227-232.
114	1938	Vitamin G (Riboflavin) Content of Colostrum and Milk of Cows Determined Biologically. M. M. Kramer, Inez Gardner, B. L. Kunerth, and W. H. Riddell. Jour. Agr. Research, 56:233-238.
115	1938	Detection of Mastitis by the Brom-Thyniol-Blue Test, Leucocyte Count, and the Microscopic Examination of Incubated Samples of Milk. A. C. Fav, H. W. Cave, and F. W. Atkeson. Cornell Vet. 28:40-50.
116	1937	The Effect of Temperature and Time of Storage of Cream on the Rate and Type of Deterioration. W. H. Martin, A. C. Fay, and W. J. Caulfield. Jour. Dairy Sci. 20:667-678.
119	1938	Some Observations on the Vitamin A Value of Butter Produced Under Drought Conditions. Bernice L Kunarth and W. H. Riddell. Jour. Dairy Sci. 21:41-44.
120	1938	An Evaluation of Several Methods of Cooling Cream. W. J. Caulfield and W. H. Martin. Jour. Dairy Sci. 21:13-20.
121	1938	Comparison of Tryptone-Glucose-Skim Milk and Standard Nutrient Agars as Media for Determining the Total Bacterial Count in Ice V. D. Foltz and W. H. Martin. Jour. Dairy Sci. 21:289-294.
. . .	1938	The Composition of Milk as Affected by Mastitis. C. H. Whitnah, W. J. Caulfield, A. C. Fay, and V. D. Foltz Intenat'l Assoc. Milk Dealers Proc. Prod. Sec. 30:1927. Milk Plant Mo. 11:61 (1937).

Department of Entomology

Serial No.	*Year of issue*	*Title, author, and publication*
415	1936	The Family Apioceratidae (Diptera) in North America. R. H. Painter. Kan Univ. Sci. Bul. 24:187-203.
431	1936	The Red Spider and the Clover Mite. Geo. A. Dean. Kan. State Hort. Soc. Bien. Rpt. 43:90-101.
432	1936	The Relation of Codling-Moth Bait Traps to Proper Spray Dates. P. G. Lamerson. Kan. State Hort. Soc. Bien. Rpt. 43:48-53.
433	1936	Substitutes for Arsenate of Lead Used as Sprays for Codling-Moth Control During the Season of 1934. R. L. Parker and P. G. Lamerson. Kan. State Hort. Soc. Bien. Rpt. 43:54-59.
435-a	1937	The Resistance of Sorghums to the Chinch Bug. R. O. Snelling W. M. Osborn, R. H. Painter, and J. H. Parker. U. S. Dept. Agr. Tech. Bul. 585:1-56.
440	1936	Substitutes for Arsenate of Lead Used as Sprays for Codling-Moth Control During the Season of 1935. R. L. Parker and P. G. Lamerson, Kan. State Hort. Soc. Bien. Rpt. 43:60-64.
442	1936	The Food of Insects and Its Relation to Resistance of Plants to Insect Attack. R. H. Painter. Amer. *Naturalist, 70:* 547-566.
443	1936	The Fifth Annual Summary of the Population of the More Important Insects in Kansas, Covering the Year 1935. R. C. Smith and E. G. Kelly. Trans. Kan. Acad. Sci. 39:129-149.
. . .	1936	Flour Mill Insects and Their Control. G. A. Dean, R. T. Cotton, and G. B. Wagner. U. S. Dept. Agr. Circ. 390:1-34.
445	1937	The Life History and Control of the Boxelder Bug in Kansas. R. C. Smith and Byron LeRoy Shepherd. Trans. Kan. Acad. Sci. 40:143-159.

Historical Document
Kansas Agricultural Experiment Station

Serial No.	*Year of issue*	*Title, author, and publication*
447	1937	Observations on the Biology of the Wheat Stem Maggot in Kansas. Merle W. Allen and R. H. Painter. Jour. Agr. Research, 55:215-238.
449	1938	Notes on an Interesting Food Habit of False Wireworm Adults. H. H. Walkden and H. R. Bryson. Jour. Kan. Ent. Soc. 11:10-13.
451	1937	The Sixth Annual Insect Population Summary of Kansas, Covering the Year 1936 R. C. Smith and E. G. Kelly. Jour. Kan. Ent. Soc. 10:113-132.
452	1938	Differntial Feeding of Grasshoppers on Corn and Sorghums. A. M. Brunson and R. H. Painter. Jour. Amer. Soc. Agron. 30:334-346.
456	1938	A Pest of the Apple Tree in the Lower Missouri River Valley Region Ornix prunivorella Chamb. (Lepidoptem, Tineidae). L. M. Copenhafer and R. L. Parker. Jour. Kan. Ent. Soc. 11:37-53.
457	1938	The Seventh Annual Insect Population Summary of Kansas, Covering the Year 1937. R. C. Smith and E. G. Kelly. Jour. Kan. Ent. Soc. 11:54-76.

Department of Home Economics

Serial No.	*Year of issue*	*Title, author, and publication*
47	1938	Aminal Products as Sources of Protein, Calcium, and Phosphorus in the Human Diet. M. M. Kramer and Isabelle Gillum. Jour. Amer. Dietetics Assoc. 14:256-260.
48	1936	Vitamin A and Carotene Determinations on a Sample of Commercial Butter. B. L. Kunerth and Sister Ethelburg Leuschen. Trans. Kan. Acad. Sci. 39:191-195.
49	1936	Some Observations Pertaining to Tenderness of Beef. D. L. Mackintosh, J. L. Hall, and Gladys Vail. Amer. Soc. Anim. Prod. Proc. 1936, pp. 285-289.
51	1937	The Composition of Certain Beef Cuts as Affected by Grade, Location in Cut, and Method of Cooking. Miriam Rogers, Isabelle Gillum, Bernice L. Kunerth, Martha S. Pittman. Jour. Amer. Dietetics Assoc. 13:320-324.
52	1937	Some Data on the Composition of Cooked Beef Rib Roasts. Alice Brill, Bernice L. Kunerth and Martha S. Pittman. Jour. Amer. Dietetics Assoc. 13:382-384.
53	1937	Vitamin A Activity of Butters Determined by Various Methods. Sister M. Ethelburg Leuschen, Bernice L. Kunerth, Martha M. Kramer, and W. H. Riddell. Jour. Nutrition, 14:247-259.
64	1937	Recovery of Carotene and Vitamin A in Butter When Cows Were Fed Unlimited Quantities of Green Rye. F. W. Atkeson, J. S. Hughes, B. L. Kunerth, W. J. Peterson, and M. M. Kramer. Jour. Dairy Sci. 14.621-629.
65	1937	Biological Assay of Milk with Lactoflavin as a Standard for Vitamin G. B. L. Kunerth, M. M. Kramer, Sister Regina Marie Dickman, and C. H. Whitnah. Trans. Kan. Acad. Sci. 40:297-299.
66	1937	Endometrial Hyperplasia as Observed in Experimental Guinea Pigs. Olga Saffry, Mary T. Harman, and M. M. Kramer. Trans. Kan. Acad. Sci. 40:389-390 Jour. Home Econ. 29:569
67	1937	A Rapid Method for the Determination of Flavin in Milk. C. H. Whitnah, M. M. Kramer, and B. L. Kunerth. Jour. Amer. Chem. Soc. 59:1153-1154.
69	1938	The Vitamin A Value of of Colostrum and Milk of Four Cows Determined by the Single-Feeding Method. M. M. Kramer, Margaret D. Barn, Bernice L. Kunerth, and W. H. Riddell. Jour. Agr. Research, 56:227-232.
70	1938	Vitamin G (Riboflavin Content of Colostrum and Milk of Cows Determined Biologically. M. M. Kramer, Inez Gardner, B. L. Kunerth, and W. H. Riddell. Jour. Agr. Research, 56:233-238.
74	1938	Some Observations on the Vitamin A Value of Butter Produced L-rider Drought Conditions. Bernice L. Kunerth and W. H. Riddell. Jour. Dairy Sci. 21:41-44.
75	1938	Lack of Vitamin C in the Diet and Its Effect on the Jaw Bones of Guinea Pigs. M. T. Hat-man, M. M. Kramer, and H. D. Kirgis. Jour. Nutrition, 15:277-284.

Historical Document
Kansas Agricultural Experiment Station

Department of Horticulture

Serial No.	Year of issue	Title, author, and publication
...	1936	Rock Gardens. L. R. Quinlan. Kan. State Hort. Soc. Bien. Rpt. 43:175-178.
...	1936	Lawns for Kansas. L. R. Quinlan. Kan. State Hort. Soc. Bien. Rpt. 43:179-181.
...	1936	Drought Injury to Ornamental Trees. L. R. Quinlan. Kan. State Hort. Soc. Bien. Rpt. 43:197-202.
127	1936	Kansas Horticultural Scciety Needs a Broader Program. R. J. Barnett. Kan. State Hort. Soc. Bien. Rpt. 43:13-19.
128	1936	Chemically Treated Codling Moth Bands. G. A. Filinger. Kan. State Hort. Soc. Bien. Rpt. 43:64-67.
133	1936	The Grower Pays. R. J. Barnett. Kan. State Hort. Soc. Bien. Rpt. 43:117-121.
137	1937	Home Vegetable Gardening in Kansas. W. B. Balch. Kan. Agr. Expt. Sta. Circ. 181:1-45.
138	1937	House Plants and Their Care. W. B. Balch. Kan. Agr. Expt. Sta. Circ. 184:1-16.
139	1937	Hotbeds for Kansas. W. B. Balch and F. C. Fenton. Kan. Agr. Expt. Sta. Circ. 183:1-29.
142	1937	The Relationship Between the Internal Structure and Photosynthetic Behavior or Apple Leaves. W. F. Pickett. Kan. Agr. Expt. Sta. Tech. Bul. 42:1-58.
143	1938	"As It Was in '85." R. J. Barnett. Kan. State Hort. Soc. Bienn. Rpt. 44:13-15.
144	1938	An Account Book is a Fruit Grower's Road Map. G. A. Filinger. Kan. State Hort. Soc. Bien. Rpt. 44:58-60.
145	1936	Garden Fertilizers. W. B. Balch. Kan. State Hort. Soc. Bien. Rpt. 43:182-183.
147	1937	Ground Cover Affects Frost Penetration. R. J. Barnett. Trans. Han. Acad. Sci. 40:203-207.
149	1938	The Story of an Orchard. W. F. Pickett. Kan. State Hort. Soc. Bien. Rpt. 44:43-48.
150	1937	The Chlorophyll Content of Wealthy and York Apple Leaves. W. F. Pickett. Amer. Soc. Hort. Sci. Proc. 35:251-252.
...	1938	The Nurseryman's Library. G. A. Filinger. Agr. Library Notes, U. S. Dept. Agr., 13:55-57. Amer. Nurseryman, 67:9. Florists' Exch. and Hort. Trade World, 90:24.
...	1938	Whence Come the Orchard Pests? G. A. Filinger. Midwest Fruitman. Vol. 11, No. 9, pp. 3-5.
...	1938	What Orchard Records Should We Keep This Year? G. A. Filinger. Midwest Fruitman Vol. 11, No. 10, pp. 3-4.
	1938	Dressings for Pruning Wounds. G. A. Filinger. Midwest Fruitman. Vol. 11, No. 11, pp. 3-4.
...	1938	Summer Pruning of Brambles. G. A. Filinger. Midwest Fruitman. Vol. 11, No. 12, p. 3.

Department of Milling Industry

Serial No.	Year of issue	Title, author, and publication
48	1936	Some Facts Concerning Vacuum Oven Moisture Determinations. J. E. Anderson. Cereal Chem. 13:437:452.
52	1936	The Chemistry of Phosphatides and Their Utilization in Industry. Earl B. Working. Oil and Soap, 13:261-263.
...	1936	Bakers' Flour. R. J. Clark. Bul. Assoc. Oper. Milers, August, 1936, pp. 733-735.
53	1937	Factors Which Influence Results in the Wheat-Meal-Time Farmentation Test. C. O. Swanson. Cereal Chem. 14:419-433.
...	1936	The Tin God Ash. R. J. Clark. Bul. Assoc. Oper. Millers, October, 1936, pp. 742-745.

Department of Poultry Husbandry

Serial No.	Year of issue	Title, author, and publication
89	1936	Linkage Relations of Crest, Dominant White and Frizzling in the Fowl. D. C. Warren and F. B. Hutt (Univ. of Minn.). Amer. Nat. 70:379-394.
92	1936	The Change in the Concentration of Ovoglobulin in Egg White During Egg Formation. H. M. Scott, and J. S. Hughes. Poultry Sci. 15:349-351.
93	1937	Turkey Production in Kansas. H. M. Scott. Kan. Agr. Expt. Sta. Bul. 276:1-95.

Historical Document
Kansas Agricultural Experiment Station

Serial No.	*Year of issue*	*Title, author, and publication*
94	1936	Influence of Light on Ovulation in the Fowl. D. C. Warren and H. M. Seott. Jour. Expt. Zoö1. 74:137-156.
95	1936	Influence of Ovulation Rate on the Tendency of the Fowl to Produce Eggs in Clutches. H. M. Scott and D. C. Warren. Poultry Sci. 15:381-389.
96	1936	The Location of the Antienzyme in Egg White. J. S. Hughes, H. M. Scott, and J. Antelyes. Indus. and Engin. Chem. (Analytical Edition). 8:310-311.
97	1937	Augmentation of Nitrogen to the Egg White after the Formation of the Shell Membrances in the Fowl. H. M. Scott, J. S. Hughes, and D. C. Warren. Poultry Sci. 16:53-61.
98	1936	Egg Size in Relation to Growth of Narragansett Turkeys. H. M. Scott and R. E. Phillips. Poultry Sci. 15:435-438.
99	1937	Physiologic and Genetic Studies of Crooked Keels in Chickens. D. C. Warren. Kan Agr. Expt. Sta. Tech. Bul. 44:1-32.
102	1937	Ligh in Relation to the Experimental Modification of the Breeding Season of Turkeys. H. M. Scott and L. F. Payne. Poultry Sci. 16:90-96.
103	1937	Fluctuations of Calcium and Inorganic Phosphorus in the Blood of the Laying Hen During a Single Egg Cycle. J. G. Femberg, J. S. Hughes, and H. M. Scott. Poultry Sci. 16:132-134.
104	1937	The Relation of the Carotenoid Pigments of Feed to the Carotenoid Piments of Egg Yolks. J. S. Hughes and L. F. Payne. Poultry Sci. 16:135-138.
105	1937	Observation Concerning the Mechanics of Ovulation in the Fowl. R. E. Phillips and D. C. Warren. Jour. Expt. Zoöl. 76:117-136.
106	1937	The Lethal Nature of Flightlessness in the Fowl. D. C. Warren. Jour. Heredity, 28:17-18.
107	1938	Studies on the Physiology and Inheritance of Feathering in the Growing Chick. M. H. Radi and D. C. Warren. Jour. Agr. Research, 56:679-705.
108	1938	The Formation of the Chalazae and Inner Thin White in the Hen's Egg. R. M. Conrad and R. E. Phillips. Poultry Sci. 17:143-146.
109	1938	A Heritable Variation of Feather Structure in the Fowl. D. C. Warren. Jour. Heredity, 29:91-93.

Department of Veterinary Medicine

Serial No.	*Year of issue*	*Title, author, and publication*
64	1936	*Two* Cases of Infection Due to Clostridium Histolyticus in the Horse. J. P. Scott and E. R. Frank. Cornell Vet. 26:252-257.
. . .	1938	One Thousand Cows Testing Suspicious (1-50) to the Bang Agglutination Test and Their Subsequent Test Behavior. C. H. Kitselman. Jour. Amer. Vet. Med. Assoc. 42 (n. s.): 678-680.
. . .	1937	The Action of Preservatives and Salts on Blackleg Cultures. J. P. Scott. Jour. Infect. Diseases, 61:103-109.
67	1938	Studies in. Anaplasmosis. Herman Farley. Kan Agr. Expt. Sta. Rpt. 1:1-32.
71	1937	Allergic Dermatitis. E. J. Frick and E. E. Leasure. Cornell Vet. 27:331-337.

Department of Zoölogy

Serial No.	*Year of issue*	*Title, author, and publication*
. . .	1937	Culturing Parasitic Nematode Larvae from Silphids and Related Insects. C. G. Dobrovolny. In culture Methods for Invertebrate Animals. James G. Needham. Ithaca. N. Y., Comstock Publishing Co. p. 173.
. . .	1937	Culture Methods for the Grouse Locusts. R. K. Nabours. In Culture Methods for Invertebrate Animals. James G. Needham. Ithaca, N. Y., Comstock Publishing Co. pp. 292-294.
154-a	1937	Endometrial Hyperplasia as Observed in Experimental Guinea Pigs. Olga Saffry, Mary T. Harman, and Martha M. Kramer. Trans. Kan. Acad. Sci. 40:389-390. Jour. Home Econ. 29:569.
161-a	1938	Lack of Vitamin C in the Diet and Its Effect on the Jaw Bones of Guin a Pigs. Mary T. Harman, Martha M. Kramer, and Homer D. Kirgis. Jour. Nutrition, 15:277-284
166	1938	On the Nutrition of the Fowl Nematode Ascaridia lineata (Schneider). Amer. Micos. Soc. Trans. 57:218-222.
168	1936	Some Observations on the Development of the Teeth of *Cavia Cobaya*. Mary T. Harman and Arlene Smith. Anat. Rec. 66.97-111.
. . .	1936	Further Studies in Ascarid Nutrition. (Abstract). J. E. Ackert and A. E. Freeman, Jr. Jour. Parasitol. 22:531.

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Kansas Agricultural Experiment Station

Serial No.	*Year of issue*	*Title, author, and publication*
. . .	1936	Resistant and Susceptible Groups of White Leghorn Chickens to the Nematode *Ascaridia lineata* (Schneider). (Abstract). J. E. Ackert, I. Pratt, and A. E. Freeman, Jr. Anat. Rec. (Supplement No. 1) 67:130.
. . .	1936	The House Fly and Fowl Tapeworm Transmission (Abstract). J. E. Ackert and W. M. Reid. Jour. Parasitol, 22:543.
. . .	1937	Culturing Eggs of the Fowl Nematode *Ascaridia lineata.* J. E. Ackert. *In* Culture Methods for Invertebrate Animals. James G. Needham. Ithaca, N. Y., Comstock Publishing Co. pp. 171-172.
170	1936	Methods and Results of Breeding the *Tetriginae* (Grouse Locusts). R. K. Nabours. *In* Biological Methods. James G. Needham. Ithaca, N. Y., Comstock Publishing Co. pp. 292-294.
172	1936	The Effect of Antuitrin Growth Injections on Female Albino Rats Fed a Diet Deficient in Vitamin A. E. J. Wimmer and J. C. Ayers. Trans. Kan. Acad. Sci. 39:391-393.
173	1936	Species from the Genetic Standpoint. R. K. Nabours. Amer, Nat. 70:191-192.
179	1937	Further Observations on Reproduction in Guinea Pigs Fed Vitamin C at Different Levels. Mary T. Harman and Isabelle Gillum. Trans. Kan. Acad. Sci. 40:369-376.
180	1937	*Metorchis Albidus,* A Dog Fluke New to North America. A. E. Freeman, Jr., and J. E. Ackert. Amer. Micros. Soc. Trans. 56:113-115.
181	1937	The Cysticercoid of *Choanotaenia infundibulum* (Bloch.) and the House Fly as Its Host. W. M. Reid and J. E. Ackert. Amer. Micros. Soc. Trans. 56:99-104.
183	1937	Paraffin Block Trimmer. G. E. Cauthen. Science, 86:248.
184	1937	Some Effects of Adrenalectomy in Fowls. E. H. Herrick and Olaf Torstveit. Endocrinology. 22:469-473.
190	1938	Observations on the Ossification of the Foot-Bones In Polydactyl and Normal Chicks. Mary T. Harman and Annette Alsop. Amer. Nat. 72:59-76.
193	1938	Studies on the Life History and Biology of the Fowl Tapeworm *Raillietina cesticillus* (Molin). W. M. Reid, J. E. Ackert and A. A. Case. Amer. Micros. Soc. Trans. 57:65-76.

Director's Office

Serial No.	*Year of issue*	*Title, author, and publication*
54	1936	The Planning and Coördination of Research Projects. L. E. Call. Assoc. Land-Grant Colleges and Univs. Proc., 1935. 49 91-95.
56	1936	Reaction of Sorghums to the Root, Crown, and Shoot Rot of Milo. F. A. Wagner. Jour. Amer. Soc. Agron. 28:643-654.
57	1936	Information Regarding Recent Publication. Kan. Agr. Expt. Sta. Circ. 179:1-2.
58	1937	Eighth Bienmal Report of Director, Kansas Agricultural Experiment Station, 1934-'36. L. E. Call. pp. 1-144.
59	1937	Safeguards Against Drought: Storing Surplus Feed. L. E. Call. Kan. State Bd. Agr. Quart. Rpt. 56:53-61.
60	1937	In formation Regarding Requests for Publications of the Agricultural Experiment Station. Director's Office. Kan. Agr. Expt. Sta. Circ. 182:1-3.
61	1938	What are the Limitations to More Interstate Coöperation in Research in Agriculture and Flame Economics. L. E. Call. Assoc. Land-Grant Colleges and Univs. Proc., 1937. 51:151-153.
62	1938	Information Regarding Recent Publications Kan. Agr. Expt. Sta. Circ. 189:1-4
63	1938	Publications Available from the Agricultural Experiment Station. Director's Office. Kan. Agr Expt. Sta. Circ. 190:1-4.

Fort Hays Branch Experiment Station

Serial No.	*Year of issue*	*Title, author, and publication*
21	1936	Effect of Germination and Seed Size on Sorghum Stands. A. F. Swanson and Robert Hunter. Jour. Amer. Soc. Agron. 28:997-1004.
23	1937	Reducing the Risk in Wheat Farming in Western Kansas. A. L. Hallsted. Kan. State Bd. Agr. 30th Bien. Rpt. 35:98-111.
24	1938	Methods of Eradicating Bindweed. F. L. Timmons. Kan. State Bd. Agr. Quart. Rpt. 42:102-112.

Historical Document
Kansas Agricultural Experiment Station

Serial No.	Year of issue	Title, author, and publication
27	1938	Bindweed Control inm Western Kansas. F. L. Timmons. Mimeographed Report, U. S. Dept. Agr., Div. Cereal Crops and Diseases, pp. 1-4.
	1938	Beef Cattle Investigations, 1937-'38, Fort Hays Branch Experiment Station. C. W. McCampbell and L. C. Aiecher. 26th Ann. Rpt. Beef Cattle Investigations, 1937.'38, Fort Hays Branch Expt. Sta.

FINANCIAL STATEMENT, 1936-'37

(The Kansas Agricultural Experiment Station in account with federal and state appropriation)

	Federal appropriations	*State appropriations and receipts*	*Totals*
Main station	$115,025.48	(a) $56,702.81	$171,728.29
Branch stations, appropriations		(b) 65,452.02	65.452.02
Branch stations, sales		66,708.95	66,708.95
Totals	$115.025.48	$188,863.78	$303,889 26
Personal services	$99,001.61	$91,951.73	$190,953.36
Supplies and materials	6.434.43	26,672.84	33,107.27
Communication service	44.73	2,288.35	2,333.08
Travel expenses	820.48	4,152.32	4,972.80
Transportation of things	11.55	1,523.89	1,535.44
Publications	305.27	1,179.72	1,484 99
Heat, light, water, and power	17.87	6,976.99	6,944.86
Contingent expenses	35.79	576.62	612.41
Equipment	4,575.93	19,840.14	24,416.07
Buildings and land	3,777.80	11,882.93	15,660.73
Balance		21,818.25	21,818.25
Totals	$115,025.48	$188,863.78	$303,889.26

(a) Includes a balance on hand June 30, 1936, of $7,538.81.
(b) Includes a balance on hand June 30, 1936, of $4,244.61.

FINANCIAL STATEMENT, 1937-'38

(The Kansas Agricultural Experiment Station in account with federal and state appropriations)

	Federal appropriations	*State appropriations and receipts*	*Totals*
Main station	$127,538.22	(a) $60,510.28	$188,048 50
Branch stations, appropriations		(b) 80,005.45	80,005.45
Branch stations, sales		64,300.64	64,300.64
Totals	$127,538.22	$204,816 37	$332,354.59
Personal services	$102.693 00	$98,133.08	$200,826.08
Supplies and materials	6,559.76	26,778.29	33,338.05
Communication service	16.83	2,214.88	2,231.71
Travel expenses	629.47	4,967.10	5,596.57
Transportation of things	11.79	2.054 03	2,065.82
Publications	199.76	1,973.21	2,172.97
Heat, light, water, and power	37.48	6,479 22	6,516.70
Contingent expenses	17.99	626.15	644.14
Equipment	3,110.53	20.613.25	23,723.78
Buildings and land	14.261.61	8,789.43	23,051.04
Balance		32,187.73	32,187.73
Totals	$127.538.22	$204.816 37	$332.354.59

(a) Includes a balance on hand June 30, 1937, of $10.750.28.
(b) Includes a balance on hand June 30, 1937, of $6.840.45.

17-6053

10-6053