

Historical Document
Kansas Agricultural Experiment Station

AGRICULTURAL EXPERIMENT STATION

KANSAS STATE AGRICULTURAL COLLEGE
MANHATTAN, KANSAS

FIFTH BIENNIAL REPORT OF THE DIRECTOR 1928-1930



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* On leave.

LETTER OF TRANSMITTAL

OFFICE OF THE DIRECTOR,
June 30, 1930.

To His Excellency, Clyde M. Reed, Governor of Kansas:

I have the honor to submit herewith the report of the Agricultural Experiment Station of the Kansas State Agricultural College for the biennium ending June 30, 1930. The report includes a brief statement of the work in progress during this period, changes in personnel of the station staff, a list of publications of the station and of the scientific contributions of the station staff, and a statement of receipts and expenditures of the biennium under review.

L. E. CALL, *Director.*

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DIRECTOR'S REPORT

INTRODUCTION

The work of the Agricultural Experiment Station, including the four branch stations, during the biennium ending June 30, 1930, has been conducted upon the project basis as previously reported. The projects included studies in five distinct fields of rural endeavor, as follows: Studies in rural economics, studies in soil conservation, investigations in the plant industries, investigations in the animal industries, and studies in home economics. In the report which follows mention is made of each of the more important projects conducted during the biennium, and the results secured are briefly summarized.

COÖPERATION WITH OTHER AGENCIES

As research in the field of agriculture progresses and the problems to be solved become more difficult, the need for coöperative effort between the departments within the station and between the station and other research and regulatory agencies becomes increasingly more desirable and necessary. The station has been fortunate in having helpful coöperative relationships during the past biennium with a number of related agencies. In fact at no time in the history of the station has as much work been undertaken coöperatively.

The coöperative work with the United States Department of Agriculture has been continued and somewhat increased. During the past biennium it has included investigations relating to: Small grain production and breeding, corn breeding, and the control of cereal diseases with the Office of Cereal Crops and Diseases; dry-land agriculture with the Office of Dry-land Agriculture; alfalfa improvement, the control of alfalfa diseases, and forage crops and turf grasses with the Office of Forage Crops and Diseases of the Bureau of Plant Industry; a soil survey of four counties with the Division of Survey of the Bureau of Chemistry and Soils; a study of soil and water conservation with the Division of Agricultural Engineering of the Bureau of Public Roads and the Division of Soil Erosion Investigation of the Bureau of Chemistry and Soils; a study of factors influencing the palatability and quality of meat with the Division of Animal Husbandry; a study of anaplasmosis of cattle with the Pathological Division of the Bureau of Animal Industry; the propagation and distribution of forest trees with the Forest Service; and farm organization, cost of production, land utilization, wheat marketing, and hay storage and grading in coöperation with the Bureau of Agricultural Economics.

1. Contribution No. 44 from the director's office.

Coöperative relations have been continued with the Kansas State Board of Agriculture in connection with regulatory activities of the board. The station has continued to provide facilities for analytical determinations of feeding stuffs, live-stock remedies, fertilizers, and dairy products, and has maintained in coöperation with the board a state seed-testing laboratory. The station has coöperated with the office of the state live-stock sanitary commissioner in an investigation of a new disease of cattle and in a study of flies troublesome to live stock. Coöperative research in a limited way has also been undertaken on industrial projects with a number of commercial agencies.

SUPPORT FROM PURNELL FUNDS

The Purnell act authorized a federal appropriation for the support of the Agricultural Experiment Station of \$20,000 for the fiscal year ending June 30, 1926, with increases of \$10,000 annually until the fiscal year ending June 30, 1930, when an appropriation of \$60,000 was made. Hence, no further increases in this fund will be received. The Purnell act particularly authorizes investigation in the fields of agricultural economics, rural life, and home economics, as well as support for investigational work "bearing directly upon the production, manufacture, preparation, use, distribution, and marketing of agricultural products." The fund for the past year was expended as follows: Investigational work in agricultural economics, including marketing, 25 per cent; investigational work in home economics, 20 per cent; and other kinds of investigational work of the station, 55 per cent.

STATION REPORTS

The Kansas Agricultural Experiment Station was organized by action of the Board of Regents of the Kansas State Agricultural College on February 8, 1888. The first report of the station was for the year 1888 and included a financial statement to June 30 of that year. Following this, the first annual report, reports were published annually until 1908, when the twenty-first annual report covering the work of the fiscal year ending June 30, 1908, was published. The annual reports for this period were numbered consecutively from one to twenty-one. For the period July 1, 1908, to June 30, 1913, the customary station reports were not issued. For this period brief reports were published in the sixteenth, seventeenth, and eighteenth biennial reports of the Board of Regents for the period, July 1, 1907, to June 30, 1912, and in the first biennial report of the State Board of Administration for the biennium ending June 30, 1914. The publication of annual reports was resumed in 1914, when a report for the fiscal year ending June 30, 1914, was published. Following this issue annual reports were published regularly until 1920, when the last annual report was issued.

Beginning with the biennium July 1, 1920, to June 30, 1922,

reports have been issued biennially, making this the fifth biennial report. Since the publication of the twenty-first annual report in 1908, the station reports have not been numbered. Starting with this report numbering will be resumed, this report being designated the fifth biennial report of the station.

BUILDINGS AND EQUIPMENT

The only building of major importance constructed during the biennium was the new institutional power plant, which was finished in 1929 and which increased the electrical power facilities for a number of the departments of the station; thus alternating current was provided for the laboratories of the Department of Milling Industry and Agronomy and for the first time electrical energy was provided by the college power plant for the Poultry Farm.

Minor buildings constructed during the biennium include a sheep nutrition laboratory for the Department of Animal Husbandry, constructed at a cost of \$2,200. The building is 24 feet deep and 136 feet long. Besides a weighing and feed room in the center, it contains 10 compartments each 12 by 20 feet opening into lots 12 by 40 feet. This equipment will enable the station to renew its study of sheep feeding and nutrition problems, many of which are quite pressing at this time.

A greenhouse used by the Department of Horticulture for the growing of tropical and other ornamental plants was reconstructed at a cost of \$4,700. An entire new superstructure was erected upon the foundation of an old house. The greenhouse consists of a central part 25 feet square with a height of 16 feet. Two wings each 18 1/2 feet by 41 1/2 feet connect with the center.

Three residences of the Fort Hays Branch Experiment Station and two at the Colby Branch Experiment Station were remodeled, made modern, and placed in excellent condition for the employees of the stations. New construction during the biennium included also a new five-span concrete bridge, 24 feet wide and 160 feet long, across Deep creek at the Fort Hays Branch Station, at a cost of \$12,500. The bridge is of excellent construction both architecturally and structurally, is built to withstand a load of 20 tons, and will greatly facilitate the movement of power machinery at the station.

New equipment constructed during the biennium includes a combined harvester-thresher suitable for use in harvesting experimental plats. This combine, developed by L. C. Aicher and A. L. Hallsted, of the Fort Hays Branch Station, has been successfully used for harvesting one-tenth-acre plats. By its use the cost of harvesting and threshing has been reduced 75 per cent, with a corresponding saving in time, and the plats are left with a high stubble and with the straw scattered over the ground as is the case under practical farm conditions. The latter is considered especially important, since the advent of the combine has introduced new problems which could not be solved by the old style of ex-

perimentation in which plats were cut with a binder and the straw removed.

A new irrigation plant has been installed at the Garden City Branch Experiment Station under conditions where the depth to water is approximately 12 feet. Six wells, 16 inches in diameter, varying from 43 to 51 feet in depth and spaced 75 feet apart, are connected by a horizontal suction line to a 6-inch single-stage, double-suction, ballbearing centrifugal pump designed to deliver 1,000 gallons of water per minute. The pump is driven by a 20-horsepower electric motor. The cost of the irrigation plant, including wells, pump, motor, suction header, 600 feet of 10-inch discharge-line piping, and pump house, was \$4,500. The new system is equipped to supply irrigation water to land lying just below the plant and to one ditch at a higher level. It is planned to install a small booster pump and extend the 10-inch discharge line to reach the highest ditch on the farm, thus connecting the experimental ditches with a second pumping plant. This will assure a supply of water for the experimental plats in case of an accident at the plant now used to pump water for experimental purposes.

Other new equipment installed during the biennium includes a cold-storage room equipped with a York ammonia direct expansion refrigeration system for cold-storage investigation with fruit, and a room for research in household equipment. The household equipment research laboratory is equipped with three 7,000-watt outlets, four 1,000-watt outlets, gas, and water. The equipment consists of ranges of various sizes designed to use different types of fuel, food choppers, electric toasters, washing machines, refrigerators, and other kinds of household equipment. The necessary apparatus for making exact measurement tests of different equipment such as gas colorimeters, precision meters, potentiometers, etc., has been installed.

DEPARTMENT OF AGRICULTURAL ENGINEERING

The increased financial support for the station as a result of the Purnell act, amounting to \$20,000 for the biennium, has made possible the addition of a Department of Agricultural Engineering in the station. Effective July 1, 1929, three members of the staff of the Department of Agricultural Engineering in the college were added to the station staff for part-time service. Prof. F. C. Fenton, head of the college Department of Agricultural Engineering, became head of the station department with Prof. R. H. Driftmier and Asst. Prof. C. A. Logan as assistants. Investigational work has been started upon three projects in this field. (1) A coöperative project between the Departments of Agricultural Engineering, Agricultural Economics, Milling Industry, and the Fort Hays Branch Station upon the effect of the method of storing combined wheat upon quality. (2) A coöperative project between the Department of Agricultural Engineering and the Fort Hays Branch Station upon methods of harvesting and storing grain sorghums. (3) A coöpera-

tive project between the Departments of Agricultural Engineering and Agronomy upon the effect of harvesting and baling alfalfa hay upon quality. The addition of the personnel in agricultural engineering has strengthened the station staff and it is believed that the assistance of trained engineers will aid materially in the solution of a number of perplexing agricultural problems.

PERSONNEL

Appointments.—The average number of persons regularly employed on the scientific staff during the biennium was 115. A total of 26 new appointments has been made, the number of appointments equaling 22 per cent of the personnel. The following appointments were made during the biennium:

- W. P. Mortenson, marketing fruits and vegetables.
- F. L. Timmons, coöperative experiments.
- Harold E. Myers, soils.
- R. O. Lewis, soil survey.
- W. H. Riddell, dairy production.
- F. C. Fenton, agricultural engineering.
- R. H. Driftmier, agricultural engineering.
- C. A. Logan, agricultural engineering.
- C. J. Whitnah, feeding stuffs analysis.
- Donald A. Wilbur, staple crop insects.
- Myra Potter, technician in food economics and nutrition.
- Mary F. Taylor, household management.
- Herman Farley, "shipping fever" investigations.
- Iva Larson, genetics.
- Chas. G. Dobrovolny, technician in zoölogy.
- R. D. Nichols, agent, U. S. D. A., farm organization.
- C. O. Grandfield, agent, U. S. D. A., alfalfa investigations.
- Christian H. Ficke, junior pathologist, U. S. D. A., footrot of wheat investigations.
- G. B. Wagner, agent, U. S. D. A., stored grain insects.
- C. A. Pyle, agent, U. S. D. A., anaplasmosis investigations, Sedan, Kan.
- E. H. Coles, superintendent, Colby Branch Station.
- J. B. Kuska, agent, U. S. D. A., dry-land agriculture, Colby Branch Station.
- R. L. von Trebra, agent, U. S. D. A., dry-land agriculture, Garden City Branch Station.
- D. A. Savage, agent, U. S. D. A., forage crop investigations, Fort Hays Branch Station.
- R. H. Davis, assistant scientist, U. S. D. A., soil erosion investigations, Fort Hays Branch Station.
- R. R. Drake, junior agricultural engineer, U. S. D. A., soil erosion investigations, Fort Hays Branch Station.

Resignations.—A total of 13 members of the staff resigned during the biennium, the number of resignations being 11 per cent of the average personnel. The persons who resigned during the biennium are listed below.

- C. O. Grandfield, coöperative experiments.
- E. S. Lyons, soils.
- R. H. Davis, soil survey.
- R. H. Lush, dairy production.
- R. W. Titus, feeding stuffs analysis.

- J. W. McColloch, staple-crop insects (deceased).
- Isabel Potter, genetics.
- C. A. Gunns, technician in zoölogy.
- S. F. Prince, biological artist.
- B. F. Barnes, superintendent Colby Branch Station and associate agronomist, U. S. D. A., dry-land agriculture, Colby Branch Station.
- J. B. Kuska, scientific assistant, Colby Branch Station.
- E. H. Coles, associate agronomist, U. S. D. A., dry-land agriculture, Garden City Branch Station.
- R. E. Getty, associate agronomist, U. S. D. A., forage crop investigations, Fort Hays Branch Station.

SCOPE OF THE STATION WORK, JULY 1, 1928, TO JUNE 30, 1930

A list of the principal active projects carried on during the biennium ending June 30, 1930, is given below, together with a statement of the source of financial support in each instance, as well as references to the discussion included in the report which follows:

NAME.	Project No.	Departments.	Funds.	Discussed on page
Studies in Farm Organization and Cost of Production.	95	Agricultural Economics.	Purnell and State.	16
Investigations in Land Tenure and Other Land Problems.	132	Agricultural Economics.	Purnell.	17
The Marketing of Kansas Wheat.	143	Agricultural Economics.	Purnell.	17
The Economics of the Poultry Industry on Kansas Farms.	144	Agricultural Economics.	Purnell.	19
The Marketing of Kansas Live Stock and Live-stock Products,	149	Agricultural Economics.	Purnell.	20
The Marketing of Kansas Fruits and Vegetables.	177	Agricultural Economics.	Purnell.	21
Soil Fertility Investigations.	17	Agronomy.	Hatch and State.	22
Tillage Investigations.	18	Agronomy.	Hatch.	23
Plant Nutrition Investigations.	152	Agronomy, Chemistry	State.	23
The Influence of Legumes and Free Living Organisms on the Growth of Plants and on the Nitrogen Balance of Kansas Soils.	172	Agronomy.	Purnell.	24
The Relation of the Absolute Reaction of the Soil Solution to the Quantity of Nitrogen Fixed by Azotobacter.	128	Bacteriology.	Adams.	25
A Study of Soil Solution as Governed by H-ion Concentra- tion.	155	Chemistry.	State.	26
A Study of Replaceable Cations and Anions in Some Kansas Soils.	179	Chemistry.	Purnell.	27
Soil and Crop Experiment Fields.		Agronomy.	State.	28
The State Soil Survey		Agronomy.	State.	29
Small Grain and Sorghum Improvement.	67	Agronomy.	Hatch.	30
Inheritance of Factors Affecting Quality of Wheat.	178	Agronomy, Milling Industry.	Purnell.	32
Sorghum Varietal Tests.	129-1	Agronomy.	Hatch.	33
Small Grain Varietal Tests	129-2	Agronomy.	Hatch.	33
Soybean Production Experiments.	129-3	Agronomy.	Hatch.	35
Miscellaneous Legumes for Forage.	129-4	Agronomy.	Hatch.	35
Pasture Improvement Investigations.	96	Agronomy, Chemistry	Purnell.	36
Corn Production and Improvement	156	Agronomy.	Purnell.	40



SCOPE OF STATION WORK-CONTINUED.

NAME.	Project No.	Departments.	Funds.	Discussed on page
Alfalfa Investigations in Relation to Winter Hardiness and Bacterial Wilt.	183	Agronomy.....	Purnell.....	42
Turf and Lawn Grass Experiments.....	167	Agronomy.....	State.....	42
Temperature Relations of Crop Plants.....	157	Agronomy.....	Purnell.....	43
Bindweed Eradication with Chemical Sprays.....	166	Agronomy, Chemistry and Horticulture.....	State.....	45
Coöperative Experiments with Farmers.....	.....	Agronomy.....	State.....	46
The Flora of Kansas.....	137	Botany.....	State.....	47
A Study of Drought Resistance of Plants.....	74	Botany.....	State.....	48
The Influence of the Method of Harvesting and Baling Alfalfa Hay upon Quality.....	182	Agricultural Engineering. . . .	Purnell.	50
A Study of the Efficiency of the Combined Harvester-Thresher for Harvesting Grain Sorghums.....	181	Agricultural Engineering. . . .	Purnell.	50
A Study of the Effect of Storing Combined Wheat on Quality, Shrinkage, Loss and Damage of Wheat in Farm Storage.....	143	Agricultural Engineering. . . .	Purnell.....	51
Chemical Factors Influencing Quality of Wheat and Flour....	143	Milling Industry.....	Purnell.....	52
The Quality of Wheat as Influenced by Cropping Systems and Fertilizer Treatments.....	60-A	Milling Industry.....	State.....	53
The Quality of Wheat as Affected by Seed-bed Preparation and Tillage Methods.....	60-B	Milling Industry.....	State.....	54
The Relation of Variety to the Quality of Wheat.....	60-C	Milling Industry.....	State.....	54
A Comparison of the Quality of Wheat Varieties Grown in Different Parts of Kansas.....	60-D	Milling Industry.....	State.....	55
A Study of the Protein Content of Some Common Kansas Wheat Varieties.....	60-E	Milling Industry.....	State.....	55
Tempering Factors Affecting the Quantity and Quality of Wheat Flour.....	60-F	Milling Industry.....	State.....	56
Flour Chemistry Investigations.....	170	Milling Industry.....	Purnell.....	57
Orchard Investigations.....	60	Milling Industry, Chemistry, Horticulture.....	State.....	57
Grape Experiments.....	25	Horticulture.....	State.....	58
Vegetable and Flower Investigations.....	26	Horticulture.....	State.....	62
Nutritive Requirements of Swine.....	27	Horticulture.....	State.....	63
Swine Feeding Investigations.....	38	Animal Husbandry, Chemistry, Veterinary Medicine. .	Adams and State....	64
	110	Animal Husbandry.....	State.....	66

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SCOPE OF STATION WORK-CONTINUED.

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Atlas Sorgo Versus Corn as a Fattening Feed for Swine.....	Animal Husbandry.....	State.....	67	
A Study of Experimental Error in Swine Feeding.....	Animal Husbandry.....	State.....	67	
Investigations in the Use of Silage for Fattening Beef cattle Feeding.....	78	Animal Husbandry.....	State.....	68	
Methods of Utilizing Native Pasture in Beef-cattle Feeding.....	151	Animal Husbandry.....	State.....	69	
A Study of Lamb and Fleece Development.....	111	Animal Husbandry.....	State.....	69	
A Study of Pasture Values and Pasture Methods for Horses, Cattle, Sheep, and Swine.....	142	Animal Husbandry.....	State.....	69	
The Influence of Feed on the Color, Chemical Composition, and Cooking Quality of the Meat of Grass-fat Cattle.....	165	Animal Husbandry, Chemis- try, Home Economics.....	Purnell.....	70	
Factors Influencing the Mineral Metabolism of Dairy Cows..	147	Chemistry, Dairy Husbandry,	State and Purnell.....	72	
Dairy Cattle Feeding Investigations.....	34	Dairy Husbandry.....	State.....	75	
Silage Investigations.....	34	Chemistry, Dairy Husbandry,	State.....	77	
Calf-feeding Investigations.....	154	Dairy Husbandry.....	State.....	78	
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Studies in Animal Reproduction and Inheritance.....	93	Animal Husbandry.....	State.....	94
Studies in the Inheritance of the Grouse Locust.....	72	Zoölogy.....	Adams and State.....	96
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DIRECTOR'S BIENNIAL REPORT

STUDIES IN THE ECONOMICS OF AGRICULTURE

The public demand during the past biennium for information relative to the business aspects of agriculture has furnished an unusual opportunity to make immediately effective the results of investigations in this field. It has also forcefully presented the need for additional exact information relative to the economics of agriculture and the necessity of enlarging these studies if the station is to fulfill its obligation to society. Increased funds have been devoted to these studies and a new project embracing a study of the marketing of Kansas fruits and vegetables has been started. The gradual expansion of the work in this field during the past six years has been made possible because of increased federal funds for the support of the station. Further development will depend upon increased financial support from the state. Studies in the economics of agriculture have been pursued during the past biennium along six major lines, each of which is discussed briefly in the following pages.

Studies in Farm Organization and Cost of Production.--The work upon this project during the past biennium has consisted of:

1. A further study of the data for Bourbon county farms similar to the study of McPherson county farms published in United States Department of Agriculture Bulletin 1296 entitled "A Study of Farm Organization in Central Kansas," and Farmers' Bulletin 1440 entitled "More Profit for the Wheat Farmers of Central Kansas." A feature of this work is a comparison of the organizations and budgets of receipts and expenses of typical and suggested systems of farming for specific-size groups.

2. A study of type-of-farming areas outlined in the biennial report for 1926-'28, which is practically complete. Twelve type-of-farming areas have been outlined, basing the distinctions upon physical and economic factors. Typical farm organizations of various sizes, within each of these type-of-farming areas, have been determined. These farms give an excellent picture of the agriculture of the various areas and should be exceedingly useful in further work in farm organization and in other agricultural work. The data have been simplified and clarified by the extensive use of maps, charts, and graphs. The material is being prepared for publication.

3. A study of "Factors Affecting the Cost of Producing Corn in Kansas," which shows significant differences in the effect of the various factors in three important corn-producing areas of the state. Considerable material from the type-of-farming study was utilized in this report. Similar reports on wheat and oats are in course of preparation.

4. A preliminary study of the effect of the combined harvester-thresher on farm organization in southwestern Kansas. This study has indicated a trend toward larger farms, larger acreages of wheat, and toward a larger proportion of the farm area in wheat. Suggested systems for farms of different sizes were worked out and the approximate results to be expected under normal conditions were estimated.

5. A study of farm practices and farm organization in the newly developed wheat area of southwestern Kansas. More than 175 farmers are cooperating in keeping farm accounts, and data on seed-bed preparation and seeding of wheat have been obtained from approximately 150 of these farmers. This study is in cooperation with the Federal Bureau of Agricultural Economics.

6. An economic study, in cooperation with the Federal Bureaus of Plant Industry and Agricultural Economics, of broom-corn production in southwestern Kansas.

7. The securing of income, expense, and inventory data on approximately 500 Kansas farms cooperating in the keeping of accounts with the Extension Service and the Department of Agricultural Economics. Much of the data obtained from the account books from 1925 to 1928 have been analyzed. A manuscript utilizing a portion of this material is in process of preparation.

The work planned for the coming year consists of a continuation of the studies of farm organization and operation in some of the type-of-farming areas not yet included in the more detailed studies. The study in the newly developed wheat area of southwestern Kansas will occupy an important place. The data on seed-bed preparation and seeding will be tabulated and analyzed. Data on harvesting and other operations will be obtained and the account books will be summarized. Analysis will proceed as rapidly as practicable. Basic data on the type of farming will be kept up to date whenever the material becomes available. Study of specific enterprises by type-of-farming areas will be continued. The studies of income, expense, and inventory data will also be continued. [Project 95; Department of Agricultural Economics; Purnell and state funds.]

Investigations in Land Tenure and Other Land Problems.-The work on this project during the last two years may be divided into three phases:

Studies in Taxation.--This work has consisted of a study of state income taxes, severance taxes, excise taxes, and other sources of revenue proposed for Kansas. Manuscripts have been prepared on some of these studies.

Studies of Land Values.--In studying land values in Kansas the *bona fide* sales of real estate in each county have been compared with the United States Department of Agriculture index and with each other to show the trends in the different farming areas within the state. The acres sold each year represent from 1 to 4 per cent of the total acreage and, it is believed, constitute a fair criterion of what the land in any particular county is selling for. These studies show that the farming sections in the eastern part of the state, including the corn belt, general farming belt, and the bluestem belt, have shown in general either a decrease or only a small increase in land values since 1925.

Studies in Land Tenure.--More than one-half of all land in farms in Kansas is operated by tenants, notwithstanding the fact that the 1925 census shows that only 42.2 per cent of Kansas farmers were tenants. More acres per tenant-operated than for owner-operated farms and a large number of owners who rent additional land account for this apparent inconsistency. [Project 132; Department of Agricultural Economics; Purnell funds.]

The Marketing of Kansas Wheat.--Tale work on this project has been centered during the biennium upon that phase of the project dealing with factors affecting seasonal price fluctuation. The work has consisted of (1) an investigation of the relation between

cash and future price changes from one season to another, (2) a determination of factors causing an abnormal relation between cash and future prices, (3) a closer check on relation between July-September price change and its influence on the following seasonal change, (4) a study of shifts in seasonal trends during the last three decades for every month of the year, (5) a study of shifts in the proportion of the total crop marketed before September, and (6) a study of the relative importance of factors determining the supply to be harvested from a growing crop and the effect of these factors on prices.

The study of shifts in seasonal trends by months during the past three decades has been completed. The results of this study are shown graphically in figure 1.

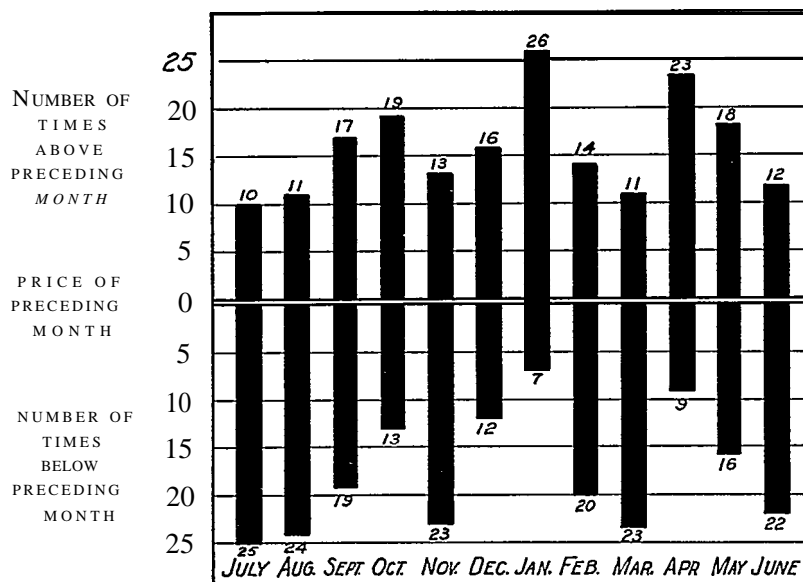


FIG. 1.--Number of times the monthly high price of No. 2 hard winter wheat at Kansas City during the month was higher and the number of times it was lower than for the preceding month for 37 years (1892-'93 to 1928-'29, inclusive).

Some of the conclusions from this study are:

1. The Kansas City cash wheat market in January is decidedly weaker than in former years, because of increased early movement of Canadian wheat before the Lakes close, an increasing westward movement of Canadian wheat, and a quicker movement of Argentine and Australian wheat.
2. The Kansas City cash wheat market in May is weaker than formerly because of increased carryovers of old wheat that have a particularly bearish effect in the closing out of the open interest in May futures.
3. The Kansas City cash wheat market in June is considerably stronger than formerly because of the growing importance of combine-territory wheat in the



Southwest and frequent reasons in this territory for crop scares right up to harvest time in June.

The study of other factors affecting seasonal prices of wheat will be continued. [Project 143; Department of Agricultural Economics; Purnell funds.]

The Economics of the Poultry Industry on Kansas Farms.--

The work during the past biennium has consisted of: (1) Price studies of poultry and eggs. (2) Detailed studies of the poultry industry on more than 400 Kansas farms relating to (a) production of eggs and young chickens by months and for the year, (b) maintenance of farm flocks through purchase or breeding, (c) distribution of production, by sale, replacements, or for food, (d) farm consumption of eggs and poultry, and (e) mortality of farm flocks.

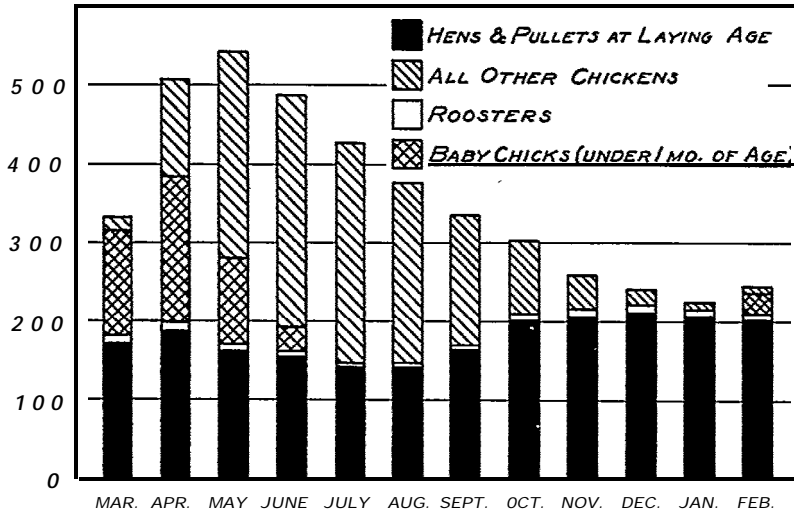


FIG. 2.-Graphs showing the average monthly number and classes of all chickens on 400 Kansas farms, March, 1928, to March, 1929.

Data were secured beginning March 1, 1928, and ending in April, 1929, covering a period of 13 calendar months. These data show that the average Kansas flock varies from about 550 individuals in the month of May, when nearly one-half the flock are baby chicks, to about 225 in the month of February, when most of the flock are hens and pullets of laying age. These and other data are shown graphically in figure 2.

The value of chickens used for food per 100 hens varied from about \$1.20 for the month of February to more than \$2.50 for the month of July. The total value per 100 hens of all poultry consumed by the farm family annually was \$24.58, and of all eggs, \$22.14. This represents about 24 per cent of the value of all poultry produced and 10 per cent of the value of all eggs produced on these

farms. The study also showed that about 84 per cent of all baby chicks were hatched on the farm where grown. The per cent of baby chicks lost varied from less than 14 in the month of March to 64 in the month of June. [Project 144; Department of Agricultural Economics; Purnell funds.]

The Marketing of Kansas Live Stock and Live-stock Products.--Four phases of this project have been active during the past biennium. Each is briefly discussed below.

Organizations Engaged in Marketing Kansas Live Stock and Live-stock Products.--Since there has been unusual interest in coöperative organizations, time has been spent in studying the possible set-ups that could be used in the program of the Federal Farm Board. Results of the study are being prepared for publication.

When and Where Kansas Live Stock and Live-stock Products Move to Market.--The work in this field of study has been continued and the results obtained have not been greatly different from those previously reported. However, additional conclusions from a survey of the data show:

1. A tendency for the smaller markets and the within-state markets to get a larger proportionate share of hogs.
2. A tendency for the use of trucking facilities for marketing to even out the monthly peaks and evidently to scatter out the home-raised and home-fattened live stock more evenly over the year.

Economic Factors Influencing the Time and Place of Marketing Live Stock and Live-stock Products.--This work has consisted chiefly of gathering opinions and ideas from county agricultural agents, farmers, and writers on agricultural subjects concerning factors that cause farmers to change from the normal time of marketing. These opinions were checked with data on the movement of Kansas live stock to verify the accuracy of the reports. The results of this study have been exceedingly interesting. Examples of some of the opinions checked were the following:

1. That bluestem hill cattlemen hold their cattle later in the fall in those years when the grazing is good.
2. That cattle and hog markets weaken one to two weeks previous to note-paying dates.
3. That the corn crop in the major corn-producing states determines the price changes of grass-fat cattle from August to September.

In these cases it was found that the opinions did not agree with the facts. Either there was no relation between the factors believed to be correlated or this relation was overshadowed by other factors. However, with respect to opinion No. 3 there did seem to be a relation between the corn crop and the price of common grades, but not of choice cattle.

Price Trends and Price-making Factors in the Live-stock Industry.--Work on this phase of the project has consisted of (1) comparing average price trends for a large number of years and for special groups of years, and (2) attempts to determine the economic

factors causing diversion from the normal trend. It is suggested that prices since 1900, omitting the war years, may be more indicative of future price trends than will averages for a longer term of years.

Other suggestions as a result of these studies are:

1. The corn crop affects cattle and hog prices from May or June of the year it is planted until two to three years later. It also affects the production of hogs for at least two years, and in certain types of situations for three years.
2. Previous profits and losses appear to be the major force in determining the demand for replacement of sheep and cattle.
3. Profits and losses are not determined by the selling price any more than by the purchase price.

Work will be continued on all four phases of the project. Reports on shipments and receipts of stock by districts will be compiled and the data will be analyzed to determine when shipments are made, where live stock goes, the economic factors causing a shift from one class of live stock to another, and to work out price relationships from one month to another for every class and kind of live stock. A bulletin on "Market Factors Affecting Profits and Losses in Cattle Feeding" is contemplated. [Project 149; Department of Agricultural Economics; Purnell funds.]

The Marketing of Kansas Fruits and Vegetables.--Efforts on this project have been concentrated on two major commodities, apples and potatoes. The work with potatoes has consisted largely of securing and tabulating (1) information on demand and supply conditions for leading markets to which Kansas potatoes are shipped, and (2) information on comparative prices of potatoes of various varieties, grades, and packs for different markets and during different periods of the season. Daily market reports for eight years have been secured from the United States Department of Agriculture.

The above data, when compiled, summarized, and correlated with other facts, will serve to throw light upon the effect of prices during different seasons of the year on the acreage of Kansas potatoes and upon the desirability of grading and packing Kansas potatoes according to certain standards.

The work with apples has so far consisted mainly of making contact with growers and in becoming acquainted with production and marketing conditions and problems.

Data are being gathered on prices of various varieties, grades, and packs of apples in markets in which Kansas apples are sold. These data, when compiled and analyzed, should be of service in choosing varieties, the type of pack to use, and methods of grading and packing. [Project 177; Department of Agricultural Economics; Purnell funds.]

CONSERVATION OF THE SOIL

A brief report of the soil investigations conducted by the station during the past biennium is given in the following pages.

Soil Fertility Investigations.--The work on this project during the past biennium has consisted in part of a continuation of the field investigations that have been in progress on the Agronomy Farm since 1910. A few new phases have been introduced and others continued. These are designed to answer certain questions that were not included in the original plan. Some of these new subprojects are essentially field projects, while others require considerable laboratory study.

In 1928 a yield of 81 bushels of corn per acre was secured on manured land in the alfalfa-corn-wheat rotation, as compared with 24 bushels on land which had been in corn continually since the inauguration of the experiment. The difference in yield due to the combination of both rotation and soil treatment was 56.9 bushels, or an increase of 235 per cent. In 1929 a yield of 64.9 bushels per acre was secured after green manure and rock phosphate in the alfalfa-corn-wheat rotation, or 49.7 bushels more than from untreated land in continuous corn, an increase of 327 per cent. The past two seasons have been on the whole rather favorable years and the crop yields, for the most part, have been above the average. Crop yields during 1929 were decidedly lower than in 1928, due mainly to a rather severe drought period during July and August.

The greatest increases in yields due to rotation and soil treatment occur in the good corn years. During very unfavorable years the land in corn continually may produce as much as in the better rotations, but in such cases the yields in both cases are low. The yields of wheat during 1928 were exceptionally high, but the 1929 yield was below the average. The yields secured from the different cropping systems are given in Table I.

TABLE I.--EFFECT OF CROPPING SYSTEM ON YIELD OF WHEAT.

Cropping system.	Yield, bushels per acre.		
	1928.	1929.	Average, 1911-1929.
16-year rotation: Alfalfa 4 years; corn, wheat, wheat (a).....	35.5	16.1	20.9
16-year rotation, as above; manured (a).....	42.1	18.7	24.8
16-year rotation, as above except brome grass instead of alfalfa; manured (a).....	32.1	17.5	25.3
3-year rotation: Corn, soy beans, wheat.....	29.7	12.8	17.5
3-year rotation: Corn, corn, wheat.....	19.2	9.4	14.0
Wheat continually.....	23.7	13.2	15.3

(a) Average of both the first and second crops of wheat in the rotation.

In the fall of 1926 work was begun to determine the effect of different methods of applying commercial fertilizer on the yields of wheat. This seemed necessary because in most of the experimental work on this problem in Kansas the fertilizer has been spread broadcast. During the biennium the application of superphosphate in the row gave an increase 82 per cent greater than was secured for broadcasting, thus confirming the results previously reported. When applied with the seed it gave better results than when applied either above or below the seed.

Soil-moisture determination made to a depth of 25 feet show that alfalfa dries out the deep subsoil so thoroughly that little or no moisture is available for a following crop. Furthermore, when the alfalfa is broken and the land is used for wheat or corn the subsoil below 10 feet does not readily regain its original moisture content. Thus the deep subsoil in the 16-year rotation that has been out of alfalfa for 12 years is practically as dry as that just recently broken out of alfalfa.

Some additional work is under way to determine the effect of fallow on the length of time necessary for alfalfa land to accumulate a good supply of moisture in the deep subsoil after it has once been depleted.

Manured land with a growing crop of corn was found to contain no more moisture than the unmanured land during a prolonged period of dry weather. [Project 17; Department of Agronomy; Hatch and state funds.]

Tillage Investigations.—The crop of 1929 was the twentieth crop year and eighteenth crop of wheat harvested from the continuous wheat series since this project was established in 1909. In 1924 and 1925 a wheat crop was not harvested, the project being cropped first to soy beans and then to oats to eradicate a foot-rot infection. The plot tillage treatments, however, were not changed. As heretofore, the yields of 1929 are in proportion to the earliness of summer plowing and degree of weed control.

Foot rot is again appearing in that part of the project where wheat is grown continually. It seems probable that this area will have recurrent infections of this disease. Because of this and because the project has already served its purpose in demonstrating the effect of early summer tillage on yield, it is planned to discontinue this phase after the 1930 crop is harvested. [Project 18; Department of Agronomy; Hatch funds.]

Plant Nutrition Investigations.—In greenhouse tests during the period covered by this report, alfalfa has been grown in an acid soil from southeastern Kansas (Cherokee silt loam) with various treatments, including applications of lime, phosphorus, and potassium. Analysis of the 1929 crop indicates an increase in calcium in the hay as a result of liming and a material increase in phosphorus where both lime and phosphorus were applied. It is significant that with increased rates of liming more phosphorus was required to show an increase in this element. [Project 152; Departments of Agronomy and Chemistry; state funds.]

The Influence of Legumes and Free Living Organisms on the Growth of Plants and on the Nitrogen Balance of Kansas Soils.—This project has been continued, following the plan previously reported. (Director's Report, 1926-'28.)

In 1928, which was a good corn year, a preceding crop of alfalfa and sweet clover for one year increased the yield of corn 16 bushels per acre compared with no legume. Soy beans increased the yield of corn 14 bushels. In 1929, a dry season for corn, the legumes did not increase the yields of the corn.

The oat crop in 1929 was the first one preceded by legumes. In that season a preceding crop of sweet clover produced a much better crop than did soy beans, the average difference for two plots of each being 18.8 bushels.

Since the rotations have not as yet made a complete cycle, only fragmentary results can be reported at this time. Wheat following legumes will be harvested for the first time in 1930. The work will be continued.

Studies of the changes in the nitrogen content of the soil of variously treated plats at Hays, Colby, and Garden City have been continued. Altogether analyses have been made of the soil of 45 plats at Hays, 33 plats at Colby, and 21 plats at Garden City. The results of these analyses, when compared with those of 1916, indicate very strongly that—

1. Very large losses of nitrogen have taken place under certain treatments.
2. The major factor influencing nitrogen losses seems to have been the original nitrogen content of the soil. A correlation coefficient of 0.64 ± 0.04 was found between the original nitrogen content and losses taking place for the entire 99 plats. The relation for small-grain cropping systems is shown in Table II.
3. Continuous small grain or alternate small grain and fallow seemed to result in the smallest loss of any cropping system tested. Three years of fallow and one of cropping produced heavy losses. Sorghums, either continuous or alternating with fallow, caused relatively large losses of nitrogen. The various rotations examined were intermediate between the small grain and sorghums in this respect. Losses were very high where stable manure was applied. With low original nitrogen contents no losses have taken place under small grain, some evidence of gains being noted. (Table II.)

TABLE II.--EFFECT OF ORIGINAL NITROGEN CONTENT OF WESTERN KANSAS SOIL UPON CHANGES IN THE NITROGEN CONTENT DURING A PERIOD OF TWELVE YEARS OF SMALL-GRAIN CROPPING SYSTEMS.

Range in nitrogen content of soil, 1916. Per cent.	Number of plats.	Nitrogen losses in pounds per acre.	
		Range.	Average.
0.08 to 0.10.....	6	+200 to -153	+34
0.10 to 0.12.....	10	+40 to -220	-80
0.12 to 0.14.....	6	-20 to -460	-221
0.14 to 0.16.....	6	-131 to -698	-353
0.16 to 0.18.....	10	-180 to -895	-542

Correlation coefficient, 0.747 ± 0.048 .

4. There are indications that when the nitrogen content of the soil of this region falls to approximately 0.1 per cent the factors responsible for additions of nitrogen to the soil counterbalance those tending to cause its removal, thereby establishing a nitrogen equilibrium near this level.

5. The very important question is raised whether at such a low nitrogen level the soil will be able to supply an adequate quantity of soluble nitrogen to enable the most efficient utilization of the available moisture.

[Project 172; Department of Agronomy; Purnell funds.]

The Relation of the Absolute Reaction of the Soil Solution to the Quantity of Nitrogen Fixed by Azotobacter.— The cylinder experiments started in 1923 in the field have been continued. In 1929 and 1930 oats were grown, the oats having been substituted for wheat because of the difficulty experienced in getting a good stand of wheat on such small areas.

The Azotobacter introduced at the time of the experiment have disappeared from all cylinders except those to which lime was applied. No differences in yield as a result of treatment have as yet appeared.

Studies have been started relative to the biological and chemical differences in the soil from extremely fertile-appearing small areas so evident in small-grain fields prior to and during the jointing period of growth. Field studies reveal the presence of such spots as far west as Scott City. Because of the intense green color and rapid growth of plants it is believed these spots are in some way connected with the nitrogen metabolism of the plant. Collections both of soil and plants from such areas and from the surrounding nonfertile-appearing field have been made over a wide territory. A summary of the 1929 results is contained in Table III.

TABLE III.—NITROGEN CONTENT OF SOIL AND WHEAT PLANTS FROM FERTILE SPOTS AND SURROUNDING NONFERTILE AREAS.

Source of material.	Per cent nitrogen in soil.	Per cent nitrogen in plants.	P. p.m. NO ₃ in fresh soil.	P. p.m. NO ₃ in incubated soil.	Height of plants in inches.	Weight of plants in grams.
Fertile spots.....	0.1434	2.630	52.4	517.6	17.1	2.32
Nonfertile spots.....	.1315	1.425	20.2	157.5	8.4	0.89
Difference.....	0.0119	1.205	32.2	360.1	8.7	1.43

These data show that plants from the spots had made 2.6 times as much growth and contained 1.8 times as much nitrogen per unit weight, or had actually assimilated 4.68 times as much nitrogen per plant as those from the field at large, yet the soil contained 2.5 times as much nitrate and was capable of increasing this surplus to 3.3 times as much in six weeks. Furthermore, the data were almost invariably of the same qualitative order. The soil from the spots, either because of the quantity or quality of its nitrogen content or because of the activity of its flora, was capable of furnishing a

much larger quantity of available nitrogen than was the general field soil.

A comparison of the phosphorus content of plants from 11 selected fields gave as an average content, 0.283 and 0.269 per cent, respectively, for plants from the general field and from the fertile appearing spots. These values indicate that phosphorus was not a causative factor. The ripe grain was harvested from the same four-drill rows for a distance of two feet in a spot and from a similar distance immediately adjacent thereto in 22 fields in the vicinity of Manhattan. The average weight of grain in grams was 44.1 and 127.5, respectively, for the general field and for the spots. This is equivalent to yields of 16 and 46 bushels per acre, respectively.

These data may be interpreted as indicating that the increased growth and yield of grain on the type of spots under study can be attributed primarily to a more abundant supply of available nitrogen. [Project 128; Department of Bacteriology; Adams funds.]

A Study of the Soil Solution as Governed by H-ion Concentration.—The work of the past biennium has been continued with emphasis on a study of the zeolitic exchange in soils, especially when saturated with various bases. The colloidal fraction of six Kansas soils was isolated by repeated washing with normal sodium chloride solution until no traces of calcium were present in the supernatant liquid. Excess electrolyte was then removed by washing with water until the finer particles remained in suspension. The fraction of the soil that remained in suspension for 24 hours in a 24-inch column of water was considered the zeolitic exchange complex. Measurements showed that this fraction contained particles varying in size from those in true solution to 0.005 mm. Particles of this maximum size apparently have the capacity of holding exchangeable bases while larger particles seem to lack this capacity. Portions of the colloidal exchange complex as isolated from the six soils were treated with aqueous solutions of the chlorides of iron (ferric), aluminum, calcium, magnesium, sodium, potassium, ammonium, and hydrogen. They were then freed from excess electrolyte by washing and then air dried. It was found that the soils treated with the tribasic bases could be thoroughly washed by water, those treated with dibasic bases by washing with alcohol, while those treated with monobasic bases could not easily be entirely freed from excess electrolyte. These basic colloids were air dried and those from the Derby silt loam were used for conductivity studies.

The colloid complex from the Derby silt loam was dried to constant weight over sulphuric acid, and suspended in water at a 1 to 2.5 ratio. Conductivity determinations were then made. Under controlled conditions of temperature and humidity absolute equilibrium was not reached in a period of five months. The results, among other things, indicate an extremely unstable condition of the soil.

Chemical analyses of the colloids treated with various basic

chlorides were made. It is of interest to note that while chemical analysis showed only a trace of aluminum to be absorbed, treatment with chloride of aluminum reduced the apparent specific gravity to about two-thirds of that before treatment; and that while only traces of iron were adsorbed those soils treated with chloride of iron (ferric) were considerably reddened in color.

Hydrogen-ion concentration determinations were made of the soils in various dilutions. Reasonably consistent results were attainable for all soils except those treated with chloride of aluminum. Great difficulty was encountered in checking these determinations from time to time. All the soils gave a somewhat more acid reaction on standing, even after an apparently air-dry condition had been reached.

The various soils were treated with several salt solutions in order to determine the effect on soil reaction. Soils first treated with hydrogen and then with aluminum and magnesium were made more acid, but were not when washed with potassium chloride. This suggests that the so-called exchange acidity is partly hydrolytic acidity.

The future work will consist of a detailed study of the effect on hydrogen-ion concentration of various salts added to soils saturated with various bases, and a study of the effect of gradual change in reaction as soils saturated with various bases gradually change their water content. [Project 155; Department of Chemistry; State funds.]

A Study of Replaceable Cations and Anions in Some Kansas Soils.—This project, recently started, has been concerned chiefly with a study of phosphorus. Studies of phosphorus brought into solution by exchange with ammonium sulphate were made, but the amounts were found to be so small that the study was discontinued. Replaceable (or soluble) phosphorus in Cherokee silt loam with various

TABLE IV.—WATER SOLUBLE PHOSPHORUS IN 100 GRAMS CHEROKEE SILT LOAM (P. P. M.)

CaCO ₃ added per cent.	No fertilizer.		CaH ₄ (PO ₄) ₂ , 0.015.		CaH ₄ (PO ₄) ₂ , 0.015, K ₂ SO ₄ , 0.015.	
	Not calcified.	Calcified.	Not calcified.	Calcified.	Not calcified.	Calcified.
0.0.....	0.345	0.485	1.000	1.080	0.905	0.835
0.1.....	.372	.355	.860	.880	.615	.745
0.2.....	.353	.350	.430	.755	.465	.715
0.3.....	.344	.260	.359	.660	.505	.742
0.4.....	.394	.260	.322	.722	.433	.745
6.0.....	.337	.255	.360	.610	.550	.622

fertilizer treatments was determined and the work repeated with Cherokee silt loam which had been treated with calcium to replace the other bases.

Soluble phosphorus was also determined in Cherokee silt loam with varying amounts of lime and fertilizer treatments. The results as reported in Table IV indicate that when the other bases in the soil are replaced by calcium the solubility of phosphorus is somewhat increased.

The future plans for this project call for the saturation of Cherokee silt loam with hydrogen, iron, aluminum, ammonium, magnesium, potassium, and sodium, and a study of the phosphorus solubility in these samples. [Project 179; Department of Chemistry; Purnell funds.]

Soil and Crop Experiment Fields.—The work on the southeastern Kansas experiment soil and crop fields during the past biennium has been a continuation of that as previously reported and consisted of variety and fertility tests of alfalfa, clover, soy beans, corn, sorghums, wheat, oats, flax, and grasses. The work has demonstrated the possibility of growing alfalfa successfully on each of the five soil types on which the fields are located when the soil is limed and fertilized properly for the crop. Some of the results of various soil treatments for alfalfa at each of the five fields are given in Table V.

TABLE V.—THE EFFECT OF SOIL TREATMENTS ON THE YIELD OF ALFALFA.
(Southeastern Kansas Experiment Fields.)

Soil treatment.	Average yields of alfalfa, tons per A., 1925-1929.					
	Columbus.	Fort Scott.	Moran.	Parsons.	Rest.	Average.
No treatment.....	0.77	1.69	1.37	1.07	1.84	1.35
Lime.....	1.79	1.77	2.23	1.19	2.11	1.96
Lime and superphosphate.....	2.12	2.75	3.31	2.49	2.74	2.68
Lime, potash, and superphosphate.....	2.04	2.14	2.78	2.63	.....	2.41
Manure.....	.....	2.22	1.66	1.87	2.20	2.05
Lime and manure.....	2.31	2.29	2.82	2.46	2.79	2.53
Lime, manure, and superphosphate....	2.24	3.36	3.62	2.88	3.41	3.10
Lime, manure, and rock phosphate.....	2.47	3.47	3.49	2.70	3.29	3.08

Unusual interest has been manifested during the biennium in the experimental work with soy beans on the experimental fields. The low yields and unsatisfactory price for wheat have directed interest toward a cash crop that might be substituted for wheat on the farms of this territory. Soy beans are being considered as a crop for this purpose. The yields of the better varieties of soy beans and wheat on the experimental fields are as indicated in Table VI.

TABLE VI.--COMPARATIVE YIELDS OF THE BETTER VARIETIES OF SOY BEANS AND WHEAT.

(Southeastern Kansas Experiment Fields.)

Average for soy beans, 1924-1929.		Average for wheat, 1925-1929.	
Variety.	Yield, bushels per acre.	Variety.	Yield, bushels per acre.
A. K.	14.4	Blackhull.	19.9
Austin.	12.0	Currell.	14.7
Laredo.	11.6	Fulcaster.	18.0
Manchu.	11.1	Harvest Queen.	18.2
Morse.	10.5	Kanred.	19.0
Sable (or Pekin).	12.0	Michigan Wonder.	20.0
Virginia.	10.0		
Wilson.	11.3		

During the coming year the number of variety tests will be reduced and the land previously used for this purpose will be used to study the effect of fertilizers and cultural practices on soy beans. [Department of Agronomy; state funds.]

The State Soil Survey.—The state soil survey was continued during the biennium in coöperation with the Bureau of Chemistry and Soils of the United States Department of Agriculture. During 1928 field work was completed and the reports were written for Johnson and Crawford counties. In 1929 field work was started in Neosho and Marion counties, but because of adverse climatic conditions it was not possible to complete either area. It will require practically the entire season of 1930 to complete the Marion county survey, but Neosho county should be completed by the middle of the summer. The Neosho party will then start work in Bourbon county.

It is planned to continue the soil-survey work at the present rate of approximately two counties a year. No reports have been published during the biennium, but the final proof has been read on the reports for Clay, Labette, Wilson, Doniphan, and Crawford counties. These reports will be ready for distribution within a few months. [Department of Agronomy; state funds.]

INVESTIGATION IN THE PLANT INDUSTRIES

Kansas devotes 23 million acres to the production of crop plants. In addition about an equal area of grassland is utilized for pasture purposes. In 1928 the value of all crops produced in the state was 382 million dollars, not including pastures. Wheat alone, according to the report of the State Board of Agriculture, represented a value of 167 million dollars, while the corn crop was valued at 117 million dollars. The pages which follow contain a brief summary of the

investigational work of the Agricultural Experiment Station during the past two years relating to the crop-plant problems of the state.

Small Grain and Sorghum Improvement.—Plant-breeding work with winter wheat, spring oats, and barley, and with sorghums, was carried on during the biennium in much the same way as in previous years. The coöperative relations with the Office of Cereal Crops and Diseases, United States Department of Agriculture and with the Departments of Milling Industry, Botany and Plant Pathology, and Entomology, so essential in the plant-breeding program, were continued.

Winter-wheat Breeding.—Much lower yields were obtained in the crop season of 1929 than in 1928, a season when yields of winter wheat in the nursery were higher than in any year since 1922. Sixteen varieties, selections, and crosses were grown in the advanced nursery. Eighty-four strains were grown in replicated rod rows and 251 strains in triplicated rod rows in the 1929 nursery.

The average yields of Kawvale and Tenmarq, two new varieties, compared with standard varieties grown in the same nursery tests for the seven-year period, 1923 to 1929, are shown in Table VII.

TABLE VII.— COMPARATIVE YIELDS OF KAWVALE AND TENMARQ AND STANDARD KANSAS VARIETIES.
 (Seven-year period, 1923-1929)

Variety.	Yield, bushels per acre.	Per cent of Kanred.
Kawvale.....	36.1	125.3
Tenmarq.....	34.4	119.4
Blackhull.....	30.4	105.6
Kanred.....	28.8	100.0
Harvest Queen.....	25.9	90.0
Turkey.....	24.1	83.7

Oat Breeding.—Nursery experiments with oats were continued in 1929 on much the same lines as in recent years; that is, with emphasis on testing varieties, selections, and crosses of spring-sown red oats, with special reference to earliness, lodging, yield, test weight, and resistance to smut and crown rust.

Yields of the strains grown in the advanced nursery in 1929 (10 three-row plats of each) varied from 60.3 bushels for a pedigree selection of Kanota, 59.8 bushels for Early Red Texas (Kansas No. 5213-7), and 59.8 bushels for a pedigree selection of Fulghum (C. C. D. No. 156), to 51.2 and 51.3 bushels for two of the less-productive selections of Fulghum and Kanota. The average yield of seven Kanota checks in this section of the nursery was 56.8 bushels per acre.

The pedigree selection from a lot of Red Texas received from Prof. T. A. Kiesselbach, of the Nebraska station, in March, 1918, (Kansas No. 5213-7) has a very good record for the seven-year period, 1923 to 1929. This strain has not lodged so much as Kanota, heads and ripens two days earlier than Kanota, yields about the same as Kanota, and is much more resistant to the forms of smut now present in Kansas. Grain of this Red Texas selection is about 1 pound lighter in test weight than that of Kanota, grown under the same conditions. This promising strain has been advanced to the field plat tests at Manhattan and Hays and has also been distributed to several other coöperating stations for testing.

During the past ten years a very large number of pedigree selections of Burt and Fulghum (including Kanota) have been tested in the oats nursery. Some of the selections of Burt have been promising because of their earliness and smut resistance, but few, if any, of them are significantly superior to Kanota in yield, and nearly all of them are inferior in test weight. Fourteen pedigree selections of Kanota have been tested in replicated rod rows during the four-year period, 1926 to 1929. Most of these lines have a slightly higher average yield than Kanota, but all of them are like Kanota in being susceptible to crown rust, to the forms of smut now prevalent in Kansas, and in having a tendency to lodge. These pedigree lines are also like Kanota in that they contain "false wild" and other aberrant types. Probably no one of these pedigree lines is enough better than Kanota to warrant the Kansas station increasing and distributing it.

Because of failure to isolate strains of agricultural value from the well-adapted varieties, Burt and Fulghum, and because it is believed that the method of hybridization offers greater promise for the future, severe cuts were made in the list of varietal selections planted in the 1930 nursery, and more time and resources will hereafter be used in the study and testing of oat crosses, with special emphasis on such specific problems as resistance to smut, crown rust, and lodging.

Barley Breeding.—More strains of barley than usual were grown in the nursery at Manhattan in 1929, as chinch bugs were not present. Seasonal conditions were rather favorable, and useful data were obtained on yield and other characters. Eight strains were grown in the advanced nursery, each strain in 10 distributed three-row plats.

Average yields of 14 checks of Vaughn, Flynn, and Stavropol H. C. No. 249 were 43.0, 39.1, and 37.0 bushels, respectively.

About 200 strains of barley were grown in triplicated rod rows. In this nursery test yields ranged from 54.4 bushels for Pryor, an early two-row barley, down to 14.3 for Archer, a late English two-row barley. Large numbers of pedigree selections of Colby six-row barley and of pure lines from heads collected on farms in western Kansas were grown. Some of these appeared very promising in

1929, and are being thoroughly tested at Manhattan, Hays, and Colby in 1930.

Sorghum Breeding.--The cross Atlas \times Early Sumac appears very promising for central and western Kansas. About 90 F₃ rows of this cross were grown in 1929. Forty-eight of these rows appeared promising as to earliness, height, leafiness, and uniformity.

Definite progress was made in breeding and testing grain sorghums suitable for harvesting with the combine. A group of selections of the cross Kansas Orange \times Dwarf Yellow milo yielded about 40 bushels per acre, are of a convenient height for harvesting, and have erect heads and long peduncles.

The selections of kafir \times milo, received from J. B. Sieglinger, of Woodward, Okla., represent another group of combine types of distinct promise. These types yielded about 48 bushels per acre in the 1929 nursery. One of them, which has been named Beaver milo, does not appear to be so well adapted to Kansas conditions as certain other kafir \times milo selections, especially No. 41-4-1. A selection from the cross Early White \times Dwarf Yellow milo, recently named Sooner, is about 15 days earlier than Dwarf Yellow milo and may prove of distinct value in northwestern Kansas.

Selections from the cross Dwarf Yellow milo \times Pink kafir, made by A. F. Swanson, of Hays, Kan., comprise a third group of promising new combine types. A yellow-seeded segregate of this cross, known as Yellow kafir, produced very high yields ranging from 47 to 72 bushels per acre, but lodged very badly, having 79 per cent of down stalks when harvested in late November.

It is planned to continue the work of this project along much the same lines as in the past, giving major emphasis to winter-wheat breeding and to the improvement of oats. It is thought desirable to reduce or possibly eliminate the barley nursery plantings and the sorghum-breeding work at Manhattan and to carry on these lines of work in coöperation with the branch stations in western Kansas. [Project 67; Department of Agronomy; Hatch funds.]

Inheritance of Factors Affecting Quality of Wheat.—The studies of protein content and other quality factors of standard varieties, and of recent introductions, selections and crosses, which have been under way for several years, have been included in a new project, approved in June, 1929. The Department of Agronomy grows and furnishes the samples for the chemical, milling, and baking studies which are made by the Department of Milling Industry. About 1,200 samples of the 1929 crop have been analyzed for protein, and studied with respect to plumpness of grain and other characteristics.

During the past three years Tenmarq has excelled Blackhull and Kanred in weight of grain per plant and in protein content, a fact that is believed to be of special significance, as these two characters are usually negatively correlated.

Another phase of the work which will aid in studies of the inheritance of quality to be made in the future is the determination

of the correlations between yield and protein, test weight and protein, and between April and May rainfall and protein content of the wheat.

All of the work upon this project so far may be considered as preliminary. It is of value mainly in laying a foundation by means of statistical studies of variation and of correlation of protein and other quality factors, as affected by environmental and hereditary factors.

In future years it is hoped that better methods of testing the milling and baking qualities of small samples will be developed, so that at least a partial understanding of the mode of inheritance of the very complex characters which are concerned in the question of quality or "strength" in wheat may be secured.

As opportunity offers and as improved technique is developed, and material becomes available, it is planned to study the segregation of quality factors in such crosses as Tenmarq x Blackhull, Tenmarq x Minturki, and others in which the parental varieties are distinctly different in quality. [Project 178; Departments of Agronomy and Milling Industry; Purnell funds.]

Sorghum Varietal Tests--The object of this project has been to study the productiveness, tendency to lodge, date of maturity, tillering, etc., of different sorghum varieties and the interrelations of these characteristics, especially as related to yield. A new variety of sorgho known as Atlas has been produced, named, and distributed partially as a result of this project. It has white seed similar to kafir, but stalk and forage characters similar to standard sweet sorghums or sorgos. It lodges less than Kansas Orange, the variety with which it is most frequently compared.

As an average for a number of years Darso has produced the highest yield of any other grain sorghum, but is not generally recommended because of the inferior feeding quality of the grain. An early variety of Red kafir recently included in the comparison has also given a good account of itself, producing a somewhat higher yield than Blackhull and Pink, the varieties generally recognized as among the best for this region.

It is expected that the project will be continued on about the same basis as in the past, since continuity of records and seasonal variation are very important considerations in attempting to evaluate varieties. [Project 129-1; Department of Agronomy; Hatch funds.]

Small Grain Varietal Tests.--Variety tests of small grains have been continued as in past years, the main objective being to compare yields of numerous new varieties and strains. Special attention has recently been given to correlating yield with different environmental and plant characters. During the season of 1929, for example, yields of wheat were found to be very definitely related to infection with leaf rust and septoria.

Also a special study has been made of the relation between

breaking strength of straw and lodging, the ultimate objective being to find some simple means of determining the tendency of new varieties to lodge. An instrument has been devised by means of which it is possible to easily and quickly determine the breaking strength of the straw. Studies including five crop seasons have shown a definite negative correlation between the breaking strength of straw so determined and lodging.

Three varieties of wheat, namely, Kanred, Turkey, and Kharkof, have been grown for a 19-year period. The average yields per acre are 31.0, 28.1, and 27.7 bushels, respectively. During an 11-year period Blackhull has produced an average yield of 35.0 bushels, as compared with 33.2 for Kanred and 31.4 for Turkey. The uncertainty of average yields based on a brief period of time is illustrated by the comparative yield of Kanred and of Fulcaster, a soft wheat known to be relatively non-winterhardy and adapted only to southeastern Kansas. As an average for four years Fulcaster has produced 38.8 bushels per acre, as compared with 33.3 for Kanred.

In the date-of-seeding test of winter wheat, the best yields in general have been secured during the last ten days of September. Yields for early October seeding are nearly as good, but they drop rapidly with seeding after the first few days in October.

With reference to the immediately practical aspects of the project, a new soft wheat variety, Kawvale, has given a good account of itself as compared with Fulcaster. The yields have not been materially higher at Manhattan, but it is known to be more winter hardy than Fulcaster, a consideration of importance even in southeastern Kansas, where Fulcaster is most generally grown. Tenmarq has continued to give a good account of itself, but is not sufficiently winter hardy to justify an unqualified recommendation. Two new unnamed wheats are of special interest because of their early maturity. One of them, a cross between Kanred and Prelude, seems to be almost as winter hardy as Kanred. The other, a cross between Kanred and Hard Federation, appears also to be relatively winter hardy and has relatively stiff straw. Cooperatoroka, a new variety introduced from Russia and distributed by private interests, has given reasonably good yields, but matures late and is believed to be relatively non-winterhardy.

Oat variety tests have now been conducted continuously for 20 years. During this period two strains of Kherson have produced an average yield of 34 bushels, one strain of Burt, 38, and one strain of Red Texas, 38.5. For a 13-year period Kanota has produced an average yield of 42.4, as compared with 38.3 bushels for Red Texas, which ranks second in point of yield. Several selections of Kanota have been tested from time to time, but none have consistently outyielded the parent.

It is expected that the project will be continued indefinitely, including, especially during the next year or two, selections from a Tenmarq \times Kanred backcross which have been selected for winter

hardiness on the basis of field tests and laboratory freezing tests. [Project 129-2; Department of Agronomy; Hatch funds.]

Soybean Production Experiments.--During the last biennium this project has included three lines of work, namely, (1) variety tests, (2) cultural tests, and (3) selection. Thirty-five varieties have been grown for comparative yields of hay and seed. Three common varieties of cowpeas have been included for comparison. Three methods of producing soy beans for hay have been used; namely, (1) in rows 38 inches apart and cultivated, (2) in rows 19 inches apart with little or no cultivation, and (3) in rows 7 inches apart planted with a grain drill. Fifteen selections from the A. K. variety were made in 1927 to obtain a high-yielding, nonlodging strain. Increased plots of five high-producing varieties have been grown to supply seed for coöperative experiments.

The varieties which have produced the highest yield of seed for 1928 and 1929 were Austin, 23.3 bushels; Hongkong, 23.1 bushels; Pinpu, 22.7 bushels; Manchu, 22.7 bushels; and Morse, 22.5 bushels. Southern Prolific, Aksarben, A. K., Hoosier, and Wea followed closely with yields of 21 to 22 bushels.

Several of the selections from A. K. appear to be very resistant to lodging, but the yields of most of them are lower than A. K. I. P. selection No. 6, however, has yielded 22.8 bushels of seed per acre compared with 21.8 for the A. K. check in the same series. Lodging in I. P. selection No. 6 amounted to 27 per cent compared with 87 per cent for A. K., as an average of the two seasons 1928 and 1929.

Tests for oil content were made on 18 samples in 1929. The per cents ranged from 18.5 to 22.5, which is approximately the same as obtained by the United States Department of Agriculture for the same varieties grown farther east in the United States.

Proposed work for the coming biennium consists of a continuation of the variety tests with several new varieties added and less promising ones dropped. Cultural work will also be continued with some additions, especially regarding rates of seeding. Selections from other leading varieties will be made. [Project 129-3; Department of Agronomy ; Hatch funds.]

Miscellaneous Legumes for Forage.--The work on this phase of the project has consisted of testing new or miscellaneous legumes to determine their adaptability and possible value as crops for Kansas. Korean Lespedeza, Kudzu, Ladino clover, Sainfoin, common, purple and winter vetch, a hardy strain of Red clover from Hungary, selected strains of sweet clover, Sesbania, and a nonleguminous drug plant called Ephedra, are among the species grown during the last two years.

Korean Lespedeza has demonstrated its ability to persist year after year by natural reseeding. A crop of seed has been harvested every season and sufficient seed has remained on the ground to renew the stand every spring.

Kudzu planted in 1927 made a very vigorous growth in the summer of 1928. A heavy crop of hay was cut about the first of September and the plants had

started growth again when the first frost came. The winter was not abnormally cold, the temperature reaching a minimum of only 12° F. An unusually large amount of moisture remained in the soil over winter. In the spring of 1929 the Kudzu plants were all dead. Three plats on land furnished by the Department of Animal Husbandry, planted in April, 1928, did not winterkill. One of these plats was pastured with sheep in 1929, but was not considered by members of the Department of Animal Husbandry as being well adapted for that purpose because the vigorous growth of vines formed obstructions which were difficult for sheep to move through. The plat planted for hog pasture was injured severely by hogs rooting after the thick, fleshy roots, which seemed especially palatable. One plat remains to be used as pasture for cattle in 1930.

Ladino clover is more productive than white clover, but appears to be less resistant to winter drought and cold.

Sainfoin has made fair growth and seems well adapted, although the yield does not compare with that of alfalfa.

Winter vetch appears to be decidedly superior to common or spring vetch, and considerably more productive than purple vetch.

Sesbania is a coarse, woody legume useful mainly as a green manure crop, but in no way superior to sweet clover.

The drug plant, Ephedra, seems to be resistant to drought, heat, and cold, but grows slowly. It is possible that the drug, ephedrine, which sells for several hundred dollars a pound when imported from China, can be produced in this country at a small fraction of its present cost.

Work during the next two years will be a continuation of most of that which is now in progress and will include tests of three selections of sweet clover obtained from Dr. L. E. Kirk, of the Agricultural Experiment Station at Saskatoon, Saskatchewan, Canada, and designated by him as Alpha 1, 2, and 3. Tests of Kobe Lespedeza, Tennessee No. 76, and Japan, in comparison with Korean Lespedeza, will also be carried on. Yields of hay will be obtained from two varieties of Sainfoin, the French giant, and the English single-cut. Additional new legumes will be included as they seem to merit attention. [Project 129-4; Department of Agronomy; Hatch funds.]

Pasture Improvement Investigations.--The investigation on this project is divided into several phases which are briefly discussed below.

Management of Live Stock on Bluestem Pastures.--Deferred and rotation grazing has been compared to season-long grazing with respect to grazing capacity, gains made by the live stock, and the effect of the two systems of grazing on the pasture vegetation. For the eleven years that these experiments have been conducted the capacity of the pastures grazed by the deferred and rotation system has averaged 30 per cent higher than the pastures grazed season long. The amount of feed expressed as animal days per acre, or the number of days that a two-year-old steer or the equivalent in other classes of live stock was grazed per acre, was 50.5 for the rotation pastures and 32.9 for those grazed throughout the season. This is a 53 per cent increase for the rotation system. The gain in weight of stock grazed in the rotation pastures was 20 per cent greater than in the other.

A detailed study of the vegetation shows the quality and quantity

of the forage on the rotation pastures to be slightly better than on the pasture grazed season long.

The study reveals the rapid invasion of blue grass in the pastures grazed under both systems, a condition that probably exists through the entire bluestem pasture region.

Effect of Burning Prairie-grass Pasture on the Yield and Succession of Vegetation.--The experiments on burned pastures are being conducted on two types of native pasture land, (1) typical hilly bluestem pastures representative of about five million acres in the bluestem region of eastern Kansas, and (2) level to rolling land somewhat more productive than the former. The first area is covered mainly with big and little bluestem, while on the second, little bluestem is the dominant grass.

Experimental plats have been laid out on the typically hilly pastures and are burned at four different periods during the year: (1) Late fall, (2) early spring, (3) medium spring, and (4) late spring. These are compared with a check or unburned plat. On the second type a similar series of plats is burned every other year. A grazed plat is included, which is burned only when the growth of grass justifies it.

Data are collected on the effect of burning at different times on the yield, and succession of vegetation, control of weeds and brush, starting of growth in the spring, temperature of the soil, and the fertility of the soil.

Five years' results are available on the hilly type of pasture land and two on the other. The results on the two areas agree with respect to the check plat having the highest yield of vegetation, the fall-burned plat, the lowest yield of vegetation and the late-spring burned, the smallest amount of weeds. The results also indicate that in an average year the growth of vegetation will be a little earlier on the burned plats. In a cold, backward spring the vegetation will be more advanced on the unburned areas.

Burning appears to have little effect on weed and brush control unless it is done as late in the season as May 1, or later. Burning late in the season tends to reduce the density of the stand of vegetation and increase the height of the top growth. It also appears to encourage the growth of the coarser grasses. There is little successional difference in the vegetation on the plats burned in the early and medium spring.

Since burning reduces the yield of vegetation it should be practiced only in years when there is a large amount of old grass on the pastures that would affect the even distribution of the live stock.

The Effect of the Frequency, Height, and Time of Cutting on the Yield and Quality of Pasture Vegetation.--Owing to the high cost of conducting pasturing experiments and to the lack of control of a number of factors affecting the results, plats on which the vegetation is clipped at different heights, times, and frequencies are used to imitate different intensities and methods of grazing. The

use of the clipping plats makes it possible to measure accurately the yield and succession under the different treatments.

The plats are clipped at frequencies ranging from two weeks to once each season and in heights varying from one to four inches. Three series of plats are used in this phase of the project. One series of the plats is located on hilly bluestem pasture land, for which three years' results are available. A similar series is located on level bluestem pasture land that has been clipped two seasons, and a third series was established last spring on the same type of pasture as the second. Large plats are used in this series and the clipping is done with a lawn mower that can be adjusted to cut at heights of from one to four inches.

The results show that the yield of the grass varies inversely and the quality directly with the frequency of the clipping. The increase in quality, however, is not enough to compensate for the damage done by frequent clipping. It has been proved that 80 per cent of the forage species composing a bluestem sod can be killed by clipping to a height of one inch every two weeks for two seasons. The injury is decreased by increasing the height of clipping. Protection of the plats for two months after growth started greatly increased the vigor of the vegetation.

The Eradication of Undesirable Plants from Pasture Lands.-- Plats containing the most common pasture weeds and shrubs have been cut at two-week intervals during the growing season, and data have been obtained on the effectiveness of these cuttings during the past three years. Samples of roots have also been collected for all the species at the time the cuttings were made, and an analysis made of the food reserves. The results show that the time of applying any method of eradication is a very important factor in the killing of worthless pasture plants. Eradication has been the most complete when the plants to be eradicated were cut at a time when they had the least amount of stored food. In most plants this is when they are in the bud or early flowering stage of growth. Where plants were cut a month earlier or later than the time of minimum storage of food reserves they were affected very little.

Mowing appears to be the most feasible method of eradicating pasture weeds. Burning may be effectively used under special conditions, and where small, dense areas of noxious weeds or shrubs occur, spraying with sodium chlorate may be a practical means of eradication.

*Pasture and Forage Crop Nursery.--*The nursery is divided into three sections as follows: Section 1, where all the common tame grasses are grown singly and in mixtures with legumes; section 2, where foreign species are planted to test their adaptability for Kansas pasture conditions; and section 3, where native pasture grasses are grown for selection and breeding purposes and for increasing their seed production. Twenty-nine plats are used for the first phase of the work, six for the second, and seven for the last. In the first section, 18 plats are used for testing individual forage

species and 11 pasture mixtures. In the introduction plats, 35 foreign grasses are planted. The breeding and selection work is being done mainly with big and little blustem (*Andropogon furcatus* and *Andropogon scoparius*).

Effect of Fertilizers on the Yield, Quality, Vigor, and Succession of the Vegetation on Tame and Native Pastures.—Two series of fertilizer treatments, one on tame pastures and one on native hilly bluestem pastures, were started in the spring of 1927. In addition a series was established on the level type of bluestem pasture in the spring of 1929. In each of these series eight fertilizer combinations are used that are compared with a check or nonfertilized plat. On two series the treatments are duplicated both with grazing and protection. The protected plats are used in order to obtain yields. Table VIII gives the average yields obtained from the different treatments stated in pounds of air-dry hay per acre for the season of 1929.

TABLE VIII.—EFFECT OF FERTILIZERS ON YIELD OF PASTURE GRASSES.

Fertilizer treatments and rate of applications per acre.	Pounds of hay per acre.		
	Tame pasture.	Native pasture.	
		Hilly.	Level.
Manure, 6 tons alternate years	3,340	4,200	3,586
Manure, 6 tons plus 200 pounds superphosphate alternate years	3,430	.....	.....
NaNo ₃ , 200 pounds, yearly, three applications	2,500	4,130	2,855
NaNo ₃ , 100 pounds, yearly, one application	2,260	3,510	2,695
NaNo ₃ , 100 pounds, yearly, plus 200 pounds, alternate years	2,935	4,320	2,555
NaNo ₃ , 100 pounds, yearly, plus 200 pounds superphosphate plus 25 pounds KCl, alternate years	3,010	4,440	2,450
Superphosphate, 200 pounds, alternate years	2,500	3,250	2,370
Superphosphate, 200 pounds, alternate years, plus 1 ton lime every eight years . . . . .	.....	.....	2,380
Lime, 1 ton at eight-year intervals	2,240	2,620	2,540
Check, no treatment	2,070	3,210	2,200

Relation of the Growth of Pasture Plants to Their Vigor and Nutritive Value.—During the biennium the following has been accomplished on this phase of the project: (1) Samples of the important pasture grasses were collected at intervals throughout the growing season. These samples were analyzed. (2) Samples of wheat, rye, and other plants commonly used as pasture were collected and analyzed. (3) Samples of roots representing the important pasture weeds were collected at intervals throughout the growing seasons and analyzed for reserve food material. (4)

Samples of grass roots were collected from grass grown on plats handled in various ways.

Briefly the results were as follows:

1. The analyses of pasture grasses collected from undisturbed areas at intervals throughout the growing season show a gradual diminution in feeding value as the season advances. Samples collected about the middle of May have a protein content approximating 14 per cent; August 1, less than 4 per cent; and September 12, less than 3 per cent. The carbohydrate content increases somewhat as the grasses approach maturity, but this increase is not particularly significant.

2. Grasses collected from fertilized versus unfertilized areas show a marked increase in protein content where nitrogenous fertilizers were applied.

3. Analyses of samples of wheat and rye leaves collected in the fall and spring show these plants to have a remarkably high protein, mineral, and carbohydrate content. The protein content approaches 30 per cent on a dry basis.

4. A study of the stored reserve food in the roots of grass plants from protected areas, collected at intervals throughout the growing season, shows:

(a) A decrease in stored carbohydrates until about June 15.

(b) A gradual increase in carbohydrate content from about June 15 until the end of the growing season. The increase in the case of little bluestem grass is approximately 300 per cent.

(c) No increase in the protein storage is recorded until the extreme end of the growing season.

5. A study of the reserves stored in the roots of grasses taken at the end of the growing season from plats cut at different times and frequencies shows the quantity of reserves to be inversely proportional to the frequency of cutting.

[Project 96; Departments of Agronomy and Chemistry; Purnell funds.]

Corn Production and Improvement.--The corn project, cooperative between the Department of Agronomy and the Office of Cereal Crops and Diseases of the United States Department of Agriculture, has been continued during the last biennium along lines similar to those followed in the past, consisting of experiments in the breeding and culture of corn.

The long-time experiments on time and methods of planting continue to show that with full-season varieties of corn, dates of planting somewhat earlier than ordinarily practiced give the highest yields. With strong, vigorous seed, April 20 to 30 appears on the average to be the optimum date at Manhattan. In an amplification of the time-of-planting work started in several western states in 1928 to obtain advance data on the possibilities of control measures for the European corn borer, it has thus far appeared impossible to obtain as large yields from early varieties planted at various rates at later dates as from full-season varieties planted at the normal time.

In both 1928 and 1929 the highest grain yields with Pride of Saline were obtained with plants spaced 16 inches apart in 42-inch rows. Closer spacings gave materially higher yields of stover with greatly reduced grain production.

Rapidly increasing interest in hybrid seed corn is being shown by

farmers. The first inbred hybrid seed to be offered for sale commercially in the state was handled by the Mangelsdorf Seed Company in the spring of 1929. The possibility of utilization of superior hybrids appears promising and the major emphasis of this project is at present being placed on their production. The frequency table (Table IX) of yields of all varieties and all hybrids grown in four-row plats during the past biennium indicates their promise.

TABLE IX.—COMPARATIVE YIELD OF ALL VARIETIES AND HYBRIDS OF CORN,
1928 AND 1929.

(Manhattan.)

Yield, bushels per acre.	Number of hybrids and varieties with distribution as to yield.			
	1928.		1929.	
	19 hybrids.	31 varieties.	13 hybrids.	33 varieties.
90 to 95 bushels.....	1			
85 to 90 bushels.....	2			
80 to 85 bushels.....	3			
75 to 80 bushels.....	6	2		
70 to 75 bushels.....	2	8		
65 to 70 bushels.....	4	15		
60 to 65 bushels.....	1	5		
55 to 60 bushels.....		1	3	
50 to 55 bushels.....			6	3
45 to 50 bushels.....			3	8
40 to 45 bushels.....			1	15
35 to 40 bushels.....				6
30 to 35 bushels.....				1

The strain of pop corn selected for high popping expansion has continued to pop better than all other varieties tested. Its yield is better than Dynamite and nearly as good as Queen Golden, the two most generally grown varieties in the state. This selection has been named Sunburst and will soon be recommended and distributed.

In 1928 a rather comprehensive test was made of hybrids of yellow segregates versus hybrids of white segregates of inbred lines from yellow \times white crosses. The pairs of yellow and white inbred segregates were practically identical in each case, with the exception of endosperm color which had intentionally been kept heterozygous throughout the inbreeding. Out of 49 comparisons, 27 showed higher yields for the yellow hybrid, and 22 showed higher yields for the white hybrid. As an average of all comparisons, the yellow hybrids outyielded the white by 1.21 ± 1.21 bushels per acre. Con-

trary to commonly accepted belief, this would indicate that under the conditions of the experiment there is no secondary effect of the factors for yellow endosperm, which necessarily depresses yield. [Project 156; Department of Agronomy; Purnell funds.]

Alfalfa Investigations in Relation to Winter Hardiness and Bacterial Wilt.--The alfalfa work coöperative between the Departments of Agronomy and Botany and the Office of Forage Crops and Diseases, United States Department of Agriculture, was enlarged beginning August 1, 1929, to include certain problems relating to winter hardiness and bacterial wilt. The project as outlined consists of five phases as follows:

1. *Crop Sequence and Cultivation in Relation to Bacterial Wilt of Alfalfa.*--The primary object of this phase of the experiment is to determine how long the bacterial wilt organism will live in the soil under two systems of handling the soil--fallow and a general crop rotation of corn, wheat, and oats. This work will be started in the fall of 1930.

2. *Time of Cutting Alfalfa.*--This phase calls for the completion of the work already under way and previously reported (Director's Report, 1926-'28).

3. *Variety Tests.*--A comparison will be made of alfalfa varieties in respect to yields, winter hardiness, wilt resistance, susceptibility to leaf spot, habits of growth, etc. Square rod plats are used for newly introduced varieties and strains. Larger plats for the study of some of the more important varieties will be used beginning in the fall of 1930.

4. *Selection and Breeding.*--About 600 individual plants of a strain of Provence F. C. I. No. 34886 and about 350 plants of a strain of Kansas Common, have been space-planted on wilt-infected ground for observation, selection, and propagation.

These plants were from an old variety plat plowed up in the fall of 1928 and were selected because of their apparent resistance to bacterial wilt.

Further selection work with other varieties for wilt resistance is being done both in the greenhouse and in the field by the artificial inoculation of the plants with bacterial wilt. Other nursery work is being started with new strains and varieties of recent introduction from Turkestan and Russia.

5. *Root Reserves in Relation to Time of Fall Cutting of Alfalfa, Winter Injury, and Bacterial Wilt.*--The purpose of this phase of the experiment is to supplement the results of the older time-of-cutting work by determining the effect of late fall cutting on root growth, root reserves, winterkilling, bacterial wilt, permanence of stand and yield.

[Project 183; Department of Agronomy; Purnell funds.]

Turf and Lawn Grass Experiments.--These experiments are carried on coöperatively with the United States Golf Association. During the last biennium three major lines of work have been conducted with the following aims:

1. To determine the adaptability of certain turf-forming grasses for greens or fairways on golf courses and for lawns.
2. To determine the effect of different cultural treatments on the maintenance and quality of the turf and the control of weeds.
3. To determine the effect of fertilization, height of clipping, and methods of watering on the maintenance of Kentucky blue grass.

In addition to the above the following minor lines of work have received attention.

1. Tests on maintenance of bent-grass turf by cutting with the ordinary lawn mower.

2. Tests with various chemicals for controlling lawn weeds. Iron sulphate, zinc chloride, sodium chlorate, sodium dichromate, ammonium sulphate, and a commercial preparation labeled Mission Dandelion and Plantain Killer, were used.

Sixteen strains of bent grass and one each of blue grass, red top, and buffalo grass were grown in the tests for adaptability. Work which has been carried throughout the biennium comprised 102 plats. In addition new work with blue grass comprising 27 plats was started in the fall of 1929.

Results of tests of adaptability of bent grasses show that the Washington and Metropolitan strains are the most desirable for this section. Promising results have been secured, also, with Astoria and Cocoos. These strains are readily propagated from seed, which is in some respects a decided advantage.

Results of fertilizer tests show that it is impossible to maintain a good turf of bent grass without fertilizers. The best turf is produced by use of both fertilizers and compost. Ammonium sulphate, sodium nitrate, and urea have given satisfactory results, and little difference in their effect has been noted. Increases in yield of clippings of 300 per cent for blue grass and of over 500 per cent for Washington bent were obtained from the use of these fertilizers.

Weed control seems to be largely a matter of maintaining a vigorous growth and dense turf of grass. Clover predominates in the unfertilized bent-grass plats, while very little appears in plats that are treated regularly with fertilizer and compost. Ammonium sulphate and iron sulphate have given promising results in controlling dandelions in blue grass.

Bent grass cut with an ordinary lawn mower, set to cut as low as possible, has not produced an attractive turf. It seems safe to conclude that bent grass is not practical for lawns in this section because of the necessity of clipping closer than can be done with ordinary lawn mowers and its susceptibility to brown patch disease.

The project will be carried on during the next biennium according to the general plan in effect during the last biennium with the addition of tests of watering, fertilizing, and height of clipping on Kentucky blue grass. A water meter will be installed and measured amounts of water applied at different intervals on various plats. It is proposed, also, to extend the work with bent grass in order to provide plats for tests of insect and weed control and additional cultural treatments. [Project 167; Department of Agronomy; state funds.]

Temperature Relations of Crop Plants.—Investigations during the biennium have been confined largely to the effects of below freezing temperatures on different varieties of winter wheat, winter rye, and alfalfa. These have included 28 varieties of winter wheat

and five of winter rye from various portions of the United States in order to determine whether the distribution of these varieties is in any way limited by their ability to survive winter temperatures. Special attention has been given to certain varieties whose relative winter hardiness under field conditions is well known and the results have been especially illuminating. Also numerous new varieties and strains of wheat from the crop-breeding nursery have been included in order to secure information as a basis for further testing and crossing. Alfalfa varieties of interest to Kansas farmers have been included in a number of trials. Some special studies having to do with the phenomena of hardening off have been under way for most of the biennium, and a study of the effect of chilling above freezing on certain crop plants was completed.

Both with rye and with winter wheat varieties an almost perfect relation has been found between the ability to survive low temperatures and distribution. That is to say, those varieties from northern regions almost invariably survived better than those from middle latitudes or southern regions. A few exceptions were found, as, for example, when in one case two varieties from the same general region were found to differ materially in ability to survive low temperatures, and in another case in which a variety from a middle latitude was found to be equal to other varieties from a higher latitude.

In extensive comparisons of Kanred and Blackhull, Kanred and Tenmarq, Harvest Queen and Fulcaster, Fulcaster and Currell, and of winter barley and winter oats, involving several hundred plants in some cases, the first named of each pair has almost invariably survived better than the other. This is in accord with known field behavior.

In a few comparisons involving very winter-hardy varieties from the north the results do not entirely agree with what is known regarding winter hardiness under field conditions. Such exceptions are believed to be related to differences in hardening off when frozen artificially, or to differences in hardiness under field conditions which in general are not recognized.

In comparative tests with alfalfa varieties a strain of Provence has survived the best of any. Grimm and Ladak have been found to be almost as good, and Kansas Common and Utah Common somewhat less hardy. In a very few tests in which Arizona Common was included, it survived the least of any. Excepting the strain of Provence, concerning which nothing definite is known, the results agree with what would be expected under field conditions.

The refrigeration tests have been used quite extensively for segregating hardy and nonhardy selections in crosses of wheat varieties. The results appear to be promising although it is yet too early to arrive at definite conclusions.

It is expected that the relation of ability to resist low temperature and the distribution of crop plants will be further investigated during the coming year. Another phase of the project it is hoped

may be undertaken is the relation of time of seeding to hardening off and the relative response of varieties to low temperature. [Project 157; Department of Agronomy; Purnell funds.]

Bindweed Eradication with Chemical Sprays.—During the last biennium the work of this project has consisted of trials with various chemicals mixed with sodium chlorate in order to determine the value of such mixtures as compared with sodium chlorate alone for the control of bindweed. The chemicals used with sodium chlorate were zinc chloride, sodium arsenite, sodium dichromate, calcium chloride, and alum. A commercial preparation manufactured by the Chipman Chemical Engineering Company known as "Atlacide" composed of a mixture of calcium chloride and sodium chlorate was tried in comparison with sodium chlorate alone. Another preparation made by the Dow Chemical Company, composed of magnesium chlorate and magnesium chloride, was also used. Tests with calcium chlorate alone were also made. Work was also carried on to determine the value of thorough distribution of the chemicals as influenced by pressure. In 1929 tests were made to determine the comparative value of sodium chlorate, "Atlacide," and a 60-40 mixture of sodium chlorate and calcium chloride when used in equal amounts per given area. Two series of treatments were made beginning on June 19 and August 12.

This work was carried on in a similar manner at the Fort Hays and Garden City Branch Stations. At Manhattan zinc chlorate was used in comparison with sodium chlorate and other chemicals. Various crops were planted in the spring of 1929 on plats treated with chlorate the previous season. For comparison duplicate plats were left uncultivated and treated with sodium chlorate as needed. Another similar set of plats was fallowed throughout the season. Bindweed roots were collected at two-week intervals throughout the growing season and analyses made to determine the food reserves.

Results of work in 1928 show that calcium chlorate and magnesium chlorate, when used in equal amounts with respect to the chlorate ion, are as effective as sodium chlorate for killing bindweed. Further tests in 1929 show that "Atlacide" is not so effective pound for pound as sodium chlorate for the reason that this material contains only about 57 per cent of chlorate equivalent. Thorough distribution of the chemical is essential as demonstrated by results from work on distribution of materials as influenced by pressure.

Results indicate that the use of other chemicals mixed with sodium chlorate is of doubtful value except in so far as they may be used to reduce the fire hazard.

Work conducted during the past two years indicates that as good results are obtained when the initial treatment is delayed as long as one to two months later than the time previously recommended. The delayed treatment results in a saving of material and labor for making one application, since three applications begun in August

were as effective as four applications beginning earlier. Similar results were obtained at Hays in 1929.

Good crops of sorghums, Sudan grass, and sweet corn were grown on plats treated the previous season. The growth of Sudan grass seemed to be more nearly normal than that of any other crop tried on the treated areas. Cultivation with a rowed crop is probably the most practical method of handling land the season following treatment for bindweed. This may be supplemented by treatment with sodium chlorate of remaining bindweed plants after removal of the crop. [Project 166; Departments of Chemistry, Agronomy, and Horticulture; state funds.]

Coöperative Experiments with Farmers.--The work in coöperative experiments during the biennium included 1,224 tests with the major field crops made in coöperation with farmers in all parts of Kansas. The kinds of tests, the number of tests, and the number of counties in which they were located are shown in Table X for each year of the biennium.

TABLE X.—COÖPERATIVE TESTS CONDUCTED DURING THE BIENNIUM, 1928-1930.

Kind of test.	Number of tests.		Number of counties.		Total number of tests.
	1928.	1929.	1928.	1929.	
Corn variety.....	100	92	52	52	192
Sorghum variety.....	82	83	49	49	165
Wheat variety.....	76	97	50	49	173
Wheat fertility.....	10	27	8	17	37
Wheat date-of-seeding.....	20	12	10	7	32
Oat variety.....	11	16	10	14	27
Barley variety.....	13	22	9	14	35
Alfalfa variety.....	46	59	30	36	105
Alfalfa treatment.....	56	76	16	37	132
Soybean variety.....	21	26	16	22	47
Other varietal tests.....	27	21	20	17	48
Miscellaneous.....	38	193	27	81	231
Total.....	500	724	82	84	1,224

The most extensive work was done with corn, sorghum, wheat, and alfalfa, although considerable attention was given to soy beans, oats, and barley, and a few tests were made with other crops such as sweet clover, cowpeas, pop corn, broom corn, and cotton. Varietal studies comprised the largest phase of the work, although tests of soil treatment, time of seeding, seed treatment, and relation of soil moisture to yield of wheat were made also.

The following are a few of the results secured in these tests:

1. In the corn variety tests Pride of Saline outyielded all other varieties in the eastern half of the state over the two-year period. Kansas Sunflower and Reid Yellow yielded about the same as Pride of Saline in northeastern Kansas in 1928, but averaged five bushels less in this section in 1929. In southeastern Kansas Midland Yellow Dent yielded slightly higher than Pride of Saline in 1929 and slightly lower in 1928. Freed White and Hays Golden made equal yields in the western half of the state and both were superior to Pride of Saline or any other variety.
2. A strain of Red kafir from southwestern Kansas averaged about three bushels more than Pink in 1928, as it had done in the two years previous. However, in 1929 it averaged two bushels less than Pink. Blackhull kafir outyielded Pink in eastern Kansas in 1928, but averaged about ten bushels less in 1929, largely due to delayed planting.
3. In 1928 Kanred and Turkey wheat averaged one bushel more than Blackhull and Superhard Blackhull, while in 1929 Turkey yielded one bushel more than Kanred, Blackhull, and Superhard Blackhull, which made about equal yields. Kanred has yielded higher than Turkey in fifteen of the last seventeen years, the average difference being nearly two bushels.
4. Kanota oats outyielded Red Texas 6.2 bushels in 1928 and 9.1 bushels in 1929. In 221 farm tests in 11 years Kanota averaged 9.7 bushels more than Red Texas. Kanota weighed more per measured bushel both years, averaging 2.5 pounds more in 1928 and 4.8 pounds more per bushel in 1929.
5. In 11 farm tests in 1929 Kanota oats treated with Ceresan for smut yielded 34 bushels per acre while untreated Kanota oats yielded 28.9 bushels, a difference of 5.1 bushels, or 15 per cent in favor of the treated plats. The average smut infection in the untreated plats was 14.6 per cent as compared to a trace in the treated plats.
6. Flynn barley averaged 2.3 bushels per acre more than Club Mariout in 1928 and 1.9 bushels more in 1929. Club Mariout in turn was superior to Stavropol and Coast, as it has been in previous years.
7. Kansas Common and Grimm were generally the most satisfactory varieties of alfalfa tested, considering yield, hardiness, and adaptation. In all tests thus far Kansas Common has made an average yield of 3 tons per acre while Grimm has yielded 2.95 tons per acre.
8. A. K. soy beans made the highest grain yield in 1928, as it has done over a seven-year period. Manchu made the highest grain yield in 1929, and over an eight-year period has averaged only slightly less than A. K.

[Department of Agronomy; state funds.]

The Flora of Kansas.—During the past biennium the herbarium was maintained in good working order and about 3,000 sheets were added. About 380 Clay county, Kansas, specimens were received from C. Weber, 175 Cherokee county plants from Anna A. Jacobs, about 400 sheets of western Kansas plants were received from P. A. Rydberg, New York Botanic Garden, and 500 miscellaneous plants were received in exchange with the University of Michigan. Some 500 numbers of Egyptian, Syrian, and Cyprian plants were received from the University of Egypt and the Egyptian Ministry of Agriculture by Prof. L. E. Melchers.

A trip last fall by the project leader resulted in the addition of about 380 numbers to the collection and in considerable data in the southwestern part of the state.

Exchanges were sent to J. M. Grant, University of Michigan, to the Bureau of Science, Manila, P. I., to the Egyptian University, and to the Ministry of Agriculture, Egypt.

Identification of about 2,341 plants were furnished persons or groups within the state, including a new weed for the state, *Lepidium perforliatum*.

The drawings and manuscript for a technical bulletin to be entitled "Principal Poisonous Plants in Kansas" were completed and have been approved by the editorial committee and transmitted for publication. [Project 137; Department of Botany; state funds.]

A Study of Drought Resistance of Plants.--During the biennium the work in this project has been centered for the most part upon the three lines of investigations as follows:

1. *A study of the Relative Loss of Water from Weeds and Crop Plants.*—This work was undertaken to determine the actual competition for water that various weeds may offer for the water available for crop production. The crops used in the experiment were corn, yellow milo, pumpkin, soy beans, cowpeas, and Russian sunflower, while the weeds were wild sunflower, cocklebur, great ragweed, lamb's-quarters, pokeweed, pigweed, smartweed, and velvet weed.

The plants were grown in soil in large containers and the loss of water determined by the weighing method. When the plants were of sufficient size the cans were weighed at two-hour intervals from 7 a. m. to 5 p.m. for three-day periods, and the loss of water during these intervals then determined. The leaf areas were obtained and the rate of water loss per unit of leaf surface calculated. In all, 20 experiments with nine different weeds and five different crop plants were performed during the growing season. The relative transpiration rates per unit of leaf surface for the plants used may be summarized as follows:

The wild sunflower, Russian sunflower, cocklebur, ragweed, smartweed, and lamb's-quarter in all the experiments showed a higher rate of transpiration than any of the crop plants. The wild sunflower showed the highest rate of transpiration of any of the plants studied and was 2.08, 1.92, 2.3, and 4.4 times as much as that of Dwarf Yellow milo, corn, cowpeas, and soy beans, respectively. Velvet weed showed the lowest rate of transpiration of any of the plants, with the exception of soy beans, and was 0.7, 0.75, 0.61, and 1.39 times the transpiration rate of milo, corn, pumpkin, and soy beans, respectively.

2. *A Comparison of the Internal and External Temperatures of Leaves.*--In 1923 Miller and Saunders published their observations on the temperature of the leaves of crop plants. Some criticisms of the methods which they employed have been raised by certain investigators who considered that the surface temperature of the leaves which was thus obtained might not be the actual temperature of the leaf. In order to obtain information on this point, some experiments were made upon plants growing in the field during the summer of 1929. By a special arrangement one thermojunction could be placed upon the surface of the leaf with only a small amount of shading. This thermojunction could also be used as

desired to determine the temperature of the air. A second thermojunction was left free to be inserted in the leaf. These two pairs of thermojunctions were then connected to a common galvanometer by means of the two damping switches.

After the thermojunction had been placed in the leaf the internal temperature was determined by opening the proper switch and noting the swing of the galvanometer. As soon as the galvanometer came to equilibrium the thermojunction, attached to the cork tips of the tongs, was placed upon the upper surface of the leaf and its temperature was measured by opening the switch that controlled its circuit and reading the swing of the galvanometer. The temperature of the air was next determined by the same thermojunction and in the same manner. This procedure was then repeated as many times as desired.

As an average of 100 observations on four turgid leaves of the milo plant when the air temperature averaged $30.3^{\circ}\text{C}.$, the average internal temperature was 31.4° , while the average temperature of the upper surface was 32.6° . With an average air temperature of $29.9^{\circ}\text{C}.$, the average internal temperature for 100 observations on five wilted leaves of milo was 32.9° , while the average temperature of the upper surface was 33.6° . In the case of cabbage leaves the average internal temperature in 80 observations of four leaves was 32.3° , while the temperature of the upper surface was 32.4° , with an average air temperature of 31.6° . In the observations that have just been cited the surface temperature of the leaves was 1.2° , 0.7° , and $0.1^{\circ}\text{C}.$ higher than the internal temperatures of the turgid leaves of milo, the wilted leaves of milo, and the turgid leaves of the cabbage, respectively. In 80 observations on five turgid leaves of cowpeas with an average air temperature of $28.1^{\circ}\text{C}.$, the internal temperature averaged 31.5° , while the temperature of the upper surface averaged 30.4° . In 60 observations upon three wilted leaves of cowpeas, the internal temperature of the leaf was 34° , while the temperature of the upper surface was 32.7° when the average air temperature was 29.2° . In this case the internal temperature of the leaf was approximately $1^{\circ}\text{C}.$ higher than the temperature of its upper surface.

The relationship between the surface temperature of leaves and their internal temperature will no doubt vary with their general structure. The data, however, obtained in these preliminary experiments are considered to indicate that the surface temperature of leaves as obtained by the thermojunction method approximates their internal temperature to within $1^{\circ}\text{C}.$

3. *The Effect of Leaf Rust Upon the Loss of Water from Wheat.*—Rather extensive preliminary experiments in coöperation with C. O. Johnston, associate pathologist, Office of Cereal Crops and Diseases, United States Department of Agriculture, have been undertaken to determine the effects of leaf rust upon the transpira-

tion rate of wheat. This work is now in progress, but no data are as yet available. [Project 74; Department of Botany; state funds.]

The Influence of the Method of Harvesting and Baling Alfalfa Hay Upon Quality.--Comparative studies were conducted in 1928 to determine the cost and effect upon quality of alfalfa hay harvested and cured by the following methods: (1) Two plats of alfalfa hay were mowed and raked simultaneously, cured in the windrow, bucked to the baler, and baled; (2) two plats were mowed, partially cured in the swath, raked, curing completed in windrow, bucked to the baler, and baled. Tractor-operated equipment was used for all field work.

The occurrence of heavy rains during a part of the harvesting period rendered leaf-loss determinations of doubtful value in comparing quality of hay secured by the different harvesting methods. For the same reason additional turning of hay was required on some plats. Cost data secured, while of value for separate operations, could not be used to compare methods of harvesting.

Due to insects and disease, the hay crop on the Agronomy Farm during the 1929 season was so light that it was felt that any experimental work conducted would not be representative of average conditions. The project will be continued during the next biennium. [Project 182; Department of Agricultural Engineering; Purnell funds.]

A Study of the Efficiency of the Combined Harvester-Thresher for Harvesting Grain Sorghums.--Seventeen 5-acre plats of different varieties of grain sorghum were planted on the Fort Hays Branch Agricultural Experiment Station in 1929 for this study. In addition, two larger areas of approximately 10 acres each were planted to Beaver sorghum for windrowing. The sorghums were dry enough to harvest the latter part of November, but due to rain and snow storms the majority of the plats were harvested on December 23 and 24.

The sorghums were harvested with a 12-foot Holt combine drawn by a Caterpillar "30." The windrower and pickup were tried on one plat.

Studies were made and records kept of the field and combine grain losses, the adaptability of various sorghum varieties to combine harvesting, and the operation of the combine under different conditions.

The grain was stored as harvested in 500-bushel bins. Moisture samples were taken as the grain was put in the bins and the grain from different plats mixed as much as possible when stored. Electrical resistance thermometers were placed at various points in two steel ventilated bins and one tight wooden bin. Temperature records were kept until April, when the thermometers failed to work. When the grain started to heat it was moved to another bin and cooled.

The results of this study may be briefly summarized as follows:

1. The wheat combine is very well adapted for the harvesting and threshing of suitable varieties of sorghum. The best varieties harvested gave results which leave little to be desired in the way of better threshing.

2. The wheat combine requires some changes in adjustment to make it suitable for sorghums. These changes, however, are easy to make and require very little expenditure of money and labor.

3. Many of the 18 varieties of sorghums tried out this year proved to be poorly adapted for combining.

4. The most important characteristic of sorghums which fits them for combining is their ability to stand up in all kinds of weather and until late in the winter.

5. From the threshing standpoint the necessity of taking considerable stalk and leaves in order to get all of the heads does not seem to be objectionable.

6. Two men with the harvesting unit and one with a truck harvested as much as 200 bushels per hour at a cost of about 62 cents per acre.

7. The safe storage of combined sorghums presents a more difficult problem than the harvesting and threshing.

8. Sorghums containing 16 per cent moisture were safely stored in a well-ventilated steel bin from December to April.

9. Sorghums having an average moisture content of 19.4 per cent were badly molded and damaged in the bottom half of the tight wooden bin after being stored until February 18. Moving the grain did not materially improve the condition.

For the coming biennium the project will be conducted on the same general plan as during the past year. A few of the less suitable sorghum types will be eliminated and possibly other types of combines used. A more comprehensive study of storage conditions will also be made. [Project 181; Department of Agricultural Engineering; Purnell funds.]

A Study of the Effect of Storing Combined Wheat on Quality.

—The phenomenal increase in the use of the combine for harvesting the winter wheat crop has introduced new problems in storage and marketing.

The experimental work on wheat storage conducted in 1929 was intended to answer two pertinent questions: (1) What type or kind of storage bin is most satisfactory for the farm storage of combined wheat, and (2) how can the farmer best handle damp wheat so as to avoid loss in storage.

Eleven grain bins, as listed below, of approximately 500-bushel capacity each, were erected on the grounds of the Fort Hays Branch Station. All of the bins were loaned or donated to the station by the manufacturers or materials companies.

Bin No. 1—Concrete stave, 10 feet diameter, similar to silo construction, placed on concrete foundation and floor; outside surface waterproofed.

Bin No. 2—Same as No. 1 except that both outside and inside surfaces of wall were waterproofed.

Bin No. 3—Square concrete, 8 by 8 by 10 feet high, constructed of concrete boards, making a wall 5 inches thick well filled with horizontal air spaces. This bin was also set upon a solid concrete foundation and floor.

Bin No. 4—Wooden bin made of 2 by 6 studs with lumber on both inside and outside of studs. Walls and roof lined with ½ inch of Celotex on the inside.

Bin No. 5—Wooden bin similar in construction to No. 4, but with the Celotex omitted.

Bin No. 6—Circular steel bin with ventilated side malls and large central flue with suction cupola on top. This bin was set upon a wooden floor.

Bin No. 7—Same type of construction as No. 6.

Bins No. 8 and No. 9—Circular steel bins with tight side malls, metal floor and roof.

Bin No. 10—Circular steel bin with tight side malls, steel floor and roof, and small central ventilator of steel.

Bin No. 11—Circular steel bin with slight ventilation in the side walls; steel floor and roof.

These bins were filled with damp wheat and the effect of the different types of storage and ventilation methods were studied. Temperature records were kept by means of electrical resistance thermometers. When the grain became hot enough to be damaged it was moved to another bin and cooled. In this way serious damage to the market grade of the wheat was avoided.

At the beginning and end of the storage period (three months), and whenever the wheat was moved, samples were taken to determine the moisture content and for the milling and baking tests.

As a result of this study the following observations were made:

1. Any wheat of 14 per cent moisture or higher may cause trouble due to heating in storage.

2. Wheat stored in tight-walled steel bins or concrete bins seems more likely to heat than when stored in wooden or ventilated steel bins.

3. It is possible to prevent damage in very damp wheat by moving it frequently.

4. The power cost of moving wheat is very small, amounting to from 8 to 15 cents for 500 bushels.

5. Hot weather seems to increase the heating of wheat in steel bins.

6. Insulation may be a valuable means for preventing the heating of wheat in hot weather.

7. In this experiment the wheat stored in the wooden bins was not damp enough to create a storage problem.

8. No definite and certain comparisons can be made between the different bins because the wheat was not sufficiently uniform in moisture content.

9. The best way to prevent damage in storage is to be prepared to move the wheat when it heats.

10. The presence of bran, dust, weed seed, and other finely divided foreign material in wheat tends to increase the danger of heating.

[Project 143; Department of Agricultural Engineering; Purnell funds.]

Shrinkage, Loss, and Damage of Wheat in Farm Storage.—

This phase of the work had to do chiefly with the quality of the wheat from the bins described in the preceding project statement.

Moisture determinations were made of the wheat during different stages of ripening and drying in the field, of the wheat as it was placed in the bins, and whenever wheat was moved from one bin to another, and finally to the elevator.

When the bins were filled, five- to eight-pound samples were taken for milling and baking tests. These were buried in the wheat in the bins. Whenever the wheat was moved these samples were moved with the wheat and hence were subjected for the entire period to the same conditions as the bulk of the wheat in the bins. Additional samples were taken whenever the wheat was moved to

determine the changes that had taken place up to that time. Samples were also taken at the end of the storage period. These samples were tested for viability, rancidity, judged for market damage, milled, and the flour baked.

The moisture content of the wheat at the time of windrowing ranged from 20 to 36 per cent. The rate of drying in the windrow depended entirely on the weather. On one occasion wheat lost only a few per cent moisture after lying in the windrow for two nights and one day. On another occasion wheat which had 16 per cent moisture in the morning had only 10 per cent by the middle of the afternoon.

The moisture content was lowered by moving the wheat. Sufficient data were not obtained to get a complete record of these moisture changes, but several movings in some of the bins lowered the moisture as much as 2 per cent.

The greatest damage occurred in one concrete bin and in one steel bin which had no ventilation. The wheat put in the concrete bin had about 16 per cent moisture, one load having 18 per cent, and the temperature of the wheat at the time of binning was 40° C. The wheat put in the tight-wall steel bin had about 15.4 per cent moisture and the temperature of the wheat was 45° C. at the time of binning. The wheat in these two bins started to heat very soon after binning, and if left undisturbed would have been entirely spoiled for milling purposes. The wheat was moved six times during the storage period. Each time it was moved there was a considerable lowering of the temperature except when the weather was very hot. The moisture content was reduced about 2 per cent.

Practically all the wheat in these two bins was dead, and the rancidity was high, showing that considerable fermentation had taken place. The milling and baking tests also showed that the value of the wheat for milling purposes had been considerably lowered. Nine of the seventeen samples from the concrete bin and four of the nine samples from the steel bin graded no damage, while eight from the concrete and five from the steel bin had a slightly sour odor or an indeterminate odor. The rancidity and other tests indicated that all the samples had suffered some damage. Before being judged for market damage the samples had been exposed to the air for several days in cloth sacks. The results of these tests indicate that wheat may suffer considerable damage in storage which will not affect the commercial grade. This will be particularly true if the wheat has been sent over cleaning machines.

The work is to be continued another year and special efforts will be made to have wheat of the same kind and moisture content in all bins so that more reliable conclusions may be arrived at. [Project 143; Department of Milling Industry; Purnell funds.]

Chemical Factors Influencing Quality of Wheat and Flour.—

In this study an attempt has been made to divide the factors controlling bread quality into two general groups: (1) Those which affect the rate of production of gas by the yeast, and (2) those

which affect the physical condition of the dough. Even in the case of factors which affect both, it is advantageous to consider them separately. Ordinarily it is desirable that gas production be rapid enough so that the dough need not stand after molding into loaves more than an hour before being light enough to be put into the oven. Otherwise the gas cells formed in the dough will break or coalesce wereily from long standing, and the texture of the bread will be coarse. If a proper quantity of active yeast is used, and the dough temperature is correctly adjusted, a failure in gas production is usually due to exhaustion of the supply of available sugar or other yeast food, or to the accumulation of too much alcohol and other end-products of fermentation, or to a combination of the two. If the flour contains substances which stimulate a very rapid yeast action, the sugar supply may be depleted and an excess of alcohol produced, so that by the time the dough is made into loaves gas production is too slow to produce bread of the best quality.

The most important known factors affecting the physical condition or gas-retaining power of the dough are mechanical treatment of the dough, the alcohols, acids, and other fermentation by-products, and the oxidation reactions occurring both before and after the making of the dough. It is the interaction of these factors upon the protein and other reactive constituents of the original flour which determine baking quality, fermentation tolerance, and other dough characteristics.

A series of baking experiments at different atmospheric pressures was conducted at Fort Collins through the courtesy of the Colorado Agricultural College. The results of these bakings were analyzed for effects on gas production and gas retention changes in the dough during fermentation.

A series of twelve papers under the general subject, "Factors of Flour Quality," was published in *The Millers Review* during the year 1928 and the first months of 1929. [Project 60A; Department of Milling Industry; state funds.]

The Quality of Wheat as Influenced by Cropping Systems and Fertilizer Treatments.—Seventy-one samples from the fertilizer and rotation plats from the crop of 1929 were analyzed for protein. The most outstanding result was the notably higher protein content of wheat grown after alfalfa. The effect of the alfalfa upon the protein content of the wheat was found to decrease with each succeeding year after plowing up the alfalfa. It appears, also, that the longer a field is in alfalfa the higher will be the protein content of the wheat from that field. [Project 60B; Department of Milling Industry; state funds.]

The Quality of Wheat as Affected by Seed-bed Preparation and Tillage Methods.—The milling and baking tests of wheat grown on the rotation and tillage plats have been conducted as in the past. In addition to the regular work on this project a number of samples from the nitrogen-fixation project were analyzed for protein. The results clearly show that a leguminous crop preceding

wheat increases the protein content of the wheat. It is considered desirable to make a more thorough study of the influence of nitrogenous fertilizers on the protein content of wheat. To obtain this information protein determinations will be made on samples of wheat secured from approximately five fields in each of six geographical regions of the state in addition to samples regularly provided from this project. [Project 60C; Department of Milling Industry; state funds.]

The Relation of Variety to the Quality of Wheat.—Milling, baking, and chemical tests were made on 37 wheat varieties grown at Manhattan in 1928. The results obtained from several of these varieties are given in Table XI.

In the future complete milling and baking tests will be confined principally to new and unknown varieties and samples will be obtained for these tests from both the Manhattan and Hays plats. [Project 60D; Department of Milling Industry; state-funds.]

TABLE XI. — MILLING AND BAKING TESTS FROM KANSAS HARD WHEAT VARIETIES, 1928.

No.	Variety.	Yield, bus. per acre.	Protein wheat.	Test weight.	Flour per cent.	Loaf volume.	Texture.
2028	Prelude × Kanred...	22.1	15.60	58.6	68.0	1,980	92
2038	Kanred × Marquis..	22.8	15.80	58.7	66.0	1,960	96
2044	Kanred × Marquis..	20.2	16.00	58.5	67.0	1,990	96
2059	Hays No. 2 (Kharkof)	12.2	16.30	52.5	61.5	2,040	92
382	Kharkof.....	14.2	17.40	52.3	66.3	1,975	90
570	Turkey.....	12.8	16.90	53.6	64.5	1,750	90
2401	Kanred.....	14.8	18.30	51.8	66.0	1,780	90
495	Oro.....	18.0	16.45	57.0	66.8	2,040	96
439	Tenmarq.....	24.3	15.00	59.2	71.0	2,045	98
2027	Kanred × Hard Federation.....	26.4	15.05	58.9	70.0	2,005	98
2025	Kanred × Hard Federation.....	17.3	14.60	58.9	70.5	1,640	90
2593	Fulhard.....	28.9	13.95	61.7	69.1	1,530	90
470	Superhard Blackhull.	16.8	14.60	61.0	69.8	1,590	88
343	Blackhull.....	18.1	14.70	60.7	70.5	1,570	90
483	Early Blackhull.....	17.4	13.55	62.6	70.0	1,685	88

A Comparison of the Quality of Wheat Varieties Grown in Different Parts of Kansas.—Milling, baking, and chemical tests have been made upon a number of common Kansas varieties grown in different parts of the state since 1920. Several thousand samples have been tested, and the data are now being summarized. A complete report is not ready at this time, but the following state-

ments may be made in regard to the quality of some of these varieties.

1. Kanred is a wheat of superior milling qualities. That is for the same test weight it yields a higher per cent of flour than most varieties. The protein is also of high quality, equal to Turkey, whose quality is acknowledged.

2. Blackhull, under the same cultural conditions, has a higher test weight than Kanred or Turkey. This characteristic is of advantage to this wheat in grading. However, in milling, the flour yield is not so high as would be expected on the basis of test weight, nor is the quality so high as the color would indicate. The outstanding fact learned about Blackhull is that it will make good bread under proper conditions, but the tolerance or the range of conditions under which it will produce good bread is more restricted than for Turkey or Kanred.

3. Superhard Blackhull is very much like Blackhull, but the unfavorable characteristics are more pronounced than in Blackhull. It has, however, an excellent color and high test weight, and therefore grades well.

4. Fulcaster has an unusually strong quality gluten for a soft wheat. In baking characteristics it is not far from a hard wheat grown in the same territory.

5. Michigan Wonder and Harvest Queen are typical soft wheats. They should be used more for making pastry flour. Kawvale is a new soft wheat variety whose quality is of the same order as Fulcaster.

6. Tenmarq is a new wheat variety of outstanding quality. It will make good bread under a wider range of conditions than any other wheat included in these tests. It appears that no matter where this wheat is grown it produces a protein of unusually high quality.

7. Early Blackhull and Red Hull are very much like Blackhull in milling and baking characteristics.

The results obtained up to this time will be prepared for publication. It appears from this work that in the future enough can be learned about the quality of new varieties by limiting the work to those samples grown at the central and branch stations. Instead of the work now done with individual varieties, it is proposed that large composite samples be made of each variety representing the three main wheat regions of the state—eastern, southwestern, and northwestern. Flour from these samples will be baked by several methods. [Project 60E; Department of Milling Industry; state funds.]

A Study of the Protein Content of Some Common Kansas Wheat Varieties.—During the past biennium 976 samples representing all the principal wheat varieties grown in the state were analyzed for protein. The results have been substantially the same as those previously reported.

In 1928, 1,056 samples and in 1929, 1,127 samples of wheat from the breeding nursery were analyzed. At the date of this report the data have not been summarized in such a way that a condensed statement may be made of the results secured. The data are being collected and summarized for interpretation.

Protein determinations on individual plant selection from the nursery will be discontinued after the 1929 crop, and of the lodging nursery after the 1930 crop. These two eliminations will make a reduction of about 580 samples. A paper embodying the results of

these studies is in process of preparation. [Project 60F; Department of Milling Industry; state funds.]

Tempering Factors Affecting the Quantity and Quality of Wheat Flour.—A questionnaire sent to 140 mill superintendents brought out the fact that the period of tempering wheat for milling ranged from three to seventy-two hours in their mills. It seems that there is need for definite information on this problem. Thus the main problem studied this year was the effect of the length of the period of tempering at room temperature and at temperature higher than room temperature upon the quantity and quality of wheat flour.

Experiments were conducted both on the small experimental mill and on the long-system mill. In experiments on the small experimental mill the tempering periods ranged from one-half hour to 96 hours. Plump new wheat, plump old wheat, and wheat very much shriveled was used. On the long-system mill periods less than a few hours are not practicable. The effect of tempering was measured by the ash content of the flour streams and the finished products, the moisture content of the products, and the weight of middlings produced in the different processes. The weight of products obtained in breaking were determined by sifting the stock on an automatic sifter for a definite period.

Baking and other tests were made to ascertain if the length of the tempering period had any effect upon the quality of the flour.

About the only definite fact that has been learned from these experiments is that a long tempering period is not necessary, at least for the kinds of wheat tried. This is especially true if temperatures higher than room temperature are used. This is of considerable economic value. Millers who use the long temper seem to do so because of habit or opinion not founded on facts. Considerable data have also been obtained on the effects of temperature. Results indicate that by using the right temperature as good results may be secured with a short as with a long temper. A shorter tempering period would greatly facilitate the milling process. [Project 170; Department of Milling Industry; Purnell funds.]

Flour Chemistry Investigations.—The work of this project for the past biennium has been continued on much the same lines as before. In addition to the ordinary work on flour, two new lines of work have been added. These are (1) a study of the nonprotein nitrogen of flour, and (2) changes taking place in eggs under different storage conditions.

The work on the hydration of the proteins of flour has been completed. It has been found that the baking quality of flour can be increased very materially by subjecting the flour to a preliminary hydration process. The viscosity and other desirable properties of the dough are increased thereby.

In the research work on fermentation of the dough, it has been found possible to determine the baking quality of flour by analyzing

the flour for the following factors: (1) H-ion concentration, (2) viscosity, (3) soluble nitrogen, and (4) salt effect at different acidities of the dough. The results by this method check exactly with those of the baking tests.

In the work with eggs it was found necessary to do considerable preliminary work to serve as a basis for future investigations. This preliminary work consisted of a determination of the moisture content and ratio of firm white to soft white in egg white. This was necessary since no data could be found in the literature on these factors. This work has been completed and, in addition, data covering the changes taking place in eggs under four different storage conditions are ready for publication. [Project 60; Departments of Milling Industry and Chemistry; state funds.]

Orchard Investigations.--The work on this project is divided into four phases, each of which is briefly discussed below.

Spraying.--During the seasons of 1928 and 1929 experiments were conducted to determine, if possible, whether the addition of certain oils to lead arsenate give a better control of codling moth than lead arsenate alone. In 1928 the apple orchard was sprayed on May 5, the calyx cup spray, in which 30° lime-sulphur solution was used 1-30 in addition to lead arsenate 1 pound to 50 gallons of spray. Six cover sprays were applied, using lead arsenate 1 pound to 50 gallons of spray, on May 21, June 8, June 22, July 5, July 20, and August 10. A solution of 1 per cent of a summer oil spray, Volk's "Orthol K," was added to the lead arsenate sprays applied on May 21, June 8, June 22, and July 5, on rows 25 and 26 (Winesaps). Three per cent of the apples on these rows were infected. The same per cent of wormy apples were harvested from other Winesap trees, indicating that the use of this oil did not increase the control of the codling moth. The unsprayed Winesap trees produced apples, 65 per cent of which were wormy. The codling moth sprays were made at intervals of approximately two weeks. This program was adopted because observations on the development of the codling moth showed that the broods were overlapping.

A codling moth attractant was made by allowing equal parts of water and molasses to ferment, to which was added a small amount of geranium oil. The object in using this attractant was to observe when the adult moths were in the orchard in order to determine the spray dates. This procedure was followed in 1928 and 1929 with satisfactory results.

A coöperative experiment with the Department of Botany was inaugurated in the spring of 1928 to determine, if possible, the relative effectiveness of control of cedar apple rust to be secured by using various kinds of sulphur dusts.

Oxidizing sulphur was furnished by Stauffer Chemical Company, of Houston, Tex., for tests of the value of three kinds of sulphur as a fungicide. Two kinds of oxidizing sulphur, designated as A-1 and

B-1, were used in addition to a similar grade of sulphur, but without the oxidizing agent.

Applications of these three sulphur dusts were made during the summer of 1928 on Jonathan apple trees growing in the experiment station orchard. The applications were made immediately after every rain that was sufficient to produce spore development from the rust galls on cedar trees. The results of this test indicated that none of the three sulphur dusts gave a high degree of control. Thus it was found that when compared with adjacent undusted check trees, the percentages of infection were 66 per cent, 47 per cent, and 46 per cent, respectively, for those dusted with A-1, B-1, and the nonoxidizing sulphur. Likewise there was no appreciable difference in the effectiveness of the oxidizing and nonoxidizing sulphur dusts.

Methods of Pruning Fruit Trees—During the past biennium this phase of the project has been prosecuted along two lines; namely, pruning of bearing trees, or maintenance pruning, and pruning for building the framework of young trees.

Maintenance pruning has followed the same course both years of the biennium and has consisted of attempts to correct errors made in pruning the apple trees of the station orchard during their juvenile period. This requires the removal of large branches at this time, a hazardous procedure because of blister canker and other rot fungi. This work has been carried on for eight years, but accurate data which might serve to give a quantitative measurement of its results are very difficult to secure. However, a study of these trees shows the advantage of drastic, heavy pruning early in the period over slower or piecemeal removal of surplus framework or secondary branches.

Observations of the 48 disbudded Jonathan trees planted in 1925 were recorded for the fifth and last time following the end of the 1929 growing season. These trees were all headed back to a height of 20 inches when set. Disbudding treatments at planting time are described below.

Treatment I. The highest and five lateral buds were left on the top 10 inches. These were spaced about 2 inches apart, which required the removal of approximately alternate buds. No buds were removed from the stem below the 10-inch level.

Treatment II. The highest and three lateral buds were left on the upper 10 inches of the stem. These remaining buds were from 3 to 4 inches apart. Lower buds were not removed.

Treatment III. Check trees. No disbudding.

Treatment IV. The highest and three lateral buds were left on the upper 10 inches of the stem, spaced as in Treatment II. All lower buds were removed, even those which appeared latent.

While the results of this experiment are not conclusive, it would appear that Treatment I was somewhat superior to the other systems, both in securing trees of better form and in stimulating growth. When only three buds were left to start lateral framework branches, one or two of them failed to grow on some trees and the result was trees with poor crotches. The effect of rubbing

out the buds on the trunk below the 10-inch level, thus preventing their "feathering out," was to lessen the increase of trunk diameter during the first year. Subsequent measurements showed that this effect did not persist beyond the first year. The untreated trees finally stood at about the median point, indicating the doubtful value of such disbudding operations.

Shaping up young apple trees to the modified leader type through annual pruning was continued. Many of these young trees are now approaching bearing age and serve to illustrate the practicability and value of this system. It has been carried to all parts of the state by the Extension Service and most of the young commercial orchards are now being so pruned.

A large increase in the work done under this subproject was initiated in March, 1930, when 234 one-year-old sour cherry trees were planted in a new station cherry orchard. These were well-grown, branched trees when set and consisted of two varieties, 188 Montmorency and 46 Early Richmond. Search of the literature indicated much variation in recommendations regarding sour cherry pruning. These variations included the general type of tree, central leader and open center, and little or no heading back, light heading back, and severe heading back. This notable lack of uniformity in cherry pruning recommendations led to the start of an experiment to compare the methods of pruning mentioned above on young sour cherry trees.

Subsequent pruning of these trees will be such as to best develop trees of the type selected. Effects will be measured after the trees come into bearing by broken and missing trees and fruit yields.

Orchard Soil Management Experiments.--A ten-year commercial fertilizer experiment instituted in 1920 was completed during the biennium. Taken as a whole this series of experiments has been productive of little in the way of positive results. A fair summing up of the evidence collected would seem to indicate that no element of fertility used in these tests and no combination of them seems to give either vegetative or reproductive increases of an order which would lead to a recommendation favoring their application on a cultivated orchard of this age and on a soil of similar characteristics.

During both years of the biennium determinations of nitrates in soils occupied by apple roots and soils of adjoining plats free from roots have been made. Plats were located on both clean cultivated and straw-mulch areas. The data collected indicate that there is no clear relation between the nitrate content of an orchard soil and the presence or absence of tree roots in that soil. The report of this experiment is printed in the proceedings of the American Society for Horticultural Science, 1929.

The peach trees planted in March, 1928, were fertilized with sodium nitrate, leaving untreated trees as checks. The first application of sodium nitrate was made April 22, 1928, at the rate of one pound to the tree. Measurements of growth were made in March, 1929, and a second application of sodium nitrate was made.

The effects of the sodium nitrate have been variable. Elberta and J. H. Hale, two very similar varieties, gave strong positive reactions. Four other varieties were rather indifferent, and Crosby showed significant negative results. This experiment will be continued. A third application of the nitrate was made March 24, 1930.

Cover crops have been grown in the station orchard for the past nine years and data regarding their culture and yield of dry matter recorded. These experiments have demonstrated that winter vetch and rye are the premier crops for this purpose in regions having climatic and soil conditions similar to those found on the horticultural farm. Immediate effects of incorporating a cover crop in an orchard soil are difficult to determine, but it seems probable that they are proportional to the quantity of top growth of the plant and its content of nitrogen. Because of the difficulties involved no attempt has been made to evaluate the actual organic content, crude or semipermanent, of the soils involved, but the dry weights of the aerial parts of the crops grown have been recorded. These results are shown in Table XII.

TABLE XII--YIELD OF VARIOUS ORCHARD COVER CROPS, 1922-1929.

Crop.	Pounds of air-dry hay per acre.							
	1922.	1923.	1924.	1925.	1926.	1927.	1928.	1929.
Winter vetch.....	4,442	5,730	5,460	4,040	6,620	4,680	4,680	4,950
Rye.....	3,173	3,650	2,621	3,783	6,496	4,308	4,312	4,490
Wheat.....	2,502	3,310	3,084	.....	.....	.....	.....	.....
Canada peas.....	1,875	.....	.....	.....	.....	.....	.....	.....
Soy beans.....	.....	Failure	3,760	4,189	.....	.....	.....	.....
Cowpeas.....	.....	Failure	3,220	5,548	.....	Failure	Failure	3,963
Dwarf Essex rape..	.....	.....	.....	.....	.....	Failure	Failure	3,955

Testing New and Promising Varieties of Tree Fruits.--The growing seasons of 1928 and 1929 were favorable for tree development, with the exception of a severe outbreak of cedar rust in 1929 and low winter temperatures in January, 1930, which caused considerable damage, particularly to peach and nectarine trees.

None of the varieties considered in this report and planted prior to 1928 has shown any marked peculiarities which would call for extended discussion, but a few interesting observations might be mentioned. Golden Delicious, planted March, 1921, bore its first crop of fruit, about one-fourth box per tree. Henry Clay, planted on the same date, has so far failed to produce any fruit. This variety suffers each year from an unidentified leaf-spot disease. Palouse, a strong growing variety in the state of Washington, makes only a weak, drooping growth here. Courtland, planted in 1924,

has shown excellent adaptation so far as growth of trees is concerned, although one tree died in 1929 from a crown injury similar to collar rot.

Some new varieties introduced in 1930 are of interest. One of these is the apple Staymared, which is a bud sport from Stayman Winesap and differs from the latter by earlier formation and greater intensity of color. These trees were purchased from Stark Brothers Nursery. United States Department of Agriculture apples Nos. 34, 49, and 57 are promising red summer varieties distributed by Prof. C. L. Close. The jujube varieties Li and Sui Men, *Ziziphus jujuba*, are introductions by the Office of Foreign Plant Introduction of the United States Department of Agriculture. They represent a very popular Chinese fruit and will be tested principally for hardiness against both summer heat and winter cold. During the drought of July and August, 1929, practically all of the nectarine varieties in the collection of the Office of Foreign Plant Introduction suffered so severely that the fruits wilted each day and finally dropped before maturity. A severe attack of bacterial leaf spot increased this damage. [Project 25; Department of Horticulture; state funds.]

Grape Experiments.---The work on this project has largely been concentrated on grapes, although a limited amount has been done with brambles. The station vineyard has developed into a satisfactory laboratory for field experiments in viticulture and it has been so utilized.

The highest yield for the two-year period, 29 pounds to the vine, was produced by a noncommercial variety, Diamond, grown on a Munson trellis, in 1929. Among the commercial varieties, Concord, on a four-cane Kniffin trellis, was the leader with a yield of 21.8 pounds to the vine.

A summary of yield records on the basis of method of trellising leads to no very definite conclusion. It does indicate the inferiority of the fan system, but whether the two-cane Kniffin is as superior as the results indicate seems questionable.

Experiments designed to show advantages, if any, of pruning grapevines to special types of canes judged on the basis of diameter and length were continued. From these studies it is evident that the diameter of a Worden cane is a poor index of its fruit production, and that in pruning Worden grapevines careful selection of canes as to their size is not necessary. However, the vigor of Worden grapevines, as judged by weight of wood removed in pruning, is an index of the fruitfulness of the plants.

Two rows of the Concord variety are being utilized this summer (1930) in an experiment designed to test the influence of severe pruning contrasted with less severe pruning combined with thinning of the fruit. These vines are on three-wire Kniffin trellises. The treatments will consist of (1) pruning to 30 buds on four-cane Kniffin; (2) pruning to 40 buds on four-cane Kniffin; (3) pruning

to 60 buds on six-cane Kniffin, four canes on upper and two on middle vine; and (4) pruning as in 3 but with fruit thinned.

Under treatment 4, thinning will consist of the removal of the outermost or smallest cluster of bloom from each shoot. This will be done just before the period of full bloom.

The effect of these treatments will be compared at harvest time, when the number of clusters and the weight of fruit will be recorded for each vine. Because of the probable greater leaf surface to each bunch of grapes, it would be expected that the thinning done under treatment 4 would result in better, if not in more, fruit without weakening the vine. The vines under treatment 3 are likely to suffer, unless the growing season is very favorable.

To date the grafted varieties of grapes, Concord and Campbell, each on Clinton and Gloire stocks, have made a disappointing vegetative development. None of the graft combinations has proved so vigorous as the cion varieties on their own roots. The first comparative fruit bearing will occur this summer. [Project 26; Department of Horticulture; state funds.]

Vegetable and Flower Investigations.---The asparagus plants started three years ago (1926) are now large enough to begin the work for which they were grown. The plan is to treat the dormant roots with various materials and in various ways in order to break the rest period of the asparagus and then force the crop in the winter months. If this can be done on a commercial basis it will be of great benefit to the commercial vegetable grower. So far it has not been possible to break the normal rest period early enough to produce a crop for market before southern-grown asparagus is available. Laboratory studies of respiratory and catalose activities, chemical changes, and the influence of the chemical and physical treatments will be made.

The lettuce seed produced last year in the search for a strain resistant to the lettuce drop produced a partial crop this winter. In the first year's test only 1 per cent of the plants were found resistant. This year nearly 30 per cent were found to be resistant. Selections were made from the resistant plants, and this will be continued.

In the greenhouse the tomato fertilizer tests were repeated. They continue to show that properly used commercial fertilizers are a profitable investment in greenhouse culture of this crop. This is being repeated this year, though it is yet too early to say definitely what results will be obtained.

The variety tests with the chrysanthemums were not continued as was planned, because of a change in the method of growing the crop. Heretofore two flowers have been produced on each of the plants of the standard varieties. This year the plants were set closer together and three flowers were produced on each plant. Larger quantities of fertilizer were used and the size of the flowers reduced, but the income, based on the wholesale price of the flowers, was greater to the square foot than under the older method of production. With the present tendency of buying according to price, this method

seems to be desirable. It is planned to grow the plants both ways this year and keep a closer check on the costs and returns from the two methods.

The perennial garden has been continued. Walks have been re-made and plants added. Some that have shown themselves not easily grown under local conditions have been removed and other plants not previously tried have been put into the space thus made available.

In the rose garden spraying tests to control the black spot on roses have been started. This disease has been a source of heavy loss to the rose growers in the state for several years, and so far it has not been possible to make any recommendations that could be followed by the amateur that would control the disease.

Several phases of a new project have been started. They consist of testing various varieties of dahlias, peonies, and gladioli. Six hundred gladiolus corms and the same number of dahlia tubers were given to the station for this purpose. Last fall twenty-five varieties of peonies for similar tests were obtained, and this year all three of these, peonies, dahlias, gladioli, will be grown in the test garden. Water has been piped to the garden so that irrigation will be possible in case of a dry season. [Project 27; Department of Horticulture; state funds.]

INVESTIGATIONS IN THE LIVE-STOCK INDUSTRIES

The total value of live stock in Kansas in 1928, as reported by the Kansas State Board of Agriculture, amounted to more than 234 million dollars. The state ranked eighth among the states in the number of swine, sixth in the number of beef cattle, and eleventh in the number of cows and heifers. A brief report of the work that the Agricultural Experiment Station has done during the past two years on problems relating to the live-stock industry of the state is contained in the pages which follow.

Nutritive Requirements of Swine.---During the earlier phases of this project, in which the vitamin A and vitamin C requirements for swine were being studied, unusually high death rates of the young pigs were encountered on rations that were supposed to provide an adequate amount of all the necessary food elements, with the possible exception of vitamins B and E. In order to see whether or not the death rate of the young pigs could be lowered by including more of these two vitamins in the ration during the gestation and lactation periods, two lots of gilts were included in the experiment in the fall of 1927. Lot I received a basal ration of yellow corn, tankage, alfalfa-leaf meal, and bone ash, while Lot II received the same ration excepting that 10 per cent of the corn was replaced by wheat germ, a substance rich in both vitamins B and E. This test was repeated the following year, using the same animals but reversing them in the two lots. The results of the work for the two years are shown in Table XIII.

TABLE XIII.--THE EFFECT OF INCREASING THE VITAMIN B AND E CONTENT OF THE RATION OF PREGNANT SOWS UPON THE MORTALITY OF PIGS.

	Lot I: Ration low in vitamins B and E.		Lot II: Ration high in vitamins B and E.	
	1927-'28.	1928-'29.	1927-'28.	1928-'29.
Number of sows farrowed.	5	3	5	4
Number of pigs died before 20 days old.	31	6	15	8
Number of sows good milkers.	2	3	5	4
Number of sows poor milkers.	3	0	0	0
Per cent of pigs weaned that were farrowed alive.	33.3	68.9	56.5	77.5

The farrowing record for 1927-'28 shows that the sows in Lot I raised only 33 per cent of their pigs, while Lot II raised 56 per cent. While these results indicate that the addition of the wheat germ reduced the death rate of the young pigs, they also indicate that some factor other than the lack of vitamins B and E was responsible, in part at least, for the high death rate, for the pigs from the sows in Lot II receiving the wheat germ had a death rate of 43.5 per cent.

Post-mortem examinations indicated that sanitation as well as nutrition was probably a factor, for most of the pigs that died showed intestinal infection.

During the past year, 1928-'29, the emphasis of the experiment has been placed on the question of sanitation during the farrowing period. At farrowing time the sows have been moved to clean quarters where every precaution has been taken to prevent the infection of the young pigs. The elimination of all the dirt from the farrowing pens resulted in the development of anemia in the young pigs the first year. After this condition was discovered it was corrected by placing in each pen a box of dirt which had been sterilized by heat and to which some iron oxide and copper sulphate had been added. No appreciable difference was obtained in the mortality of the pigs of the two lots the second season, when the number of pigs involved is taken into consideration.

A third farrow is now in progress with two new lots of gilts. During this farrow additional sanitary precautions will be maintained. This farrow is advisable because it is possible that the effect of the wheat germ may be greater on gilts than on sows that have previously farrowed a litter. The third farrow will be completed in July, 1930. A report of the results of the first two farrows was published in the record of the proceedings of the annual meeting of the American Society of Animal Production for November 19 to December 1, 1929. [Project 38; Departments of Animal Husbandry, Chemistry, and Veterinary Medicine; Adams and state funds.]

Swine Feeding Investigations.--During the biennium a study was made of the value of different protein supplements for fattening swine. These included (1) a study of the value of corn-gluten meal as a protein supplement in the dry lot, during the winter of 1928-'29, (2) a study of the value of corn-gluten meal as a protein supplement on alfalfa pasture, during the summer of 1929, and (3) a study to improve and cheapen protein supplements in hog-feeding rations by combining tankage, linseed-oil meal, cottonseed meal, and alfalfa meal in different proportions, during the winter of 1929-'30.

The results secured from the feeding of corn-gluten meal as a protein supplement to pigs in the dry lot show:

1. That the swine fed corn-gluten meal and alfalfa hay as a protein supplement to corn, all self-fed, made a poorer showing than those fed alfalfa hay and tankage as a supplement.
2. That the addition of bone meal to the corn-gluten meal did not materially improve its value.

The results from feeding corn-gluten meal as a protein supplement on alfalfa pastures show:

1. That the swine fed corn-gluten meal as a protein supplement to corn made less satisfactory daily gains, and the cost of gains were greater than those fed tankage.
2. That the addition of bone meal to the corn-gluten meal increased its value from the standpoint of daily gains, cost of gains, and finish when fed to hogs on alfalfa pasture.
3. The addition of tankage to the corn-gluten meal proved to be no more satisfactory than the addition of bone meal so far as daily gains and growth were concerned, but was less satisfactory from the standpoint of cost of gains.

The results from the feeding of protein supplemental mixtures were :

1. A ration consisting of 25 per cent linseed-oil meal or cottonseed meal, 50 per cent tankage, and 25 per cent alfalfa meal, self-fed, produced slightly better daily gains and finish of the hogs, but the amount of corn and supplement consumed per 100 pounds gain was greater as compared with hogs fed tankage and alfalfa hay self-fed.
2. The addition of alfalfa meal to tankage did not increase the gains, but did increase the amount of feed consumed per 100 pounds gain when compared with hogs fed tankage and alfalfa hay self-fed.

[Project 110; Department of Animal Husbandry; state funds.]

A Preliminary Study of a High Calcium Carbonate Pig-fattening Ration.—During the summer of 1929 four lots of five fattening pigs each were fed rations with increasing amounts of calcium carbonate. Lot I received shelled corn and alfalfa hay self-fed, 1 pound of shorts per head per day, and 0.4 of a pound of tankage. Lot II received the same ration and in addition received 0.25 of a pound per head daily of finely ground limestone, Lot III received the same ration as Lot I and 0.5 of a pound of finely ground limestone, and Lot IV received in addition 0.75 of a pound of ground limestone per head daily.

The average daily gains for the four lots were 1.28 pounds for

Lot I, 1.03 pounds for Lot II, 0.98 of a pound for Lot III, and 0.87 of a pound for Lot IV.

The shelled corn required per 100 pounds gain: 322.66 for Lot I, 395.15 for Lot II, 420.83 for Lot III, and 470.11 for Lot IV.

These results would seem to indicate that the more ground limestone in a ration above normal requirements the greater will be the amount of feed consumed per 100 pounds gain, thus increasing the cost of gains and decreasing the daily gains. [Department of Animal Husbandry; state funds.]

Atlas Sorgo Versus Corn as a Fattening Feed for Swine.-- During the winter of 1930 two lots of 10 hogs each were fed for 110 days as follows: Lot I--ground Atlas sorgo plus tankage and alfalfa hay, all self-fed. Lot II--shelled corn plus tankage and alfalfa hay, all self-fed.

The hogs self-fed corn, tankage and alfalfa hay made slightly larger gains than those self-fed ground Atlas sorgo, tankage and alfalfa hay, the gains for corn being 1.72 pounds, and for Atlas 1.66 pounds, per day.

The hogs receiving corn consumed less grain per 100 pounds gain than did the Atlas-fed hogs. The consumption of hay and tankage was about the same. Thus Lot I consumed 373 pounds of Atlas sorgo 58 pounds of hay, and 29.5 pounds of tankage per 100 pounds gain, and Lot II consumed 350 pounds of corn, 57 pounds of hay, and 30 pounds of tankage per 100 pounds gain. [Department of Animal Husbandry; state funds.]

A Study of Experimental Error in Swine Feeding.--- During the winter of 1928-'29 four lots of 10 pigs each of Duroc Jersey feeder pigs from the federal station at Ardmore, S. Dak., were fed identical rations consisting of shelled corn, self-fed *ad libitum*, shorts hand-fed 1 pound daily, tankage hand-fed 0.4 of a pound daily, and alfalfa hay *ad libitum*. During the winter of 1929-'30 the test was repeated with similar pigs from the same station.

The purpose of the project was to determine, if possible, what may be considered significant differences in swine-feeding tests.

The average daily gain per head per day in 1928-'29 varied from 1.89 pounds for the lowest gaining lot to 2.06 pounds in the highest gaining lot, a difference of 0.17 of a pound per head per day; in 1929-'30 they varied from 1.54 pounds to 1.72 pounds, a difference of 0.18 of a pound per head per day.

In 1928-'29 the corn consumed per 100 pounds of gain varied from 342.54 pounds to 372.21, a difference of 29.67 pounds; in 1929-'30 from 382.90 pounds to 414.33 pounds, a difference of 31.43 pounds.

It will be noted that the variations for the two years are relatively close and may indicate that greater differences than are usually accepted must be secured before differences in hog-feeding tests are really significant. [Department of Animal Husbandry; state funds.]

Investigations in the Use of Silage for Fattening Beef Cattle.
--This project for the past biennium has included two distinct phases.

Phase I consisted of a study of cottonseed meal, linseed-oil meal, and corn-gluten meal fed separately and in combination as protein supplemental feeds in calf-fattening rations, the roughage portion of which is largely silage. This study was started in the fall of 1928. The test made in 1928-'29 was duplicated in 1929-'30.

The results of this test, based upon daily gains, the selling price per hundredweight, which is the only available measure of finish, and margin per head over steer cost plus feed cost, ranked these supplemental feeds as indicated in Table XIV.

TABLE XIV.--THE RANK OF DIFFERENT PROTEIN SUPPLEMENTAL FEEDS FED TO BEEF CALVES, AS INDICATED BY DAILY GAIN, SELLING PRICE AND MARGIN OVER COST.

Supplemental feed.	Daily gain.		Selling price per hundred weight.		Margin per steer.	
	1928-'29.	1929-'30.	1928-'29	1929-'30	1928-'29.	1929-'30.
Cottonseed meal.....	6	7	4	6	6	7
Linseed oil meal.....	3	6	1	4	3	6
Corn gluten meal.....	5	3	5	5	5	5
Cottonseed meal, one-half; linseed oil meal, one-half.....	2	4	2	3	2	3
Cottonseed meal, one-half; corn gluten meal, one-half.....	7	5	4	4	7	4
Linseed oil meal, one-half; corn gluten meal, one-half.....	1	2	1	2	1	2
Cottonseed meal, one-third; linseed oil meal, one-third; corn gluten meal, one-third.....	4	1	3	1	4	1

Phase II consisted of a study of the possibility of depending upon silage alone as the roughage portion of a calf-fattening ration.

Lot I was fed corn, cottonseed meal, alfalfa hay, and corn silage; Lot II was fed corn, cottonseed meal, corn silage, and finely ground limestone. Since no alfalfa hay was fed in Lot II the cottonseed meal allowance was increased enough to make the protein content of each ration practically the same. Ground limestone was added to provide the calcium in Lot II furnished by the alfalfa hay in Lot I.

In the first year's experiment, 1928-'29, the daily gains were almost identical. The selling price per hundredweight was greater where the alfalfa was fed, and the margin per steer was 84 cents per head greater.

In the second year's experiment, 1929-'30, the daily gains were greater, the selling price was greater, and the margin per steer was considerably greater where no alfalfa hay was fed. [Project 78; Department of Animal Husbandry; state funds.]

Methods of Utilizing Native Pasture in Beef-cattle Feeding.
--During the past year a three-year study of a method of utilizing bluestem grass in fattening young cattle for market was completed. This method involves the purchase of calves in the fall, wintering well, grazing without feed other than grass to August 1, and then full feeding for approximately 100 days in a dry lot. Some of the results may be summarized as follows:

1. This method produces highly finished light-weight cattle as evidenced by the fact that they sold within 50 cents per hundredweight of the top of the week in which they were marketed.
2. It produces highly finished light-weight cattle at a time when comparatively few of this kind are coming to market.
3. It produces highly finished light-weight cattle by the use of a maximum of roughage, including grass, and a minimum of concentrates.
4. The study indicates the advisability of producing approximately 250 pounds of gain during the winter in order to have sufficient finish the next fall to meet the demands of a discriminating market. This will require feeding from 4 to 5 pounds of grain per head per day during the winter period.
5. A significant result is the fact that the necessary selling price per hundredweight to break even by this method of feeding was approximately \$1 per hundredweight less than the initial cost per hundredweight.

The work of this project for 1930-'31 will involve a study of the advisability of full feeding on grass, from May 1, calves that have been well wintered. [Project 151; Department of Animal Husbandry; state funds.]

A Study in Lamb and Fleece Development.--During the winter of 1928-'29 a study was made of (1) the comparative rate of gain of pure-bred Hampshire, Shropshire, Dorset, and Southdown lambs; (2) the comparative production of wool by lambs of those breeds on a quantity basis; (3) the fineness of wool produced by those breeds; and (4) the returns from the wool of each breed.

During the winter of 1929-'30 the same study was continued and in addition a study was made of (1) the correlation, if any, between grade and yield within the breed; (2) the influence of sex upon the grade of wool within the breed; and (3) a comparison of grades of wool of the same and similar breeding for 1929 and 1930.

Information relative to all points of the study has been accumulated, but further study will be required before definite results can be given. A means is now available for obtaining shrinkages of fleeces, and this will be incorporated in the study. The data being accumulated in this project offer an opportunity to study the inheritance of grades of wool, and such a study is now in progress. [Project 111; Department of Animal Husbandry; state funds.]

A Study of Pasture Values and Pasture methods for Horses, Cattle, Sheep, and Swine.--A study of several tame-pasture crops suitable for this section of the state has been continued through the past two years. The crops used have been brome grass, orchard grass, Sudan grass, and sweet clover. During the past two years certain observations were made that may be summarized as follows:

1. The brome grass planted on upland in the fall of 1925 was practically worthless as a pasture crop during the grazing season of 1928. It was sod bound and made very little growth. This area was seeded to sweet clover in the spring of 1929, made a good growth, and pastured approximately one head per acre the entire season. The second year's growth has come on splendidly and promises to pasture at least two head per acre during the summer of 1930 until seed sets.

2. A 60-acre field, one-half of which is seeded to brome grass and one-half to orchard grass, promises some interesting data. It was not grazed during the summer of 1928, but representative areas from each section were cut and cured for hay. The orchard grass produced twice as much hay per unit of area as did the brome grass. During the summer of 1929 from 20 to 40 head of mature cattle were grazed on this area. Pasture was available from April 15 to December 1. No particular preference was noted for either the brome grass or orchard grass.

3. Sudan grass continued to be the best mid-summer pasture crop for all classes of live stock.

[Project 142; Department of Animal Husbandry; state funds.]

The Influence of Feed on the Color, Chemical Composition, and Cooking Quality of the Meat of Grass-fat Cattle.---During the last biennium studies of two phases of this project have been conducted. During the year 1928-'29 the work consisted of an exact duplication of the previous year's work, the chief object of which was to determine the color of the beef produced on bluestem pasture. During that year all the cattle were pastured on bluestem grass without supplement and slaughtered in the station abattoir, where detail studies of the meat were made.

During the year 1929-'30, 24 head of cattle similar in type, quality, and origin to those used in previous years, were purchased and divided into three lots. Lot I was full-fed corn and bluestem grass hay in dry lot, Lot II was full-fed ground shelled corn on bluestem grass pasture, and Lot III was pastured on bluestem grass pasture without supplement. Six animals from each lot were slaughtered in the station abattoir. The killing dates were parallel with those of previous years, as were the methods of dressing and storing the carcasses.

Briefly, the indicated conclusions to be drawn from this project to date as they relate to the color of the meat are as follows:

1. The color of beef brightens very materially after cutting. During the first few minutes the brightening is very rapid, and continues for a period of about three hours. Therefore, the color of grass-fat beef should not be measured as at the time of cutting.

2. There is relatively little variation in color or degree of brightening between the various cuts studied and, therefore, anyone of these cuts may be taken as a standard measure of the color of any carcass.

3. Based on the readings of the 74 cattle studied during the four-year period, cattle pastured on bluestem grass do not produce dark-cutting beef, since none of the carcasses were found undesirable or dark in color. This statement is made with full appreciation of the fact that there is a wide difference of opinion between individuals relative to when beef is dark or acceptable in color, for even the ultracritical could have found fault with only two or three carcasses.

4. Supplemental feeds increased the degree of finish of cattle grazed on bluestem pasture, but had no influence upon the color of the meat.

5. Bluestem grass pasture without supplement produced a more desirable grade of beef than corn and bluestem grass hay in dry lot.

6. Cooking tests demonstrated that beef produced on bluestem grass pasture is highly palatable, rich in flavor, and very desirable in aroma.

7. Other factors indicative of quality in raw beef being equal, the color of the lean muscle apparently has no relation to the color, quality, and palatability of the meat when cooked.

8. Beef fattened on bluestem grass can be "ripened" satisfactorily, and ripening improves the quality of the cooked meat.

A chemical analysis of the hemoglobin and calcium of the blood from the experimental animals showed that there was no marked change in these constituents throughout the period of the experiment. The blood from animals on grass was slightly higher in per cent of hemoglobin and calcium than animals held in dry lots.

There was a noticeable relationship between the calcium content of the blood and the temperament of individual animals. Those animals with blood of a low calcium content were without exception nervous and excitable.

The moisture content of the rib fat varied between 17.04 per cent and 33.03 per cent in 1928. In 1929 the variation was not so marked, the limits being 14.54 and 24.84 per cent. It is noticeable that the fatter the animal the less moisture the fat contains. The analyses of fat from animals reveal a number of interesting comparisons as follows:

1. The degree of unsaturation of the fat (iodine number) is inversely proportional to the moisture content of the original fat, that is, the more unsaturated fat has less water.

2. The moisture content of original fat is directly proportional to the melting point; that is, the more moisture the higher the melting point.

The calcium content of the outside fat appears to have a relationship to the degree of unsaturation, melting point, and moisture content. The same relation exists, but is not so pronounced, in the case of fat from the entire sample.

The collagen content of meat ripened 30 days is approximately 60 per cent of that found in fresh meat. The per cent muscle hemoglobin (a measure of the color of meat) was determined on the water extract from the meat. The average muscle hemoglobin content was highest in the case of animals fed on grass alone; namely, 0.4584 per cent as compared with 0.4164 per cent for those on corn and grass and 0.3960 per cent for those in a dry lot. There is considerable variation in the muscle hemoglobin content of individuals on the same kind of feed.

A study of the cooked meat showed that the meat of grass-fed cattle could be ripened satisfactorily. The rib roasts of ripened meat were palatable and tender when cooked. Ripening was found to increase tenderness, but an unduly long ripening period was found not to be desirable as it tended to produce objectionable flavors in the fat.

In cooperation with Prof. E. V. Floyd, of the Department of Physics, progress has been made toward the completion of a device

for the measurement of the proper temperature for searing meat. Further work has been done, also, with a device for measuring the tenderness of meat. Much credit is due Professor Floyd for his cooperation and ingenuity in designing and constructing these pieces of equipment.

Valuable data were collected in a study of the preparation of meat for cooking. Among other things, the following points were outstanding:

1. The total waste from various cuts in preparation for cooking was less than 25 per cent for rounds prepared as Swiss steak; between 25 and 50 per cent for chuck, brisket, ribs, and rump; and more than 50 per cent for plate and flank.
2. When meat was prepared without the addition of liquid, shrinkage during cooking ranged from 16 to 25 per cent.
3. The serving weights for sirloin, round, and rib were about 60 per cent of the original weights, while for rump they were only 45 per cent.

[Project 165; Departments of Animal Husbandry, Chemistry, and Home Economics; Purnell funds.]

Factors Influencing the Mineral Metabolism of Dairy Cows.--Five phases of this project have been active during the past biennium, each of which is briefly described below.

*The Growth of Calves on Milk Alone.--*The work for the biennium has consisted chiefly of a study of the effects of supplementing milk with iron in which milk is lacking. Six calves are now on the experiment. They are from six to seven months old and have received no food but milk. Three of the calves have received mixed whole and skim milk, while the other three have received the same supplemented with iron, copper, and manganese. The calves are carefully muzzled with a leather muzzle so that they cannot lick themselves or secure any food or other material. They are allowed what distilled water they care to drink. The calves are weighed and measured at regular intervals. Every two weeks the hemoglobin content of the blood is determined.

Milk alone does not supply all the factors necessary for normal growth. Mineral supplements seem to be necessary to raise a calf to more than a few months of age. There is a strong tendency for an anemic condition to develop. The addition of minerals seems to prevent this.

A nervous condition leading to spasms noted in several animals can apparently be cured by the addition of a small amount of wheat-germ stock to the ration. This may be due to the vitamin B contained in the germ stock. Those receiving mineral supplements (200 mg. Fe, 15 mg. Cu, 30 mg. Mn daily) have a normal hemoglobin content, but the three receiving no supplement are all anemic. Since nutritional anemia has been one of the problems that has developed where an attempt has been made to raise calves on milk alone, a study has been made of this type of anemia by the use of small experimental animals. The purpose of this work has been to determine whether or not manganese is effective in promot-

ing the building of hemoglobin when the animals are fed milk and iron.

Hemoglobin determinations show that calves are like other animals in that they will slowly develop nutritional anemia if fed milk alone. This anemia does not develop if the milk is supplemented with a small amount of iron to which has been added small amounts of copper and manganese.

This influence of the iron, copper and manganese is clearly shown by the last hemoglobin reading on the six calves now in the experiment. Thus hemoglobin content of the blood of the three calves getting milk alone was 8.13, 8.18 and 7.19 grams per 100 c. c. of blood, while that of the three receiving the mineral supplements was 10.59, 12.36 and 12.77 grams per 100 c. c.

The results obtained with the small animals on the influence of manganese are conflicting. Last year the results indicated that manganese was effective in hemoglobin building. This year those receiving the manganese did no better than those receiving iron alone. As other workers do not agree on this question, some finding that manganese is effective and others finding that it is not, it seems that there are some unknown factors in the hemoglobin building which are not being controlled in these experiments. Further work on this phase of the problem is necessary for its solution.

Studies of the Blood Sugar Content of Dairy Cattle.--The work of this phase of the project has consisted of the following studies: (1) Establishment of a normal average blood sugar content for dairy cattle; (2) a comparison of the average blood sugar content of the various breeds of dairy cattle; (3) the influence of age on the blood sugar content of dairy animals; and (4) the blood sugar content of cows at different stages of lactation.

The results of the study justify the following deductions:

1. The average blood sugar content for dairy cattle, all ages, is 63.84 mg. per 100 c. c. of blood.
2. Animals under two years of age show a definitely higher blood sugar content than animals over two years of age. At birth the average blood sugar content is about 100 mg. per 100 c. c. of blood. This shows a definite regression until the animal reaches two years of age, where it remains at about 52 mg. per 100 c. c. of blood throughout the remainder of life.
3. The average blood sugar content of the various breeds of dairy cattle seems to show no significant differences.
4. The advancement in the stage of lactation apparently has little effect upon the blood sugar content, there being no apparent difference in the average blood sugar content of lactating and dry animals.
5. The injection of large amounts of readily absorbable carbohydrate material increases the blood sugar content over 100 per cent.
6. That starvation causes a decrease in the blood sugar content to the extent of about 30 to 40 per cent.

The Hemoglobin Content of the Blood of Dairy Cattle.--Determinations have been made the past year on cattle of the four major dairy breeds in the college herd, state institution dairy herds, and privately owned herds in order to determine the hemoglobin con-

tent of the blood of dairy cattle under normal conditions. The determinations have been made by the acid-hematin method. A total of 335 determinations on 252 head of cattle representing both sexes and all ages of the four major breeds have thus far been made. Results have been secured from three herds, all under similar conditions of feeding and management. The following conclusions seem justified:

1. The hemoglobin content of the blood of dairy cattle is a rather uniform and constant factor.
2. The individuality of the animal seems to be the most important factor influencing the hemoglobin content of the blood.
3. The mean for all determinations is 11.25 grams of hemoglobin per 100 c. c. of blood. The lowest for any group was 9.46 grams for the calf herd at the Osawatomie State Hospital, and the highest was 12.99 grams for four aged bulls at the Topeka State Hospital. These averages represent a variation of 15.7 per cent and 15.6 per cent, respectively, from the mean of all groups.
4. The hemoglobin content of calves' blood seems to run slightly lower than that of older animals.
5. No significant daily variation was found in a group of three animals during a period of eleven days.
6. A fasting period of 14 days for five animals failed to exert any influence on the hemoglobin content of the blood.

The Relation of Phosphorus Intake to the Utilization of Feed.-- This phase of the project was started in the fall of 1929, when two lactating cows were put on a ration low in phosphorus to compare with one other, as a check, which received a phosphorus supplement.

As anticipated, the inorganic phosphorus content of the blood in the experimental animals dropped after several months' feeding of the low phosphorus ration until it was less than one-fourth of normal. This condition was followed later by symptoms of phosphorus deficiency, such as abnormal appetite, loss of weight in spite of adequate intake of protein and total nutrients, and a general unthrifty condition. The check animal has remained normal in every respect, gaining in weight and showing excellent condition. It may also be remarked that calcium, hemoglobin, and red-blood-cell determinations have also been made at regular intervals on the blood of these animals. The calcium remains normal, apparently, irrespective of the behavior of the phosphorus. The hemoglobin and red-blood-cell determinations in one of the low phosphorus animals fell considerably below normal for a time when the animal was in a particularly unthrifty condition. In the other animal there has been also a significant deviation from normal, but the change was less striking.

The Influence of the Ration on the Vitamin C Content of Cow's Milk.—Experimental work on this phase of the project started in May, 1930. Seven cows are being used, some of which are on pasture and some in a dry lot. The vitamin C content of the milk is being compared by feeding it to guinea pigs. The cows in the dry lot are further divided to study the influence of silage on the antiscorbutic value of the milk—two cows being fed silage of good quality while two are fed no silage. In addition one cow is being

fed a ration low in vitamin C. The work has not progressed far enough to warrant making a report.

It is planned to continue this phase of the work and make a thorough test of the vitamin C content of cow's milk produced under the conditions noted above. The guinea pigs will be carried for 90 days on the different kinds of milk, when they will be killed and scored for evidence of scurvy. [Project 147; Departments of Dairy Husbandry and Chemistry; state and Purnell funds.]

Dairy Cattle Feeding Investigations---Eight different phases of this project have been active during this biennium. Six have had to do with a comparison of different feeds for the production of milk and butter fat, one with a comparison of feeds for the development of dairy heifers, and one with a determination of silage weights. Each phase of the project is briefly discussed below.

1. *A Comparison of Sorgo Silage and Ground Sorgo Fodder for Milk and Butter-fat Production.*--This work consists of a comparison of sorgo as silage and as ground fodder, fed on the same dry-matter basis. The cows are fed silage at the rate of three pounds for each 100 pounds of live weight or an amount of ground sorgo fodder sufficient to give the same amount of dry matter as is fed in the silage. These feeds are supplemented by alfalfa hay and a concentrate mixture consisting of 4 parts corn chop, 2 parts wheat bran, and 1 part oil meal. The concentrate mixture also contained 1 per cent salt and 1 per cent steamed bone meal. The double-reversal method was used for the two groups of five cows each. Each period consisted of thirty days with an eight-day preliminary feeding period.

The results indicated that silage was slightly superior in maintaining the live weights of the animals, although the small difference was probably insignificant.

2. *Atlas versus Kansas Orange Sorgo Silage for Dairy Cows.*--A total of 17 cows have been carried through three feeding periods during two different years. They received a basal ration of alfalfa hay and a grain mix made up of 4 parts corn chop, 2 parts bran, and 1 part linseed meal. In addition they received either Atlas silage or Kansas Orange silage in alternate periods. The Morrison standard was used in estimating the requirements of the animals. Body weights were secured on the first and last three days of each experimental period, and samples for butter fat on the three center days of each period. The cows gained in weight both while on Atlas and Kansas Orange silage, the gain per animal per period being 3 and 5 pounds, respectively. In milk production the difference was very slightly in favor of Atlas, while in fat production the difference was somewhat greater in favor of Kansas Orange. The results of the two years' work indicate very little difference in the value of the two silages.

3. *Corn and Cob Meal versus Corn Chop for Milk and Butter-fat Production.*--This phase of the project was started in 1928 and has been conducted during two years. A total of 18 cows, divided into two balanced lots, have been fed. Body weights were taken for three days at the beginning and end of each experimental period, and fat tests were secured on the three center days of each period. The basal ration consisted of alfalfa hay and sorgo silage. The grain ration was 5 parts of either corn chop or corn and cob meal and 1 part of cottonseed meal. The grain was all fed on a corn-chop basis, using the Morrison standard for requirements. One group of cows was started on the corn-chop mixture while the other received the corn-and-cob-meal mixture. At the beginning of each period the kind of grain given the lots was reversed.

A slight gain in weight was made on both of the feeds. This amounted to about 2 pounds per cow on corn chop and about 6 pounds per cow on corn-

and-cob meal, neither being particularly significant. Slightly more of all feed was consumed while on the corn chop grain mixture, but the difference in consumption was not marked. In the production of milk and fat there was practically no difference when using the different grains. The results of these trials would indicate that corn-and-cob meal can be substituted for corn pound for pound in the grain mixture with equally good results.

4. *A Comparison of Sorghum Grains and Corn for Developing Dairy Heifers*—In this experiment heifer calves are raised and continued through the first and second lactations on a grain ration containing 50 per cent of sorgo, kafir, or corn, the remainder of the ration being balanced with alfalfa hay and sorgo silage. Six weeks prior to freshening, 1 pound of linseed-oil meal is added. Abortion disease has made heavy inroads on the experiment during the past biennium, and this has necessitated some removals.

Little difference in the appearance and general condition of the lots fed on the different kinds of grain can be observed. All appear to be developing satisfactorily.

5. *Soy-bean Hay versus Alfalfa Hay for Dairy Cows*.—A total of 17 cows have been fed on a grain mixture of 4 parts corn chop, 2 parts bran, and 1 part linseed meal with sorgo silage as the basal ration. In addition one group of cows gets alfalfa hay and the other soy-bean hay. The double reversal plan, using three 30-day periods, 10 days of which served as a preliminary period, has been used. The kind of hay was reversed for each group at the start of each period. The Morrison standard served as the basis for estimating the requirements of the animals. Body weights were taken on the first three and the last three days of each 20-day experimental period. Samples taken from the six milkings in the center of each period were tested to determine the average fat content of the milk.

In body weight the cows averaged slightly higher on the alfalfa but the difference was well within the range of experimental error. On soy-bean hay the cows produced 4.5 per cent less milk and 1.8 per cent less fat than while on alfalfa. This may be of some significance, but in the first trial, where the difference in production was greatest, the soy-bean hay was of poor quality as compared with the alfalfa, which might account for some of the difference.

6. *A Comparison of Stack-browned versus Field-cured Alfalfa for Lactating Cows*.—A total of 16 cows were carried through two 30-day periods in this experiment, the first 10 days of each period serving as a preliminary. All cows throughout the periods received a ration of sorgo silage and grain mixture of 5 parts corn chop, 2 parts bran, and 1 part linseed meal. During the first period one group of cows received field-cured alfalfa hay while the other group received stack-browned hay. During the second period these feeds were reversed. Body weights were secured on the first three and last three days of each 20-day experimental period, and fat tests were taken on the center three days of the period.

The average body weight per cow was exactly the same on both feeds. Somewhat more feed was consumed while the cows were on the brown hay. An increase of 7.6 per cent in the grain ration fed the cows receiving the brown hay should have given them an advantage, but this was not the case since the cows receiving the brown hay produced 4.3 per cent less milk and 4.1 per cent less butter fat. The greatest part of this difference occurred during the first trial, when the brown hay was very dark brown. Another trial will be conducted as soon as conditions are suitable for securing a satisfactory quality of brown hay.

7. *A Comparison of Ground Sorgo Heads versus Corn Chop for Dairy Cows*.—Sorgo grain, thought at one time to have a depressing effect on milk production, has been shown to be a satisfactory grain for dairy cows by work at this station. This phase of the project was started to see whether feeding the entire sorgo head might be detrimental. Ten cows were fed through three 30-day periods, using the first 10 days of each as a preliminary. Alfalfa hay and sorgo silage were fed throughout the trial. In addition one group of cows

received a grain mixture of 640 pounds ground sorgo heads, 200 pounds bran, and 100 pounds linseed meal. The other group received a grain mixture of 400 pounds corn chop, 200 pounds bran, and 100 pounds linseed meal. At the beginning of each new period the grain mixtures used were reversed.

The cows gained in body weight both while on corn chop and while on sorgo heads, the gain being 5 pounds per cow per period on the former and 3 pounds on the latter. The production of milk and butter fat was very near the same on both feeds. Slightly less was produced while on sorgo heads, but the difference in both milk and fat was less than 1 per cent, which is within the limits of experimental error. This trial would indicate that the panicle of the sorgo head will not reduce milk production when fed to dairy cows.

8. A Determination of Silage Weights.—The object of this phase of the experiment is to determine the weight per cubic foot for untramped silage at various levels and points in a silo. An effort was made to take three weights as the silage decreased each foot in depth. One sample was taken in the center, one next to the wall and the third at a midpoint between the other two locations. At various times moisture determinations were taken. Those in 1928-'29 were air-dried, while in 1929-'30 they were accurately determined in the drying oven of the Department of Chemistry.

The results in 1928-'29 on three silos indicated that the silage was heavier at a point half way between the edge and the center than it was at either extreme. In 1929-'30 the results with one silo indicated that the center was the heaviest. The average of six moisture determinations in 1928-'29 was 72.8 per cent; eight determinations in 1929-'30 showed an average of 67.4 per cent moisture.

This work will be continued until sufficient data are secured to justify the formation of definite conclusions. [Project 34; Department of Dairy Husbandry; state funds.]

Silage Investigations.—This project consists of a study of the variation in the chemical composition of sorgo and sorgo silage made under varying conditions from year to year.

The practice followed is to fill a number of telescoping cans with the cut sorgo as the silos are filled. These cans are placed in a silo and buried. The cans are removed some months later, at which time they are weighed to determine loss from siloing. Samples are taken for chemical analyses. The analysis of the cured silage is compared with the analyses made from samples of the green sorgo going into the cans.

During the past year a number of automobile inner tubes were filled with cane at the time the cans were filled. The tubes were then vulcanized and placed in the silos with the can samples.

The results show that the moisture content of the green sorgo is fairly constant from year to year. The protein content varies considerably among lots of sorgo cut during the same year. This difference was as high as 50 per cent in the case of samples collected in 1928 and 38 per cent for samples collected in 1929. The year-to-year variation in protein content is considerable. The average protein content of all samples of sorgo analyzed in 1928 was 1.58 per cent, while for 1929 the average was 1.91 per cent.

It is significant that there is little loss in weight from siloing, the average over a period of years being approximately 2 per cent. Samples sealed in rubber tubes, on an average, showed no loss or

gain in weight. The amount of acid formed from normal sorgo during the process of siloing varies only slightly from year to year. The average acid content is slightly over 3 per cent with a maximum of 3.7 per cent.

A year-to-year comparison of the feeding value of green sorgo as compared with sorgo silage shows little change. The protein, ether extract, crude fiber, ash, and nitrogen free extract content are essentially the same for silage as for the green sorgo.

The change in composition of sorgo brought about by siloing is mostly in the sugar content. While the starch content of the silage is about the same as the green sorgo, the sucrose and reducing sugars almost entirely disappear. [Project 34; Departments of Chemistry and Dairy Husbandry; state funds.]

Calf-feeding Investigations.—The active phase of this project during the biennium consisted of feeding ten heifer calves on a ration of sorgo grain in comparison with corn.

The calves were fed a basal ration of alfalfa hay, cane silage, and milk. The grain mixture was composed of 300 pounds of ground corn or sorgo, 100 pounds each of ground oats, bran, and linseed meal. Monthly weights and height measurements were taken, which were compared with the normal. At 180 days of age the average weight of the calves receiving sorgo grain was 251 pounds, while the average weight of those receiving corn was 257 pounds. The former group received a severe setback early in the experiment from overfeeding. Their feed consumption was therefore noticeably below that of the corn-fed heifers. The work upon this project will be continued until data of a significant nature are available. [Project 154; Department of Dairy Husbandry; state funds.]

Normal Growth of Dairy Cattle.—As previously reported, an attempt is being made to determine the normal growth of dairy calves by weighing and measuring the height at withers of each female calf dropped in the station herd. Records are made of each female up to 24 months of age and of as many males as possible up to 12 months of age at intervals of 30 days from birth. The four major dairy breeds are represented in this study. Records have been started for 191 females and completed for 115. Records of weight and size at birth have been obtained upon 213 males, while complete records for one year are available for 27. The project will be continued indefinitely. [Department of Dairy Husbandry; state funds.]

A Study of the Use of Fly Repellants for the Control of Flies on Dairy Cattle.—During the past year twelve cows were used to test the repellent properties of two commercial and one "home-mixed" fly sprays. Repellent properties were judged by counting the flies on the left side of each cow just before spraying and one-half hour after spraying. In the case of the home-mixed spray they were also counted one hour after spraying. Data were taken

through three 20-day periods with a 5-day interval between. An unsprayed group was used as a check.

All three sprays used were efficient in repelling flies for one-half hour. The home-mixed spray was also efficient for one hour. The total milk production of the cows sprayed with fly repellants was 5,215 pounds, while the production of the unsprayed lots was 5,270 pounds. The repellants did not benefit the cows as determined by milk production. The cows in this study were barn-fed. It is possible that some benefit might have resulted had the cows been exclusively on pasture. [Department of Dairy Husbandry; state funds.]

Ice Cream Investigations.—The work during the biennium has consisted of studies of methods used in the manufacture of ice cream and sherbets. The work is divided into five phases, each of which is discussed below.

Chocolate Ice cream Investigations.—This work has consisted of a study of nine prepared chocolate ice cream syrups used in mixes according to the manufacturers' directions; also of the best manner of processing chocolate ice cream mixes.

A comparison of the samples of ice cream flavored with these syrups showed that the three most desirable samples were those flavored with cocoa, cocoa and chocolate liquor, and chocolate liquor when they were added to the respective mixes in dry form during the pasteurization process.

Preliminary results on the processing of chocolate ice cream mixes indicate that the viscosity is most easily controlled by raising the homogenization temperature to 165-175°F. The most desirable homogenization pressure seems to be about 2,000 to 2,500 pounds.

The Use of Butter in Ice Cream.—The work has consisted of a study of (1) the whipping properties of ice cream mixes containing butter compared with similar mixes deriving their butter fat from sweet cream; (2) the use of certain emulsifying agents as a means of improving the whipping properties of ice cream mixes; and (3) the effect of standardizing the acidity of sour cream prior to churning it into butter to be used in ice cream.

A total of 13 freezing trials were made in which sweet cream and butter were compared. The results showed that butter increased the total freezing time per batch two minutes and eighteen seconds and reduced the total overrun. The reduction in overrun amounted to an average of 3.1 per cent.

The use of 0.16 per cent soy bean lecithin increased the total time in the freezer four minutes per batch as compared with a check mix containing no emulsifying agent. Dehydrated egg yolk used in concentrations of 0.3 to 0.5 per cent shortened the total time in the freezer three minutes per batch.

An attempt was made to restore the whipping properties of ice cream mixes deriving their fat from butter by incorporating a proportional amount of buttermilk into the butter mixes. It was

found that the use of buttermilk did not restore the whipping properties.

It was also found that butter made from neutralized cream increased the total freezing time as compared with the butter made from unneutralized cream.

A Study of the Manufacture of Ice Cream Mixes in a Vacuum Pan.—Studies have been made to determine (1) the feasibility of superheating the mix to 190° or higher for varying lengths of time, and the effect of such heating on the texture, flavor, and whipping qualities of the ice cream; (2) the effect of superheating before and after adding sugar on the flavor, texture, and whipping qualities of ice cream; (3) the effect on whipping quality of homogenizing butter mixes before and after superheating; (4) the possibility of excluding gelatin from superheating mixes; (5) bacterial destruction as a result of superheating; and (6) the effect of superheating on viscosity.

The following results were obtained:

1. In every case superheating the mix or any of the ingredients used in it gave a cooked flavor to the finished ice cream.
2. A mix made in a coil vat from pasteurized products, but using superheated plain condensed milk as the source of serum solids gave only a slightly cooked flavor to the finished ice cream, while a mix made in the same way, except that superheated sweetened condensed milk was used, gave a more pronounced cooked flavor.
3. In every case when the entire mix was superheated the cooked flavor was more noticeable than if any one part of it was superheated. The body and texture of ice cream made from these superheated mixes were good.
4. Practically all superheated mixes took from two to five minutes longer to whip to a certain overrun (95 to 100 per cent) than did mixes of the same composition made from unsuperheated products.
5. If the sugar used in the mix was superheated a distinct caramelized flavor was present; if the sugar was added after superheating only a cooked flavor was noticeable.
6. Butter mixes homogenized before and after superheating whipped faster than a like mix homogenized only after superheating.
7. In every case the ice cream frozen from mixes which were superheated and then homogenized without using gelatin was coarse and rough, as compared with mixes of the same kind which contained gelatin.
8. The greatest benefit derived from superheating ice cream mixes appears to be in bacterial destruction. One mix that had a count of five million bacteria per cubic centimeter in the raw state had only 300 after superheating. In nearly all cases condensing the mix reduced the count appreciably, and in all cases superheating the mixes reduced the count to 1,000 bacteria per cubic centimeter or under. Superheating to 190° F. for 10 minutes reduced the count practically as much as a temperature of 210° F. for 10 minutes.
9. The correct Baumé for "striking" a mix testing 12 per cent fat, 10 per cent serum solids, 15 per cent sugar, and 0.35 per cent gelatin is between 11 and 12 at 120° F. For striking a batch of skim milk and cream for such a mix, from 4 to 5 is approximately correct.
10. The superheated mixes were more viscous than mixes of the same composition not superheated.
11. In general, it appears that superheating a mix or part of it is detrimental to the production of high-quality ice cream.

The Use of Frozen Strawberries in Ice Cream.—In 1929 cost data were secured relative to the price of strawberries, the labor

cost in preparing them, container cost, and the cost of sugar used in preserving berries used in ice cream mixes. An examination has been made from time to time of their flavor and other characteristics.

A total of 441 pounds of stemmed berries were stored at an average cost of 18.8 cents per pound. The total weight of berries with the sugar was 59 pounds, at an average cost of 14 cents per pound of preserved berries. This distribution of the costs was as follows: Cost of berries, 64.6 per cent; labor cost, 14.7 per cent; container cost, 10.4 per cent; sugar cost, 10.3 per cent.

All of the berries stored maintained their flavor perfectly throughout the year. The frozen berries, after being stored for a period of 11 months, were much superior in flavor to the first fresh strawberries placed on the market.

Berries which were put up with 2 pounds of berries to 1 pound of sugar were too sweet for use in a standard commercial ice cream mix. The extra sugar, however, did extract more moisture from the berry, which produced a softer berry and one that did not freeze so hard in the ice cream. The best proportion for preserving berries for ice cream is 1 pound of sugar to 3 pounds of berries.

Sherbet Investigations.—These investigations have consisted of the following studies: (1) The composition of the sherbets manufactured throughout the state of Kansas by means of an analysis of 50 commercial samples; (2) the establishment of a desirable composition for a good commercial sherbet; (3) the manner of processing and preparing sherbets; and (4) factors involved in the freezing of sherbets.

The analysis of 50 commercial sherbets for butter fat, total solids, and titratable acidity showed conclusively that very little attempt has been made to standardize the composition of commercial sherbets. A summarized result of the study is shown in Table XV.

TABLE XV.—AN ANALYSIS OF FIFTY COMMERCIAL SHERBET SAMPLES SHOWING THE MAXIMUM, MINIMUM, AND AVERAGE COMPOSITION.

Constituent.	Maximum per cent.	Minimum per cent.	Average per cent.
Water.	75.39	58.370	66.380
Butter fat	4.00	0.400	1.372
Acidity expressed as citric acid	3.90	0.163	0.536

An examination of frozen sherbets made from mixes containing varying amounts of cane sugar showed that the samples increased in smoothness in direct proportion to the amount of sugar present. Those containing less than 30 per cent sugar were unsatisfactory from the standpoint of their body, texture, and flavor. It was concluded from this study that a good commercial sherbet should con-

tain 33 to 35 per cent cane sugar. Trials with corn sugar indicated that it is undesirable for use in sherbets because of its effect on the freezing point of the mix.

Approximately 14 per cent ice cream mix was necessary with 28 per cent sugar to produce a sherbet that compared favorably in body and texture with a sherbet containing 34 per cent sugar and only 6.75 per cent ice cream mix. No advantage could be found in using more than 6.75 per cent ice cream mix with a sherbet containing 34 per cent sugar.

Overrun in sherbets must be limited to not more than 30 per cent if the sherbet is to possess a satisfactory body and texture. Experimental trials in which the amount of sherbet mix frozen at one time was varied show that overrun can be most easily controlled in freezing sherbets by reducing the size of the batch. The batch should be sufficiently reduced so that it will not require longer than eight to ten minutes to complete the freezing process. [Project 124; Department of Dairy Husbandry; state funds.]

A Bacteriological Study of Ice Cream and Sherbet.—The work during the past biennium has been directed along the following lines of investigation: (1) Study of the bacterial content of sherbets; (2) comparison of the volumetric and gravimetric methods of sampling ice cream for bacteriological analysis; (3) development of simple methods of analyzing sweet cream to be used in ice cream; (4) study of oxidation-reduction potentials of ice cream mixes with special reference to the reduction of organic dyes; (5) study of the factors affecting the depletion of hypochlorite disinfectants; (6) cheaper methods of manufacturing hypochlorite disinfectant applicable to dairy plant conditions; (7) development of a new and simple method of testing the effective strength of hypochlorite disinfectants; and (8) study of the *Brucella abortus* content of sweet cream used in the manufacture of ice cream.

The study of the bacterial content of sherbets was designed to show the value of bacteriological analysis of this product as an index to the sanitary conditions of the plant. Since the ingredients used in sherbets consist of products which usually contain very few bacteria, high bacterial counts are indicative of excessive contamination from equipment. Analyses of 21 samples from various sections of Kansas and from some of the adjoining states showed the bacterial counts to vary from less than 200 bacteria per gram to more than 100,000 per gram.

In comparing the relative value of the gravimetric and volumetric methods of sampling ice cream for bacteriological analysis, over 1,600 analyses were made of 11 samples. Statistical treatment of the data indicates that the errors inherent in the plate method of bacterial enumeration overshadow the variations introduced by volumetric sampling.

In the development of simple methods for analyzing sweet cream to be used in the manufacture of ice cream, an attempt has been made to adapt the methylene blue reduction test to cream. Preliminary

results indicate the probable necessity of altering the concentration of the dye in order to overcome the natural color of the cream. A similar attempt has been made to adapt the test to the finished product, ice cream. These studies have revealed the necessity of a study of the fundamental factors which affect the test. Accordingly, studies are now under way involving the factors affecting the oxidation-reduction potentials of cream, milk, ice cream mix, and ice cream.

The enormous increase in the use of chemical disinfectants in all phases of the dairy industry has created a demand for information relative to these products. A study of the factors affecting the rate of depletion of hypochlorite disinfectants shows that organic matter accompanied by high temperatures results in almost instantaneous and complete loss of chlorine. Butter fat has very little influence on the rate of loss of available chlorine. Increasing concentrations of casein, albumen, or lactose, induce an increased rate of loss of available chlorine.

The method of manufacturing sodium hypochlorite disinfectant from chlorine gas and sodium hydroxide has been worked out and is now being tried in one Kansas creamery with gratifying success. The results to date indicate that a satisfactory disinfectant solution can be made by dissolving sodium hydroxide and soda ash in water, allowing to cool, and bubbling chlorine gas through the solution. The jar containing the water and salts is weighed on ordinary platform scales and the chlorine is admitted to the solution until the increase in weight indicates that the calculated amount of gas has been dissolved.

In an effort to devise a simple method of testing the effective strength of chlorine solutions, tablets have been compounded so as to contain sufficient sodium thiosulphate to react quantitatively with the available chlorine in one quart of a rinse solution containing a specified strength of available chlorine. If the chlorine content is in excess of the specified strength, the iodine liberated from potassium iodide in the tablet will cause the starch present to turn purple. If the rinse solution does not contain enough chlorine to react with all the sodium thiosulphate, no purple color will appear. Through cooperation with Parke, Davis & Company, of Detroit, Mich., some of these tablets have been compounded. Titrations indicate that the accuracy of the quantitative amount of sodium thiosulphate in the tablets is well within the limits of accuracy which practical application of the test would demand. In the first attempt to make these tablets, however, it was found that they did not disintegrate readily when placed in water. Experiments are now in progress to solve this practical difficulty. [Project 124; Department of Bacteriology; state funds.]

Butter Investigations.--Treating off-flavored cream with chemical deodorants is common in this section of the Middle West. Little definite information is available relative to the value of this

practice. Chlorine compounds, such as sodium hypochlorite, chloramine T, and calcium hypochlorite, are the deodorants most commonly used. A solution containing about 2 per cent available chlorine is added to the cream prior to pasteurization. The usual rate of treatment varies from 2 to 5 pints per 1,000 of cream, depending upon the degree of the undesirable flavor. When these substances come in contact with organic material, free chlorine is liberated which acts as a strong oxidizing agent. Theoretically the nascent oxygen, produced by the reaction between chlorine and water, will unite with or drive off certain compounds which produce the undesirable flavor. While the project has not been completed, the following general observations have been made:

1. More than 125 lots of cream have been treated in different ways with deodorants and churned with suitable checks. Each sample of butter has been scored fresh and after different intervals of time. The average scores on groups of preliminary churning show little difference between the treated and untreated samples.

2. It was found that no germicidal action took place in the cream until the concentration of chlorine was at least 180 p.p.m. This is considerably more than is added to off-flavored cream under ordinary conditions.

3. Cream has been treated with excessive amounts of chemical deodorants. More than 400 p.p.m. of chlorine is necessary before it can be tasted in the butter. If treated with this amount or as high as 500 p.p.m. the chlorine flavor leaves the butter within two or three days, and there seems to be no tendency for more rapid deterioration of the butter under such conditions. Amounts in excess of 500 p.p.m. produce a tallowy flavor.

4. No significant differences were noted in the body and texture of butter made from treated and untreated cream.

5. Earlier experiments have proved that the vitamin A in butter is very easily destroyed by oxidation. Since chlorine is a strong oxidizing agent, it is thought that a part or all of the vitamin A may be destroyed by chlorination. White rats are being fed vitamin-A-free diets supplemented with equal amounts of treated and untreated butter to determine this point.

6. More than 40 samples of butter have been held at 40° F. and scored at regular intervals until they developed off flavors. There was no significant difference between the treated and check samples in the time at which they began to develop off flavors.

7. A modified method of "Rupp hypochlorite test" has been devised which is satisfactory for detecting butter made from treated cream.

[Project 175; Department of Dairy Husbandry; state funds.]

Dairy Chemical Investigations.---Some attention has been given to seven research problems during the past year as follows: (1) Fractionation of egg yolk, (2) effect of preservation with formaldehyde on fat tests for cream, (3) methylation of lactose, (4) rate of oxidation of sugars with potassium permanganate, (5) detection of chlorinated butter, (6) melting characteristics of butter and oleos, and (7) selective fermentation of sugars as applied to lactose and glucose in milk sugar.

The following are a few of the observations made from these studies:

1. In cooperation with the Department of Dairy Husbandry, it was found that neither any part into which dried egg yolk was divided nor the composite obtained by reuniting these parts was so effective for promoting overrun in ice

cream as the original substance. An article reporting this work is in the process of preparation.

2. In as much as certain cream samples preserved in formaldehyde, received from the Dairy Control Division, could not be satisfactorily analyzed, some observations were made on the effect of long-time preserving. It was found that after sweet cream preserved with formaldehyde stood at room temperature three or four weeks the curd could not be satisfactorily decomposed either by the Rose-Gottlieb method or by the modification of the Babcock method adopted by the Dairy Control Division. The time limit was a week or two longer if the three-whirl modification of the Babcock method was used. The cream could be analyzed satisfactorily by this last method after standing six to eight months in a refrigerator, though the samples had evidently lost water and had molded somewhat.

3. In cooperation with the Department of Dairy Husbandry it was found that butter from cream which had been "deodorized" by active chlorine could be readily identified by applying the test for halogens to the settlings, that is, curd and water after melting the butter. The iodine number and acetyl number of the butter was not changed enough to distinguish treated and untreated butter.

4. Some success was obtained in observing the visible melting characteristics of butters and oleos of varying ages and compositions as a measure of quality. Continuance of this study may depend on the interest evoked and the development of other measures such as penetration tests.

5. The determination of fermentable sugars in milk is in line with new studies on fermentable sugars in blood and other biological materials. The study of the relation of kind and quantity of milk sugar to various influences appears very promising and is the subject of a cooperative project now being formulated.

[Department of Chemistry; state funds.]

Inheritance of Standard Characteristics in Poultry.---Three phases of this project have been active during the biennium. Each phase is briefly discussed below.

The Inheritance of Rhode Island Red Chick Down Color Variations and Their Relation to Color Variations in Adult Plumage.--This study has covered a period of several years and was terminated at the end of the first half of the past biennium. By means of selection, dark and light down color strains have been established.

Although the dark and light down color strains had but very little overlapping, the offspring resulting from their crossing showed such a continuous series of grades that a definite Mendelian analysis was difficult. It is believed, however, that a single pair of genetic factors will explain the major differences between the dark and light strains. The F_1 generation was intermediate, so that neither can be said to be dominant.

No significant correlations were found between down color and adult surface color, breast color, amount of black in large wing feathers, and eye color.

There was a significant positive correlation between shade of down color and shade of adult undercolor. The correlation coefficient was 0.478 ± 0.008 for males and 0.517 ± 0.006 for females. Smut and white in the adult undercolor seemed to be associated with striping in the chick. Light-colored chicks developed into adults with either dark or light surface color, but dark-colored

chicks seldom produced anything but adults darker than the average.

This completes one phase of the study, and it is planned to consider next the mode of inheritance of some of the adult color variables mentioned above. A manuscript entitled "The Inheritance of Rhode Island Red Chick Down Color Variations and Their Relation to Color Variations in Adult Plumage" was published in the *Journal of Agricultural Research*, 39:781-794.

Inheritance of Crookedness of the Keel Bone.--Although this condition has usually been considered a result of nutritional factors, evidence has been accumulated which strongly supports the view that the deformity referred to as crooked keel (breast) bone is inherited. Although the per cent of crooked and straight keels has varied considerably, it has been possible to establish by selection strains which differ strikingly in the frequency of the occurrence of this deformity. These differences occur in strains being reared under identical environmental conditions.

Inheritance of Salmon Breast in White Leghorns.--The occurrence of red color in any section of the plumage of White Leghorns constitutes a disqualification. The salmon-tinted breast is a common defect of females of the White Leghorn breed. By selection for this color defect it was found that it did not appear in males as such, but was expressed as varying degrees of red in the wing-bow region.

Salmon-breasted females and red-shouldered males were mated to a strain of White Leghorns known to be free from this color. From the study of 271 F₁ and F₂ generation birds, it was found that a single major autosomal factor difference would explain the occurrence of salmon breasts in White Leghorns. The salmon breast was recessive to its absence and it may be considered a pattern factor having a different expression in the two sexes. This pattern may be related to the well-known duckwing pattern. [Project 77-3; Department of Poultry Husbandry; state funds.]

Inheritance of Breed Characteristics in Poultry.--It is the purpose of this study to consider the linkage relations of the autosomal group of characters in the fowl. During the past two years seven pairs of factors have been studied. Those considered were naked and normal neck feathering, rumpless and normal tail vertebrae, white and yellow legs, rose and single comb, black and Columbian plumage patterns, feathered and unfeathered legs, and pea and single comb. By appropriate crosses it was found possible to produce two males heterozygous for five of the seven characters. By back-crossing these males to Rhode Island Red females that carried recessive members of each pair, it was possible to determine the linkage relations of the five characters involved.

The five characters were naked neck, rumpless, black plumage, white legs, and rose comb. The ratios obtained were such as would be expected from independent assortment and indicated that there was no linkage between any of them. The segregation ratio for

naked neck and rumpless was slightly unequal, but until larger numbers are available it cannot be held to be evidence for linkage. The linkage relations between feathered legs and rose comb, and pea comb and feathered legs were also considered. The ratios from the latter pair were sufficiently unequal to furnish slight evidence for loose linkage between these two. It is planned to obtain more data on the two cases where there was slight evidence for loose linkage and to determine the relations of pea comb and leg feathering with the members of the independently assorting group of characters. [Project 77-4; Department of Poultry Husbandry; state funds.]

Inheritance of Egg Production in Single-comb Rhode Island Reds.--The work on this problem has consisted of selection in the third and fourth generation of late- and early-maturing strains of Rhode Island Reds.

Two early and three late matings were made in the 1928 season, and three of each during the 1929 season. The two early matings of 1928 had average maturity ages of 218.8 and 222 days and the three late matings average maturity ages of 255, 240, and 248.5 days. For the 1929 season the averages of the three early maturity matings were 194, 205.5 and 222.4 days; and of the three late matings 255.9, 253.6 and 248.7 days. It is seen that the two strains are becoming very different in their age at sexual maturity. There still remains considerable variability within the strains, but there is a difference of about 46 days in the average maturity age. [Project 75-5; Department of Poultry Husbandry; state funds.]

Poultry Flock management.--The object of this project, which was started in the fall of 1923, is to develop a practical system of managing the farm flock to obtain maximum egg production from pullets during the fall and winter, when the price is high, and maximum fertility and hatchability from the hens during the spring.

The production of high-priced eggs has been attempted by confining in the laying house 75 March-hatched Barred Plymouth Rock pullets from October 1 to April 15, and feeding for egg production during that period. The pullets are permitted to have free range with the hens after the middle of April.

High fertility and hatchability is attempted by giving 50 Barred Plymouth Rock hens that have completed one or more years' production free range throughout the year. They are fed sparingly during the winter months to avoid the development of an overfat condition. As the breeding season approaches they are fed liberally to stimulate egg production. The chicks hatched from these hens are grown to maturity and 75 pullets are selected for the laying house October 1. The 50 most desirable individuals from the one- and two-year-old hen group are chosen in the fall to continue the breeding pen.

Rhode Island Reds, White and Barred Plymouth Rocks have been tested thus far. The fertility and hatchability results for

both Barred Plymouth Rock hens and pullets for the year 1928-'29 are given in Table XVI.

TABLE XVI.--THE FERTILITY AND HATCHABILITY OF EGGS PRODUCED BY BARRED PLYMOUTH ROCK HENS AND PULLETS, 1928-'29.

	Number eggs set.	Number infertile.	Per cent fertile.	Number chicks hatched.	Per cent hatch.	
					Fertile eggs.	Total eggs.
Hens.....	392	33	91.5	225	62.6	57.3
Pullets.....	806	179	77.7	393	62.6	48.7

These figures show superior fertility and hatchability of total eggs from the hens. However, there is but little difference between the hen and pullet eggs when compared on a basis of fertile eggs.

The project will be continued two or three more years with White Leghorns in order to compare their adaptability to confinement with the general-purpose breeds. [Project 77-6; Department of Poultry Husbandry; state funds.]

Physiology of Reproduction in the Fowl.--The work on this project has developed along two distinct lines. One has had to do with fertilization and hatchability of eggs and the other the effect of disturbance on egg production.

1. The earlier work of Crew has shown that although sperm are capable of living in the oviduct of the female for a maximum period of about 30 days, if one male is substituted for another in a breeding pen, the sperm of the original male functions for only a few days and there is but very little overlapping of the offspring of the two males. He came to the conclusion that sperm held in the oviduct for longer than a week, although capable of fertilizing eggs, seldom produced viable embryos. To find, if possible, the cause of the restricted functional period of the sperm of a male when replaced by another, and to determine whether the findings of Crew regarding the viability of embryos resulting from fertilization by stale sperm were correct, were the objects of this study.

Repeated alternations of pairs of males in the same pen of females substantiated Crew's findings. By means of autopsies, microscopic examination was made of sperm having been in the oviduct for periods varying from a few hours to 20 days. It was found that the flagellum of the sperm was lost after about 24 hours existence in the oviduct. Since the flagellum is probably the propelling organ, this may account for the failure of stale sperm to compete with fresher ones.

Eggs fertilized by sperm which had been in the oviduct for varying periods up to 20 days showed no effect of staleness of sperm upon the viability of the embryo. So it appears that any sperm capable of stimulating development produces a normal embryo.

2. The examination of the egg records of most females will show them to have a rather definite rhythm of ovulation. Various types of rhythm are found, but when a pullet starts production the rhythm is maintained relatively uniformly throughout life. It is known that disturbances react unfavorably upon the egg production. It was the purpose of this study to determine just how disturbances affect the rhythm of egg production.

A group of 300 females were driven into catching coops, caught, and the leg bands read. About half of them were then removed to new quarters while the remainder were released in the house where they were found. The cycles of production for the 15-day period previous to and after the disturbance were compared.

The disturbance of handling and releasing had practically no effect upon the rate of production. There was a considerable decline in production for the group that was moved into new quarters. It was found that most of the decline was due to birds entirely ceasing to produce rather than a decided effect upon the rhythm. For the birds that were moved there was a slight lengthening of the intervals following the disturbance, but this was not sufficient to cause any conspicuous change in the characteristic rhythm. [Project 77-12; Department of Poultry Husbandry; state funds.]

The Effect of Age on the Vitamin D Potency of Cod-liver Oil.

--The object of this experiment is to test the antirachitic potency of cod-liver oil when mixed and stored in feed for six and twelve months. Five different all-mash rations were prepared in sufficient quantity to last the entire year and biologically tested with chicks when freshly mixed and six and twelve months after mixing. The feed was kept in burlap bags and stored in a dry, well-ventilated room free from direct sunshine. One per cent of cod-liver oil stored in feed for one year was found to prevent rickets when tested by feeding chicks for eight weeks. A 5 per cent mineral mixture also prevented rickets for that length of time.

This was the second year's work on the project and the results confirmed those of the first year. A sufficient amount of the feed is being retained to repeat the experiment after it has been stored for two years. [Project 77-13; Department of Poultry Husbandry; state funds.]

Turkey Production.--During the past two years 149 turkeys were raised to maturity. Each year the poults were confined within a brooder house until 16 weeks of age and then placed on range until mature at 24 weeks. Data were obtained on incubation, feed consumption, rate of growth, and fattening.

A study was made to determine the effect of age upon the hatchability of turkey eggs. Eggs were held 1 to 36 days before setting. It was found that in 36 days the per cent of fertile eggs that hatched was reduced from 82 to 48 per cent in 1928 and from 74 to 3 per cent in 1929.

In 1928 the average amount of feed consumed per turkey up to

24 weeks of age was 59 pounds, as compared with 61 pounds in 1929. It was found that turkeys could be fattened very satisfactorily on a moist mash fattening ration, provided they were not confined too closely. [Project 77-15; Department of Poultry Husbandry; state funds.]

Influence of Hybridization upon Vigor in Poultry.--This project, started in 1928, embraces two phases of work, each of which is briefly reported below.

The Cross of the Single-comb White Leghorn and the Single-comb Rhode Island Red Breeds.--During the 1928 breeding season reciprocal matings were made between the two breeds involved in this experiment. The pure breeds and hybrids to be compared were produced from four pens of White Leghorn and four pens of Rhode Island Red pullets. An equal number of cockerels of the two breeds were used and were rotated at weekly intervals, so that all hybrids and pure-bred offsprings were half brothers and sisters. By this procedure the influence of the variability in the genetic constitution of the birds used as parents was reduced to a minimum.

Chick mortality, rate of growth, and egg production during the pullet year were the three major criteria used for comparing the vigor of the pure breeds and hybrids. Due to the procedure followed in rotating the males, it was not possible to consider hatchability. The birds in each of the four lots were hatched and reared under identical conditions and the pullets to be compared for egg production were kept in the same laying house.

The numbers of individuals involved were approximately equal for each group of hybrids and pure breeds. A total of 776 chicks were compared for mortality and rate of growth, and 159 females for egg production. The cross of White Leghorn male by Rhode Island Red female was superior in all comparisons. The reciprocal cross did not exhibit the same vigor, but when all criteria are considered it may be said to be superior to either of the pure breeds. The cross utilizing the White Leghorn male produced females that matured considerably earlier than did its reciprocal. This difference is probably due to the fact that age at sexual maturity is inherited in a sex-linked manner. Both crosses were intermediate between the two breeds with regard to age at sexual maturity. The eggs of the hybrids were also intermediate in tint. The hybrids produced eggs that were slightly larger than either pure breed, but the size was not significantly greater than those of the Rhode Island Reds, which had the larger egg of the two. As adults the hybrids were intermediate in size between the two breeds, and there was but very little difference between reciprocal crosses. These results complete this phase of the project.

The Effect of Crossing Distantly Related Strains of the Same Breed.--In order to determine whether crossing strains of the same breed has a stimulative effect similar to that obtained from crossing different breeds, two strains of Single-comb White Leghorns were

used. The Kansas Agricultural Experiment Station flock was used as one strain and the other was a well-known production-bred strain from the West Coast. It was known that the two strains had had an independent history for at least eight generations, and it is improbable that they have common ancestors for a period considerably longer.

Eight breeding pens were used for production of the birds to be compared. Half of the pens were headed by Kansas males and half by the West Coast males. The females in each pen were equally divided between the two strains. Thus it was possible to compare pure and cross-strain chicks that were half brothers and sisters. All individuals compared were hatched at the same time, in the same incubator, and kept in the same brooder houses.

Complete results are not yet available from the experiment, since the females have not finished their first year's production.

With all factors available considered, it may be said that the cross of the West Coast male by the Kansas female ranks first. Its hatchability was considerably better than any of the other three. Its chick mortality was not significantly higher than West Coast strain, which ranked best in this respect. In weight at eight weeks of age the chicks from the cross of the West Coast male by Kansas female were very near the West Coast strain, which was the largest of the four groups. In egg production to March 1, the two crosses were considerably better than the two pure-strain females, there being practically no difference between the crosses.

The final results on the annual egg records of the pullets now under test will complete this phase of the study. [Project 173; Department of Poultry Husbandry; Purnell funds.]

The Effect of Inadequate Rations on the Production and Hatchability of Eggs.--During the first year of the biennium the work of this project was devoted to a study of alfalfa-leaf meal as a source of vitamin A; during the second year, to a study of factors involved in the malformation of bones in young growing chicks. Each phase is briefly reported below.

A Study of the Deficiency of Vitamin A.--The object of the work reported here was to determine the proper amount of alfalfa-leaf meal to use in rations comprising 65 per cent of yellow corn, which is rich in vitamin A. It was shown that 10 per cent of alfalfa-leaf meal is slightly more desirable as a source of vitamin A than 5 or 15 per cent in a ration otherwise deficient in this vitamin.

One hundred White Leghorn females and six males were placed in each of four pens, November 1, 1928. The birds were confined to their pens, which were 20 feet square, for the duration of the experiment, November 1 to August 1. Four different all-mash rations were fed, as shown in Table XVII.

TABLE XVII.--RATIONS FED IN VITAMIN A EXPERIMENT.

Pen number.	87	88	89	90
	<i>Lbs.</i>	<i>Lbs.</i>	<i>Lbs.</i>	<i>Lbs.</i>
Yellow corn meal.....	00	65	65	65
White corn meal.....	65	00	00	00
Meat scraps.....	10	10	10	10
Wheat bran.....	15	15	15	15
Alfalfa leaf meal.....	10	10	5	00
Synthetic alfalfa (a).....	00	00	5	10
Total.....	100	100	100	100

(a) The synthetic alfalfa consisted of white corn meal, 40 pounds; meat scraps, 29 pounds; sweet clover stems, 26 pounds; and alfalfa ash, 5 pounds.

The synthetic mixture, which had about the same chemical analysis as alfalfa-leaf meal, was used as a substitute for leaf meal in pens 89 and 90. Therefore, the chemical composition of all rations was practically the same. The results of the test are shown in Table XVIII.

TABLE XVIII.--EGG PRODUCTION, FERTILITY, AND HATCHABILITY OF EGGS FROM HENS WHICH RECEIVED DIFFERENT AMOUNTS OF VITAMIN A.

Pen number.	Average production, Nov. 1 to Aug. 1.	Mortality of hens.	Number of eggs set.	Per cent fertile.	Number vigorous chicks.	Per cent fertile eggs hatched.
87.....	93	18	1,504	88	1,139	86
88.....	94	18	1,492	88	1,150	88
89.....	98	16	1,528	88	1,123	83
90.....	90	22	1,368	81	812	73

The average egg production for the different pens was rather low, but the uniformity of fertility and the unusually high hatchability are noteworthy. Pen No. 90, which received yellow corn as the only source of vitamin A, showed higher mortality and lower egg production, fertility, and hatchability than any of the other pens. The addition of 5 per cent of alfalfa-leaf meal to the ration in pen No. 89 gave slightly better results than 10 per cent in pen No. 88. The figures show that a ration consisting of 65 per cent white corn does, when supplemented with 10 per cent of the alfalfa-leaf meal, compare very favorably with rations composed of an equal amount of yellow corn or yellow corn and alfalfa-leaf meal. The results of this study, which has extended over a period of 11 years, are now being prepared for publication.

The Etiological Factors Involved in the Malformation of Bones in Young Chickens.--The prevalence of enlarged hock joints and

crooked legs in young chickens four to eight weeks of age has become so general that it is a serious malady, especially since the advent of the storage brooder. An experiment was outlined in the fall of 1929 for the purpose of determining, if possible, the cause of this malformation.

Three hundred sixty Rhode Island Red chicks were divided into 12 lots of 30 each. Six of the lots were placed in a warm room which was maintained at brooding temperature (92°F.) the first week, and six pens were placed in an adjoining cool room, the temperature of which was kept at 70°F. Individual hovers were used in each lot in the cool room to keep the chicks comfortable. Three of the lots in each room received a ration containing 20 per cent crude protein and three lots received a ration composed of 15 per cent crude protein. The rations were similar in other respects. In addition to these differences two lots in each room were placed in storage brooders, two lots were placed in pens 3 by 7 feet with board floors and peat litter, and two lots were placed in pens of similar size which were equipped with one-half-inch hardware cloth floors, the object being to study the effect of (1) high- and low-room temperature, (2) high and low protein, (3) restricted and liberal room for exercise, and (4) a solid bottom versus wire-bottom floors.

All chicks made a very satisfactory growth, but only a small number developed hock-joint trouble. The chicks fed the 20 per cent protein grew much faster and feathered better than the chicks that received the 15 per cent protein rations. There was a difference in the quality as well as the quantity of protein in the two groups, since the 20 per cent groups received a slightly larger proportion of protein from an animal origin.

The Department of Chemistry analyzed the feed and also determined the ash content of the thigh bone of one chick from each lot each two weeks during the duration of the experiment. At the conclusion of the test a blood and urine analysis was made on representative chickens receiving the high- and low-protein ration.

There was nothing in the chemical analysis of the bone of the chickens to indicate the cause of the malformation. The ash content of the bones of all lots was within normal limits, so the deformities do not seem to have been due to a variation in the amount of ash.

The opinion of the pathologist that the malformation is due to a contraction of the tendon seems to be the best explanation, but why the tendon should contract is yet to be determined. [Project 127; Department of Poultry Husbandry, Chemistry, and Veterinary Medicine; Adams and state funds.]

Antagonism of Monovalent and Polyvalent Metals in Biological Processes.--In this experiment, recently started, the sodium and calcium ratio of the blood and nerve tissue in normal dogs and in dogs showing signs of tetany has been studied. The experiments were designed to determine if the sodium-calcium ratio in nervous tissue is appreciably changed from the normal in dogs showing signs

of tetany, which was produced by intravenous injection of sodium bicarbonate solution. The experiment has not shown any decisive effect on the sodium-calcium ratio in the brain tissue. The results may be due to insufficient time allowed for the tissue to change through a normal metabolic process and to inexperience in analytical procedure which is rather difficult. [Project 184; Department of Chemistry; Adams funds.]

Studies in Animal Reproduction and Inheritance.--Four phases of this project have been active during the biennium as follows:

Color Inheritance in Guinea Pigs.--A number of modifications of the white face in guinea pigs have been observed. For example, the white face may be either narrow or extremely wide, and these differences are inherited. Some of the white-faced animals also produce offspring with white chins and no white spotting on the face. All of these seem to be inherited quite definitely, but the exact mode of inheritance has not yet been determined.

Cherry reds are a very desirable shade of red and are the color found in show-type reds. When crossed with extremely light reds, such as creams, the crossbreds are somewhat intermediate, but resemble to a greater degree the cherry-red parent. As yet there have not been enough F_2 's produced to warrant any prediction as to the number of factors concerned.

For a number of years preparation has been made to study the linkage relations of salmon eye with other factors. Within a short time it will be possible to produce an animal that is homozygous, not only for salmon eye, but for five other recessive factors. These animals, however, will be homozygous for the dominant allelomorph of pink eye in order to prevent the pink eye factor from interfering with the results.

For a number of years a genetic analysis has been in progress of the show-type creams. In previous reports it was stated that one of the factors (*f*) caused the animals to fade from a yellow to a cream. In addition it has been found that a second factor (*li*) causes the animals to be somewhat lighter at birth, and the combined results of *f* and *li* in the homozygous condition is to produce a light cream, a very desirable shade from the show standpoint.

In making a study of the long-hair condition it was found that animals differed in the distribution of these hairs. Some had long hairs all over the back while others had them only on the posterior half of the back. This difference is due to modifiers of the factor for long hair (*l*), but the mode of inheritance in relation to each other has not as yet been fully determined. The long-hair factor and its modifiers are being combined in one animal also carrying five recessives, in order to test the linkage relation of these factors.

Recently crosses have been made for the purpose of determining the mode of inheritance of "Roman nose," a desirable character from the show standpoint. Straight-nosed animals have been crossed with Roman nose and the offspring have all been like the latter, thus

indicating that one or more dominant factors produce the Roman nose character.

Inheritance of Defects in Guinea Pigs.--The results obtained thus far in the study of the inheritance of eye defects in guinea pigs still continue to be negative.

A new character, "waltzing," has been discovered in the colony during the past few years. Animals having this characteristic have a tendency to throw their heads upward. When confined to a small cage they tend to run around in circles like a "waltzing" mouse. The characteristic is due to a simple Mendelian recessive. Because of their excessive activity, animals showing this characteristic tend to wear themselves down, and consequently always weigh less than their normal litter mates. The young animals especially seem to be lacking in nerve control, and for this reason one is occasionally found drowned in the water dish.

Inbreeding in Guinea Pigs.--The inbreeding is being continued along the same lines as outlined in previous reports; that is, a male is mated to his female offspring for a number of generations. His offspring are then used for starting new lines. One of his sons is mated to a sister and thereafter mated to a daughter by the sister, etc. This has been continued for a number of years. At the present time all the animals in the experiment are descendants from one male that is over four years old and still continues to produce offspring. It seems quite reasonable to suppose that this inbred line will remain vigorous indefinitely if proper care is taken. No new characteristics have cropped out as a result of the above inbreeding.

Inheritance in Rabbits.--In spite of all precautions, coccidiosis has not been entirely eliminated from the rabbit colony. Sporadic outbreaks still occur, thereby interfering with a number of the experiments.

Several new characteristics have been worked with during the past biennium. The most striking of these is "bad temper." Animals possessing this characteristic make violent attempts to scratch or bite persons who approach their cages. If these animals are taken out of their cages they temporarily lose much of this tendency, but it is a permanent condition and increases with age. Two animals having this characteristic have been mated and almost all of their offspring have had bad tempers. Recently a bad-tempered female was mated with a nonbad-tempered male, and the only offspring produced is extremely bad-tempered like the female parent. The meager evidence produced thus far seems to indicate that bad temper is dominant to the condition usually found in rabbits.

In certain crosses made for another purpose black individuals with white ticking have been produced. These animals seem quite desirable from a fur standpoint. As yet there has not been enough evidence obtained to determine the hereditary factors concerned in

the production of this characteristic. [Project 93; Department of Animal Husbandry; state funds.]

Studies in the Inheritance of the Grouse Locust.--The following lines of work have been in progress: The species *Apotettix eurycephalus* and *Paratettix texanus* have been bred in the normal way and data on the inheritance of the color patterns accumulated. A factor for lethal has been discovered in *A. eurycephalus*. It appears to be on the same chromosome as the color patterns described in previous papers. It is, so far, the only strictly discrete characteristic outside color patterns to have been determined definitely in the grouse locusts.

Considerable further data on location of the factors for color patterns in *P. texanus*, *A. arenosum*, and *A. eurycephalus* have accrued.

Significant progress in studying the chromosomes, especially of the parthenogenetic specimens of *A. eurycephalus* and *P. texanus* has been made. It has been shown, among other things, that it is possible to distinguish partheno-produced from sexually-produced grouse locusts by merely examining their chromosomes, a fact not only of importance in heredity studies in particular, but of wide implications in the field of biology, both pure science and practical. Substantial progress has been made in ascertaining the chromosomal positions of the factors for color patterns in *A. arenosum*, which are much more complicated than in the other species studied.

The discovery and location of the factor for lethal in *A. eurycephalus* mark a departure in this work from a study, hitherto almost exclusively, of the color patterns.

The work for the coming year will be carried on along the same lines as during the previous year. Special attention will be given the study of the effects of ultra-violet and X-rays on the growth, general development, and germ plasm. The lethal in *A. eurycephalus* will receive special attention. The very interesting characters of *A. arenosum* will be studied more intensively. [Project 72; Department of Zoölogy; Adams and state funds.]

The Influence of Climate on Inheritance in the Grouse Locusts.--A mercury lamp which gives off ultra-violet rays practically equivalent to mild sunshine was installed in 1929. The experiment, previously reported, in which celoglass was used as cage material, had resulted negatively.

Specimens of *Acrydium arenosum*, the northern species, have been bred under the mercury lamp, and one extra generation, in the fall, has been secured. Their vigor seems to have been improved.

Specimens mainly of *Apotettix eurycephalus* and a few *Paratettix texanus* have been submitted to X-raying at the Cold Spring Harbor Station of the Carnegie Institution of Washington.

The X-ray work has only just been started, but a few results have accrued. A specimen of *A. eurycephalus* with a distinctly new color pattern was reared. However, it was lost before being bred further. The mortality among the specimens X-rayed at 6,000

R units was quite high within two weeks. Further work with ultra-violet lamp and X-ray machine will be carried on. This should go on with facility, due to the experience gained this year. [Project 104; Department of Zoölogy; Adams funds.]

Bee Investigations.--Data are being collected relative to the relation of climatic conditions to nectar. Hard, beating rains prevent the soil from storing the maximum amount of moisture and thus reduce the production of honey-producing plants. Two such rains came during the summer of 1929 at about one month apart. These rains were followed by dry weather. Because of this condition, the vigorous growth of essential nectar-producing plants was retarded. Very little honey, therefore, was obtained in the vicinity of Manhattan from such important nectar-producing plants as white sweet clover and alfalfa.

Certain insulating materials have been used for the winter protection of colonies of honeybees. These are used in one, two, and three thicknesses. The three-layer cases gave better protection than did the two-layer cases, and both gave better protection than the one-layer cases. It appears that a one-layer case does not give sufficient protection to a colony of honeybees under conditions existing in this section of the state.

Formaldehyde solutions of different strengths, together with other disinfectants, have been used in an experiment to determine the best strength for disinfecting brood combs which contained the bacteria of American foulbrood. Results of this work will be reported later.

Some work relating to powdered dry yeast as food for caged colonies of bees is being done, and results will be reported later. [Project 126; Department of Entomology; state funds.]

DISEASES OF PLANTS

The diseases injurious to agricultural plants have increased in number and virulence in Kansas within recent years. This is especially true of diseases attacking the major crop of the state--wheat. The loss sustained from wheat diseases alone amounts to millions of dollars annually. The perfection of methods whereby plant diseases may be controlled constitutes an important feature of the work of the station. Some of the phases of this work are briefly discussed below.

Cereal and Forage-crop Disease Investigations.--This project, in coöperation with the Office of Cereal Crops and Diseases, Bureau of Plant Industry, United States Department of Agriculture, consists of several distinct phases, as follows:

1. *Barley Stripe Disease Investigations.*--A limited study of barley stripe indicates that Ceresan gives satisfactory control. Only a trace (less than 1 per cent) of stripe occurred in treated plats, while in the untreated the infection was more than 10 per cent.

2. *Oat Smut Investigations.*--Data secured in 1928 and 1929 prove that at least two distinct physiologic forms of loose smut of oats occur in Kansas. One of these was first discovered in fields of Kanota oats at Columbus and Harper. Kanota and Fulghum, two varieties heretofore considered resistant, have been shown to be susceptible to this new form of smut. Ceresan, "Oat Dust," and Smuttox have given almost complete control of oat smut. Some other "dusts" have not given satisfactory control; therefore, it appears necessary to try out new brands of fungicide as they appear on the market.

3. *Sorghum and Millet Disease Investigations.*--Experimental studies at this station have proved the adaptability and effectiveness of copper carbonate and sulphur dusts for the control of sorghum kernel smut. Millet smut is effectively controlled by copper carbonate, but not by sulphur dusts.

A study of physiologic forms of *Sphacelotheca sorghi* indicates that several distinct forms occur. Three forms have been identified and described. These may be separated by differential hosts, by cultural methods on artificial media, and apparently by morphologic differences in the sporangia of the fungus. Milo, hegari, and certain feterita selections which heretofore have been regarded as immune or highly resistant to smut have been shown to be susceptible to one or more of these forms. Several Red Amber X feterita hybrids have so far proved to be resistant to the three described forms.

Sorghum rust, *Puccinia purpurea*, appeared in abundance on sorghums in the vicinity of Manhattan in 1927 and 1928. The season of 1929 was too dry for the best development of this rust, but considerable appeared on susceptible varieties late in the season. Rust readings were made on about 80 inbred varieties, strains, and hybrids in each of the three seasons. Distinct differences in susceptibility were noted. Infection was so severe on very susceptible varieties in 1928 as to cause premature death of the leaves.

Sorghum varieties growing in nursery rows and field plats at Manhattan were heavily infected with leaf stripe, *Bacterium andropogoni*, in 1927 and 1928. Sharp differences in susceptibility were noted. In 1929 more careful experiments were begun in cooperation with the Office of Cereal Crops and Diseases, United States Department of Agriculture. In these experiments artificial inoculation is being used. Although the season of 1929 was dry and unfavorable for leaf stripe, the results secured corroborated those presented above.

4. *Corn Disease Investigations.*--Inbred lines of corn have become fixed in their reaction to natural infection of smut. During the last three years several lines were free of infection, others were extremely susceptible, while a large number were intermediate in their reaction to smut under field conditions. The reaction to smut of some F₁ crosses of these lines in 1929 may throw some light on the method of inheritance. In one cross of a high X low smut line,

the F_1 hybrids remained immune and in the reciprocal cross only one plant out of fifty was smutted. The F_1 hybrids of high X intermediate smut lines were less resistant than open pollinated plants of the same variety. Those produced by crossing high X high smut lines were very susceptible to smut. Any program of breeding for resistance to corn smut must consider the presence of physiologic strains of the organism and the need for natural epiphytotics for securing the reaction of corn lines to smut, rather than the use of cultures of smut hypodermically injected into plants.

No consistent or outstanding differences in stand or yield have been obtained by treating good quality seed corn with organic mercury compounds or other disinfectants for the control of seed-borne diseases as compared with untreated seed.

Corn and sorghum smuts were fed to cattle and horses. The spores in the excreta were thereafter examined for germination. These tests were conducted during the winter and spring seasons of two years with dry smut collected from the crop of the preceding summer. The experiments showed that the passage of chlamydo-spores of corn and sorghum smut fungi through the digestive tract of horses or cattle almost completely destroyed their viability. The survival of sorghum-smut spores is somewhat greater than the survival of corn-smut spores. Apparently the sporangium which covers the spore mass of covered kernel smut provides considerable protection. However, the number of spores which remains viable in the feces in either case is so small that it can be considered a negligible factor in the perpetuation and spread of either of these diseases in the field.

The contents of different parts of the alimentary canal of several horses to which smut had been fed were examined in order to learn in what part of the digestive tract smut spores lose their germinating power. It was found that for the most part the spores lose their viability in passing through the stomach. This loss of stability is apparently due to the action of acids. The acidity of the contents of the stomach of horses was found to be great enough to prevent the germination of nearly all spores when in contact with the contents for about two hours at body temperature.

There seemed to be no injurious effect from feeding either corn or sorghum smut to animals. Large amounts of both of these smuts were fed to cows and horses without apparent injury. Most of the animals to which smut was fed were carefully observed for several days after feeding and appeared normal in every respect. In fact, some individuals seemed to relish smut in their feed. At the beginning of the experiments some animals showed a decided preference for smut, but at the end of a few days they preferred other feed, although they continued to eat smut without apparent injury.

5. *Wheat Smut Investigations.*--The testing of numerous chemical dust compounds for the control of bunt has shown that several of the 18 to 20 per cent grades of copper carbonates, or dusts having

metallic copper, have given satisfactory control of stinking smut, and when used in correct amounts and when the seed is properly treated are almost as effective as the 50 to 55 per cent grades. These compounds are replacing the 50 to 55 per cent grades.

It has been discovered that smut in very badly smutted wheat with smut balls included can be completely eliminated in two years' time by treating with copper carbonate. A small amount of smut remains in the crop at the end of the first year, but if this grain is again treated the smut is completely eliminated.

A study of bunt collections used on 16 varieties of wheat indicates that several distinct physiologic forms occur in Kansas. Turkey, Redit, and Banner Berkely showed the greatest difference in reaction to these collections. Circumstantial evidence indicates that the serious bunt epiphytotics in Kansas in recent years may be explained on the basis of the occurrence of new virulent forms of bunt. In years past Turkey strains of hard red winter wheat had not been subject to bunt epiphytotics, but bunt now is common in Kansas.

In a uniform winter wheat bunt nursery, where smut was used from Kansas, Nebraska, South Dakota, Minnesota, Colorado, and Montana, it was found that Minturki C. I. 6155, Minturki X Bel-Buffum C. I. 8033, and Oro C. I. 8220 were the most resistant. All other varieties were susceptible to all collections of smut except Newturk, Kanred, Tenmarq, and Nebraska No. 60, which were resistant to the collections from Redfield, S. Dak. This study is in coöperation with the Office of Cereal Crops and Diseases, United States Department of Agriculture.

6. *Foot Rots of Wheat.*--During the past two years the work has consisted of an effort to determine (1) the effect of fertilizers on the severity of take-all, (2) the effect of placing the inoculum of take-all at different depths below the seed, (3) the effect of summer conditions on the life of *Ophiobolus graminis* in the soil, (4) the reaction of different varieties to take-all, (5) the effect of variation in the water content of the medium on the growth of *Ophiobolus graminis* in pure culture, (6) the relation of the hydrogen-ion concentration in soil to the occurrence of the disease, and (7) the carbon content of the soil in diseased and healthy spots in the field.

Fairly good control was secured by using fertilizers of an organic nature, especially chicken manure, and sweet clover and alfalfa plowed under for green manure. Inorganic fertilizers either had no effect or increased the virulence of the disease.

In general it may be stated that when the inoculum of take-all is four or more inches below the seed the resulting injury to the plant will not be great.

Experiments in the field during the summer of 1928 show that there was no sterilization, so far as take-all is concerned, of the upper or any layer of soil, due to the heat or dryness of summer. Abundant infestation was present in field soil from the surface to a depth of 10 inches.

So far no variety of wheat has been shown to be highly resistant to take-all. However, many have been found to be very susceptible and have been discarded from further tests.

Under the condition of the element *Ophiobolus graminis* in pure culture made its best growth with very moist conditions. Thus the weight of the fungus was greatest, the respiration was greater, and the amount of nutrients remaining in the medium after growth was least when the moisture content was high.

Neither the hydrogen-ion nor the carbon content of the soil in take-all spots in the field was found to be appreciably different from other portions of the field. [Project 76; Department of Botany; state funds.]

Fruit and Vegetable Disease Investigations.--Various diseases of fruits and vegetables have been investigated during the biennium. These investigations have dealt mainly with the Rhizoctonia and scab diseases of the Irish potato, stem rot of sweet potato, Septoria leaf spot of tomato, and cedar-apple rust of apples.

1. *Rhizoctonia.*--The importance of soil-borne Rhizoctonia in infection of the potato plant has been investigated and biological studies of this fungus have been undertaken. The corrosive-sublimate treatment was most efficient in controlling Rhizoctonia and highest yields were obtained from potatoes treated by this method. Hot formaldehyde treated potatoes, when compared to those treated with corrosive sublimate, had 12 per cent more diseased sprouts in 1928 and 1 per cent more in 1929, and as an average yielded less by 3.5 per cent. Bayer's Dip Dust in 1928 and Semesan Bel in 1928 and 1929 did not control the Rhizoctonia disease.

Investigations in the Kansas river valley as to the source of infection of potato plants indicated that Rhizoctonia in the soil is of great importance. Rhizoctonia-free potato seed planted in three commercial fields in 1928 and in fourteen such fields in 1929 resulted in a sprout infection of 53 per cent in 1928 and 50.5 per cent in 1929. A similar test in experimental plats in 1928 resulted in 76 per cent infection. Rhizoctonia-infected and Rhizoctonia-free potato seed was planted in 1929 in five locations in the Kaw valley on soil where potatoes had not been grown for five years or longer. The Rhizoctonia-free seed produced plants 17 per cent of which were infected. Sixty-six per cent of the sprouts from the Rhizoctonia-infected seed were infected. The Rhizoctonia-free seed out-yielded the Rhizoctonia-infected seed by 8.5 per cent.

The fungicides formaldehyde, mercury hydroxide, Semesan, Ceresan, and sulphur were applied in 1929 to the soil in potato rows to test their value in controlling Rhizoctonia infection. None of these materials produced a material reduction of the disease.

Biological studies of the Rhizoctonia fungus have shown that various strains of this organism exist in Kansas, and that these strains have different effects on the potato and other host plants.

2. *Potato Scab*.--Field tests have been continued to find methods by which satisfactory yields of scab-free potatoes may be produced on scab-infested soil.

The most satisfactory results have been obtained from plats treated with 600 pounds of sulphur per acre on which cowpeas or vetch had previously been grown as fertilizing crops. Results obtained indicate (1) that sulphur applications decrease the scab but also decrease the yield, and (2) that a combination of sulphur and leguminous fertilizing crops controls the scab and maintains the yield.

3. *Sweet Potato Stem Rot*.--Stem rot is the most destructive field disease of sweet potatoes in Kansas. A large per cent of infection occurs after the slips are planted in the field, and tests were undertaken in 1928 and 1929 to control such infection.

Sweet-potato sprouts were dipped in various fungicidal mixtures just before the sprouts were planted in order to determine if stem-rot infection could be prevented. Bordeaux mixture, mercury hydroxide, and Semesan Bel were compared. In 1928 the stem-rot disease did not develop in the experimental field, but the Bordeaux-dipped sprouts yielded 16.6 per cent more than the untreated check. In 1929, as compared with the untreated sprouts, treating with Bordeaux reduced the infection 22.5 per cent and increased the yield nearly 12 per cent; mercury hydroxide reduced the infection 18.5 per cent and increased the yield 11.5 per cent; and Semesan Bel reduced the infection 23 per cent and increased the yield 11 per cent.

4. *Septoria Leaf Spot of Tomato*.--During 1929 eight varieties of tomatoes were sprayed to determine the most practical means of controlling *Septoria* leaf spot. One-third of the plants were sprayed with Bordeaux and one-third dusted with Sanders Bordeaux dust at ten-day intervals. The remaining plants were untreated. Both treatments controlled the disease satisfactorily.

5. *Cedar-apple Rust*.--Cedar-apple rust is a serious disease of certain susceptible varieties of apples in sections where cedar trees are growing in the vicinity of orchards. Sulphur, being specific for the control of certain rust diseases, has elsewhere been tested for the control of the cedar-apple rust. Certain improved sulphur compounds have recently been developed, and two such compounds (Stauffer oxidizing sulphur A-1 and B-1) containing oxidizing agents were tested in cooperation with the Department of Horticulture on Jonathan apples in comparison with unoxidizing sulphur and untreated checks.

A count of the treated leaves infected with rust as compared to the leaves of adjoining check trees was as follows for the three sulphur dusts tested: A-1, 66 per cent infection; B-1, 47 per cent infection; and nonoxidizing sulphur of the same grade, 46 per cent infection. While sulphur dust reduced the infection, the oxidizing sulphur dusts apparently had no merit over the nonoxidizing sulphur. [Project 130; Department of Botany; state funds.]

Resistance of Winter Wheat to Leaf Rust.--Detailed studies have been made on the inheritance of resistance to leaf rust in the greenhouse and rust nursery at Manhattan. F_1 and F_2 generations usually are studied in the greenhouse, while F_3 and subsequent generations are studied both in the field and greenhouse. A nursery of about 1,500 rows is grown each year. More than 70 crosses have been studied in the past biennium. Uniform leaf-rust nurseries composed of promising varieties, hybrids, and selections have been grown at three points in Texas, two in Oklahoma, four in Kansas, and one in Nebraska, in coöperation with the Bureau of Plant Industry, United States Department of Agriculture. Leaf-rust collections have been made at as many points as possible in the Southern Great Plains each year. These have been studied in the greenhouse for their physiologic form content. Studies have been made on oversummering, overwintering, and spread of leaf rust at several stations.

Many hybrids and pure-line selections have proved to be resistant in one or more of the uniform nurseries, but few have been resistant in all nurseries. Kawvale C. I. 8180 and several Texas selections of soft red winter wheat have shown marked resistance for several years and are also agronomically promising. Several hybrids have shown promising resistance to leaf rust, but are as yet untested agronomically. Greenhouse studies have proved that resistance to leaf rust usually is recessive and dependent on a single main factor difference for its expression. Cases have been found, however, where two or more factors are involved and where an inhibitor for susceptibility is operative. The reaction of certain varieties and hybrids was found to depend on the age of the plant, seedlings often being susceptible and mature plants resistant. Physiologic form 9 has been found to be the most abundant and widely distributed form in the Southern Great Plains, although other forms have been isolated. Leaf rust usually overwinters in abundance in central and southern Texas and moves gradually northward in the spring. Overwintering in small amounts occurs in Kansas and Oklahoma, but does not seem to be the principal reason for heavy leaf-rust infections in those states. Heavy fall infections of leaf rust are of frequent occurrence in Kansas. The rust lives over summer on volunteer wheat, which often is in great abundance since the advent of the combined harvester-thresher. [Project 171; Department of Botany; Purnell funds.]

INJURIOUS INSECTS AND OTHER PESTS

Some of the more important features of the work of the Agricultural Experiment Station relating to the investigation of methods for the control of injurious insects and other pests are described on the following pages.

Climate and Injurious Insect Investigations.--As has been the policy in the past, much of the work on this project is coöperative with other projects. Hygrothermograph records were kept during

the past biennium and will be continued. During parts of the summer of 1929; namely, between June 19 and July 6 and between August 5 and September 13, the hygrothermograph records were supplemented by evaporation records, using the Livingston white porcelain bulb atmometers.

The atmometers were set up as recommended by Livingston and equipped with rain valves so that when the humidity is 100 per cent, as is frequently the case at the lower levels in an alfalfa field, absorption does not take place in the porcelain bulbs. The evaporation at different levels above ground in an alfalfa field is shown in Table XIX.

TABLE XIX.—EVAPORATION IN AN ALFALFA FIELD AT DIFFERENT DISTANCES ABOVE GROUND.
 (1929)

	Ground level.	Height above ground.			
		12 inches.	24 inches.	36 inches.	60 inches.
June 19 to July 6.					
Total c.c. evaporation.....	331.1	523.5	597.5	601.5	661.2
Per cent increase in evaporation compared with that at ground level....	0.0	37.0	56.0	58.0	73.0
August 7 to September 13.					
Total c.c. evaporation.....	1,013.1	1,247.3	1,308.6	1,417.3	1,569.5
Per cent increase in evaporation compared with that at ground level....	0.0	22.1	36.2	39.8	54.8

It will be noted that there is a regular and definite increase in the evaporation with each additional 12-inch level above the ground. The humidity must, therefore, show a corresponding decrease. The total evaporation for the June period was less than for any period of corresponding length in August, and the increase in evaporation above the ground was higher. These facts may be explained by the greater moisture content of the soil during June and hence the higher relative humidity, especially at the ground level. These data have not been correlated with any definite insect habits.

Previous studies have shown that the temperature of insect cages is appreciably the same as that outside, but that the relative humidity varies greatly. Data on evaporation within various types of cages were obtained between June 20 and June 29, 1929. These data are presented in Table XX.

TABLE XX.--THE EFFECT OF DIFFERENT TYPES OF INSECT CAGES ON RATE OF EVAPORATION.

Type of cage.	Level of atmometer above ground.	Total c.c. evaporation.
Outside of cage	<i>Inches.</i> 12	224.7
3x3x2 feet cage covered with 14-mesh wire	12	172.3
3x3x2 feet cage covered with gauze	12	108.2
Small round cage covered with very fine mesh wire	12	176.1
Square cage covered with exceedingly fine mesh wire	12	158.2
Round celoglass cage	10	85.0

The evaporation in all cages was less than the normal evaporation at the same level outside of the cages. The evaporation in the celoglass cages was only one-third normal and in the gauze cages only one-half normal.

These data are of interest in the rearing of such insects as the chinch bug, which is especially sensitive to humidity conditions.

The air-conditioning apparatus was used to investigate the migration of adults of the confused flour beetle, *Tribolium confusum*, from within the center of 100-pound sacks of flour, at various temperatures. The apparatus was also used to establish optimum conditions of temperature and humidity for the breeding of large numbers of the rice weevil, *Sitophilus oryzae*, and of the confused flour beetle, which were used in extensive experiments over the state. [Project 6; Department of Entomology; Hatch funds.]

Hessian Fly and Other Wheat Insects.--The work on this project has consisted of eight phases during the past biennium, each of which is described below.

1. *Distribution of the Hessian Fly*--For several years the area of heavy infestation of Hessian fly has been in south central Kansas. Surveys made in the fall of 1928 indicate that the area of heavy infestation has moved northward, centering in Lincoln and Ottawa counties. Another area appears to be developing in the southeast corner of the state. In the fall of 1929 the infestation was fairly general through the eastern half of the state. Fields were observed in Lincoln, Rice, Reno, and Riley counties in which more than 30 per cent of the plants were infested. Over this area about 70 per cent of the wheat was planted and much of it germinated before the fly-free date. Early in the spring of 1930 some fields in Marshall county were plowed up because of damage from the Hessian fly. In southeastern Kansas drought prevented much planting before the fly-free date.

2. *Life History of the Hessian Fly in the Field*--The life history of the fly under field conditions has been followed as closely as possible during the biennium. Several variations in the usual life history were noted. A moderately heavy midsummer brood appeared in volunteer wheat in August, 1928. Throughout most of the central wheat belt the emergence of the main fall brood was delayed until about October 10, due to dry weather. As a result

many of the maggots did not reach the flaxseed stage before cold weather, and consequently went through the winter as unprotected maggots.

The emergence of the first spring brood in 1929 was about normal. In the fall of 1929 practically no flaxseed were present in the volunteer early in the season. The main fall brood emerged about October 1 in the vicinity of Manhattan. In southeastern Kansas emergence was delayed by weather conditions, and oviposition was observed in the field near Iola on October 29. The first adults of the spring brood were collected on March 19. The first eggs were found April 9. Oviposition was light throughout the month. The Hessian fly near Manhattan are heavily infested with a species of *Platygaster* emerging from the fall brood.

3. *History of the Hessian Fly in Kansas.*--The study of the history of the Hessian fly in the state was practically completed during 1928. Data for this history have been compiled from the *Kansas Farmer*, the reports of the State Board of Agriculture, and the files of the Department of Entomology. Particular attention has been paid to the distribution, spread, relative abundance, and losses each year. These data are now being correlated with climatic conditions, changes in agronomic practices, and other factors which influence the activities of the fly.

4. *Time of Planting Wheat.*--About 25 time-of-planting plats were planted in various parts of the state during the fall of 1928. Owing to absence of the fly and delayed emergence, infestation occurred in only eight of these tests. The work of summarizing the 20 years' work on time-of-planting wheat has gone forward slowly, due to pressure of other work. It is hoped to complete this summary in the near future. Due to weather conditions, relatively few tests were completed in 1929.

5. *Influence of Cultural Methods on Insect Injury.*--Very little data were obtained on this phase of the work during 1928, due to the absence of any serious pests at the Agronomy Farm. The various plats at the farm were studied as in previous years, but no outstanding differences were noted relative to insect infestation and damage. In the fall of 1929 Hessian fly were fairly abundant on the Agronomy Farm. A count on the tillage and fertilizer plats showed a variation in infestation of from 4 to 39 per cent. This difference perhaps may be correlated with the difference in the time at which wheat on these plats sprouted and came through the ground.

6. *Census of Insects of a Wheat Field.*--The objective of this work, which was started in the spring of 1928, is to make a complete study of insects found in wheat. It has been continued throughout the biennium. This study has included various places in the state. A large number of insects have been collected and now await identification. Several interesting species were found which may be potential pests. In the spring of 1930 measured sweepings were taken with a square net at weekly intervals to determine the relative abundance of the different species of insects.

7. *The False Wireworm.*--Because of the increasing importance of the false wireworm as a wheat pest, a start was made in 1928 to summarize the results of studies during the past 20 years for the purpose of preparing a station publication on this pest. The files of the Department of Entomology contain complete notes on distribution, economic importance, life history, enemies, and control.

8. *The Wheat Strawworm.*--In parts of western Kansas this insect caused a considerable reduction in yield in the 1929 harvest. A sample of wheat from the Fort Hays Branch Experiment Station showed over 25 per cent of the upper nodes infested. Other samples of wheat were also brought in and used in life history studies, which are still in progress.

[Project 8; Department of Entomology; Hatch and state funds.]

Corn Earworm and Other Insects Injurious to Corn.—The work of the past two seasons has consisted of the following lines of investigation:

1. *Corn Earworm Studies.*—The time-of-planting experiments were continued in coöperation with the Department of Agronomy. Plantings were made at ten-day intervals through April and May. Three methods of planting were used; namely, listing, surface planting, and open furrow. In 1928 the earworm infestation was comparatively light, but counts made at harvest time coincide with the results of previous years in showing that corn planted about May 1 escapes with a minimum amount of injury.

In 1929 bad weather at harvest prevented detailed counts, but such as were made are in line with previous studies. Special attention has been paid during the past year to the parasitism of the corn earworm. In addition to the usual dipterous and hymenopterous parasites which emerged, a number of larvæ were killed by a nematode parasite. Bacterial diseases were also present. A number of hibernating pupæ dug from a late cornfield, are being carried over the winter for a study of this phase.

2. *Biological Studies of the Corn Leaf Aphid.*—The corn leaf aphid infestation was very light both years; consequently, very little has been accomplished. Data were secured on the migration from sorghums to corn and from corn to sorghums. The results confirm previous observations in showing that corn is a secondary host, being infested principally during the tasseling period.

3. *Biological Studies of the Corn Rootworm.*—Studies of the southern corn rootworm and the western corn rootworm were continued. Injury by both species was less noticeable than in 1927. The work with the southern corn rootworm was devoted largely to confirming life-history studies of the past three years and attempting to determine the method of overwintering. In the case of the western corn rootworm, a start was made on the life-history study. Particular attention was paid to the number of eggs deposited per female. During 1928 a total of 204 females collected in the field gave an average of 19.7 eggs per female, with a maximum of 105 eggs. The results in 1929 were similar. Attention was also paid to the food plants of the adults and the effect of cultural practices as a method of control.

4. *Influence of Cultural Systems on Insect Injury.*—In this study special attention has been given to the effect of different cultural systems on insect injury. Rotation plats, fertilizer plats, time and method of planting plats, and general fields at the Agronomy Farm, are all studied. During the past two years there was very little insect damage of any kind. In a few cases, wireworms, cutworms, and corn rootworms did a little injury, but the damage was not significant enough to draw definite conclusions. In general the results were in accord with previous years.

5. *Studies on the Common Stalk Borer.*—This insect continued to be a common pest throughout northeastern Kansas. Studies were started on the life history with special reference to the feeding habits of the larvæ, the length of the larval stage and pupation.

6. *Insects of the Cornfield.*—Collections of insects found in cornfields were continued and additional data were obtained on distribution and relative abundance. The records of insects collected on corn are now being tabulated and distributional maps are being prepared. A card catalogue of insects reported in the literature as feeding on corn is also in the process of preparation.

7. *Lepidopterous Enemies of Corn and Their Parasites.*—In this study a number of different species have been collected and partial life histories have been worked out.

8. *The Smartweed Borer and Its Parasites.*—The smartweed borer (*Pyrausta ninsliei* Hein) is the most nearly related species to the European corn borer that is found in Kansas. In weedy fields the larvæ sometimes infest corn plants. This insect is being studied as one of the things which may be

done in anticipation of the probable future presence of the European corn borer. Considerable progress has been made on the biology and parasites.

[Project 9; Department of Entomology; Hatch funds.]

Fruit and Vegetable Insects.--Four phases of this project have been active during the past two years: (1) Apple curculio control in northeastern Kansas, (2) a study of the seed corn maggot, a pest of cabbage, (3) a study of automatic bands for trapping codling moth, and (4) work on the biology of the strawberry leaf roller.

The June crop of apples is being destroyed as a means of control for the apple curculio. This work will of necessity have to continue for several years before results of value are secured.

The seed corn maggot, a destroyer of transplanted cabbage, has been found to be directly associated with organic refuse and organic fertilizer. Applying manure to the field ten days to two weeks after transplanting is apparently a better method than to apply in the fall. Application just before planting invites injury.

Of the various treated bands (automatic) for the control of codling moth, the betanaphthol and medium lubrication oil appears to be the best in two years' trials. There has been as yet no apparent injury to the trees from the treatment.

A study is being made of the ecology, life history, parasites, and control methods, including resistant varieties, of the strawberry leaf roller. The results of the study are as follows: (1) Of several varieties tested, the everbearing types showed the smallest amount of injury; (2) the usual attractant solutions and strawberry juice had no effect in attracting the insects; (3) it seems that weather in Kansas does not play a large part in the control of this insect; (4) a fungous disease plays a small part in the control of the insect; and (5) two dipterous parasites, *Nemorilla maculosa*, Meig., and *Phorocera tortricis* Coq. (Tachinidæ) were reared from *Ancylis comptana* Frohl. Where only five in one case and six species in another of hymenopterous parasites had been reared by others, eighteen were reared in 1929 and two new species were found among them. [Project 13; Department of Entomology; Hatch funds.]

Insects Attacking the Sorghums.--Considerable progress in the investigations of sorghum insects was made during the biennium as follows:

1. The data obtained from the investigation of the effectiveness of Sudan grass as overwintering quarters for the chinch bug were summarized and published.

2. Studies pertaining to the survey of insects attacking or associated with sorghums were continued. Many additional species were added to the collections made in the past. The collection consists of carefully mounted specimens on which individual records are kept regarding abundance, food habits, associations with other insects, and the type of injury which each causes. These studies are being continued from year to year to discover potential pests of sorghums as well as to secure necessary data for the compilation of a key for the identification of insect injury to sorghums.

3. Further observations on the habits of *Aphis maidis* Fitch to determine the reason for this insect attacking sorghums in the spring, going to the corn when the corn begins to tassel, and returning to the sorghums at heading

time, have been made. Attempts to determine how and where this insect overwinters have so far been unsuccessful.

4. Additional studies were conducted with insects attacking sorghum heads. Injury to the heads of Sudan grass and other sorghums, although not serious, continued to appear in the field. The amount of injury depends upon the abundance of snowy tree crickets and meadow grasshoppers. The injury to the heads and stems was not so apparent as during the fall of 1927. Considerable progress has been made in determining the food habits of the nymphs and adults. They have been found to be predacious upon aphids and, hence, are beneficial to this extent. The stems of Freed's sorghum, Sudan grass, and Pearl millet were preferred by the females for oviposition.

5. The life-history studies of the southern corn rootworm in relation to Kansas conditions were continued. No new facts were added except some additional data relative to the food habits of the adults. The attempts to carry the adults over winter in three types of hibernating cages have been unsuccessful. Although some investigators assume that this insect hibernates as an adult in rubbish, leaves and trash, attempts at this station during the past biennium to carry 1,500 adults over winter have failed. No stage in the life cycle of this insect has been found during the winter months in the course of these studies.

6. Considerable data have been accumulated during the past two summers on seed treatment as a means of preventing insect damage to germinating seed. The effect of a number of recommended materials upon the germination of the treated seeds of corn and kafir has been determined. Following are some of the points of interest which were revealed in this study: (a) In general, the dipped seeds had a higher rate of germination than the soaked seeds. (b) Seed corn was injured less than was kafir seed when subjected to the same treatment. (c) The most promising materials to be used as repellents seem to be creosote mixtures. (d) The majority of creosote mixtures left the seed in such a condition that it could be handled if allowed to dry.

7. Further studies were made on the life history of the insects infesting sorghum seed, especially the Dermestidæ larvæ. Larvæ placed in salve boxes containing 25 kernels of kafir, in 1926, failed to mature. Observations suggest that the limited number of kernels furnish an inadequate diet for the larvæ. Additional data were also secured relative to the egg-laying habits of the

[Project 92; Department of Entomology; state funds.]

Insects Attacking the Roots of Staple Crops.--During the past biennium an extensive study was begun on the ecology of May beetles, click beetles, white grubs, and wireworms. Hibernation observations were also recorded. A number of representative areas, including high prairies, low prairies, rocky hillsides, river bottoms, sand hills, and wooded land have been used in this work. A series of holes 2 by 3 feet have been dug each month in each area to determine the relative abundance, habits, movement through the soil, and depth of hibernation.

One hundred holes representing an area of 600 square feet have been dug to date, and the data are being summarized. The morphology and taxonomy of the white grubs have also been given some attention.

Considerable time and energy have been spent the past year developing a satisfactory technique for rearing wireworms to the adult stage. A new method makes use of a cage constructed of two 6-inch, unglazed grain tile, on the top of which is placed a screen wire cone. This method proved very satisfactory during the sum-

mer of 1928, when 38.9 per cent of the wireworms collected emerged as adult click beetles, and it was possible to account for 44 per cent of the 525 larvæ placed in the tiles.

It is interesting to note that only one adult click beetle emerged from 525 collected larvæ placed in salve boxes and handled individually. The number of wireworms collected and placed in tile during the summer of 1929 was increased approximately four times, but the rearing data are not complete at the present writing. However, out of the 2,500 larvæ placed in the tile 300 adult click beetles were reared the first season.

The results obtained during the past two years indicate that the tile cage is not only more economical, but also offers a greater opportunity for observing the food habits and other activities of the larvæ under conditions which approximate their natural habits. Since large numbers can be handled, this method will no doubt prove invaluable for rearing the species from the egg stage to the adult, as well as insure a better condition of specimens used in taxonomic studies.

The studies of wireworm injury occurring on corn grown in various cropping systems were continued, in coöperation with the Department of Agronomy. The results of six years' studies were summarized and prepared for publication.

The taxonomic studies were pursued with greater effort during the past year. Much progress has been made toward listing the Elateridæ occurring in Kansas, as given in fragmentary and scattered literature sources, in an effort to determine the species present in the state. Progress has also been made in the identification of specimens taken or reared in Kansas.

Considerable time has also been devoted to life-history studies. Particular attention has been given to the determination of the length of the egg, larva, pupa, and adult stages. The number of eggs laid and the habits of the larvæ and the adults have also been under investigation. Data pertaining to the feeding habits of several species have been added to the previous knowledge of this phase of the work.

Over 1,000 insect burrows have been studied and data collected on the type of burrow, the amount of soil brought to the surface, the amount of organic matter incorporated in the soil, the interchange of soil, and the factors which influence distribution. Studies were also made on the amount of soil brought to the surface by insects during the past two years, and several one-thousandth-acre plats were treated with insecticides. The data pertaining to this latter study are summarized in Table XXI.

TABLE XXI.—INFLUENCE OF INSECTICIDES UPON AMOUNT OF SOIL BROUGHT TO SURFACE BY SOIL-BURROWING INSECTS.

Plat.	Treatment.	Amount of soil, in grams, brought to surface annually.		
		1928.	1929.	Average.
28	Pesticide, 1,000 pounds per acre.....	210.07	171.86	190.96
29	Paradichlorobenzene, 1,000 pounds per acre.....	275.27	476.86	376.06
30	White arsenic, 500 pounds per acre.....	553.13	431.44	492.28
31	Watered daily, 2½ gallons water per plat.....	270.97	687.93	479.45
32	No treatment.....	879.56	1,343.53	1,111.54

An examination of the foregoing table shows that insects brought to the surface on plat 32 an average of 1,111.54 grams of soil annually, which is equivalent to 2,443 pounds to the acre. It is also interesting to note that insects did considerable burrowing on the plats treated with various insecticides.

The work with soil insecticides has been concentrated on the effect of these materials on the soil, crop plants, and nitrifying bacteria. These investigations have been carried on in the field and in the greenhouse. Much of the work has been in cooperation with the Departments of Agronomy and Bacteriology. The field work is conducted on 41 one-thousandth-acre plats laid out and treated in 1927 with the more common recommended soil insecticides. During the biennium corn, peas, wheat, beans, oats, tomatoes, asters, radishes and potatoes have been grown on the plats. A summary of the results shows that all of the arsenicals are injurious to plant growth. Sodium cyanide and paradichlorobenzene greatly reduced the yield. Most of the sodium compounds had a deflocculating effect on the soil, rendering it more impermeable to water.

A brief survey of the data gathered during the summer of 1929, which is the third summer for the treated plats, showed very little deleterious effects by the chemicals upon the growth and germination of the plants, as compared with the two years previous. [Project 100; Department of Entomology; state funds.]

Insects Injurious to Alfalfa and Allied Plants.--During the past biennium 18 species of Curculionidæ have been added to the list of those taken on alfalfa, bringing the total up to 24. Most of these are probably occasional visitors to alfalfa and only three are believed to be of importance at present. These are *Sitones hispidulus*, *Phytonomous punctata*, and *Epicæreus imbricatus*. *Sitones hispidulus* is undoubtedly the most injurious and presents a real menace to the alfalfa industry. Some of the results of the investigation are as follows:

1. Larvæ or adults have been found in every alfalfa field examined in Riley, Pottawatomie and Marshall counties. Infestation counts have revealed over

a million larvæ per acre in some of the fields examined. The adults appear to have a varietal preference, as indicated by collections taken on the alfalfa varietal plats on the Agronomy Farm.

2. The larvæ first consume the fine feeding roots and bore into the nodules, and later gouge the bark on the tap roots. This not only serves to injure the roots but provides an excellent entrance for infectious diseases and parasites, especially as the work is done during the spring and summer when the ground is moist and diseases spread rapidly.

3. The adults feed by consuming the leaves of alfalfa and other plants throughout the summer.

4. Few examples of disease by fungi or bacteria have been found, and no parasites have been observed.

The biology of *Phytonomus punctata* was found to check quite closely for Kansas conditions with records found in the literature. A serious outbreak of this insect occurred near St. Marys, Kan., on the Rouse Brothers farm. Two sprays, the first calcium arsenate, 2 pounds to 50 gallons of water, and the second lead arsenate, 2 pounds to 50 gallons of water, were tried, but both proved ineffective. The crop was saved, however, by the appearance of the fungus *Empusa*.

The incipient flower bugs which are taken in alfalfa fields in great abundance have been given some attention because of their manner of oviposition in alfalfa stems. The females deposit a large number of eggs closely packed together in the main stem at a node in the upper region of the plant. The damage, though readily found, is never extensive or severe. As *Orius insidiosus* is largely predacious and has a long list of hosts and also is long-lived and a rapid multiplier, it is mostly beneficial.

A small portion of the alfalfa plat at the insectary was so seriously injured that not a plant survived on an area 20 feet square following an attack of *Halticus citri*. This demonstrated the destructive ability of the species when given favorable circumstances. The insect punctures the leaves and extracts the juices from the cells, causing a white mottled appearance of the leaf.

Because of their great prevalence, repeated efforts were made to discover the egg-laying habits of the thrips on alfalfa *Frankinella tritici*. Dissections of females showed at most four eggs and generally but two or three. Only two eggs were found on the plants, these inserted in the upper surface of the leaf. The adults are generally found in pairs feeding on the purple petals of the flower. They are responsible for the occurrence of numerous white patches against the purple and also the presence of balls of purple material on the petals.

Collection data show that in the summer and fall leaf hoppers are the most abundant of the insects injurious to alfalfa. There are about 20 species commonly taken in alfalfa around Manhattan, those occurring in greatest numbers being *Empoasca fabae* (Harris), *Cicadula sexnotata* (Fall.), *Agallia sanguinolenta* (Prov.), and *Draeculacephala mollipes* (Say).

The leaf hoppers of alfalfa are of special importance because the

two found in greatest abundance, *E. fabæ* and *C. sexnotata*, are two of the three leaf hoppers in the United States definitely connected with the spread of serious plant diseases. *E. fabæ* is responsible for a physiological disturbance in various plants causing yellows of alfalfa and other legumes, tip burn of potatoes, beans, and other plants, and curly leaf of apple, etc. *Cicadula sexnotata* is the alternate host of a filterable virus causing a disease known as yellows in asters, celery, lettuce, and a host of other garden and flowering plants. It has been reported as spreading a disease of wheat in Europe.

For some reason *E. fabæ* does not cause the amount of yellows to alfalfa in Kansas that it does in the East, although it is readily found around Manhattan from the middle of the summer through the fall.

The relationships between alfalfa and potato growing and *E. fabæ* were made evident last season. Two rows of potatoes were planted through the alfalfa. These were untouched by any but occasional leaf hoppers until the latter part of June, when the alfalfa was cut. At that time the leaf hoppers migrated *en masse* to the potatoes and within three days every potato plant was scorched so that all growth ceased.

Efforts to overwinter *E. fabæ* in caged alfalfa resulted in failure during winters of 1928 and 1929. Also efforts to locate adults in alfalfa fields, in the weed areas around, under leaves in a neighboring apple orchard, and in fence rows were unsuccessful. The hibernating *E. fabæ* is everywhere an unknown quantity, though they appear in great numbers as adults in early summer. [Project 115; Department of Entomology; state funds.]

Shade-tree Insects.--Cankerworms have rapidly increased in numbers each of the past seven years. Warnings of the increases were sent out to the public in 1928 and 1929. Banding has been carried out in the eastern part of the state. Reports from the Smoky Hill and Saline river valleys indicate that there was severe damage from this insect in 1929.

During March, 1929, two consecutive freezes a week apart caused great damage to the spring and fall cankerworms. This check in the rapid increase in numbers was noted in the work during the spring of 1930. (Table XXII.) Such temperature influences are a factor in the reduction of these insects from time to time.

The ecology and biology of the sumac flea beetle is being studied on various sumacs. Hibernation is within a few inches of the host plant and only 1 to 2 inches deep. Adults and mature larvæ were found in hibernation. Egg masses are being examined to determine the average number per mass. Female beetles are being dissected to determine the number of eggs each is capable of laying. The length of the life-history stages is being worked out and parasites of this insect are being studied. This insect is of economic importance as a factor in sumac eradication from pastures.

TABLE XXII.--RECORD OF CANKERWORM EMERGENCE FOR A SEVEN-TEAR PERIOD.
 (Manhattan.)

Year.	Number of trees.	Number of insects.			Greatest number females on one tree.
		Females.	Males.	Total.	
1924.....	10			33	
1925.....	10	28	54	82	
1926.....	10	138	152	290	48
1927.....	10	471	509	980	98
	10	1,156	752	1,907	283
1928.....	10	52	47	99	13
	5	443	171	614	118
	10	1,806	380	2,186	294
	10	1,294	468	1,762	282
1929.....	10	134	247	381	51
	10	1,818	2,549	4,367	1,122
	10	4,629	4,430	9,059	1,010
	5	491	745	1,236	178
1930.....	10	396	467	863	106
	10	182	212	394	34
	10	194	365	559	43
	10	145	210	355	27
	10	328	811	1,139	118

The Pond Lily Midge has been observed causing damage to pond lily leaves. The lilies were imported from Ohio and the insects with them. This injury was observed late in August and September, 1929. A life-history study is being made and the insect is to be determined as to the species. [Project 116; Department of Entomology; state funds.]

Codling Moth Investigations.--This project, in coöperation with the Bureau of Entomology, United States Department of Agriculture, consists of three phases, each of which is briefly described below.

1. *The Testing of Promising Insecticides for the Control of Codling Moth.*--This investigation was designed to give additional data on the efficiency of various dosages of lead arsenate and the relative effectiveness of certain lead substitutes. The season's work showed again very conclusively that dosages of 1:50 were utterly ineffective, that at 1½:50 the margin of safety was so small as to preclude effective commercial control, that at 2:50 control was excellent where proper spraying was done, using about 12 to 15 gallons of spray to the average 20-year old tree, and that dosages stronger than 2:50 gave slightly better control, but were not sufficiently more effective to be desirable from a commercial standpoint.

Several substitutes, including nicotine 1:800, oleoresin of pyrethrum (Evergreen brand) 1:600, and derrisol 1:200, all used with summer oil at the rate of 2:100, gave fair to good control. All seemed worthy of further trial. Spray residue on these blocks was

about 0.013 gram per pound as against about 0.045 gram per pound for standard lead.

2. *Timing Experiments.*—This set of experiments undertook a further investigation of the problem of spray schedule. The material used was lead arsenate at dosages of 1½:50 and 2:50, the spray being timed from the first application at 12- and 16-day intervals, with an 18-day interval between the third and fourth cover sprays. These tests showed that the 2:50 was far better than the 1½:50 mixture under all conditions. Trees heavily infested when sprayed at the 12-day interval gave results equally good with trees with a no more than average carry-over sprayed at a 16-day interval.

3. *Distribution Studies.*—This investigation was designed to be continued over a number of years, including a study of the distribution of the part of the moth, with such subsidiary problems as the effect of the previous season's infestation on any given season's crop, and the effect of points of high infestation on the surrounding areas. For this series two large blocks of Winesap trees were selected having about sixty trees in each block. All fruit on all trees was checked for worm injury. Thus a point of departure for every tree in the two blocks was established. Since the spray history of each tree for two seasons is known, and for some of them for four seasons, sufficient data have been accumulated to indicate how the main problem will develop. The study has already shown that the infestation seems to be a localized one on the whole, each tree being more or less an independent unit and not very seriously affected by its neighbors. Infestation over a distance of a single row under field conditions does not seem to take place, and if control is fair even adjacent trees may be practically unaffected by their more heavily infested neighbors.

Within the tree there is a tendency for infestation to accumulate on the top sections and on those portions of the tree receiving the most sun, especially is the earlier part of the season. Whether this is a worm response or one that is found in the adult moth has not been determined. [Project 163; Department of Entomology; Purnell funds.]

The Resistance of Crop Plants to Insect Injury.—This project was started in September, 1926. Except for a few observations on other forms made as opportunity presented itself, most of the time has been devoted to a study of two insects--the chinch bug and Hessian fly. During the summer attention is confined mostly to the chinch bug, while during the other seasons of the year the Hessian fly receives major attention.

There were so few chinch bugs in the summer of 1928 that practically no damage was done in the sorghum nursery, and hence little progress was made in this phase of the study. However, sufficient bugs were available in the earlier part of the season for some laboratory and insectary studies in connection with the olfactory response

of the chinch bugs and of the composition of the sheath which forms in the plant tissue about the stylets of chinch bugs. In the latter case methods were worked out and a number of preliminary tests were made. The fresh sheath in susceptible corn gives a protein reaction with Millon's reagent, appears to contain no tannin, but gives some of the reactions for pectic material and callose. The study will be continued and enlarged to include both resistant and susceptible varieties when chinch bugs are again available.

Two methods were used in studying response of chinch bugs to odors. In the laboratory an olfactometer similar to that designed by McIndoo (Jour. Econ. Ent., 19:545-571) was used. Outside a type of field olfactometer was used by means of which it was possible to compare the reaction of the chinch bugs to different varieties and under different conditions. The instrument was constructed so as to allow the bugs the choice of going toward different varieties of sorghums growing naturally at each end of the box. In a number of instances plants were used at one end of the box and only the soil at the other. The insects appeared to be unable to distinguish between varieties at a distance of a few inches by a sense of smell, or even between the end of the box containing the plants and the end which did not contain them.

Studies were continued by placing a number of chinch bugs on single plants, or pairs of plants--one susceptible and one resistant. At various time intervals the bugs were etherized and the number in various situations on each plant recorded. Due to scarcity of bugs, only a few experiments were run, but it was found possible to kill or stun the bugs with their stylets in place in the plants. In that situation more than 100 bugs have been recorded from a single plant. In a season when more bugs are available valuable data should be gathered as to the feeding habits of the insects on different varieties.

The most important result of the past two years' work on the resistance of wheat to Hessian fly attack has been the demonstration of the presence of physiological strains of the fly. A report of the first year's work appeared in the *Journal of Economic Entomology* under the title "The Biological Strains of Hessian Fly."

The second year's study was more extensive so far as field work was concerned. Twenty-five varieties were planted at seven different places in the state. Five of these gave excellent infestation data.

If the difference in intensity of infestation is taken into consideration, the results are fairly uniform for the localities in the hard-wheat belt. The infestation at Columbus, Kan., was very heavy, but some significant differences were evident among the several varieties. A uniform greenhouse test was carried on with nine varieties, using fly from Manhattan, Reno county, and Columbus, Kan. The data from both greenhouse and field experiments support the conclusion mentioned above as to the presence of biological strains.

In the following the individual histories of eggs laid on different leaves, it was found that no flaxseed survive from eggs laid on the outer (first) leaf; only 6.35 per cent survive from eggs laid on the second leaf; and 45.4 per cent survive from those on the third (central) leaf. This decrease in survival on the different leaves is paralleled by an increase in deposition of cellulose or, perhaps, with some condition arising with it. These facts are of interest in connection with the resistance of certain cereals to the attack of Hessian fly.

The progeny from isolated single pairs of fly were predominantly of one sex. Out of 13 matings, 4 gave all males, 5 all females, and 4 gave offspring predominantly of one sex. In one case 74 females and no males were reared from one pair.

The data on the infestation of wheat varieties by Hessian fly are being summarized for publication in a technical bulletin. It is hoped to have this available for publication early next year. [Project 164; Departments of Entomology and Agronomy; Purnell funds.]

Investigations in the Control of Injurious Mammals.--The work during the past two years has consisted of (1) hibernation studies on the thirteen-lined ground squirrel (*Citellus tridecemlineatus*), (2) experiments on poisoning moles, (3) effect of bovine anterior pituitary extract upon growth of white mice and rats, (4) effect of removal of ovaries in pregnant rats and ground squirrels and influence of a bovine corpus luteum extract upon the duration of pregnancy in these animals, (5) experiments on obtaining reproduction of ground squirrels in the laboratory, (6) temperature rise in lizards in recovering from hibernation, and (7) experiments on poisoning of rats. Stated briefly the results have been as follows:

1. Previous observations on the process of waking from hibernation were checked and the results published in two papers. A drop in temperature of from 2° to 4° C. or more an hour was observed in ground squirrels going into hibernation or already partly torpid, in a cold room. More evidence was gathered to the effect that confined air and precooling aid in the production of hibernation, but that anterior pituitary extracts hinder entrance into hibernation.

2. Both strychnine and carbolineum again appeared to be of value in protecting seed corn against moles in laboratory experiments in 1928, to some extent acting as repellents and to a greater extent as poisons. Field experiments on treating seed corn to protect it against moles led to improved methods of treating the corn, but few results were obtained because of lack of mole injury. The poisoned corn killed several field mice which might have produced damage to the sprouting corn.

3. Bovine anterior pituitary extract promoted body growth in both male and female mice, produced luteinization, with considerable sterility in the females, and more sterility accompanied by histological changes in the testes and Cowper's glands.

4. Removal of ovaries in pregnant ground squirrels resulted in absorption of the embryos. In late stages of pregnancy death of the mother appeared to result rather than abortion. The *corpus luteum* extract prepared tended to delay or prevent abortion, which normally occurs after ovariectomy in pregnant female rats.

5. The experiment to obtain reproduction of ground squirrels in the laboratory has just begun. Various possible factors, including transplantation of anterior pituitaries of rats, the use of ultra-violet light, and diet are being tried.

6. Temperature graphs in lizards recovering from hibernation were obtained.

7. Red squill was found somewhat effective and barium carbonate still more effective in poisoning rats in cages.

[Project 84; Department of Zoölogy; state funds.]

DISEASES OF FARM ANIMALS

Some of the more important features of the work of the Agricultural Experiment Station during the past biennium relating to animal diseases and parasites are discussed below.

Miscellaneous Animal Disease Investigations.--The work on this project has consisted of post-mortem and laboratory examinations of diseased animals and tissues, and of investigational trips to determine the cause of mysterious animal diseases as they present themselves.

During the two years 20,535 laboratory examinations have been made. This is a decided increase as compared with the preceding biennium, when a total of 6,514 examinations were reported. Several disease outbreaks have been investigated, one of the most interesting having to do with diseases in baby pigs. This type of trouble seems to be increasing, and our investigations yield the following conclusions:

1. Petechial hemorrhages on the kidneys of baby pigs are normal and gradually disappear as the pig grows older.

2. Some few pigs from two unrelated immune sows exhibited unquestionable evidence of hog cholera, as proved through the injection of their filtered blood into susceptible animals.

3. The majority of sick pigs on immune and nonimmune sows died of infections of which colon and intermediate colon organisms were the cause. The chief lesion present consisted of a marked inflammation of the intestine.

4. Normal, healthy pigs on immune or nonimmune sows did not sicken following injections of bacteria isolated, or of whole blood and tissue juices, or from intestinal or stomach contents from sick pigs.

5. It is felt that the majority of the troubles in baby pigs can be prevented or largely controlled through proper, rigorous, sensible sanitation. This conclusion has been substantiated by studies in coöperation with the Department of Animal Husbandry during the past two years.

6. Pig anemia has been quite prevalent during the past two years and seems to respond to treatment with iron, copper, and manganese.

[Project 102; Department of Veterinary Medicine; state funds.]

Abortion Disease Investigations.--A large part of the time during the past year has been used in establishing abortion-free herds. The agglutination test and certain well-defined sanitary procedures are the basis upon which the success of this plan depends. These herds now number 53 and are well distributed over Kansas. Of the herds under supervision, 35 are dairy and 18 beef herds. Table XXIII gives the breed and the number of infected animals in these herds.

TABLE XXIII.—THE KIND AND NUMBER OF INFECTED CATTLE IN 53 HERDS TESTED FOR ABORTION.

Breed.	Number of infected animals.	Number of negative animals.	Number of herds.	Total number of animals.
Jersey.....	68	110	6	178
Ayrshire.....	93	161	4	254
Guernsey.....	10	54	2	64
Holstein.....	322	734	21	1,056
Mixed dairy.....	21	137	2	158
Angus.....	37	75	1	112
Hereford.....	130	756	11	886
Shorthorn.....	27	114	5	141
Mixed beef.....	20	72	1	92
Total.....	728	2,213	53	2,941

Ten of the herds have been abortion-free for a period of over one year, one for over two years, and nine for at least six months.

There has been a marked increase in the numbers of blood samples tested in the abortion laboratory, increasing from 6,282 for the year ending June 30, 1929, to 11,321 for the year ending June 30, 1930.

It has been definitely proved that no specificity exists for cytochrome or animal-tissue ash, and work with this product has been discontinued, at least temporarily.

The work which was started last year in an attempt to influence the blood agglutinins by intravenous injection of certain drugs has been continued with two more products. It was found that formalin and metaphen (a proprietary mercury preparation) had no such effect upon rabbits and guinea pigs. The flavine dyes (acriflavine and proflavine) were used on a series of 12 rabbits and an equal number of guinea pigs with negative results.

Colloidal carbon was also used on the same number of animals and on two heifers. All of these animals after six months gave about the same degree of positive reaction that they did before the treatment.

It is planned to continue this work in the hope that a specific drug will be found similar in its effect on *Brucella abortus* to that of salvarsan on the causal organism in the treatment of syphilis.

Two facts have been discovered in connection with the effort to eradicate abortion disease in the dairy herd at the Kansas State Agricultural College which are of the greatest importance. These facts are:

1. Calves up to three weeks of age, born in an infected herd and fed abortion-infected milk, will be blood positive, but when removed

from such an environment to clean surroundings and fed abortion-free milk, will in all cases become completely negative in periods ranging from three to eight weeks, and will continue negative. This information is of immense value in raising replacement heifers from the infected or isolation unit, and will render the task of eradicating abortion disease both more rapid and economical.

2. In a barn thoroughly saturated with abortion infection (a herd of 24 positive cows being stabled therein for 18 months with numerous abortions during the time), two thorough clean-ups, followed by whitewashing and three months of summer sunning during which the premises were kept free from cattle, resulted in a complete eradication of the abortion germ from the premises. This is well proved by the experience obtained in placing all the negative heifers, both bred and unbred, of the college herd in such a stable and the subsequent testing of them monthly over a nine-months period. There has not been a single reactor found in this herd of heifers to date.

The college dairy herd has finally, after three years of study and work, been cleaned up of abortion infection entirely. There have been no reactors in the dairy herd since September, 1929.

The rapid test or plate agglutination method has been adopted as a routine test and has proved equally sensitive with the long or tube test on 1,100 samples tested. Antigens of different ages are checked on known sera and a marked correlation noted in the lowering of sensitivity in picking reactors with the greater age of the antigen. Antigens differently prepared were studied with the following results:

1. An antigen suspended in physiological saline solution is quite stable, but is less sensitive than a 12 per cent saline-suspended antigen.

2. A 12 per cent saline-suspended antigen is more sensitive than No. 1, but less stable, and if used should be freshly prepared every 30 days.

3. An antigen suspended in buffed solution (Na/OH) is quite stable but less sensitive, and is slightly inferior to No. 1.

4. A 12 per cent saline-suspended antigen when three months to twelve months of age will miss as high as 5 per cent reactors, as determined by a fresh antigen, and will give a high per cent of suspicious or 1-50 reactors which will be clearly positive on the freshly prepared 12 per cent antigen. The work on antigens will be continued.

[Project 135; Department of Veterinary Medicine; state funds.]

Blackleg Investigations.--The work on this project during the past two years has consisted of the production and distribution of blackleg aggressin, blackleg filtrate, and blackleg bacterin. About 40,000 doses of these three products have been distributed each year. Experimental work on the action of salts in the culture medium used for the production of blackleg filtrate and bacterin has been carried out. The action of formaldehyde on the aggressive substances in blackleg filtrates, bacterins, and aggressins was also studied. From these experiments it is now possible to produce blackleg filtrates and bacterins having a potency of 260 units, where in the past it was possible only to produce aggressins and filtrates having a potency of about 20 units.

In the biennial report for 1926-1928 it was shown that certain salts--sodium citrate, ammonium phosphate, and potassium tellurite--increased the potency of blackleg filtrates. During the past biennium a systematic study of the action of 68 salts on the growth, fermentation, and gelatinolysis of anaerobic organisms was made. For accurate comparison it was first necessary to determine the optimum concentration of each of these salts for the growth of *Clostridium chauvæi*. It was found that this organism would not grow in the simple media necessary for such a study. Therefore, three easily growing anaerobes, *Clostridium sporogenes*, *Clostridium welchii*, and *Clostridium novyi* were grown in gelatine and beef broth containing 0.5 per cent peptone and 0.5, 0.05, 0.005, 0.0005, and 0.00005 molar concentrations of the 68 salts. From a comparison of the growth obtained it was possible to determine the amount of each salt which should be used. The growth of *Clostridium chauvæi* and *Clostridium septicus* was tested on media containing ammonium dihydrogen phosphate and potassium bicarbonate. The growth of these organisms corresponded closely with that obtained in the same media by the three actively growing organisms.

A comparison of the growth of *Clostridium novyi*, *Clostridium welchii*, and *Clostridium sporogenes* in the 68 salts (53 inorganic salts, 9 amino acids, 3 extractives, 2 phosphatids, and 1 nucleoprotein) showed that in most cases there was a definite concentration which produced optimum growth. In many cases there was also a definite toxic concentration.

Further work on the use of formaldehyde for increasing the potency of blackleg filtrate has been carried out. The results confirm those previously reported. It has been decided to produce and distribute a blackleg bacterin made by adding 1 per cent commercial formalin to clarified cultures of the blackleg organism grown in liver meat piece medium containing a mineral mixture. [Department of Veterinary Medicine; state funds.]

Shipping Fever Investigations.--This project was started July 1, 1929, and is being conducted as a coöperative project with the state live stock sanitary commissioner, who is collecting statistical data on shipments of cattle into Kansas.

Clinical and sanitary inspections of farms on which losses have occurred are made by representatives of the state live stock sanitary commissioner, the Bureau of Animal Industry, United States Department of Agriculture, and the Department of Veterinary Medicine. Bacteriological and pathological examinations of material obtained from cases of shipping fever, immunological studies on small animals, and infection studies on large animals are made by the Department of Veterinary Medicine.

A total of 105 herds in which sickness was reported from the state live stock sanitary commissioner's office were investigated. These investigations showed that losses are heavier in early winter

when weather conditions are bad, and when large numbers of young cattle are being shipped. They also indicate that vaccination does not control this condition. Losses among vaccinated animals were twice as great as in unvaccinated animals, and the number of recovered animals was over twice as high as in unvaccinated herds.

A study of the handling facilities and feeding conditions on farms where losses were high as compared to shelter and food on farms where losses were low, shows clearly that proper shelter and feeding practices will minimize losses.

Tissues from 17 cases of shipping fever have been studied. The lung and heart blood were examined in all cases and other tissues in a few cases. *Pasteurella bovisseptica* was isolated from 14, or 82.35 per cent, of these cases.

Large pieces of 83 lungs from healthy normal cattle were obtained from a packing house and shipped to Manhattan packed with ice. A study of the bacterial flora of these normal lungs was made. It was found that the most common organisms were cocci. Colon group organisms were found in about 65 per cent of the cases. A few cases showed nonfermentative gram negative organisms, and a few others contained organisms similar to the lung edema organism.

From this study it is suggested that many organisms may be associated in shipping fever, but that *Pasteurella bovisseptica* plays the major rôle in the final outcome of this disease.

The growth of *Pasteurella* organisms on ordinary media has not been satisfactory. During the past few years the Department of Bacteriology has used a medium containing ferrous sulphate and sodium citrate with very good success. A study of this medium and of media prepared with some of the mineral salts used for the growth of the blackleg organism led to the trial of forty different mineral mixtures, and a very efficient agar was finally developed. This medium has enabled *Pasteurella bovisseptica* to remain viable for at least seven weeks, and it also greatly increases the virulence of cultures of this organism.

Seven calves were obtained and injected with cultures of *Pasteurella bovisseptica* and *Escherichia coli* administered under different conditions. These experiments indicate that calves can be easily killed by intravenous injections of living pathogenic and normally nonpathogenic organisms, and that the amount of food in the stomach influences the outcome of injections with pathogenic organisms. Field investigations have shown that losses in herds which are fed a reduced diet during the first few days after arrival, are much less than in those herds in which the animals are allowed access to abundant food.

A comparison of the immunizing value of eight lots of commercial bacterins and two bacterins prepared by the department was made. Ten pigs and one rabbit were injected with two to five cubic centimeters of each bacterin. Fourteen days later these animals were

injected with virulent culture. Within 24 hours from 33 to 84 per cent of the guinea pigs inoculated with each lot of bacterin were dead. All the rabbits also died within 24 hours. There was no consistent difference between the immunization produced by the different doses.

Eight rabbits were immunized with bacterins made from eight strains of *Pasteurella bovisseptica*. The sera from these rabbits were tested against antigens from 18 strains. It was found that the majority of strains belong to one serological type. One strain was agglutinated only by its homologous serum and another strain partially by three sera. [Project 176; Department of Veterinary Medicine; state funds.]

Studies in Hog Cholera Immunity.—Work on this project has been continued as previously reported. The results obtained this biennium have again been gratifying. The difference in the number of pigs farrowed and those raised to maturity cannot be accounted for other than as the result of the action of the virus administered to them. Of 68 that received virus and were examined daily, only one died. This pig was a "runt" and did not show an elevation of temperature, and no cholera lesions were found on post-mortem examination. The results suggest that immunity sufficient to withstand hyperemia may be produced by giving virus to young pigs from immune sows. The project will be discontinued. [Project 150; Department of Veterinary Medicine; state funds.]

Anaplasmosis Investigations.—A disease of cattle known as anaplasmosis has caused serious losses in sections of southeastern Kansas during the past three years. A study of the disease was undertaken at Sedan, Kan., in cooperation with the state live stock sanitary commissioner and the Bureau of Animal Industry, United States Department of Agriculture. Seventeen animals have been used in the experiment, the main object of which has been to study the disease and endeavor to transmit it by means of various insects, together with an effort to study the various immunologic phases possible in such a limited number of animals.

From the study of the blood of the animals under observation it has been shown that the appearance of the blood picture gives a fairly definite index as to the course of the disease. Further study seems to justify the following tentative conclusions.

1. Iron, manganese, and copper will build up the hemoglobin content of the blood, but does not increase the animal's resistance to anaplasmosis.

2. The blood of "carrier" or recovered animals retains the ability to transmit the disease as rapidly as blood taken from acute cases of anaplasmosis.

3. "Carrier" or recovered animals have been resistant to infection.

4. Flies show no effect on animals when the flies are put in darkened inclosures.

5. Calves from infected and well animals do not sicken following their inoculation with blood taken from an acute case of anaplasmosis.

6. Calves inoculated with infective blood seem to acquire a resistance to anaplasmosis.

7. Many infected animals appear to recover completely after a period of six months (approximately) except for the continuance of cell inclusions.

8. The inoculation with ground lice taken from an animal sick with anaplasmosis did not reproduce the disease in a susceptible animal.

9. Out of 12 experimental cases of anaplasmosis there were but two deaths, or 16 per cent mortality. These animals never received medication of any sort. This seems to indicate clearly that care, water, feed, and protection from flies and sun are important factors in minimizing losses from the disease.

[Department of Veterinary Medicine; state funds.]

Histopathology of Poultry Diseases.—The work on this project during the past biennial period has consisted of an endeavor to familiarize ourselves with the normal histology of the chicken. A satisfactory set of slides has been prepared showing the normal histology of the various organs of the chicken on an adequate diet.

Some studies were taken up on a peculiar condition known as “crooked legs” in chicks. Nerves were taken from the chicks on a vitamin-A-free diet, namely, a fatty degeneration.

As a part of Project No. 127 (page 91) representative chicks were taken every two weeks and carefully autopsied, and sections were made from each organ and tissue. There were no diseased tissues seen either from a macroscopic or a microscopic examination, with the exception of the legs where the tendon was found to have contracted and pulled itself away from the condyles where it normally is found. The growth of bone occurs from the center to the ends of the bone, and as this growth continues the soft bone that is being generated is bent out of shape in direct proportion to the contracture of the tendon. Because of the total lack of lesions in these chicks and the occurrence of contracture of tendons in other animals, it is thought that the tendency for this condition is probably transmitted through the egg.

It has been suggested that chicks showing the condition of “crooked legs” be raised and eggs be collected for hatching in an endeavor to study the inheritance of this characteristic. [Project 168; Department of Veterinary Medicine; state funds.]

Poultry Disease Investigations.—The work of this project is divided into four phases as follows: (1) A general study of poultry diseases; (2) studies on pullorum disease; (3) a study of *Pasteurella avicida*, the causative agent of fowl cholera; and (4) studies of fowl paralysis.

1. *A General Study of Poultry Diseases.*—No general change has been made in the routine examination and study of diseased fowls received at the laboratory. The large number of cases received for diagnosis precludes the possibility of making a comprehensive study except in a few birds. During the biennium 22,624 laboratory diagnoses on common diseases of the fowl have been made.

The study of a few definite problems previously recorded has been continued during the past biennium while several new problems have been given special consideration.

Data on intestinal parasitisms have been collected to determine the prevalence of worms and coccidia in Kansas poultry. Table



XXIV is a summary of observations made on birds recieved during the four-year period ending June 1, 1929. Only birds over eight weeks of age are included.

TABLE XXIV.—NUMBER AND PER CENT OF BIRDS EXAMINED SHOWING PRESENCE OF WORMS OF DIFFFERENT KINDS.

	Total.	Per cent.
Birds infested with cecum worms (<i>Heterakis papillosa</i>)	985	38.46
Birds infested with large roundworms (<i>Ascaris lineata</i>)	851	53.23
Birds infested with tapeworms (all kinds)	669	26.12
Birds infested with gizzard worms (<i>Dispharagus hamulosus</i>)	56	2.19
Totals	2,561	100.00

During the past year attention to coccidiosis outbreaks in birds from one to four months of age has shown that there were 151 outbreaks, which represents 32.9 per cent of all cases of this age which were examined. The significance of parasitic infestations and the enormous losses they cause is indicated by these data.

Studies of the distribution of lesions in avitaminosis A cases in birds of various ages, the distribution of lesions of avian tuberculosis, and the monthly distribution of poultry diseases in Kansas have been continued and additional data have been collected.

During the spring of 1928 acute generalized *Excherichia coli* infection in chicks 10 to 20 days of age was recognized as a separate disease. Previous to this time *E. coli* had been considered a secondary invader in the agonal stages of disease or immediately following death. A number of outbreaks of disease in chicks two weeks of age were encountered in which a sudden onset of symptoms of pulmonary dyspnea accompanied by great depression was followed by death in three to four hours. *E. coli* was isolated in pure culture from the heart's blood of specimens in the later stages of the disease and from recently dead chicks. The average mortality was approximately 4 per cent of affected broods. Seventeen outbreaks of colibacillosis have been encountered in station flocks, and 32 outbreaks were observed in outside flocks.

A disease condition in "green" and one- to two-day-old chicks from incubators in commercial hatcheries in this and other states has been encountered, which is typical of omphalitis, or navel infection, in other species, except that the course is more rapid and the causative agent appears to be an aërogenic sporulating anaërobe with very active proteolytic properties. In one commercial hatchery approximately 5 per cent of the chicks hatched during the 1928 season succumbed to this disease. As the disease appeared to be associated with filthy methods during incubation, formaldehyde fumigation of cultures in forced-draft incubators was carried out. It was found that at least three times the quantity of ingredients

necessary for destroying *S. pullorum* were required to destroy the spore forms of the anaërobe and a mixture of organisms from superficial tissues. Inoculation experiments indicated that subcutaneous injection of the culture or contaminated material was necessary to reproduce the infection in susceptible chicks.

The work on fowl-pox vaccination which was begun in 1929 was continued. The method of feather follicle, or stick vaccination, has been found to be preferable to subcutaneous injection of finely ground pox scabs. The results of vaccination of 4,660 birds in field and College Poultry Farm flocks during 1928 were very promising, and consequently a limited quantity of fowl-pox virus was prepared for field distribution during the 1929-'30 season.

2. *Studies on Pullorium Disease (Bacillary White Diarrhea).*— During the past biennium testing for carriers of pullorum disease as a coöperative project with hatcheries and flock owners has been discontinued. However, testing of experimental and field flocks in connection with the work with pullorin has allowed a further study of the agglutination test.

Although no definite figures are available, it is evident that there has been a continued marked increase in the volume of testing throughout the state.

Antigen for conducting the agglutination test has been supplied at a nominal charge to laboratories, veterinarians, and flock owners. Antigen for conducting 133,220 tests was sent out during the biennium.

The work on the agglutination test has consisted of a study of the rapid antigens with regard to keeping qualities, salt concentration, and the use of buffer solutions as suspendents. The following conclusions were reached.

1. A 10 per cent instead of a 12 per cent NaCl concentration reduces the number of doubtful or delayed clumping tests.
2. Suspensions of *S. pullorum* to be used for rapid-test antigen should be held in physiological salt solution and additional NaCl added shortly before making tests.
3. Buffered rapid antigens give clearer reactions with far fewer doubtful tests than unbuffered antigens. A buffer with a pH value of 8.2 to 8.6 appears to give the most satisfactory results.

Particular attention has been given to the "pullorin" or wattle test for detecting carriers of pullorum disease, and to date 7,815 tests have been made in experimental and field flocks. The following conclusions were reached from this rather extensive investigation.

1. The very thin skin of the wattle of the fowl precludes the possibility of intradermal injection in many cases, with the methods generally employed.
2. The reaction to a single "intradermal" injection of digest pullorin is manifested by a nonspecific early swelling in infected as well as noninfected fowl, which reaches its maximum size at three to four hours following injection, and a later specific reaction which attains its maximum size at an average time of 22.5 hours.
3. The character of soft edema, with more or less severe swelling as detected by the touch, is a more satisfactory criterion for interpretation of the reaction to pullorin than is the increase in the thickness of the wattle as measured with the micrometer.

4. Macroscopically and microscopically the pullorin reaction resembles the tuberculin reaction as manifested in birds and other species.

5. No group activity is manifested in local tissue reactions to antigens prepared from *Escherichia coli* and *Salmonella pullorin*. The close relationship of *S. pullorum* and *Salmonella gallinarum* may be demonstrated by tests with "intradermal" agents prepared from them.

6. Frequent repeated tests with digest pullorins does not cause significant desensitization of reactive individuals.

7. Tests for ophthalmic sensitivity to pullorin confirmed the observations of Ward and Gallagher that a response or reaction is seldom manifested.

8. The ecto and digest pullorins used in these studies were more satisfactory than other types prepared in our laboratory or obtained from other sources.

9. In an effort to develop a satisfactory pullorin, sources of variation in the test, including methods of application and standards of interpretation and comparison, must be given major consideration.

3. *Studies of Fowl Cholera.*—This study has been confined to a study of the development of the organisms in the body of the bird. It was found that there was a marked decrease in the number of organisms within one-half hour after they were introduced. This decrease persisted for but one-half hour and was followed by a rapid increase which continued to the death of the bird.

There is considerable evidence that death from fowl cholera is due to oxygen starvation of the tissues. This is indicated (1) by the cyanotic comb, (2) the dark appearance of the arterial blood, (3) the enormous growth of the organism in the blood stream, (4) the fact that these organisms possess a marked affinity for oxygen when grown on artificial media, and (5) the fact that during growth the organism apparently injures the endothelium of the capillaries in the walls of the alveoli of the lungs, thus allowing an escape of plasma which fills the alveoli and prevents the proper oxygenation of the blood.

4. *Studies of Fowl Paralysis.*—During the past biennium a study has been made of a disease commonly known as "range paralysis."

The symptoms of the disease are paralysis of one or both legs or wings, and blindness. The disease attacks from a few birds to nearly the entire flock, and losses by-death are nearly 100 per cent of the affected birds. To date clinical and pathological symptoms have been found to be the same as those described in Europe and the eastern portions of this country. The bacteriological findings are negative and it has been impossible to transmit the disease experimentally in the laboratory.

Birds from 53 flocks have been examined which showed symptoms similar to those described for fowl paralysis. Of these 30, or 56.7 per cent, showed the lesions typical of "range paralysis." The remainder had developed a complete or partial paralysis due to several factors. Among these factors were tapeworm infestation, coccidiosis, inadequate diets, tumors which involved the peripheral nerves or tissues adjacent to it, etc.

The lesion which characterizes the disease is a very heavy round cell infiltration into the peripheral nerves and tissues adjacent to it.

This may or may not involve the cord. This infiltration of round cells is followed by a partial or complete disappearance of the nerve fibers, a thickening of the perineurium, a paralysis of the involved member, and atrophy of the muscles supplied by the nerve.

The name "range paralysis" should be discontinued as soon as it is possible to apply a more exact term. There are numerous factors which indicate that it is in the nature of a tumor growth which involves the central nervous system. Other tissues may or may not be involved, and in some cases birds show typical lesions of the disease without demonstrating clinical symptoms. However, this latter condition is not common, and in all cases in which the lesions are extensive the clinical symptoms of paralysis are in evidence. [Project 85; Department of Bacteriology; state funds.]

A Study of the Dissemination of Pullorum Disease in Incubators.—The work reported covers a period of two years. The object the first year was to determine the effect of varying degrees of humidity in forced-draft incubators at hatching time upon the dissemination of *Salmonella pullorum* from infected to noninfected chicks. The two objects in the second year's work consisted (1) of a study of hatchability when using varying degrees of temperature and a constant wet-bulb reading of 95° F. during the time of hatch, and (2) a study of the control of the transmission of *Salmonella pullorum* organisms from infected to noninfected chicks in a forced-draft incubator operated at the optimum temperature and humidity found in the first study.

In the first year's work six different settings were incubated at the normal temperature of 100° F. with a wet-bulb reading of 95° F. (relative humidity, 84.5 per cent). The wet-bulb reading in the next four settings was 75° F. (relative humidity 32 per cent), and the wet-bulb reading for the last two settings was 85° F. (relative humidity 56.5 per cent).

Eggs from a flock of Rhode Island Red hens known to be infected with pullorum disease and eggs from a flock of the same breed known to be free from the disease were incubated in a forced-draft incubator in order to determine the extent to which the disease would be transmitted from the diseased to the disease-free chicks.

From the results obtained it was concluded that a humidity shown by a wet-bulb reading of 95° F. at hatching time practically eliminated the spread of pullorum disease. The hatchability of the eggs, however, was 9.5 per cent lower than for the hatches under optimum temperature and humidity conditions.

It was discovered during the experiment that "chick down" consists of a scalelike substance that surrounds small bundles of chick fluff on the newly hatched chick, and as the chick dries and brushes against other objects the scale peels off and circulates through the air. It is thought to be this scale, together with dust particles, that carries the pullorum disease from diseased to healthy chicks. A high humidity at time of hatch greatly reduces both the number of

scales that peel off of the chicks and the number that float through the air.

This project has been completed and a report of the work will be prepared. [Project 77-10; Departments of Poultry Husbandry and Bacteriology; state funds.]

Relation of Adequacy of Diet to Disease.—Two distinct lines of work have been pursued this biennium in connection with this experiment.

1. The study of the increase of the uric acid in the blood of chickens in the last stages of avitaminosis A has been continued. In this connection analysis has been made of the blood and urine of normal hens, fasting hens, and of hens in various stages of avitaminosis A.

Kidney function tests were made on a number of normal and avitaminosis A hens by means of injecting a dye into the body and determining the amount of the dye excreted by the kidneys during one hour's time. The urine for this test as well as the analysis mentioned above was collected by a new method which has been perfected. In this method the hen is placed on her back on a table which makes an angle of about 30 degrees to the horizontal. With the hen in this position a glass cannula with a funnel-shaped end is inserted into the cloaca. From 30 to 50 c. c. of urine per hour, free from feces, can be collected in this manner.

By the new method described above urine was collected from 60 hens—30 avitaminosis A hens, 18 normal hens, and 12 fasting hens. Table XXV shows the average results obtained.

TABLE XXV.—PER CENT OF URINARY NITROGEN FROM HENS IN DIFFERENT CONDITIONS WITH RESPECT TO DIET.

Condition of hens.	Uric acid N.	Other purine N.	Urea N.	Ammonia N.	Creatine N.	Allantoin N.	Total.
Normal.....	65.80	9.57	6.45	7.58	4.56	3.83	97.79
Avitaminosis A.....	63.62	6.20	6.81	8.28	6.10	5.78	96.80
Fasting.....	62.22	9.33	5.68	8.55	6.47	7.78	100.03

The results indicate that there is very little difference in the relative amounts of the nitrogenous constituents in the urine of the fasting hens and the avitaminosis A hens, and that the retention of uric acid may, in a large part, be due to the fasting in the last stage of the disease rather than to the lack of vitamin A.

In both the fasting and avitaminosis A hens the results seem to indicate some decreased elimination of uric acid.

The increased excretion of creatine nitrogen and loss of weight of the fowls indicate the breakdown of body proteins, and account for an increased production of uric acid.

2. A study has been begun on the influence of vitamin A on the immunity to fowl cholera. For this purpose young Leghorn pullets were placed on feeds containing varying amounts of vitamin A. They were then inoculated with cholera organisms, and in order to secure definite information as to the manner in which cholera kills the birds an analysis of the blood is being made during the development of the disease. Results are not yet available.

Both lines of work will be continued for at least another year. [Project 131; Departments of Chemistry, Bacteriology, and Poultry Husbandry; state funds.]

Parasitological Investigations.—During the past biennium the work has consisted of (1) further search for intermediate hosts of fowl tapeworms, (2) studies of the biology of the large roundworm, *Ascaridia lineata* (Schneider) of chickens, (3) development of a new technique for isolating intestinal worms, and (4) development of a safe, effective anthelmintic against the large round-worm in growing chickens.

Crickets, cockroaches, spiders, sowbugs, and earthworms collected in poultry yards where the chickens were heavily infested with tapeworms, were fed to chicks reared in confinement with negative results for tapeworms. But six chickens fed earthworms, *Helodrilus caliginosus* (Savigny) var. *trapezoides* (Dugés), on October 12, 1928, became infested with sexually mature cecal worms, *Heterakis papillosa* (Bloch). These cases of parasitism establish a new record (27 days) for the maturing of this common roundworm of chickens.

Studies on the anatomy of *A. lineata* show mouth parts equipped for a limited amount of cutting or biting. The feeding habits of this parasite are unknown.

Results of placing eggs of *A. lineata* in soil and in chicken yards and houses show that high temperatures and low humidity are the most potent factors against the survival of the eggs in nature. Low temperatures are also unfavorable, those from 10° to 20° F. below zero being lethal in most cases. Eggs on the surface of the soil do not survive the entire winter, but those deposited in late February survive and develop slowly, reaching the infective stage in late April or early May in time to be eaten by the second brood of baby chicks. It is these broods that suffer the most from worms.

The chief obstacle in the post-mortem removal of small roundworms from the intestine of an animal is the mucus, which is secreted rapidly and copiously as the intestine loses the body heat. The small worms become imbedded in the mucus and are both seen and removed with difficulty. By a new method the intestine is promptly removed and its content is quickly flushed out with warm water under pressure, thus washing the worms out into a container before the mucus glands become active. This method has now been adopted by the United States Department of Agriculture and several other research laboratories.

The results of a series of experiments with carbon tetrachloride as an anthelmintic for the intestinal worm, *A. lineata*, showed that

growing chickens could be safely and effectively treated for the worms with a dosage rate of 4 c. c. per kilo of body weight. [Project 79; Department of Zoölogy; Adams and state funds.]

A Study of the Resistance of Chickens to Parasitism.—During the past biennium the work has consisted of studies of various factors in the resistance of chickens to the parasite, *Ascaridia lineata* (Schneider). The special factors considered were (1) vitamin A, (2) vitamin B, (3) vitamin D, and (4) acquired resistance due to a previous parasitism with *A. lineata*.

The results of two preliminary tests on 60 White Leghorn chickens and of four experiments on 127 chickens showed that the resistance of growing chickens was significantly lowered when the chickens were kept on a diet deficient in vitamin A. At autopsy both more and longer worms were found in the vitamin A deficient chickens than in the control birds from the same hatch.

Studies on vitamin B as a factor with 438 White Leghorn chickens showed this vitamin is a significant factor in the elimination of worms from the intestines of the chickens, since when vitamin B was lacking in the diet more worms were able to remain in the intestines. The lack of the vitamin produces partial paralysis of the intestine, thereby weakening peristalsis and facilitating retention of the worms. Concerning length of the worms, the results indicated that the yeast which constituted the source of vitamin B contained a factor that stimulated the growth of the worms.

Using daily irradiation or aërated cod-liver oil as sources of vitamin D, studies were made to ascertain if vitamin D is a factor in the resistance of chickens to the parasite, *A. lineata*. Although leg weakness (rickets) developed in the chickens not supplied with cod-liver oil or the irradiation, no constant differences in resistance occurred between these chickens and the controls to which vitamin D was supplied.

The results of seven experiments on 478 growing chickens indicated that an infestation of the parasite, *Ascaridia lineata* (Schneider), increased the resistance of the hosts to this parasite, if the chickens were not more than 10 weeks of age. Age resistance of chickens to this parasite became so potent in fowls 11 to 14 weeks old that the acquired resistance could not be demonstrated.

It is proposed to conclude the work on vitamins A and B as factors in the resistance of chickens to *A. lineata*, and to finish the work on acquired resistance due to previous infestations. Studies on the mechanism of resistance to the parasite will be continued. [Project 169; Department of Zoölogy; Purnell funds.]

Studies Relating to the Embryology of Parasitic Worms.—During the past biennium the work has consisted of studies relating to (1) the anatomy and development of *Passalurus ambiguus* (Rudolphi), a parasite of rabbits, (2) filaria (*Onchocerca cervicalis*) larvæ in fistulous withers in horses, (3) effect of thymectomy on growing chickens and upon fowl parasitism.

Studies on immature and mature specimens of the rabbit nema-

tode, *Passalurus ambiguus* (Rudolphi), resulted in presenting for the first time four cephalic papillæ, 12 longitudinal muscle plates and structural details of the annular portion of the female tail.

Examinations of cases of fistulous withers in horses gave evidence that this disease, instead of being caused by bruises, results from the invasion of the nematode, *Onchocerca cervicalis* (Railliet and Henry). The laborious examinations yielded portions of worms or fragments of their calcified bodies in 10 of the 12 ligamentum nuchæ (seat of the disease) studied.

Comparisons of normal and thymectomized purebred White Leghorn chickens from the same hatches failed to show any constant differences in the following criteria: Weight of eggs, strength of eggshells, calcium carbonate in eggshells, appearance and thickness of eggshell, fertility and hatchability of eggs, lengths of spurs and tibiotarsi, weights of testes, livers, and gizzards, hemoglobin estimate of blood, sugar in blood, and host resistance to the intestinal roundworm, *Ascaridia lineata* (Schneider). These results do not confirm those of other workers reported for the egg envelopes of pigeons.

It is planned to complete the studies on the effect of thymectomy on chickens and on fowl parasitism. [Project 119; Department of Zoölogy; state funds.]

Studies Relating to the Control of the Feather Mite of Chickens.—The object of this experiment was to find, if possible, a remedy for feather mite that could be used in cold weather without handling each bird. Since nicotine sulphate (Black Leaf 40) had proved effective in controlling lice on chickens it was decided to test this product. A number of preliminary tests were made by painting nicotine sulphate on the roosting poles in the evening a few minutes before they were occupied by the birds. The results were sufficiently encouraging to warrant further trial.

This product was finally tested by placing 13 White Leghorn cocks which were heavily infested with feather mites in a house with an adjoining small yard. The roosts occupied by these birds were painted with nicotine sulphate on the evening of May 3, 1929. A second and a third application were given just before dusk May 6 and 9. After this the birds were carefully examined for living feather mites, but none could be found. A second examination of each bird June 5 resulted in the failure to find a live mite. One male which escaped when the others were confined was heavily infested with mites June 1.

It appears from these tests that nicotine sulphate can be safely used to eradicate the feather mite without the necessity of handling the individual birds. [Project 77-16; Department of Poultry Husbandry; state funds.]

A Study of the Control of Stomach Worms in Sheep.—During the past four years an effort has been made to maintain a worm-free flock that must necessarily graze on permanent pasture, known to be infested with stomach worms, and on annual pastures that

are so handled that they are not unlike permanent pastures with regard to stomach-worm infestation.

The entire station flock was drenched with a 1 per cent solution of copper sulphate each 28 days after April 1, continuing during the grazing season. The flock was grazed on blue grass, bluestem, orchard grass, rape, rye, Sudan, and sweet clover at different periods during the grazing season. Post-mortem examinations of the fourth stomachs of 50-odd sheep, slaughtered in the College meats laboratory over a period of four years, have revealed no stomach-worm infestation, except in three cases where a very mild infestation was found. [Department of Animal Husbandry; state funds.]

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. Some of the more important features of the work in this field are briefly discussed below.

Factors Affecting the Seasonal Variation in the Growth of Children.—During the past biennium the work of this project has been a continuation of that previously reported. The experimental phase of the investigation was concluded the first year of the biennium; during the last year the work that has been done includes rechecking of figures, tabulation of data, and a study of the results.

The plan of the experiment was similar to that of 1926-'27 and 1927-'28 (Director's Report, 1926-1928). Healthy children from five to eleven years of age were the subjects. Fifty-nine children, including twenty-nine girls and thirty boys, were used. The children were divided into three groups as evenly as possible, regarding age, sex, and number. As far as it could be arranged children have been continued in the group to which they were assigned in past years.

For all children in the experiment the regular routine of the school has been retained. The children included in the orange group received daily the equivalent of two medium-sized oranges, the juice was prepared from Califorange, a concentrated orange juice purchased from the Exchange Orange Products Company. This juice has been biologically tested and its vitamin C content demonstrated.

The children in the light group received irradiation from an Alpine lamp. The treatments were given on alternate days, Sunday excepted. The exposure lasted for five minutes; the distance from the lamp was 30 inches.

The third group of children was used as a control group and had no addition to the regular routine of the school.

In 1928-'29 special effort was made to begin both orange and light treatments early in the fall. These were started on September 21.

At monthly intervals throughout the school year the children were weighed and measured, using the same technique practiced previously. Data concerning illnesses of the children were obtained, and in all instances where sickness was considered sufficient to re-

tard growth the case was dropped from the study. The rate of gain for each group is shown in Table XXVI.

TABLE XXVI.--MONTHLY GAIN IN WEIGHT OF CHILDREN IN POUNDS, 1928-1929.

Number in group.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	Total.
Control Group.									
Boys, 7.....	3.2	0.6	1.1	0.2	2.2	0.2	1.0	1.1	9.2
Girls, 7.....	2.4	2.0	-0.2	0.7	2.1	1.5	1.7	2.4	12.6
Light Group.									
Boys, 11....	2.3	1.4	0.4	0.1	2.2	0.6	0.9	0.2	8.1
Girls, 11....	1.9	1.7	-0.5	1.5	1.2	0.6	2.0	1.5	9.9
Orange Group.									
Boys, 12...	2.5	1.5	-0.1	0.1	0.1	1.5	1.3	1.0	7.9
Girls, 11....	2.2	1.9	0.1	0.3	1.9	1.0	0.9	1.2	9.5

Briefly the results were as follows:

1. Seasonal variation in growth occurred in all groups of children. Growth was more rapid in the fall months than in the months of January and February.

2. The gain during the spring months of 1928-'29 was greater than during the spring of the past two years, and there were fewer months in which there was a loss of weight. It is thought that this may be due to the fact that the light and orange treatments were begun early in the fall of 1928, whereas in previous years the treatments were begun at or after the depression period had begun.

A study of these data and those of height is at present being carried further. It is expected that the final report of the project will be completed early next fiscal year. [Project 158; Department of Home Economics; Purnell funds.]

A Determination of the Vitamin Content of Some Common Fruits and Vegetables.--During the past biennium the work has included an investigation of the vitamin A and vitamin D content of cherries and the vitamin A content of the very green outer leaves as compared with the bleached inner leaves of market head lettuce.

The green outer leaves of heads of lettuce have been found to contain 30 to 40 times as much of vitamin A as the inner bleached leaves of the same heads of California lettuce, obtained in the local markets.

Early Richmond cherries grown near Manhattan in 1929, and canned by the cold-pack process, were found to be rich in vitamin A. The same variety of cherries grown in 1927, with a season of

similar rainfall, showed about the same vitamin A content. Montmorency sour cherries, grown and canned in 1929, showed a similar richness in vitamin A. It was found, on the other hand, that canned red cherry cannot be considered a source of vitamin D, as no positive findings were secured with the largest doses that animals would take.

Future study will be devoted to the problems of variety, origin, season, and other factors that may influence the vitamin content of fruit and vegetables. These factors have been largely neglected by those working with the vitamin content of foods. [Project 158; Department of Home Economics; Purnell funds.]

The Utilization of Calcium and Phosphorus from Various Forms of Milk.—During the past biennium calcium and phosphorus balance studies have been made with human subjects as follows:

1. Ten college women, five of whom received ultra-violet irradiation daily and five of whom did not. A simple mixed diet was used, the greater portion of the calcium being furnished by raw milk for the first nine days and for the remaining nine days by ice cream made with condensed skim milk.

2. Two college women with the greater portion of the calcium from raw milk for 11 days followed by an equal number of days with the calcium and phosphorus supplied in inorganic form. The diet was very carefully planned, casein furnishing much of the protein after the manner of animal feeding experiments.

3. Two school children with the greater portion of the calcium from raw milk and with added doses of viosterol (irradiated ergosterol) during the second phase of the experiment.

The results were as follows:

1. The ten subjects utilized the calcium of the ice cream at least as well as the calcium of raw milk. The subjects who received irradiations utilized the calcium no better than the subjects who were not irradiated. Phosphorus balances followed the trend of the calcium balances.

2. The two adult subjects seemed to utilize the calcium of inorganic origin at least as well as the calcium of raw milk.

3. The two school children utilized the calcium of raw milk to no better advantage with viosterol than without.

[Project 159; Department of Home Economics; Purnell funds.]

The Protective Value of Certain Clothing Fabrics.—During the past biennium work was completed on that phase of the study dealing with the protective value of clothing fabrics against heat loss when air is in motion, and a manuscript has been prepared for publication. The following conclusions were drawn from the data collected under the conditions of this study:

1. The rating of the fabrics studied, based on increasing protective ratio, was found to be the same in still air and in air moving at the rate of 2.2, 3, 4.5, and 8.5 miles per hour.

2. The protective ratio of a fabric increases as the speed of the wind increased. An increase from 0 to 8.5 miles per hour corresponds to an average increase in protection of 5.67 per cent.

3. When made into a closely fitted cover, fabrics having a pile or nap afforded greater protection when the smooth surface was next to the body. This was found to be true in determination made in both still and moving air.

A study is also being made of the effect of fitting on the protective value of clothing fabrics and of the effect of the nature of

the surface of the fabric in contact with the body upon its protective value. During the past year a study was made in still air of the protective value of canton flannel coverings for an oilfilled copper cylinder which served as the body in this investigation. Also coverings were made in duplicate, having the nap inside and outside, which were fitted over a series of wood cylinders increasing in size one-eighth of an inch in length and in diameter.

When the covering was fitted tightly the average protective ratio was 1.15 with the napped side of the canton flannel placed in, and 1.24 when it was placed out. When the covering was fitted one-eighth of an inch larger than the body the protective ratio increased to 1.40 and 1.44, respectively. A greater increase was shown when the covering was one-fourth of an inch larger than the body, the protective ratios being 1.53 and 1.55, respectively. The protective influence of the nap when placed next to the body increased as the covering became looser about the body. When fitted tightly the nap becomes pressed down, thus decreasing the amount of air held in the interstices of the fabric. As the layer of air between the covering and the body increases the transfer of heat from the body through the fabric covering decreases. The following conclusions seem justified from the results of the study:

1. The protective ratio of canton flannel increases with an increase in the looseness with which it is fit about the body, from a tightly fitted garment to one-fourth inch space in every direction.

2. The position of the nap of canton flannel with relation to the body is a factor in its protective ratio in garments that have one-eighth- and one-fourth-inch space between the body and the fabric.

3. The effect of the position of the nap of canton flannel with relation to the body decreases as the looseness of the garment increases within the limits of the study.

[Project 161; Department of Home Economics; Purnell funds.]

A Comparison of Cooking Equipment for the Farm Home.— This study, started within the past year, has consisted chiefly of perfecting methods for making the desired determinations. It was necessary to perfect and construct a number of pieces of special apparatus. The gas stove was used first and it was found that heat loss due to air currents in the room influenced the results. Screens were then built so that the stoves could be tested in a room in which air currents and air circulation is diminished to such a point that consistent data were obtained. Most of the work up to the present time has been with the gas stove. The potentiometer has been used in obtaining the hottest flame for the rate at which gas is used. The fuel value of the gas for each set of runs was determined by the use of a Sargent gas calorimeter and the pressure and rate at which gas is being used was determined by the precision gas meter.

Tests have been made to find the relationship between size and shape of utensil and the size of burner; also, to determine the relationship between the size of the kettle and burner and the quantities of water heated. Comparison of efficiencies found under the different conditions are being made, as well as comparisons of length of

time to heat the different quantities of water, and the amounts of fuel used. It has been found that for gas stoves the efficiencies, lengths of time, and amounts of fuel vary with the gas pressures used and the rates at which the gas is burned.

Tests are to be made on long- and short-time cooking processes on the gas stove, on different types of heating elements of electric stoves, and on kerosene and gasoline stoves. [Project 174; Department of Home Economics; Purnell funds.]

BRANCH EXPERIMENT STATIONS

Four branch experiment stations, located at Hays, Garden City, Colby, and Tribune, are maintained primarily for the purpose of supplementing the work of the central station with special reference to conditions that prevail in the western part of the state. At all the branch stations, with the exception of the station at Tribune, co-operative assistance from the Office of Dry-land Agriculture, Bureau of Plant Industry, United States Department of Agriculture, is obtained for the investigation of tillage and rotation problems of this section. In addition coöperative assistance at the Fort Hays station is obtained from the following agencies of the United States Department of Agriculture: Forest Service in the production and distribution of trees; Office of Cereal Crops and Diseases, Bureau of Plant Industry with cereal problems; Office of Forage Crops and Diseases, Bureau of Plant Industry, with forage problems; and Bureaus of Chemistry and Soils and Public Roads with moisture-conservation and erosion problems.

Because of such helpful cooperation and reasonably liberal support from the state the experimental work has been maintained upon a high plane and the results of the work have been effectively presented to the residents of western Kansas through field days, bulletins, and press reports. A total of 14 field meetings have been held at the branch stations during the biennium. There is presented below a brief description of each station and a brief discussion of a few of the more important lines of work of each of these stations.

FORT HAYS BRANCH EXPERIMENT STATION

The Fort Hays Branch Experiment Station, consisting of 3,600 acres, was established on the old Fort Hays military reservation by legislative enactment in 1902. Approximately 2,000 acres are under cultivation, the remainder being pasture, creek bed, experimental feeding yards, campus, and state park. The station is equipped to conduct experimental work with soils, crops, trees, and live stock. Brief statements regarding the more important projects follow:

Dry-land Agriculture.—The work on the dry-land project during the past two years has been a continuation of the work established in 1906, with several additions since that time. The work is conducted coöperatively with the Office of Dry-Land Agriculture of the

United States Department of Agriculture. It embraces a large number of cultural experiments which include seed-bed preparation, rotation of crops, the use of sod crops, green-manure crops, barnyard manure, and commercial fertilizers. Meteorological observations are taken daily during the growing season for study in connection with crop behavior and development.

Experiments have been conducted throughout the period to determine the value of tillage in the storage of moisture in the soil and the influence that stored moisture may have on crop yields. The results show that timely tillage is an important factor in the storage of moisture in the soil, and that moisture can be stored for crops successfully to a six-foot depth.

In a preliminary report, soon to be published, on the relation between yields of winter wheat and moisture in the soil at seeding time, it is pointed out that in nearly every case studied where there has been as much as 20 per cent moisture stored in the first three feet of soil at seeding time a profitable crop of wheat has been produced. With less than 20 per cent of moisture in the soil at seeding time the chances for securing a large crop are much less and the chances for securing a small crop or failure are measurably increased. Within certain limits it appears that this information may be valuable in forecasting yields, but it is of more practical value in predicting failure. [Fort Hays Experiment Station; state and federal funds.]

Cereal Investigations.--The work on the cereal project has been continued with very little change during the biennium. In addition to carrying on the varietal testing and cultural work with the cereal crops, sorghums, broom corn, and flax, the cotton crop was introduced to determine its limitations in Kansas.

A special effort has been made in the development of new types of grain sorghums suited to combine methods of harvesting. The urgent demand from farmers for a grain sorghum that could be combined led to an investigation in 1929 of the plant characteristics of a number of divergent types in order to study their adaptability to such methods of harvesting. The studies had particularly to do with those characters which have to do with dwarfness, resistance to lodging, ease of threshing, resistance to shattering, and ease of cutting, particularly the development of types which would not require too much changing and readjustment of the wheat combine equipment to harvest them successfully. [Fort Hays Experiment Station; state and federal funds.]

Forage Crop Investigations.--This experimental project, since its inauguration in April, 1913, under a coöperative agreement with the Office of Forage Crops and Diseases of the United States Department of Agriculture, has been concerned with the culture and improvement of a large number of cultivated feed crops adapted to the nonirrigated lands of this region. Varieties and methods of growing sorghums, the chief annual forage crop of western Kansas,

have received major attention. Recently, however, the work with alfalfa and sweet clover has been greatly increased. Other crops tested on an extensive scale include Sudan grass, millets, cowpeas, and soy beans. Special work is being done to determine the best method of reseeding land with native buffalo grass.

The yields of a few representative varieties of sorghums and one of corn for the past biennium, a favorable period for crop production, are presented in comparison with the averages for the five-year period in Table XXVII.

TABLE XXVII.—YIELDS OF SEVERAL VARIETIES OF SORGHUMS AND ONE OF CORN AT HAYS, KAN., FOR 1928 AND 1929, AND AVERAGE YIELDS FOR 1925 TO 1929.

Variety.	Total crop, air-dry; tons per acre.			Grain yields; bushels per acre (a).		
	1928.	1929.	Average, 1925 to 1929.	1928.	1929.	Average, 1925 to 1929.
Western Blackhull kafir..	4.34	4.75	3.81	64.8	48.4	44.0
Pink kafir.	4.76	4.90	3.89	71.4	50.0	43.7
Select'd Dawn kafir.	4.25	4.76	3.71	58.6	38.6	38.6
Feterita.	3.33	3.28	3.08	42.1	46.6	38.9
Dawn.	4.39	5.46	3.81	60.9	45.0	38.5
Dwarf Yellow milo.	4.68	4.39	3.43	68.8	40.4	37.9
Dwarf Hegari.	2.83	5.46	3.84	40.4	26.4	34.7
Early sumac.	4.69	4.37	3.89	45.9	27.2	30.9
Atlas.	5.09	7.34	4.94	33.0	20.9	28.4
Leoti Red.	5.16	4.90	4.31	45.4	23.9	27.7
Sumac.	5.68	7.47	5.10	42.9	18.4	27.0
Kansas Orange.	5.63	6.69	4.92	43.2	12.2	25.8
Bloody Butcher corn.	3.83	2.91	2.85	38.6	28.4	29.1

(a) Grain yield calculated at 56 pounds per bushel.

Early sumac, a development of this station, retains its rank as the best forage sorghum for western Kansas. Its earliness, superior quality of forage, and general dependability overcome a slight reduction in yield, as compared with other varieties.

Western Blackhull kafir, also a product of this station, has out-yielded all other varieties in grain production during the last nine years.

Farmers have encountered considerable difficulty in reestablishing permanently stands of alfalfa on old alfalfa bottom land which have become grassy and depleted in stands after many years of successful production. Experimental work, outlined for the solution of the many perplexing problems associated with the production of alfalfa

on bottom lands, was started in 1926 and expanded in 1930. Various methods of tilling and cropping old alfalfa land in preparation for new alfalfa represent the chief lines of study. This work was expanded to include varietal tests, dates of seeding, and additional methods of seed-bed preparation. Preliminary results indicate that the restoration of subsoil moisture, by summer fallowing for at least one year, is essential to the maintenance of permanent stands.

Experimental work with sweet clover was increased in 1930 to determine definitely the possibilities and limitations connected with the production of this crop. These studies include dates of seeding of hulled and unhulled seed, methods of preparing the soil for planting, the use of nurse crops, varietal testing, and the function of the crop in the control of erosion and in the rejuvenation of eroded soils. [Fort Hays Experiment Station; state and federal funds.]

Soil Erosion and Moisture Conservation Investigations.--A new coöperative project embracing investigations in soil erosion and moisture conservation was inaugurated in July, 1929. This project is conducted in coöperation with the Bureau of Chemistry and Soils and the Bureau of Public Roads of the United States Department of Agriculture.

The object of the work is to determine the carrying capacity of terraces for the prevention of soil erosion and the conservation of water on farm land. At the same time it is hoped to develop economical methods of constructing terraces; also to develop terraces which can be farmed over with modern farm machinery. An attempt will be made to develop equipment which will reduce the amount of labor necessary in the construction of terraces.

A topographic map has been made of the area to be devoted to the project. The area embraces approximately 200 acres. Terrace construction began in September, 1929, and was intermittently continued until late in the spring. At the present time about eight and one-half miles of terraces have been constructed. The terraced area has slopes varying from 0.2 to 9 per cent, most of it having less than a 4 per cent slope. Terraces of varying widths, height, and vertical spacing have been constructed.

Measuring devices have been installed on some of the terraced areas to determine the amount of soil erosion. The Killifer chisel is being used to determine its value in preventing soil erosion and increasing the water content of the soil.

Extensive equipment has been installed to study the run-off from land with a 5 per cent slope which has been planted to various crops, in addition to studying run-off from native sod and from sub-soil, the top soil on one plot being entirely removed.

Soil-moisture samples will be taken on the various areas and compared with areas which have not been terraced. At the same time physical and chemical studies of various soil types will be made to determine factors that influence rate of erosion.

Studies are also being made of grazing areas to determine losses

of water from land having different types of native vegetation, the effect of grazing and overgrazing on the amount of run-off and erosion, and the subsequent effect of these conditions on the changes in vegetative types. [Fort Hays Experiment Station; state and federal funds.]

Dairy Cattle Pasturing Investigations.—During the season of 1928, 13 Holstein cows were pastured from July 1 to October 10, a period of 102 days, on a Sudan grass pasture of 15 acres. The average daily milk production for the herd was 276.5 pounds. Each cow averaged 21.3 pounds of milk and 0.74 pound of butter fat per day for the 102 days. In addition to the pasture, the field furnished 1.44 tons of hay per acre.

In 1929, 16 Holstein cows were grazed from June 19 to September 26, on a pasture of 13.6 acres. The daily milk production per cow was 29.1 pounds and the daily butter-fat yield, 0.97 pound. The hay produced from the field in addition to the pasture was 1.4 tons per acre. [Fort Hays Experiment Station; state funds.]

Beef Cattle Feeding Investigations.—The feeding experiments for the past two years have been concerned largely with the utilization of western Kansas feeds for the maintenance of beef cattle. In addition to the feeding experiments a series of tests were run on several different ensilage cutters and hammer mills to determine their energy requirements, capacities, and characteristics when used for processing the feeds used in the feeding experiments.

The 1928-'29 feeding trials were planned to study (1) the comparative value of kafir fodder fed in different forms to yearlings, (2) the comparative value of kafir stover and kafir hay fed in different forms to yearling steers, and (3) the value of adding finely ground limestone to a ration consisting of kafir silage and cottonseed meal when fed to calves.

In these trials chopped kafir fodder produced less gain per acre than whole kafir fodder. On the other hand, when the kafir fodder was run through a hammer mill the ground fodder produced 93 pounds more gain per acre than whole fodder. Kafir fodder silage produced 238 more pounds per acre than whole kafir fodder. Ground kafir stover produced 15 pounds more gain per acre than whole kafir stover. Kafir stover silage produced 118 pounds more gain than whole kafir stover, indicating that if kafir stover is to be fed it had best be fed as silage. Ground kafir hay produced 43 pounds more gain per acre than whole kafir hay. Adding ground limestone to a ration of kafir silage and cottonseed cake was found unnecessary.

One phase of the work for 1929-'30 had to do with the value of supplemental feeds in winter rations for stock cattle. Calves fed the same basal ration of Atlas silage gained 57 pounds more when fed a supplement of 1 pound of cottonseed cake than when fed a supplement of 2 pounds of ground kafir grain per head per day. Adding 2 pounds of ground kafir grain per head per day to kafir hay increased the gains 294 pounds per acre. Adding 1 pound of cotton-

seed cake per head per day increased the gains 522 pounds per acre. Kafir hay and Atlas silage had approximately the same feeding value, acre per acre, when fed to calves.

The most important single factor affecting the energy requirements of ensilage cutters was the speed at which the elevating fan was operated. If the speed was excessive, energy was wasted in overcoming air friction. Increasing the speed increased the capacity, but the power requirement was increased more rapidly. Thus, when the speed was doubled the power consumption increased approximately seven times, due to the increased air friction. Four hundred to 550 r. p. m., if maintained, was sufficient to operate any of the cutters while elevating into a 40-foot silo. The energy for cutting kafir silage into 1/4-inch lengths increased approximately 1 per cent for every ton load that passed through the cutter, due to gradual dulling of the knives. The power consumption was 35 to 60 per cent greater for dull knives than for sharp ones, depending upon the material cut. The capacities of the cutters varied from 5 to 15 tons per hour, using a 10 h. p. motor, depending upon the condition of the material and the length of cut. The capacity for 1/2-inch cut was approximately 35 per cent greater than for 1/4-inch cut.

The greatest benefit from grinding forage was found to be derived from cracking of the grain. Therefore, a good roughage mill should be able to crack the grain without using excessive power. A mill using a drag elevator requires less power than the same mill equipped with a blower elevator. Poor adjustment of the cutter bar may cause a 100 per cent increase in power consumption. [Fort Hays Experiment Station; state funds.]

Pure Seed Distribution.--The growing and distribution of pure seed continues to be one of the major functions of the station. In 1928-'29 the station sold 24,108 pounds of pure certified Kanred seed wheat and 256,613 pounds of pure certified sorghum seed in 92 counties in Kansas and in 13 states. The 1929-'30 crop sales were the largest in the history of the station, comprising a total of 429,650 pounds of Kanred wheat and 285,456 pounds of pure certified sorghum seed. There were 1,173 orders. The seed went to 86 counties in Kansas and to 11 states. [Fort Hays Experiment Station; state funds.]

State Forest Nursery.--The work in the forest nursery has largely been a continuation of the work of previous years in the experimental planting of new and untried varieties of trees and shrubs and the propagation and distribution of hardy types adapted to western Kansas.

The total number of ornamental trees and shrubs distributed in the spring of 1929 amounted to 14,470 units, going to 74 counties in Kansas. In 1930, the number of units sent out reached 12,493, and these were distributed to 78 counties.

There has been a rapid increase in the distribution of forest-tree seedlings. This distribution is made in coöperation with the Forest

Service of the United States Department of Agriculture, under the provisions of the Clarke-McNary act. In 1929 the number of seedlings sent out amounted to 31,684 units, and in 1930 the number of units distributed reached 53,033. Sixteen species of forest trees made up the list of those distributed. All of these are adapted to the western Kansas area. It is surprising to note that the Osage Orange constituted over one-fifth of the stock sent out in 1929 and almost one-fourth of the stock sent out in 1930.

The planting of evergreen trees for permanent windbreaks and shelter belts, in preference to deciduous trees, has been encouraged and gratifying results are being secured. In 1929 a total of 9,760 evergreen seedlings were distributed, while the number distributed in 1930 reached the total of 22,241.

An experimental vineyard is in process of development, the first plantings having been made in 1927. Several varieties proved unable to withstand the winter conditions, and replacements have been made. At the present time 21 varieties of grapes are growing and some fruit will be harvested this year.

A demonstration orchard of 1,000 trees, chiefly cherry, was planted in the spring of 1930 on a hillside which had previously been terraced. Several new varieties of plums and cherries have been planted, the orchard now having 13 varieties of plums, 8 varieties of sweet and sour cherries, and 2 varieties of apricots. It is planned to add new varieties as space becomes available to determine the best varieties for this territory. [Fort Hays Experiment Station; state and federal funds.]

GARDEN CITY BRANCH EXPERIMENT STATION

The Garden City Branch Experiment Station occupies 320 acres of upland five miles northeast of Garden City, Finney county. The experimental work is divided into two main projects, dry-land agriculture and irrigation agriculture.

Dry-land Agriculture.--The Office of Dry-land Agriculture, United States Department of Agriculture, has coöperated with the station since 1907 in conducting crop experiments under dry-land conditions. The dry-land project consists of approximately 30 acres of land divided into one-tenth-acre plats or fractions thereof. The work consists of studies of rotations of adapted crop varieties, tillage experiments, seed-bed preparation, date of planting wheat and sorghums, and methods of preparing fallow for wheat and milo.

Rotation studies are conducted on the effect of one crop following another and their response to methods of seed-bed preparation and tillage practices in the rotation. Various methods of tillage are practiced in the rotations and under continuous cropping conditions, including the time of plowing or breaking the ground.

Seed-bed-preparation studies on continuously cropped land have given definite results in favor of early cultivation previous to planting, for weed control and conservation of moisture. Kafir lister

planted on land previously cultivated to control weed growth has averaged 5.1 bushels more to the acre than kafir lister planted on land that had not been cultivated in the early spring.

The date-of-planting tests for sorghums show that grain sorghums should be planted on or shortly after June 1. Feterita, an exception, does best when planted shortly after June 15. Forage sorghums have also produced their heaviest yields when planted about June 15.

Various methods of preparing fallow are under test and have given valuable information. The best methods of fallow for wheat have consisted of fall listing or fall plowing, followed by clean cultivation the following summer. Wheat on the best prepared fallow has averaged 12½ bushels per acre, while the yield on the poorest method of fallow, which was late-spring plowed, has been 9 bushels per acre, practically no better than the best method of continuous cropping for wheat.

In addition to the work mentioned above considerable attention is given to the testing of different varieties of corn, sorghums, small grains, and sugar beets, and to spacing experiments with Dwarf Yellow milo. Cassel, Colby, Freed, and Hays Golden have been the highest-yielding varieties of corn on both irrigated and unirrigated lands. Dwarf Yellow milo, Wonder kafir, Feterita, Dawn kafir, Sunrise kafir, and Pink kafir have been the highest-yielding varieties of grain sorghum. Dwarf Yellow milo has averaged 25 bushels to the acre during the past nine-year period. Corn has produced approximately one-half as much as milo. Standard sumac, Honey, and Kansas Orange sorgos have been the highest yielding forage varieties.

Two coöperative corn and sorghum variety tests with farmers have been carried since 1923 on sandy land. Most of the varieties that have proved best on the heavy soils of the station have also been the high-yielding varieties on the sandy land. One variety of sorghum, however, Reed kafir, shows a decided preference for sandy land.

A spacing test with Dwarf Yellow milo has been conducted since 1918 in which rows 44 inches apart have been compared with rows 88 inches apart. The data that have been collected indicate that in years of normal rainfall, or above, the 44-inch planting will produce more grain than the 88-inch planting, but in years of less than normal rainfall, the 88-inch rows produced the best yields. Planting in wide rows can be considered as a form of crop insurance somewhat similar to planting on fallow land. Milo in the 44-inch rows has been a near failure in three years of the past nine, while that planted in 88-inch rows has never failed to produce a fair amount of grain. The average yield for the nine years is 19 bushels for the 44-inch rows and 17½ bushels for the 88-inch rows.

Many varieties of fruits and ornamentals are being tested in an attempt to find kinds that are sufficiently well adapted to the climatic and soil conditions to permit of their being grown. Some varieties of grapes, cherries, and plums appear promising as pro-

ducers of fruit. [Garden City Experiment Station; state and federal funds.]

Irrigation Agriculture.--Experiments with crops under irrigation started in 1920 have been continued and many additions have been made. The work includes rate and season of watering alfalfa; rotations with alfalfa grown from three to fifteen years, followed by forage sorghos, grain sorghums, sugar beets, barley, and alfalfa; continuous cropping experiments with forage sorghos, sugar beets, and alfalfa; fertility experiments with alfalfa, Dwarf Yellow milo, winter wheat, sugar beets, and pasture grasses; variety tests with corn, sorghums, small grains, and cultivated grasses; a comparison of a mixture of cultivated grasses and of sweet clover alone for dairy-cow pasture; and an alfalfa pasting experiment in which one lot of pigs is fed a limited ration of ground milo while on alfalfa pasture and another lot in comparison has access to ground milo in self-feeders.

The rate-of-watering experiments indicate that alfalfa requires from 36 to 40 inches of water annually in addition to the rainfall for the best results. Still larger amounts of water can be used and will produce larger yields, but the increase in yield is not sufficient to justify the additional cost.

Irrigation water applied in the early spring seems to stimulate early growth and is more effective than an equal amount of water applied the previous fall. The highest annual yield of alfalfa hay has been produced on land that was irrigated in the late fall and again in the early spring. The lowest yield was secured from land that received no irrigation water between the time of the last cutting in the fall and the first cutting in the spring. Irrigation for the second, third, and fourth crops was uniform in all cases.

Commercial fertilizer and barnyard manure have not increased appreciably the yields of alfalfa, milo, and winter wheat. Sugar beets, however, have shown a material increase in yield when barnyard manure has been applied at the rate of 10 tons to the acre every second year to land continuously cropped to beets. Average yields of sugar beets for the past five years have been 20.8 tons in rotation with alfalfa and sorghums, 19 tons on manured land continuously cropped to beets, and 16 tons to the acre on land continuously cropped to beets and not fertilized. Cultivated grasses in irrigated pastures have also shown an increase in growth when manure has been applied. Both grain and forage sorghums have produced higher yields when grown in rotation with alfalfa than when grown on land continuously cropped to sorghum. The increase in the case of grain sorghums has been, approximately, 36 per cent, and with the forage sorghums about 27 per cent.

A single heavy application of water to the land previous to planting the crop has approximately doubled the yields of the better varieties of corn and sorghums, as compared with the same crops grown without irrigation. Fall irrigation has produced yields still

greater than early spring or winter irrigation. Four varieties of corn and 50 to 60 varieties of sorghums are grown each year. Generally speaking, the same varieties that have been the most satisfactory on unirrigated land have also been the best-yielding varieties under irrigation. A few low-yielding varieties on unirrigated land have produced exceptionally well when irrigated, but none of them have exceeded in yield the better adapted and consistent yielding Dwarf Yellow milo, Dawn, Sunrise, and Pink kafirs, Feterita, Sumac, and Kansas Orange sorghos.

Attention has been given to the testing of types of grain sorghums adapted for combining. Eight of ten new strains have been tried out during the past two years, and several more are being included in the 1930 plantings. Three or four of the new types are promising, when yield and ability to stand without lodging for sometime after maturity are considered. One block of Beaver milo was not harvested until December 27 and 28, 1929, and only 10 per cent had lodged at that date. None of the old standard sorts are altogether suited to harvesting with the combine because of too great a height, unevenness of height, unevenness in ripening, or inability to stand after maturity.

Kanred and Blackhull winter wheats, Kanota oats, Coast and Club Mariout barleys, and Marquis and Preston spring wheats have been the highest yielding varieties in the different classes of small grains.

Two varieties of cultivated grasses, Western wheat grass and Crested wheat grass, were seeded in the spring of 1929, and both made a fairly satisfactory growth. Crested wheat grass appears especially promising and is making an excellent growth this season. There are few perennial grasses that are adapted to this section, and these newer varieties will be watched with interest. Plantings were made in the spring of 1930 on unirrigated land as both Crested wheat and Western wheat grasses have been found to be drouth-resistant in other states.

The pasturing of alfalfa with hogs has been studied since 1924 and has proved to be a very profitable practice. Pigs self-fed on ground milo while on alfalfa pasture have made rapid gains and have paid an average price of \$18.22 per ton, on a hay basis, for the alfalfa they have used. When fed only two pounds ground milo daily for each 100-pound pig in the pasture, the return per ton of hay has been \$13.07. Both figures are above the average market price of the hay on the farm, and the pigs have done the harvesting without extra cost.

A small plot of red clover was sown for seed production in the spring of 1928, another in 1929, and another in 1930. The clover made excellent growth and has come through the winters in good condition. Approximately 7½ bushels to the acre of very fine seed was secured in 1929 from the 1928 planting. The favorable yield was so encouraging that in 1930 a variety test of 12 different lots of seed secured from different states and from Russia was started.

A variety test with sugar beets was started in 1928 in cooperation with the Utah Agricultural College and the United States Depart-



ment of Agriculture. Definite conclusions cannot as yet be drawn, but thus far none of the newer strains under test has been superior to the German seed that has been regularly used in the beet district of this section.

A serious new disease of Dwarf Yellow milo has appeared during the past few years. The plants appear normal until the latter part of July, when they begin to turn a reddish-yellow color similar to plants that are growing on soil deficient in moisture. The plant dies to the ground, and shoots that start from the base also die in a short time. The cause of the trouble is not known. An experiment is being started in an effort to determine the cause of the disease and possible methods of prevention. Eleven varieties and strains of milo and fourteen varieties of other sorghums are being planed on land that has shown the disease in the past in order to find resistant varieties. Different cultural methods are being used on other plats in an effort to learn how long the disease will carry over in the soil. [Garden City Experiment Station; state funds.]

COLBY BRANCH EXPERIMENT STATION

The Colby Branch Experiment Station contains 274 acres of land lying immediately southwest of Colby, Thomas county. The work is divided into three major phases: Dry-land agriculture investigations, a study of varietal adaptation of crops, and a dairy herd improvement project. A brief outline of each is given below.

Dry-land Agriculture Investigation.--Dry-land agriculture investigations in crop rotation and tillage methods, in coöperation with the Office of Dry-Land Agriculture of United States Department of Agriculture, were continued.

This work is conducted on an area of approximately 25 acres of land, divided into 180 tenth-acre plats. Each year there are 46 plat's of winter wheat, 10 of spring wheat, 7 of barley, 12 of oats, 18 of corn, 1 of beans, 35 of milo, 4 of feterita, 3 of kafir, 3 of rye, 1 of peas for green manure, and 40 are fallow.

Some of the yields secured with barley with different methods of seed-bed preparation as an average of the past 15 years have been as follows:

	Bushels per acre.
Barley, continuous, on spring plowing.....	19.5
Barley, continuous, on fall plowing.....	21.0
Barley, after oats on spring plowing.....	19.9
Barley, on disked corn ground.....	17.8
Barley, on summer-fallowed ground.....	35.8

Fifteen-year averages with corn on different seed-bed preparations are as follows:

	Bushels per acre.
Corn, continuous, on spring plowing.....	15.7
Corn, continuous, on fall plowing.....	16.2
Corn, continuous, fall plowed and subsoiled.....	17.6
Corn, continuous, listed without previous cultivation.....	19.9
Corn, continuous, disked early and listed.....	20.9
Corn, after small grain on spring plowing.....	17.8
Corn, after small grain on fall plowing.....	15.0

[Colby Experiment Station; state and federal funds.]

Crop Adaptation.--A study of crop adaptation including variety test with winter wheat, spring wheat, oats, barley, corn, and grain and forage sorghums was made.

During the biennium 12 varieties of winter wheat, 12 of spring wheat, 6 of oats, 22 of barley, 26 of corn, 21 of grain sorghum, and 5 of forage sorghum were tested. Most of these varieties were the same that have been tested previously, while a part were new strains or at least varieties that had not been previously in the test at this station.

The yields of winter wheat varieties in the past two years have not changed the relative standings of the varieties as published in the last report. Some rather outstanding differences in winter hardiness were observed in the spring of 1930. In the fall of 1929 excellent stands were secured on all plats in the test. The per cent of survival as noted in the spring of 1930 was as follows:

Kanred	97	Kawvale.	91
Kharkof	97	Tenmarq.	86
Turkey	97	Blackhull	70
Oro.	97	Superhard Blackhull.	40

Of the corn varieties, the shorter-growing and earlier-maturing have produced the highest yields. The six-year average yield of leading varieties is as follows:

	Bushels per acre
Cassell.	13.1
Colby.	12.6
Blue Squaw	11.5
Freed.	10.8
Pride of Saline.	4.5

Four selections of Colby have yielded approximately the same as the original variety.

The following is a list of some of the barley varieties and the yield produced by them during the period from 1923 to 1929:

	Bushels per acre.
Local Six-row.	24.0
Coast	23.5
Stavropol.	22.4
Flynn.	22.0
Himalaya.	20.8
Blackhull	20.5
Hannchen.	20.7

In addition to the variety studies made with these crops, considerable effort has been directed toward studying strains in the nurseries. Uniform winter hardiness and uniform rust nurseries have been carried on both years in coöperation with the United States Department of Agriculture. A corn nursery, in coöperation with the same agency, has also been carried on during the two-year period. A winter wheat nursery, which consisted of 1,500 rows in 1929, was conducted. Four hundred and fifty rows of barley were

grown in the nursery in 1930. Many of the barley strains are selections made from Local Six-row. [Colby Experiment Station; state funds.]

Dairy Improvement--As previously reported, the dairy work consists of a herd-improvement study. The herd was started in 1915 with grade cows. A pure-bred Ayrshire sire has been used since that time. Through selection; a herd of the grade heifers has been produced uniform in appearance and conforming rather closely to the Ayrshire type.

The herd now consists of eleven cows in milk, eleven heifers, one mature bull, and one bull calf. Of this number, three cows, three heifers, and the two bulls are registered Ayrshires. The remainder of the herd are grades.

For the most part the grade cows are producing as well as the pure bred. During the calendar year 1929 two of the pure bred and two of the grades produced more than 300 pounds of butter fat. A grade cow made the highest record, 368 pounds of butter fat. These records were made with two milkings a day under average farm-herd conditions. [Colby Experiment Station; state funds.]

TRIBUNE BRANCH EXPERIMENT STATION

The Tribune Branch Experiment Station contains 110 acres of land located in Greeley county midway between the Arkansas and Smoky Hill river valleys, 16 miles from the Colorado line.

The work of the station centers chiefly around problems of direct importance to the agricultural industry of the high-plains region of western Kansas. The experiments include studies of forage and grain crops for the production of feed for live stock and poultry, of potatoes and garden crops for the family, and of wheat as a cash crop. The results of some of the experiments made during the last two years are noted briefly in this report.

Progress was made in developing an early-maturing hardy variety of grain sorghum suitable for harvesting with the combine, from a cross of Freed sorgho and Pink kafir. Several strains of this cross, particularly two designated as Nos. 12 and 14, yielded appreciably more grain and ripened earlier than Feterita, Dwarf Yellow milo, or Dawn kafir.

In both years of the biennium, with relatively favorable weather conditions, corn made higher yields of grain than sorghum. Over a period of nine years, corn averaged about four bushels more than milo or kafir. Sorghum is more drought-resistant than corn and, therefore, complete failures or low yields occur less frequently. On the other hand, corn outyields sorghum in favorable seasons.

Cassel, the best variety of dent corn tested by the station, yielded higher than Freed or Colby both in 1928 and 1929. It has out-yielded both of the later varieties 10 times in 13 years and has averaged 25 bushels per acre as compared to 21.9 bushels for Freed and 20.4 bushels for Colby.

A light application of manure, amounting to 5 tons per acre once

every five years, increased the yield of both Red Amber and Dwarf Yellow milo forage about 10 per cent in 1929. A similar application also increased the yield of barley grain 29 per cent and produced a yield of 10 bushels per acre of corn where the untreated field was practically a failure, making only 2.5 bushels. Little, if any, increase resulted where a heavier application was used consisting of 10 tons per acre once every five years. Over a longer period, the light application has increased the yield of milo grain 21 per cent, of corn 30 per cent, and of sorgo forage 12 per cent, while the increases due to the heavier application amounted to 2 per cent, 10 per cent, and 4 per cent, respectively. Thus, the evidence so far indicates the advisability of conserving the manure on the farm and spreading it on the land in light applications.

Experiments have shown that potatoes are adapted and do well if enough water is provided, either by irrigation or by fallowing the land the preceding year. Irish Cobbler was the highest-yielding variety, having made 72.5 bushels per acre in 1929, and an average of 75.3 bushels over a period of 10 years.

Pinto is the best among the three varieties of beans that have been tested, giving a five-year average yield of 496 pounds per acre. In 1929 the yield was 690 pounds. Pinto beans made about 100 pounds per acre more when planted on June 17 than on May 25. [Tribune Experiment Station; state funds.]

STATION PUBLICATIONS

The results of investigations by the Agricultural Experiment Station are reported in four series of publications: Biennial reports, bulletins, research or technical 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 active 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. Five new bulletins were printed 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. One such bulletin was issued during the biennium.

Circulars.--Brief popular reports of experimental results and popular discussions on various agricultural problems are published as circulars. Sixteen circulars were published during the biennium.

The following are the regular station publications listed by series and showing the title, size of edition, and the number of pages issued during the biennium:



BIENNIAL REPORT			<i>Total</i>
	<i>Edition.</i>	<i>Pages.</i>	<i>Pages.</i>
Director's Report, 1926-1928.	2,000	153	206,000
GENERAL BULLETINS			<i>Total</i>
<i>No.</i>	<i>Title.</i>	<i>Edition.</i>	<i>Pages.</i>
246	Country Elevator Margins and Costs in Marketing Kansas Wheat	7,500	60 450,000
247	Poultry Diseases Their Prevention and Control.	40,000	107 4,280,000
248	Wheat Production in Kansas.	50,000	84 4,200,000
249	Soy-bean Production. in Kansas.	12,500	32 400,000
260	A Report of the Tribune Branch Agricultural Experiment Station	10,000	36 360,000
TECHNICAL BULLETIN			
24	Potato Experiments for the Control of Rhizoctonia, Scab, and Blackleg, 1922 to 1927.	5,000	37 185,000
CIRCULARS			
141	Information Regarding Recent Publications.	15,000	6 90,000
142	The Effect of the Combined Harvester-Thresher on Farm Organization in Southwestern Kansas and Northwestern Oklahoma	10,000	24 240,000
143	Cattle Feeding Investigations, 1926-'27.	15,000	13 195,000
144	The Taxation System of Kansas.	10,000	24 240,000
145	Spraying Fruit Plants	15,000	32 480,000
146	Making Cottage Cheese on the Farm.	10,000	12 120,000
147	Culling Poultry	40,000	51 2,040,000
148	Farm Dairying	20,000	31 620,000
149	Information Regarding Recent Publications.	15,000	3 45,000
150	Accounts for Kansas Farms	25,000	36 900,000
151	Cattle Feeding Investigations, 1927-'28	15,000	20 300,000
152	Cattle Feeding Investigations, 1928-'29	15,000	14 210,000
153	Pruning Fruit Plants	15,000	23 345,000
154	Producing Quality Cream	10,000	18 180,000
155	The Stock-share Lease	10,000	16 160,000
156	Farm Land Values in Kansas.	10,000	12 120,000

SOME INFORMATION REGARDING EACH PUBLICATION ISSUED

BIENNIAL REPORT

Director's Report, 1926-1928: For the Biennium, July 1, 1926, to June 30, 1928.--This report outlines the scope of the work of the Agricultural Experiment Station for the biennium indicated in the title, including brief summaries of the results on some projects and brief statements of progress regarding each of the others. Brief statements are made covering the coöperation of the Kansas station with other agencies; the support provided by the Purnell act of 1925; and the changes in personnel for the period. 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 also included. The main body of the report is grouped under nine subjects as follows: Economics of agriculture; conservation of the soil; the plant industries; diseases of plants; injurious insects and other pests; the live-stock industries; diseases of farm animals; studies in home economics; and the branch stations. (By. L. E. Call, Director, Agricultural Experiment Station of Kansas State Agricultural College. 153 pages; 34 tables; 4 figures.)

TECHNICAL BULLETIN

Technical Bulletin 24: Potato Experiments for the Control of Rhizoctonia, Scab, and Blackleg. -This bulletin is a report of seven years' results on the control of three common and serious potato diseases in the Kaw valley. The experiments reported here relate to the efficiency of various seed treatments for the control of these diseases as well as soil treatments. It was found that rhizoctonia and blackleg were controlled satisfactorily with various treatments, the efficiency of which did not vary to any appreciable extent. Due

to the rapidity of the hot-formaldehyde treatment and the instantaneous dips in organic mercuries, these treatments are to be recommended over the old, long-time treatments in corrosive sublimate.

Experiments are also reported on the control of seed and soil-borne scab by the use of green manures and sulphur. It was found that by the use of proper green manures the per cent of scab resulting from soil-borne organisms could be materially lessened. (By R. P. White, Department of Botany. 37 pages; 30 tables.)

GENERAL BULLETINS

Bulletin 246: Country Elevator Margins and Costs in Marketing Kansas Wheat.--How much margin country elevators take in buying wheat and the extent to which differences in size of margins are due to fluctuations in size of crops, to variations in costs per elevator, to risks of price fluctuations at terminal markets, and to local competition and variation in quality of wheat are the first points considered in this bulletin. The following more general problems are then discussed: How nearly do buying margins come to covering costs of local elevator operation? How does volume of business affect costs? How may sales policy affect the margin of profits actually realized?

The general conclusion is reached that local consolidations or mergers and a more extensive use of well-located line elevator systems offer more in the way of low margins than the possibility of reducing the costs of operation of any large number of Kansas country elevators. (By R. M. Green, Department of Agricultural Economics, and E. B. Ballow, Bureau of Agricultural Economics, United States Department of Agriculture. 60 pages; 7 figures; 25 tables.)

Bulletin 247: Poultry Diseases, Their Prevention and Control.--This bulletin (Circular 106, revised) gives information on essentials of poultry hygiene, health feeding, poultry diseases, etc. A scheme to aid in the diagnosis of poultry diseases is included. This scheme gives the chief symptoms of the common poultry diseases of this and surrounding states. Following this is a detailed description of the more common poultry diseases with a discussion of symptoms of each and suggestions for treatment. An appendix gives useful information, including table of dosage for the more common drugs, and directions for collection and shipping blood for the white diarrhea test. (By L. D. Bushnell and C. A. Brandy, Department of Bacteriology. 107 pages; 32 figures; 4 tables.)

Bulletin 248: Wheat Production in Kansas.--This bulletin presents a comprehensive discussion of the production of wheat in all its phases as it pertains to Kansas. Soil and climate for wheat, rotations, fertilizers, time, method, and depth of plowing, listing, the use of the one-way plow, disposition of surplus straw, varieties of wheat, choice of seed, what constitutes good seed, time of seeding, harrowing and rolling wheat, pasturing wheat, and harvesting in its various aspects come in for attention. The treatment of various diseases, the control of insect and weed pests, and the marketing of wheat are also discussed in some detail. (By S. C. Salmon and R. I. Throckmorton, Department of Agronomy. 84 pages; 44 figures; 17 tables.)

Bulletin 249: Soy-bean Production in Kansas.--The essential facts relating to the soy bean as a crop for Kansas are presented in this bulletin. The value of soy beans for seed, hay, and soil improvement, use in rotations, relation to soil and climate, preparation of the ground, time, method and rate of planting, cultivation, methods of harvesting and threshing, and growing with corn, are among the topics discussed. Tables showing comparative yields of hay and seed of several varieties and including a comparison with cowpeas are given. Several of the best varieties for Kansas conditions are described in detail. (By J. W. Zahnley, Department of Agronomy. 32 pages; 10 figures; 7 tables.)

Bulletin 250: A Report of the Tribune Branch Agricultural Experiment Station.--This bulletin includes a discussion of the climatic conditions at the station in Greeley county and of the development of agriculture in the high-

plains region of western Kansas between the Arkansas and Smoky Hill risers. Results of experiments are reported from the establishment of the Tribune Branch Station in 1912 to 1928. Sorghum versus corn, winter wheat versus spring small grains, the use of manure, and the method and value of summer fallow are considered. Attention is given the adaptation of varieties of field crops and methods of producing them, including preparation of the land, planting, cultivating, and harvesting. Sorghum, corn, winter wheat, barley, oats, spring wheat, Sudan grass, legumes, and potatoes are discussed. Trees for the homestead, flowers, lawns, and adapted vegetables and fruits for the home garden are mentioned. (By T. B. Stinson, superintendent of Tribune Agricultural Experiment Station, and H. H. Laude, Department of Agronomy. 36 pages; 16 figures; 17 tables.)

CIRCULARS

Circular 141: Information Regarding Recent Publications.--This circular is the third of a series of informational circulars. It contains bits of information or publicity covering each bulletin and circular issued by the station from March 1, 1926, to June 30, 1928. The publications presented are: Bulletins 237, 238, 239, 240, 241, 242, 243, 244, and 245; and Circulars 125, 126, 127, 128, 129, 130, 131, 132, 133, 134, 135, 136, 137, 138, 139, and 140.

Circular 142: The Effect of the Combined Harvester-Thresher on Farm Organization in Southwestern Kansas and Northwestern Oklahoma.--The agriculture of this region has been affected materially by the introduction of the combined harvester-thresher and other power machinery. Information showing the extent and the trend of these changes is included. Comparative costs of harvesting with various types of harvesting equipment are given. Several suggested organizations for wheat farms of varying sizes in this region are included with statements showing probable expenses, income, and net returns from such organizations. (By W. E. Grimes and J. A. Hodges, Department of Agricultural Economics, and R. S. Kifer, Bureau of Agricultural Economics, United States Department of Agriculture. 24 pages; 6 figures; 12 tables.)

Circular 143: Cattle Feeding Investigations, 1926-'27.--This publication consists of two parts. Part I gives the results of a test in which a further study was made to determine the possibility of making prairie hay and silage compare favorably with alfalfa hay and silage as the roughage portion of a winter calf-fattening ration. Alfalfa hay is rich in lime. Prairie hay is deficient in lime. In this test lime in different forms was fed with prairie hay.

Part II gives the results of one of a series of tests in which an attempt is being made to produce more gain and finish on young cattle from less grain than the usual feeding methods demand. (By B. M. Anderson, C. W. McCampbell, and H. W. Marston, Department of Animal Husbandary. 13 pages; 1 figure; 7 tables.)

Circular 144: The Taxation System of Kansas.--This circular presents to the general reader the fundamentals of the taxation structure of Kansas. A description is given of the principal source of state and local revenues, together with a brief summary of federal finances. The general property tax, the tax on inheritances, and such special problems as the taxation of intangible property and banks are also discussed. (By Harold Howe, Department of Agricultural Economics. 24 pages; 1 figure; 8 tables.)

Circular 145: Spraying Fruit Plants.--Brief descriptions of some of the injurious orchard insects and fungous diseases of fruit plants are presented in this circular. Instructions for the use of important insecticides and fungicides are given and spraying schedules are outlined for apples, plums, peaches, apricots, sour cherries, grapes, strawberries, and brambles. (By W. F. Pickett, Department of Horticulture, and W. R. Martin, Jr., Extension Specialist in Horticulture. 32 pages; 16 figures.)

Circular 146: Making Cottage Cheese on the Farm.--The methods of making both the acid and rennet types of cottage cheese on the farm are described in this circular. The methods described are those that have proved most satisfactory and best adapted to farm conditions. The circular closes

with a section on "Serving Cottage Cheese," consisting of 15 different ways of using this product in the diet. (By W. J. Caulfield, Department of Dairy Husbandry. 12 pages; 4 figures.)

Circular 147: Culling Poultry.--Part I of this circular is practically a reprint of Circular 93 of the Agricultural Experiment Station on "Culling Farm Poultry," published in 1922. This part discusses all the common practices relating to culling, including the judging of present production, persistence in laying, rate of production, and the effect of broodiness on production.

Part II, pages 34 to 48, deals with head characters and their relation to culling. Four head types are discussed and they are sufficiently well illustrated so they can be understood by anyone familiar with poultry. The prediction of future production and the judging of pullets and cockerels for productivity by the use of head characters are discussed.

A glossary of terms, a culling chart, and a list of references on culling are included in the circular. (By Loyal F. Payne and Howard H. Steup, Department of Poultry Husbandry. 50 pages; 30 figures.)

Circular 148: Farm Dairying.—This circular, a revision of Circular 90, covers the chief problems confronted in handling dairy cattle. The different breeds of dairy cattle are discussed and compared. Selection, feeding, and management are taken up and various rations suggested. Methods of keeping records are given as well as brief directions for making the Babcock test for fat in milk. (By J. B. Fitch, Department of Dairy Husbandry. 31 pages; 12 figures; 3 tables.)

Circular 149 : Information Regarding Recent Publications.--This circular is the fourth of a series of informational circulars. It contains bits of information or publicity covering each bulletin and circular issued by the station from July 1, 1928, to June 30, 1929. The publications presented are: Bulletins 246, 247, and 248; and Circulars 142, 143, 144, 145, 146, 147, and 148.

Circular 150: Accounts for Kansas Farms.--This circular presents the relation of accounts to the farming business. It discusses the benefits of the keeping, summarizing, and analyzing of the accounts of all farm enterprises. The different methods of accounting are discussed and the advantages and disadvantages brought out. The circular also discusses the study of costs of production in the various enterprises. (By Morris Evans, Department of Agricultural Economics, and I. N. Chapman, Extension Economist in Farm Management. 35 pages; 4 figures; 9 tables.)

Circular 151: Cattle Feeding Investigations, 1927-'28.--This publication consists of four parts. Part I gives results of a test in which ground limestone is added to rations, the roughage portion of which are made up of alfalfa hay alone, prairie hay alone, alfalfa hay and silage, and prairie hay and silage. These rations are compared to similar rations containing no ground limestone. Part II gives the results of a comparison of full feeding for 150 days with light feeding for 90 days, followed by a full feed for 60 days; also a comparison of a full feed for 225 days with a light feed for 90 days, followed by a full feed for 145 days. Part III gives further data regarding the advantages of wintering calves well, grazing until August 1, and then full feeding 90 to 100 days. Part IV gives data showing the possibility of wintering and grazing calves, then selling them in the fall as stocker yearlings. (By B. M. Anderson, C. W. McCampbell, and M. A. Alexander, Department of Animal Husbandry. 20 pages; 1 figure; 12 tables.)

Circular 152: Cattle Feeding Investigations, 1928-'29.--This circular consists of three parts. Part I gives the results of a test comparing the value of cottonseed meal, linseed-oil meal, and corn-gluten meal as protein supplements in cattle feeding rations. Part II shows the results secured in using silage alone as the roughage portion of a cattle fattening ration. Part III gives further data relative to the plan of wintering calves well, grazing to August 1, and then full feeding 90 to 100 days. (By B. M. Anderson, C. W. McCampbell, and M. A. Alexander, Department of Animal Husbandry. 13 pages; 1 figure; 7 tables.)

Circular 153: Pruning Fruit Plants.--This circular, a revision of Circular 102, gives the reader information about pruning from two viewpoints: First, it considers the principles which underlie successful pruning of fruit plants and the objects which the pruner seeks to attain; second, the actual practice of pruning is described. Pruning implements are also discussed. (By R. J. Barnett, Department of Horticulture. 23 pages; 8 figures.)

Circular 154: Producing Quality Cream.--This circular describes some of the important practices employed in the production of cream for butter making. Detailed directions are given for making and using a hypochlorite disinfectant. Construction details together with illustrations for building concrete cooling tanks are included. Several cooling devices are illustrated and the importance of cooling cream to prevent spoilage is described and discussed. (By W. H. Martin and W. J. Caulfield, Department of Dairy Husbandry. 18 pages; 7 figures; 5 tables.)

Circular 155: The Stock-share Lease.--This circular describes the stock-share lease and discusses its advantages in eliminating many of the undesirable characteristics of the usual rented farm. The conditions favorable to the stock-share method of leasing are given and Kansas conditions favorable to its use are described. The limitations of such leases and their usual provisions are included, together with adaptations of it to varying conditions. Sample stock-share leases are given for conditions when the arrangements are between landlord and tenant and when a father wishes to take a son into the business of farming with him. (By W. E. Grimes, Department of Agricultural Economics. 16 pages; 2 tables.)

Circular 156: Farm Land Values in Kansas.--The trend of farm land values in Kansas and in the different farming sections of the state is discussed in this circular. The publication covers the period 1910 to 1928, and the basic data were obtained from county assessors' reports to the State Tax Commission. (By Harold Howe, Department of Agricultural Economics. 12 pages; 7 figures; 3 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		
<i>Serial No.</i>	<i>Year of issue.</i>	<i>Title, author, and publication.</i>
30	1928	Country Elevator Margins and Costs in Marketing Kansas Wheat. R. M. Green and E. B. Ballou. Kan. Agr. Expt. Sta. Bul. 246.
40	1929	Marketing the Corn Crop. R. M. Green. Corn in Kansas. Quarterly Rpt. Kan. State Bd. Agr., 48:243-246.
41	1929	Cost of Producing Corn in Kansas. W. E. Grimes and J. A. Hodges. Corn in Kansas. Quarterly Rpt. Kan. State Bd. Agr., 48:23-28.
44	1928	Prediction from Correlation, II. Non-Pearsonian Type of Analysis. R. M. Green. Handbook of the Social Science Research Council, 2: 311-314.
45	1928	The Effect of the Combined Harvester-Thresher on Farm Organization in Southwestern Kansas and Northwestern Oklahoma. W. E. Grimes, R. S. Kifer, and J. A. Hodges. Kan. Agr. Expt. Sta. Circ. 142.
46	1928	Some Relations of Industry and Agriculture. W. E. Grimes. Twenty-sixth Bien. Rpt. Kan. State Bd. Agr., 31:60-65.
47	1929	Accounts for Kansas Farms. Morris Evans and I. N. Chapman. Kan. Agr. Expt. Sta. Circ. 150.
48	1929	The Taxation System of Kansas. Harold Howe. Kan. Agr. Expt. Sta. Circ. 144.
49	1930	The Stock-share Lease. W. E. Grimes. Kan. Agr. Expt. Sta. Circ. 155.

Serial No.	Year of issue.	Title, author, and publication.
50	1928	Trends in the Agriculture of the Hard Winter Wheat Belt. W. E. Grimes. Jour. Land Econ., 4:337-354.
51	1929	Diversification of Agriculture: Its Limitations and Its Advantages. W. E. Grimes. Ann. Amer. Acad. Polit. and Social Sci. 142: 216-221.
52	1929	Experimental Method in Economic Research. W. E. Grimes. Jour. Farm Econ., 11:584-586.
53	1929	Discussion of the paper by Doctor Nourse entitled "The Farmers' Interest in the Great Lakes-St. Lawrence Waterway Project." W. E. Grimes. Jour. Farm Econ., 11:19-21.
54	1929	Price Trend Forecasts and Their Uses. R. M. Green. Quarterly Rpt. Kan. State Bd. Agr., 48:67-71.
55	1929	Interrelations of Production and Marketing. W. E. Grimes. Quarterly Rpt. Kan. State Bd. Agr., 48:17-28.
56	1930	Farm Land Values in Kansas. Harold Howe. Kan. Agr. Expt. Sta. Circ. 156.
57	1929	The Effect of Changes in Human Relations on Bargaining Power. W. E. Grimes. Sci. Agr., 10:232-238.
58	1929	The Effect of the Combined Harvester-Thresher on Farming in a Wheat Growing Region. W. E. Grimes. Sci. Agr., 9:773-782.
60	1930	The Federal Farm Board and Research. W. E. Grimes. Jour. Farm Econ., 12:25-28.
Department of Agronomy		
135	1929	Egilops <i>cylindrica</i> Host., a Wheat-field Weed in Kansas. C. O. Johnston and J. H. Parker. Trans. Kan. Acad. Sci., 32: 80-84
157	1928	A Soil Study of Scott County, Kansas. M. C. Sewell and W. L. Latshaw. Trans. Kan. Acad. Sci., 31: 81-86.
162	1928	The Effect of Different Proportions of Calcium Nitrate and 1 Potassium Dihydrogen Phosphate on the Growth of Wheat in Sand Culture. Duke D. Brown. Soil Sci., 26:441-446.
165	1928	The Effect of Acid Phosphate on Soil Reaction and Growth of Alfalfa. M. C. Sewell, W. L. Latshaw, and E. L. Tague. First Internatl. Cong. Soil Sci. Proc., 1927, 2:439-455.
167	1928	Base Exchange Studies on Kansas Soils Correlated with Crop Performance and Fertilizer Practice M. C. Sewell and A. T. Perkins. First Internatl. Cong. Soil Sci. Proc., 1927, 2:175-198.
170	1928	Easily Replaceable Calcium in Relation to Returns from Liming. F. L. Duley. First Internatl. Cong. Soil Sci. Proc., 1927, 3: 484-497.
174	1928	Killing Field Bindweed with Sodium Chlorate. W. L. Latshaw and J. W. Zahnley. Kan. Agr. Expt. Sta. Circ. 136.
175	1928	The Influence of Chilling Above the Freezing Point on Certain Crop Plants. J. P. F. Sellschop and S. C. Salmon. Jour. Agr. Res. 37:315-338.
176	1929	Why We Believe. S. C. Salmon. Jour. Amer. Soc. Agron., 21:584-589.
177	1928	Magnesium and Calcium Chlorate as Substitutes for Sodium Chlorate for Killing Field Bindweed. W. L. Latshaw and J. W. Zahnley. Jour. Amer. Soc. Agron., 20:1329. (Note.)
178	1929	The Effect of Alfalfa on Soil Moisture. F. L. Duley. Jour. Amer. Soc. Agron., 21:224-231.
179	1929	The Eradication of Brush and Weeds from Pasture Lands. A. E. Aldous. Jour. Amer. Soc. Agron., 21:660-666.
180	1929	Discussion of "Organic Matter Problems Under Dry Farming Conditions." M. C. Sewell. Jour. Amer. Soc. Agron., 21:967-969.
181	1929	A Head of Sorghum with Greatly Proliferated Spikelets. H. H. Laude and F. C. Gates. Bot. Gaz., 88:447-450.
182	1929	Correlations Between Seed Ear and Kernel Characters and Yield of Corn. A. M. Brunson and J. G. Willier. Jour. Amer. Soc. Agron., 21:912-922
183	1929	The Nitrogen Balance in Cultivated Semiarid Western Kansas Soils. P. L. Gainey, M. C. Sewell, and W. L. Latshaw. Jour. Amer. Soc. Agron., 21:1130-1153.
...	1929	Corn Breeding. A. M. Brunson. Corn in Kansas. Quarterly Rpt. Kan. State Bd. Agr., 48:73-80.
...	1929	Corn Varieties for Kansas. H. H. Laude. Corn in Kansas. Quarterly Rpt. Kan. State Bd. Agr., 48:43-47.



<i>Serial No.</i>	<i>Year of Issue.</i>	<i>Title, author, and publication.</i>
...	1929	Cultural Practices in Growing Corn. S. C. Salmon. Corn in Kansas. Quarterly Rpt. Kan. State Bd. Agr., 48:90-99.
184	1930	The Point Binomial Formula for Evaluating Agronomic Experiments. S. C. Salmon. Jour. Amer. Soc. Agron., 22:77-81.
185	1930	A Report of the Tribune Branch of the Agricultural Experiment Station. T. B. Stinson and H. H. Laude. Kan. Agr. Expt. Sta. Bul. 250.
186	1929	Wheat Production in Kansas S. C. Salmon and R. I. Throckmorton. Kan. Agr. Expt. Sta. Bul. 248.
187	1929	The Statistical Method: A Reply. S. C. Salmon. Jour. Amer. Soc. Agron., 22:270-271.
188	1929	Relation of Organic Food Reserves to the Growth of Some Kansas Pasture Plants. A. E. Aldous. Jour. Amer. Soc. Agron., 22:385-392.
189	1930	Methods of Applying Fertilizers to Wheat. F. L. Duley. Jour. Amer. Soc. Agron., 22:515-521.
190	1930	Indications that Available Nitrogen May Be a Limiting Factor in Hard Winter Wheat Production. M. C. Sewell and P. L. Gainey. Jour. Amer. Soc. Agron., 22:639-641.
193	1930	Soy-bean Production in Kansas. J. W. Zahnley. Kan. Agr. Expt. Sta. Bul. 249.
194	1930	The Relation of Organic Food Reserves to the Effect of Cutting Pasture Weeds at Different Stages of Growth. C. O. Grandfield. Jour. Amer. Soc. Agron., 22:709-713.
197	1930	Harvesting Grain Plots with a Combine. L. C. Aicher and A. L. Hallsted. Jour. Amer. Soc. Agron., 22:574-575. (Note.)
...	1929	The Experimental Method. S. C. Salmon. The Amer. Miller, May 1, p. 481.
Department of Animal Husbandry		
90	1928	Cattle Feeding Investigations, 1926-'27. B. M. Anderson, C. W. McCampbell, and H. W. Marston. Kan. Agr. Expt. Sta. Circ. 143.
91	1929	Cattle Feeding Investigations, 1927-'28. B. M. Anderson and M. A. Alexander. Kan. Agr. Expt. Sta. Circ. 151.
92	1929	Cattle Feeding Investigations, 1928-'29. B. M. Anderson, C. W. McCampbell, and M. A. Alexander. Kan. Agr. Expt. Sta. Circ. 152.
93	1929	Eye Defects in Rabbits. H. L. Ibsen and L. D. Bushnell. Anat. Rec., 41:110.
...	1928	One Substitute for the Aged Steer to Utilize Bluestem Grass. C. W. McCampbell. Record of Proc. Amer. Soc. An. Prod., p. 52.
...	1928	A Three-year Study of the Value of Adding Calcium Carbonate to Cattle Fattening Rations Containing Only Nonlegume Feeds. B. M. Anderson. Record of Proc. Amer. Soc. An. Prod., p. 59.
...	1929	Marketing Corn Through Live Stock. C. W. McCampbell. Corn in Kansas. Quarterly Rpt. Kan. State Bd. Agr., 48:246-249.
...	1929	A New Character in Guinea Pigs. Waltzing. H. L. Ibsen and K. T. Risty. Anat. Rec., 44:294.
...	1929	Medicated Salt as a Fly Repellent. C. W. McCampbell. Record of Proc. Amer. Soc. An. Prod., p. 35.
...	1929	A Study in the Control of Stomach Worms. H. E. Reed. Record of Proc. Amer. Soc. An. Prod., p. 109.
...	1929	The Influence of Vitamins B and E on production in Swine. C. E. Aubel. Record of Proc. Amer. Soc. An. Prod., p. 133.
Department of Bacteriology		
97	1928	The Occurrence of Azotobacter in Soil. P. L. Gainey. First Internat. Cong. Soil. Sci. Proc., 1927, 3:107-117.
100	1928	A Comparison of Serologic and Pullorin Tests for Bacillary White Diarrhea. L. D. Bushnell. Jour. Infect. Dis., 43:60-66.
101	1928	The Effect of Hydrogen-ion Concentration on the Bacterial Content of Gelatin. A. C. Fay. Jour. Dairy Sci., 11:313-324.
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<i>Serial No.</i>	<i>Year of issue.</i>	<i>Title, author, and publication.</i>
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104-A	1928	Improvement in the Sanitary Quality of Gelatin. A. C. Fay. Jour. Ice Cream Trade., 24:57-58.
105	1928	Comparison of Tube and Slide Agglutination Tests for Bacillary White Diarrhea. L. D. Bushnell and C. A. Brandly. Jour. Amer. Vet. Med. Assoc., 73(n.s.26):844-847.
106	1929	A Comparison of the Pullorin Reaction and the Agglutination Test for Bacillary White Diarrhea. L. D. Bushnell and C. A. Brandly. Jour. Amer. Vet. Med. Assoc., 74(n. s. 27):364-371.
107	1928	Bacterial Content of Orange Sherbet. A. C. Fay. Jour. Dairy Sci., 11:404-408.
109	1929	Autopsy Findings in Field Cases of Fowl Paralysis. K. W. Niemann. Jour. Amer. Vet. Med. Assoc., 75(n. s. 28):38-50.
110	1929	Relative Rates of Decomposition of Corn and Kafir Stubble. P. L. Gainey. Jour. Amer. Soc. Agron., 21:323-343.
111	1930	A Comparison of the Volumetric and Gravimetric Methods for Bacteriological Examination of Ice Cream. A. C. Fay. Jour. Bact., 13:40-47.
112	1929	The Hatchery and the Veterinarian in the Control of Poultry Disease. C. A. Brandly. Jour. Vet. Med., 24:297-298.
113	1929	Some Experiments on the Control of Bacillary White Diarrhea. L. D. Bushnell and C. A. Brandly. Jour. Amer. Vet. Med. Assoc., 74(n. s. 27):444-453.
115	1929	Distribution of Lesions in 1,008 Chicks Affected with Bacillary White Diarrhea. K. W. Niemann. North Amer. Vet., 10:51-52.
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117	1929	The Nitrogen Balance in Cultivated Semiarid Western Kansas Soils. P. L. Gainey, M. C. Sewell, and W. L. Latshaw. Jour. Amer. Soc. Agron., 21:1130-1153.
118	1929	Fumigation of Forced-draft Incubators. L. D. Bushnell, L. F. Payne, and C. J. Coon. Jour. Amer. Vet. Med. Assoc., 75(n. s. 28):611-025.
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121	1930	The Normal Limits of Variation of the Methylene-Blue Reduction Test. A. C. Fay. Jour. Agr. Res., 40:855-864.
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130	1930	Some New Developments in Poultry Practice. C. A. Brandly. Cornell Vet., 19:395-398.
Department of Botany		
196	1923	Star-Thistle (<i>Centaurea picris</i> Pall.), a New Weed in Kansas. F. C. Gates and Dorothy J. Cashen. Kan. Acad. Sci., 31:50. (Abs.)
197	1929	Take-all Disease of Wheat in Kansas. R. P. White and L. E. Melchers. Trans. Kan. Acad. Sci., 32:141.
198	1929	Studies of Foot Rot of Wheat (Take-all) in Kansas: Second Report of Progress. L. E. Melchers and H. H. McKinney. Trans. Kan. Acad. Sci., 32:142-143.

Serial No.	Year of issue	Title, author, and publication.
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226	1928	Kansas Botanical Notes, 1923-1928. F. C. Gates. Trans. Kan. Acad. Sci., 31:49-50.
258	1928	Some Chemical Morphological Phenomena Attending Infection of wheat, plant of <i>Ophiobolus graminis</i> . Hurley Fellows. Jour. Agr. Res., 37:647-661.
286	1928	Alfalfa Diseases in Kansas. L. E. Melchers. Twenty-sixth Bien. Rpt. Kan. State Bd. Agr., 31:153-173.
267	1928	Handbook of Kansas Trees. F. C. Gates. Trees in Kansas. Part II. Quarterly Rpt. Kan. State Bd. Agr., 47:148-363.
270	1928	Potato Experiments for the Control of Rhizoctonia, Scab, and Blackleg, 1922 to 1927. R. P. White. Kan. Agr. Expt. Sta. Tech. Bul. 24.
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278	1928	Some Diseases of the Peach. O. H. Elmer. Proc. Kan. State Hort. Soc., 1926-'27, 39:77.
281	1928	A Wilt Disease of Alfalfa Caused by <i>Fusarium oxysporum</i> var. <i>medicaginis</i> , n. var. J. L. Weimer. Jour. Agr. Res., 37:419-433.
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283	1929	Some Factors Involved in the Winterkilling of Alfalfa. J. L. Weimer. Jour. Agr. Res., 39:263-283.
286	1930	The Development of Dormancy in Seeds of Cocklebur (<i>Xanthium</i>). W. E. Davis. Amer. Jour. Bot., 17:77-87.
287	1930	Temperature and Soil-moisture Relations of <i>Fusarium Oxysporum</i> var. <i>medicaginis</i> . J. L. Weimer. Jour. Agr. Res., 40:97-103.
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<i>Serial No.</i>	<i>Year of issue</i>	<i>Title, author, and publication.</i>
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142	1928	Manganese as a Factor in Hemoglobin Building. R. W. Titus and J. S. Hughes. Science, 68:410.
143	1929	The Nutritional Value of Copper in Powdered Whole Milk. R. W. Titus and J. S. Hughes. Jour. Dairy Sci., 12:90-93.
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149	1930	The Structure of Methylated Sugar. Carrell H. Whitnah. Jour. Amer. Chem. Soc., 52:1627-1633.
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64	1929	Making Cottage Cheese on the Farm. W. J. Caulfield. Kan. Agr. Expt. Sta. Circ. 146
66	1929	The Use of Butter in Ice Cream. W. J. Caulfield and W. H. Martin. Jour. Ice Cream Trade. 25:56.
67	1929	Producing Quality Cream. W. H. Martin and W. J. Caulfield. Kan. Agr. Expt. Sta. Circ. 154.
...	1929	Cottage Cheese and How to Make It. W. H. Martin. Milk Dealer, 18:54.
68	1930	The Limits of Error of the Babcock Test for Cream. W. H. Martin, A. C. Fay, and K. M. Renner. Jour. Agr. Res., 41:147-159.
69	1930	The Use of Prepared Chocolate Syrups in the Manufacture of Chocolate Ice Cream. W. J. Caulfield. Jour. Ice Cream Trade, 26:47.
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362	1929	Insects Injurious to Corn. J. W. McColloch and G. A. Dean. Corn in Kansas. Quarterly Rpt. Kan. State Bd. Agr., 48:193-233.
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365	1928	Some Mites Infecting Fruit Trees. G. A. Dean. Bien. Rpt. Kan. State Hort. Soc., 39:31-35.
366	1928	The Hibernation of Chinch Bugs in Sudan Grass. H. R. Bryson. Jour. Econ. Ent., 21:857-863.
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9	1930	A Comparative Study of the Protective Value of Certain Fabrics in Still and Moving Air. Katherine Hess, E. V. Floyd, and Lilian Baker. Jour. Agr. Res., 41:139-146.
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78	1928	Enrich Orchard Soils While the Trees Grow. R. J. Barnett. Proc. Neb. State Hort. Soc., pp. 53-65.
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<i>Serial No.</i>	<i>Year of issue.</i>	<i>Title, author, and publication.</i>
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35	1928	The Mechanical Method of Modification of Dough. C. O. Swanson. Jour. Cereal Chem., 5:375-385.
36	1928	Some Oxidizing Effects of Flour Bleaching. E. B. Working. Jour. Cereal Chem., 5:431-435.
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37	1929	Fermentation Tolerance. E. B. Working. Jour. Cereal Chem., 6:506-512.
38	1930	Evaluating the Quality of Wheat Varieties by Cooperative Tests. C. O. Swanson. Jour. Cereal Chem., 7:66-78.
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43	1928	Sex-linked Characters of Poultry. D. C. Warren. Genetics, 13:421-433.
44	1928	Inheritance of Earlobe Color in Poultry. D. C. Warren. Genetics, 13:470-487.
45	1929	Culling Poultry. L. F. Payne and H. H. Steup. Kan. Agr. Expt. Sta. Circ. 147.
46	1929	Fertilization in the Domestic Fowl. D. C. Warren and Lester Kilpatrick. Poultry Sci., 8:237-256.
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52	1929	Feather Mites and Their Control. L. F. Payne. Poultry Sci. Assoc. Proc., Twenty-first annual meeting, pp. 61-63.
53	1930	The Effect of Disturbance Upon the Rhythm of Egg Production. D. C. Warren. Poultry Sci., 9:184-193.
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55	1930	The Inheritance of Two Standard Disqualifications in Single-comb White Leghorn Chickens. D. C. Warren. Poultry Sci., 9:271-282.
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39	1928	Correlation of the Rapid and the Long Agglutination Test for Infectious Abortion of Cattle. H. F. Lienhardt and Chas. H. Kitselman. Jour. Amer. Vet. Med. Assoc., 73(n. s. 26):328-330.
40	1928	Action of Phenol and Formol on Aërobic and Anaërobic Organisms. J. P. Scott. Jour. Infect. Dis., 43:90-92.
41	1928	Etiology of Blackleg and Methods of Differentiating <i>Clostridium chauvæi</i> from Other Anaërobic Organisms Found in Cases of Blackleg. J. P. Scott. Cornell Vet., 18:259.
44	1929	The Use of Salts in the Production of Blackleg Filtrate and Bacterin. J. P. Scott. Jour. Amer. Vet. Med. Assoc., 76(n. s. 27):525-537.
45	1930	A Simple Mineral Mixture Agar for the Cultivation of <i>Pasteurella bovisepitica</i> . J. P. Scott. Jour. Bact., 20:9-14.
47	1930	The Action of Formaldehyde on the Aggressive Substance of Blackleg Filtrate, Bacterin, and Aggressin. J. P. Scott. Jour. Infect. Dis., 46:460-468.
Department of Zoölogy		
87	1926	Food Selection of Ground Squirrels (<i>Citellus tridecemlineatus</i>). F. L. Hisaw and Frederick E. Emery. Jour. Mammal., 8:41-44.
97	1928	The Duration of Pregnancy in Guinea Pigs After Removal and also After Transplantation of the Ovaries. Earl H. Herrick. Anat. Rec., 39:193-200.
98	1928	Insect Food of Kansas Lizards with Notes on Food Habits. Charles E. Burt. Jour. Kan. Ent. Soc., 1:50-67.

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99	1928	Lizards of Kansas. Charles E. Burt. Trans. St. Louis Aca. Sci., 26:1-81.
100	1928	The Development of the Spermatozoon in <i>Cavia cobaya</i> . Mary T. Harman and Frank P. Root. Biol. Bul., 55:235-255.
101	1928	Heat as a Factor in Producing Abnormalities During Incubation in the Chick. Mary T. Harman. Trans. Kan. Acad. Sci., 31:66-76.
102	1929	Vitamin D and Resistance of Chickens to Parasitism. J. E. Ackert and L. A. Spindler. Amer. Jour. Hyg., 9:292-307.
103	1929	Hibernation of the Thirteen-lined Ground Squirrel, <i>Citellus tridactylus</i> (Mitchell). II. The General Process of Waking from Hibernation. G. E. Johnson. Amer. Nat., 63:171-180.
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106	1928	The Maturation and Segmentation of the Eggs of <i>Leptopoda</i> (sp.). Mary T. Harman and Florence M. Stebbins. Puget Sound Biol. Sta., Pubs., 6:239-251.
107	1928	Effects of the Nematode <i>Ascaridia lineata</i> (Schneider) on Growing Chickens. J. E. Ackert and C. A. Herrick. Jour. Parasitol., 15:1-13.
108	1929	On the Anatomy of the Nematode <i>Passalurus ambiguus</i> (Rudolphi). Bertha L. Danheim and J. E. Ackert. Amer. Micros. Soc. Trans., 48:80-85.
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111	1929	Studies on Northern Michigan Bog Lakes. Minna E. Jewell and Harold W. Brown. Ecology, 10:427-475.
112	1930	Emergent Evolution and Hybridism. R. K. Nabours. Science, 71:371-378.
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118	1930	Hibernation of the Thirteen-lined Ground Squirrel, <i>Citellus tridactylus</i> (Mitchell). V. Food, Light, Confined Air, Precooling, Castration, and Fatness in Relation to Production of Hibernation. G. E. Johnson. Biol. Bul., 59:114-127.
Director's Office		
35	1929	Crop Rotations for Kansas. L. E. Call. Corn in Kansas. Quarterly Rpt. Kan. State Bd. Agr., 48:145-150.
37	1928	Aids to Cooperative Marketing from Agricultural Research. L. E. Call. Jour. Coop. Marketing, 2:195-199.
38	1928	Information Regarding Recent Publications. Kan. Agr. Expt. Sta. Circ. 141.
39	1928	Director's Report, 1926-'28. L. E. Call.
40	1929	The Increased Efficiency of Agriculture. L. E. Call. Science, 69:54-60.
41	1929	Information Regarding Recent Publications. Kan. Agr. Expt. Sta. Circ. 149.

FINANCIAL STATEMENT, 1928-'29

(The Kansas Agricultural Experiment Station in account with federal and state appropriations.)

	Federal appropriations.	State appropriations and receipts.	Totals.
Main station	\$80,000.00	(a) \$70,103.45	\$150,103.45
Branch stations, appropriations		(b) 50,328.59	50,328.59
Branch stations, sales		84,947.13	84,947.13
Totals	\$80,000.00	\$205,379.17	\$285,379.17
Salaries	\$47,500.20	\$81,455.02	\$78,955.22
Labor	24,164.33	66,641.26	90,805.59
Stationery and office supplies	88.48	1,887.76	1,976.24
Scientific supplies, consumable	1,045.47	2,570.60	3,616.07
Feeding stuffs	933.71	10,950.15	11,883.86
Sundry supplies	993.82	12,841.16	13,834.98
Fertilizers			
Communication service	204.39	2,151.53	2,355.92
Travel expenses	659.16	5,729.03	6,388.19
Transportation of things .....	.57	2,623.81	2,624.38
Publications	8.92	1,068.41	1,077.33
Heat, light, water, and power	105.93	4,930.21	5,036.14
Furniture, furnishings, fixtures	130.44	1,282.75	1,413.19
Library		39.65	39.65
Scientific equipment	1,013.40	968.04	1,981.44
Live stock	2,285.00	9,271.67	11,556.67
Tools, machinery, and appliances	685.99	10,121.62	10,807.61
Buildings and land	180.19	9,296.50	9,476.69
Contingent expenses		797.83	797.83
Balance, June 30, 1929		30,752.17	30,752.17
Totals	\$80,000.00	\$205,379.17	\$285,379.17

(a) Includes a balance on hand June 30, 1928, of \$10,113.45.

(b) Includes a balance on hand June 30, 1928, of \$6,078.59.

FINANCIAL STATEMENT, 1929-'30

(The Kansas Agricultural Experiment Station in account with federal and state appropriations.)

	Federal appropriations.	State appropriations and receipts.	Totals.
Main station	\$90,000.00	(a) \$75,117.81	\$165,117.81
Branch stations, appropriations		(b) 65,061.30	65,061.30
Branch stations, sales		83,165.67	83,165.67
Totals	\$90,000.00	\$223,344.78	\$313,344.78
Salaries	\$50,000.00	\$35,039.09	\$85,039.09
Labor	28,175.89	75,176.68	103,352.57
Stationery and office supplies	100.56	2,466.54	2,567.10
Scientific supplies, consumable	1,272.23	2,864.88	4,137.11
Feeding stuffs	522.87	12,426.55	12,949.42
Sundry supplies	780.10	12,451.64	13,231.74
Fertilizers		51.46	51.46
Communication service	43.34	2,072.56	2,115.90
Travel expenses	1,643.54	6,620.15	8,263.69
Transportation of things	50.30	4,085.51	4,135.90
Publications	401.55	1,003.92	1,405.47
Heat, light, water, and power	72.62	6,361.77	6,434.39
Furniture, furnishings, fixtures	455.78	1,375.76	1,831.54
Library	4.25	107.57	111.82
Scientific equipment	1,333.64	675.59	2,029.23
Live stock	2,631.70	3,450.67	6,082.37
Tools, machinery, and appliances	2,252.79	19,290.08	21,542.87
Buildings and land	223.24	21,890.19	22,113.43
Contingent expenses	15.51	446.63	462.14
Balance, June 30, 1930		15,487.54	15,487.54
Totals	\$90,000.00	\$223,344.78	\$313,344.78

(a) Includes a balance on hand June 30, 1929, of \$10,117.81.

(b) Includes a balance on hand June 30, 1929, of \$5,811.30.