

**AGRICULTURAL EXPERIMENT STATION
KANSAS STATE AGRICULTURAL COLLEGE
MANHATTAN, KANSAS**

**DIRECTOR'S REPORT
1918-19**



**KANSAS STATE PRINTING PLANT
IMRI ZUMWALT, STATE PRINTER
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* In cooperation with the United States Department of Agriculture
 †On leave

LETTER OF TRANSMITTAL

OFFICE OF THE DIRECTOR

June 30, 1919

To His Excellency, Henry J. Allen, Governor of Kansas:

Pursuant to the Act of Congress approved March 2, 1887, establishing Agricultural Experiment Stations, I transmit herewith the report of the Agricultural Experiment Station of the Kansas State Agricultural College for the fiscal year ended June 30, 1919. It includes a brief account of the work completed or in progress, a statement of receipts and expenditures, and the principal changes which have occurred since the issuance of the last report.

F. D. FARRELL, *Director*

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DIRECTOR'S REPORT

INTRODUCTION

The principal work of the Kansas Agricultural Experiment Station during the fiscal year, 1918-19, comprised 55 primary investigational projects. Many of these were subdivided into two or more secondary lines of investigation. The work included inquiries into certain of the economic features of agriculture; the conservation of the soil; problems involved in the maintenance of the plant industries and animal industries of the state, including diseases and pests affecting plants and animals; and a small number of miscellaneous agricultural problems.

The work of the Agricultural Experiment Station is constantly being brought into closer contact with the agriculture of the state. As it progresses it becomes more and more useful to the state's agricultural industries. The present character of many of these industries in Kansas and elsewhere has resulted largely from the work of the Agricultural Experiment Stations during the past 30 years.

During the fiscal year, 1918-19, it was not possible to maintain all the work of the experiment station at a wholly desirable standard, because of the greatly increased costs of operation without corresponding increases in available funds. Nevertheless, through the loyalty of the station staff and their devotion to their work, it was possible to keep most of the investigations going. No marked expansion in any direction was possible. The present report contains brief discussions of the principal activities of the Kansas Agricultural Experiment Station during the fiscal year, 1918-19.

COOPERATION WITH THE UNITED STATES DEPARTMENT OF AGRICULTURE

Several of the important lines of investigational work are carried on in cooperation with the United States Department of Agriculture. This cooperative work during the fiscal year, 1918-19, included the work of cereal improvement and the investigation of cereal diseases in cooperation with the office of

Cereal Investigations; experiments in the production of sweet clover, in cooperation with the Office of Forage Crop Investigations; the investigation of sex type as related to functional development and performance in Shorthorn cows, in cooperation with the Division of Animal Husbandry of the Bureau of Animal Industry; cereal production experiments at the Fort Hays Branch Station, in cooperation with the office of Cereal Investigations; dry-land agriculture investigations at the Fort Hays, Colby, and Garden City Branch Stations, in conjunction with the Office of Dry-Land Agriculture; and forage crop investigations at the Fort Hays Branch Station, in cooperation with the Office of Forage Crop Investigations.

SCOPE OF THE STATION WORK IN 1918-19

A list of the investigational projects which were active during the fiscal year is given below, together with a list of the service and regulatory activities of the experiment station during the same period.

ACTIVE PROJECTS

No.	NAME	Departments	Funds	Discussed on page
6	Climate and Injurious Insect Investigations.....	Entomology.....	Hatch.....	75
8	Hessian Fly Investigations.....	Entomology.....	Hatch.....	41
9	Corn Earworm Investigations.....	Entomology.....	Hatch.....	42
13	Fruit Insect Investigations.....	Entomology.....	Hatch.....	44
17	Crop Rotation and Soil Fertility Experiments.....	Agronomy.....	Hatch.....	16
18	Tillage Investigations.....	Agronomy.....	Hatch.....	21
25	Orchard Management Investigations.....	Horticulture.....	State.....	37
26	Garden Crop Investigations.....	Horticulture.....	State.....	38
27	Potato Investigations.....	Horticulture.....	State.....	37
34	The Weight of Silage.....	Dairy Husbandry.....	State.....	57
38	Alfalfa as a Supplement to Certain Inadequate Diets for Swine.....	Animal Husbandry and Chemistry.....	Adams and State..	51
60	Wheat and Flour Investigations.....	Chemistry and Milling Industry.....	State.....	36
67	Crop Improvement.....	Agronomy.....	Hatch and State..	27
72	Inheritance in Orthoptera.....	Zoology.....	Adams.....	74
74	Physiological Investigations with Drouth-Resistant Plants..	Botany.....	State.....	24
76	Cereal Disease Investigations.....	Botany.....	State.....	39
77	Improvement and Conservation of Farm Poultry.....	Poultry Husbandry.....	State.....	65
78	Silage Feeding Investigations.....	Animal Husbandry.....	State.....	52
79	Parasitology Investigations.....	Zoology.....	Adams.....	48
82	Forest Tree Investigations.....	Horticulture.....	State.....	38
84	Injurious Mammal Investigations.....	Zoology.....	State.....	48

ACTIVE PROJECTS—*Concluded*

No.	NAME	Departments	Funds	Discussed on page
85	Poultry Disease Investigations	Poultry Husbandry and Bacteriology	State	72
90	The Effects of Cutting Alfalfa at Different Stages of Growth,	Agronomy and Chemistry	Adams and State	33
92	Field Crop Insects of Southern Kansas	Entomology	State	45
95	Farm Management Investigations	Agricultural Economics	State	12
96	Management of Native Pastures	Agronomy	State	36
97	Sex Type as Related to Functional Development and Performance in Shorthorn Cattle	Animal Husbandry	Adams and State	50
99	Dairy Heifer Development	Dairy Husbandry	State	58
100	Insects Injurious to Roots of Staple Crops	Entomology	State	45
101	Termite Investigations	Entomology	State	44
102	Miscellaneous Diseases of Farm Animals	Veterinary Medicine	State	71
103	Effect of Prolonged Production of Alfalfa Upon Soil Fertility	Chemistry and Agronomy	Fees	18
104	The Effects of Various Constant Temperature and Moisture Conditions on Inheritance in Orthoptera	Zoology	Adams	75
106	Cooperation in Kansas	Agricultural Economics	State	12
110	Swine Feeding Investigations	Animal Husbandry	State	53
111	Feeding Western Lambs	Animal Husbandry	State	56
113	Nutrients in Forage Crops	Agronomy and Chemistry	State	33
115	Insects Injurious to Alfalfa	Entomology	State	47
116	Shade-Tree Insect Investigations	Entomology	State	44
119	Embryology of Cestodes	Zoology	State	48
120	Bacteriology of Canning	Bacteriology	State	76
124	Ice Cream Investigations	Dairy Husbandry	State	62
126	Bee Investigations	Entomology	State	67



127	Deficiencies of Feeds Fed Hens as Affecting the Vitality of Chicks	Chemistry and Poultry Husbandry	Adams	66
128	Influence of Absolute Reaction of the Soil Solution Upon Azotobacter	Bacteriology	Adams	19
129	The Superiority of Kanred Wheat	Agronomy	Hatch	26
129	The Furrow Method of Seeding Wheat	Agronomy	Hatch	26
129	Seeding Sweet Clover	Agronomy	Hatch	27
130	Miscellaneous Plant Disease Investigations	Botany	State	40
131	Relation Between Adequacy of Diet and Immunity to Roup,	Poultry Husbandry, Chemistry, and Bacteriology	State	73
132	Investigations of Tenancy, Agricultural Credit, and Other Land Problems	Agricultural Economics	State	10
140	Value of Various Protein Supplements for Growing Dairy Heifers	Dairy Husbandry	State	60
	Cooperative Experiments with Farmers	Agronomy	State	34
	Blackleg Investigations	Veterinary Medicine	Receipts	69
	Value of Sweet Clover Pasture	Agronomy and Dairy Husbandry	State	60
	State Serum Plant	Veterinary Medicine	Receipts	70
	Seed Testing	Agronomy	State	35

SERVICE AND REGULATORY WORK

Fertilizer Inspection	Director's Office and Chemistry Department	Fees	22
Feedingstuffs and Livestock Remedy Control	Director's Office and Milling Industry Department	Fees	66
Dairy Inspection	State Dairy Commissioner	State	63
Stallion Licenses	State Livestock Registry Board	Fees	56
Official Testing of Dairy Cows	Dairy Husbandry	Fees	61
Improvement of State Institutional Dairy Herds	Dairy Husbandry	State	61

STUDIES IN THE ECONOMICS OF AGRICULTURE

For more than 30 years after the first Agricultural Experiment Stations were established in this country, practically all their efforts were devoted to investigations of the problems of agricultural production. As the agriculture and the industries of the country expanded their social and industrial relationships became more complex, and the necessity arose for paying more attention to the economic features of agriculture. As a result of this, during recent years these stations, including the Kansas station, have begun investigations into economic problems as rapidly as available funds permitted. During the fiscal year, 1918-19, the work of this station in Agricultural Economics was confined primarily to three lines of inquiry, all of which are briefly discussed on the following pages.

I

INVESTIGATIONS OF TENANCY, AGRICULTURAL CREDIT, AND OTHER LAND PROBLEMS

As one phase of the investigation of the farm tenancy problem, a study was begun in February, 1919, to determine the steps taken by Kansas farm owners in their rise from non-ownership to ownership of farms. Questionnaires were sent to several thousand farmers in 53 counties of the state. Carefully prepared and adequate answers were received from 2,539 farm owners. Of these farm owners, 73.1 percent were born on farms; 16.3 percent were not born on farms; and 10.6 percent did not designate where they were born.

The climb which a young man makes from the time that he first engages in farm work as a propertyless boy to a farm-owning farmer is called the "agricultural ladder." In this climb a man may work in one or more of five distinct capacities; namely, (1) unpaid worker on the parent's farm; (2) hired man for parents; (3) hired man for others than parents; (4) tenant; and (5) farm owner. Each of these is thought of as a step in the ladder. The 2,539 farmers of this study did not climb the ladder in the same manner, nor did they all rise one step after another from the first to the fifth rung of the ladder. Twenty-seven percent worked as hired men for their parents and received wages. A little less than one-half, or 44.5 percent, worked as hired men for others than their

parents. In combined figures a little more than one-half, or 55.3 percent, worked as paid hired men either for their parents or for others. More than two-thirds, or 67.6 percent, of these farm owners had previously been tenants.

Considering the combination of steps which various men took in their climb up the ladder, slightly more than 4 percent took all five steps. When only the three steps known as hired farm laborer for anyone, tenant, and owner are considered, more than two-fifths, or 41.1 percent, worked on each step; a few more than one-fourth, or 26.5 percent, worked only as tenants and then as owners; between one-fifth and one-sixth, or 18.1 percent, worked as owners only; and one-seventh, or 14.3 percent, worked as hired men and then as owners.

The data reported from 2,533 farms indicate land ownership gained as follows: By purchase, 68.8 percent; by homestead, 12.2 percent; by inheritance, 6.9 percent; by gift, 3.3 percent; by marriage, 1.9 percent; and by other methods (chiefly trading), 0.7 percent. The number not reporting on this point amounted to 6.2 percent. The average size of home farm was 254 acres; of the farm which men hired out on, 370 acres; of the farm operated as tenant, 208 acres; and of the farm of which ownership was obtained, 155 acres.

The principal tendencies brought out by the data obtained appear to be as follows: (1) The age at which men become farm owners in Kansas has steadily increased from 24.6 years in 1875-1880, to 34.7 years in 1915-1919. Thus, the 324 men reporting who became owners in the period, 1915-1919, did so at ages averaging 10.1 years greater than did the 101 farmers reporting who became owners in the period, 1875-1880. (2) The period of years which young men have spent as tenants has increased from 4.1 years in 1875, and before, to 9.4 years in 1915-1919. This is an increase of 5.3 years or almost 130 percent. The increase has been consistent for over 40 years. (3) The period of years which young men have spent as hired farm laborers has increased from 4.2 years in 1875, and before, to only 5.5 years in 1915-1919. This is an increase of only 1.3 years, or less than 31 percent. [Project 132; Department of Agricultural Economics; state funds.]

II

COOPERATION IN KANSAS

A full report on the investigation of cooperation as applied to marketing has been made and presented for publication as a station bulletin—"Cooperation Applied to Marketing by Kansas Farmers." The facts in this report were gathered from detailed and carefully prepared reports of more than two hundred farmers' organizations. They show that in 1915 about one-sixth of the farmers of Kansas were members of cooperative concerns and the value of their business exceeded forty-one million dollars. About two-thirds of these concerns should be classified as successful business enterprises. They made savings of 6 percent and upwards, on the value of total business transacted, after paying all costs including interest on their capital.

Although Kansas has a cooperative law which clearly stipulates the essential principles of cooperative organization, farmers' concerns in many cases fail to apply all of these principles. The experience of the concerns reporting indicates, however, that application of the principles of cooperative organization dealing with membership, capital, payment of interest on capital, division of savings, management, and voting is essential to the successful establishment and maintenance of truly cooperative enterprises.

The benefits which cooperative organizations have obtained are not confined to financial returns. In addition to money savings, cooperation stimulates improvement in the quality and quantity of farm products, promotes knowledge of marketing, and creates individual and group interest in the economic and social problems of the community.

It is expected that this bulletin will be available for distribution in the near future. [Project 106; Department of Agricultural Economics; state funds.]

III

FARM MANAGEMENT INVESTIGATIONS

The farm management investigations made in 1914, 1915, and 1916 applying to tenancy have been reported in full in station bulletin 221, "Farm Leases in Kansas," issued, June, 1919.

This year's investigations included: (1) A labor income survey of 201 farms in Jackson County, in which records of the farm business for the season of 1917 were obtained, and

(2) an enterprise survey of 300 farms in 12 counties, to determine the cost of producing the 1918 wheat crop. The labor income survey was a repetition of a similar survey of 250 farms made the previous year for the season of 1916. The 1917 records were obtained only on farms included in the 1916 records. Because of change of occupants or other reasons, 49 of the farms included in the 1916 records were not included in the 1917 records. The average labor income for the 201 farms, on which records were obtained in 1917, was \$1,556, as compared to an average of \$406 for the same farms in 1916. This increase was due to crop yields that were nearly twice as large in 1917 as in 1916, and to the increase in price of farm products due to war conditions.

The labor income survey tended to substantiate the results obtained in the previous year's survey in Jackson County and similar surveys in other counties, which showed that the principal factors influencing the success of the farm business are: (1) Volume; (2) diversity of enterprises; and (3) productivity. Lack of sufficient livestock of good quality and failure to maintain soil fertility and crop yields were the outstanding faults of the average farm included in the survey,

In the enterprise survey dealing with the cost of producing wheat, records were obtained in the following counties: Doniphan, Pottawatomie, Clay, Jewell, Thomas, Ellis, Ford, Barton, Harvey, Sedgwick, Sumner, and Cherokee. These records were obtained from the farmers after the wheat had been harvested and threshed, the farmers giving the information as accurately as possible from memory. The costs which could not be given directly by the farmer were estimated, the estimates being based on the cost accounting investigations of the experiment station. These figures are, therefore, essentially estimates.

Table I gives the average cost per acre and per bushel, and the average yield on the farms in each county included in the survey.

TABLE I.—ESTIMATES OF THE COST OF PRODUCING WHEAT, 1918
(An enterprise survey of 300 Kansas farms located in 12 counties)

COUNTY	Number of farms	Av. yield per acre	10-year av. yield per acre 1908-1917	Av. cost per bu.	Av. cost per acre
		<i>Bushels</i>	<i>Bushels</i>		
Harvey	60	18.0	16.2	\$1.47	\$26.50
Jewell	20	16.7	15.8	1.48	24.66
Sedgwick	40	19.4	13.7	1.56	30.26
Sumner	20	17.8	12.3	1.70	30.30
Cherokee	20	17.7	12.9	1.72	30.48
Doniphan	20	19.7	19.3	1.89	37.32
Pottawatomie	20	19.1	20.1	1.93	36.83
Barton	20	10.8	13.5	2.19	23.62
Thomas	20	6.0	9.0	2.31	13.93
Ellis	20	10.2	11.6	2.35	24.06
Clay	20	11.3	16.3	2.42	27.35
Ford	20	3.4	12.2	5.48	18.58

It will be noted that where the average 1918 yield was greater than the 10-year average yield, the cost per bushel was less than \$2, and where the 1918 yield was less than the 10-year average yield, the cost per bushel was more than \$2. With an average yield in each of the counties, the average cost per bushel would have been approximately \$2.

Table II shows the relation of the yield per acre to the cost per bushel and profit per farm on the 60 farms included in Harvey County.

The greater the yield the greater the profit, and even though the acre cost increased somewhat with the increases in the yield, the increases were not in proportion to the increased yield, and the cost per bushel decreased. Better seed and other farm practices which will increase the yield without materially increasing the cost per acre seem to be the best methods available to the average farmer for increasing his profits from the production of wheat. [Project 95; Department of Agricultural Economics; state funds.]

CONSERVATION OF THE SOIL

One of the most important problems in Kansas is the problem of a declining soil fertility. A large proportion of the agriculture of the state in the past has been essentially exploitive, with the result that the soil in large districts of the state is much less productive now than it was 50 years ago. This condition calls for the investigation of a number of problems in connection with the conservation of Kansas soils. The work of the Agricultural Experiment Station during the fiscal year

TABLE II.—RELATION OF YIELD OF WHEAT PER ACRE TO COST, 1918
 (Figures obtained from 60 Harvey County farms)

YIELD PER ACRE	Number of farms	Av. yield per acre	Av. cost per bu.	Av. cost per acre	Av. area of wheat per farm	Av. number of bushels per farm	Av. value of wheat per farm at \$2 per bu.	Av. cost of wheat per farm	Av. profit from wheat per farm
15 bushels or less.....	12	13.31	\$1.90	\$25.62	95.6	1,272	\$2,544	\$2,417	\$127
15 to 20 bushels.....	35	17.95	1.47	26.67	114.3	2,052	4,104	3,016	1,088
20 bushels or more.....	13	22.28	1.21	27.62	86.4	1,925	3,850	2,329	1,521
Average.....	60	18.00	\$1.47	\$26.50	105.2	1,894	\$3,788	\$2,784	\$1,004

included a number of inquiries into these problems. Some of the more important results are discussed below.

CROP ROTATION AND SOIL FERTILITY EXPERIMENTS

Because of the adverse climatic conditions of 1918 no grain was produced on the corn series, and alfalfa yields were unusually low. Conditions were more favorable for wheat but low yields were secured.

Corn.—The average yields of corn from 1911 to 1918, inclusive, show that commercial fertilizer cannot be used profitably when corn is grown in rotation and that the increase from the use of fertilizer is very small when corn is grown continuously.

Wheat.—Wheat yields were light on all plots as a result of dry soil conditions at seeding time and an unfavorable winter and spring. In the 16-year rotation, acid phosphate increased the yield of wheat 2.65 bushels per acre while a complete fertilizer increased the yield 3.65 bushels per acre. The plots receiving manure produced an increase of about 1.6 bushels per acre. The average increase from the use of manure has been about 4.5 bushels per acre.

In the three-year rotation, acid phosphate caused a decrease in yield due to earlier maturing at a critical time. Complete fertilizer increased the yield 2.78 bushels per acre and an application of five tons of manure on corn every three years increased the yield of wheat 4.85 bushels per acre. The average increase from acid phosphate has been 2.61 bushels per acre, from a complete fertilizer, 2.59 bushels per acre, and from the manure application, 3.53 bushels per acre.

In the continuous production of wheat, acid phosphate increased the yield 1.01 bushels per acre in 1918 while the average increase has been 2 bushels per acre. Potassium sulphate gave an increase of 0.26 bushels per acre while the average yield has been 0.75 bushels per acre less than the check plot. Complete fertilizer produced an increase of 0.61 bushels per acre while the average increase has been 4.34 bushels. Barnyard manure gave an increase of only 0.81 bushels per acre, compared with 6.42 bushels, the average increase. Green manure resulted in a decrease in yield. The differences in yield due to the different cropping systems are shown in Table III.

TABLE III.—EFFECT OF CROPPING SYSTEM ON YIELD OF WHEAT

CROPPING SYSTEM	Yield in bushels per acre	
	1918	Average, 1911-1918
16-year rotation—corn, 2 years, wheat 1 year, alternating for 12 years; alfalfa, 4 years	11.00	16.51
3-year rotation—corn, cowpeas, wheat	15.02	15.66
Corn, 2 years, wheat, 1 year	12.44	13.27
Wheat continuously	6.45	13.83

Yellowberry.—Studies on the effect of fertilizer on yellowberry indicate that phosphorus and manure reduce the percent of yellowberry.

Alfalfa.—As the alfalfa on Series III was seeded in 1917 the yields were very light. The highest yield was obtained from the plot receiving a complete fertilizer and the second highest from a manured plot. In this rotation acid phosphate has increased the average yield of hay 878 pounds per acre. Complete fertilizer has increased the yield 1,378 pounds per acre. The increase from manure has not been as great as from a complete fertilizer. Potassium sulphate has increased the average yield only 273 pounds per acre.

The results secured from the continuous production of alfalfa are much more outstanding than those secured from alfalfa growing in rotation. Table IV gives a summary of these results.

TABLE IV.—EFFECTS OF MANURE AND OF COMMERCIAL FERTILIZER ON ALFALFA GROWN CONTINUOUSLY

ANNUAL TREATMENT	Yield in pounds per acre	
	Average yield 1911-1918	Average increase 1911-1918
Acid phosphate, Potassium sulphate	4,273	1,031
Potassium sulphate	3,339	97
None	3,242	
Manure, 2½ tons	5,449	2,207
Manure, 2½ tons, and rock phosphate	5,760	2,538
Manure, 5 tons	6,749	3,507

It will be noted that when manure was applied at the rate of 5 tons per acre, each ton of manure produced an increase of 701 pounds of alfalfa, and that when manure was applied at the rate 214 tons per acre, each ton produced an increase of

883 pounds of alfalfa. An annual application of 380 pounds of rock phosphate has given an average increase of only 331 pounds of hay.

[Project 17; Department of Agronomy; Hatch funds.]

**EFFECT OF PROLONGED PRODUCTION OF ALFALFA UPON
 SOIL FERTILITY**

The object of this investigation is to determine the effect of the prolonged production of alfalfa upon the fertility of the soil. Samples of soil were taken from fields which had grown alfalfa continuously for a long term of years, from fields near by which were in native sod, and from others which had been cropped to grain. These samples were analyzed for nitrogen, carbon, phosphorus, calcium, and carbon dioxide.

In examining the data, it was found instructive to divide the state into three sections: (1) Humid, where the average annual rainfall is 30 inches or more; (2) subhumid, where the rainfall is between 30 and 22 inches; and (3) semiarid, where the rainfall is less than 22 inches.

Briefly, and in terms of general averages, the most important conclusions deduced from the analytical work are as follows:

1. The most significant changes are confined to the surface soil, the first seven inches.

2. In the humid section the cropped soil contains one-third less nitrogen than the soil in native sod. The alfalfa soil contains 23.8 percent more nitrogen than the cropped soil, but 13 percent less than the native soil.

3. In the subhumid section, the cropped soil contains one-fourth less nitrogen than the soil in native sod. The alfalfa soil contains 20 percent more nitrogen than the cropped soil, but 5 percent less than the native soil.

4. In the semiarid section, the cropped soil contains one-fifth less nitrogen than the soil in native sod. The alfalfa soil contains 15.7 percent more nitrogen than the virgin soil and 30 percent more than the cropped soil.

5. From extended calculations and comparisons, it is concluded that the only fields in the state which gain in nitrogen due to the growing of alfalfa are in the semiarid section. In the other two sections of the state some fields show a loss and others show a gain. It is concluded that the average nitrogen

content of these fields is the same as when the alfalfa was seeded.

6. In the humid section the cropped soils contain 36 percent less carbon than the soils in native sod; the alfalfa soils contain 38 percent more carbon than the soils continuously cropped, but 21 percent less than the soils in the native sod.

7. In the subhumid section, the cropped soils contain 26 percent less carbon than the soils in native sod; the alfalfa soils contain 17 percent more carbon than the soils continuously cropped, but 10 percent less than the soils in native sod.

8. In the semiarid section, the cropped soils contain 30 percent less carbon than the soil in native sod; the alfalfa soils contain 23 percent more carbon than the cropped soil, but 9 percent less than the soil in native sod.

9. Extensive comparisons and calculations on the carbon content of these different soils fail to show that the growing of alfalfa has changed the carbon content of the soil. The carbon content of alfalfa soils is about the same as it was when the alfalfa was seeded.

10. The average phosphorus content of the cropped soil is somewhat lower than that of the alfalfa soil or the soil in native sod. Alfalfa removes more phosphorus from the soil than a grain crop. The fact that the alfalfa soils do not show a lower phosphorus content than the soils in native sod may be taken to mean that there has been a transfer of phosphorus from the subsoil to the surface.

11. In subhumid and semiarid sections, most of the soils contain 1 percent or more of calcium and nearly all have some calcium in carbonate form. In the humid section the calcium content of most soils is from 0.5 to 1 percent, and very few contain any calcium in the carbonate form.

[Project 103; Departments of Chemistry and Agronomy; fertilizer-fee funds.]

INFLUENCE OF ABSOLUTE REACTION OF THE SOIL SOLUTION UPON AZOTOBACTER

This station has shown that many soils in central and eastern Kansas, after having produced grain crops for a decade or more, have lost approximately one-third of their original supply of nitrogen. This is not true in the case of all cultivated soils in all sections of western Kansas. It has been shown

further that in central and eastern Kansas the continuous growth of alfalfa only maintains the supply of soil nitrogen. It has been maintained that in eastern Colorado the azotobacter group of organisms, in conjunction with the vitrifying group, can not only maintain the supply of available soil nitrogen but actually cause large accumulations. There is extreme variation in the distribution or activity of this azotobacter group of organisms. In many Kansas soils they are not to be found. Herein may lie the correct explanation for the rapid decline of soil nitrogen in many cultivated soils in central and eastern Kansas. It is hoped that this investigation will throw some light upon the fundamental differences among soils from different localities of the state with respect to the relation of the bacterial flora to the nitrogen content of the soil.

The work of the year may be summarized as follows: (1) Approximately 40 percent of the soils examined failed to show the presence of this azotobacter group of organisms and possessed a corresponding low nitrogen-fixing ability. (2) The presence or absence of azotobacter appears to be correlated with the absolute reaction of the soil solution. As far as examined, those soils from which the aqueous extract show a H-ion concentration greater than 1×10^{-6} do not contain azotobacter, while those with a less concentrated H-ion extract do contain azotobacter. (3) The degree of acidity tolerated by pure cultures of azotobacter appears to be a H-ion concentration of approximately 1×10^{-6} . (4) If an excess of calcium carbonate be added to a soil the acidity of which is too great for the growth of azotobacter and at the same time the soil be inoculated with this group of organisms a vigorous azotobacter flora can be established. This has been demonstrated both in laboratory and field. (5) The addition of lime without the addition of the organisms is without effect in the laboratory. Under field conditions where the organisms exist in the immediate vicinity, the artificial addition of the organisms in order to establish an azotobacter flora appears to be unnecessary. (6) The quantity of inoculum necessary to establish an azotobacter flora in a soil rendered alkaline with CaCO_3 is very small, and a vigorous flora will be established in a very short time. [Project 128; Department of Bacteriology; Adams funds.]

TILLAGE INVESTIGATIONS

Tillage problems have been studied during the year along four lines as follows:

1. Seedbed Preparation for Wheat.—During the season of July, 1918, to July, 1919, the importance of early summer seedbed preparation for wheat was again clearly shown by the ninth consecutive crop produced under various tillage treatments. Laboratory studies conducted in conjunction show that the effect of early summer tillage is to prevent weed growth and thus conserve the soil's supply of available moisture and plant food. All cultivation on plowed ground needs only to be sufficient to keep down weeds and to produce a firm seedbed.

Reference reading conducted in prosecution of this project leads to the conclusion that there is a great lack of definite information as to the proper depth and frequency of plowing necessary for economic production.

The wheat seedbed rotation work shows that it is possible to economize on the depth of plowing by the practice of a rotation.

In cropping wheat continuously, July plowing six to seven inches deep produces the greatest yield. August plowing reduces the yield about one bushel per acre. Disking in July and plowing in September only reduces the yield a little less than three bushels per acre, while plowing in September without the July disking, reduces the yield eight and one-half bushels. Early plowing is preferable to early listing, but early listing is preferable to September plowing without disking in July.

2. The Soil Mulch.—During the 1918 season, three surface treatments were compared for their effect upon soil moisture and nitrification. The treatments were: (1) Cultivating six inches deep; (2) a bare surface with weeds removed; and (3) an uncultivated surface upon which weeds were permitted to grow. Soil samples were taken monthly to a depth of six feet. Nitrification was found as active in the bare soil as in the cultivated soil. In moisture there was but little difference in the cultivated and bare surface soils.

3. Nitrification.—Similar results were secured to those reported in 1918. Moisture did not appear to be a determining factor in nitrification unless the amount was decreased to the

wilting coefficient of the soil. One plot wet weekly to maintain a moisture content above 20 percent in the surface two feet, showed less nitrification than similar cultural treatments not irrigated. The cultivated treatments gave an increase of nitrification, yet the amount of nitrates present in the uncultivated plots, but without weed growth, was large.

4. Crop Sequence of Sorghums.—Field studies during the season of 1918 were not successful due to the firing of corn in August and the sorghums not maturing because of frost. Greenhouse studies were carried on with corn, kafir, and milo soils in pot cultures, growing winter wheat. The pots were kept at optimum moisture and at intervals nutrient solutions of various composition were used to increase the moisture to the optimum point. From the result of the wheat growth it was quite evident that nitrogen seems to be the limiting factor with wheat crops succeeding sorghum crops.

[Project 18; Department of Agronomy; Hatch funds.]

FERTILIZER INSPECTION

Two inspection trips are made each year, one in the spring and the other in the fall. In the fall of 1918, 20 towns were visited and 31 samples of fertilizers obtained from 28 dealers. In the spring of 1919, 17 towns were visited and 52 samples of fertilizers obtained from 27 dealers, representing 31 brands.

There have been registered in Kansas 148 brands of fertilizers. That samples of only 21 percent of the total number of brands registered were found by the inspector, shows that many more brands are registered than the trade calls for. It should be noted in this connection that some companies which had brands registered have either ceased doing business in the state or have merged their business with other companies. The total tonnage of fertilizers sold in the state for the calendar year 1918 was 16,936 tons. These figures are based on the number of tax tags sold and are therefore no doubt somewhat high since the law calls for a tax of 2½ cents on each 200 pounds or fraction thereof and some companies sell in 125-pound bags.

The purchasers of fertilizers, as a rule, pay too little attention to the relation between composition and price. A study was made of the comparative prices charged for different fertilizers, and on the basis of this study, a press bulletin was

prepared advising the purchasers what classes of fertilizers were most economical for them to buy. On the basis of comparative prices, it was found that nitrogen sold at 50 cents per pound, and potassium at 36 cents per pound. Phosphorus showed a very great variation. In acid phosphate, it was sold at 20 cents per pound. One of the most extensively sold brands of steamed bone meal contained 20.6 pounds of nitrogen and 262 pounds of phosphorus per ton. The average price obtained from five dealers was \$46.60 per ton. At 50 cents per pound for nitrogen, the 262 pounds of phosphorus was obtained for \$36.30, or a little less than 14 cents per pound. A steam bone substitute, containing 32 pounds of nitrogen and 85.8 pounds of phosphorus per ton was sold for \$40 per ton. If the nitrogen in this is valued at 50 cents per pound, the phosphorus would cost very nearly 28 cents per pound. A mixed fertilizer having the formula 1-12-1, or 16.4 pounds nitrogen, 104.8 pounds phosphorus, and 16.6 pounds potassium per ton, is manufactured and sold by three different companies. The average price obtained from 12 dealers was \$42.16 per ton. At 50 cents per pound for the nitrogen and 36 cents per pound for the potassium, the phosphorus in this mixed fertilizer figures at 27 cents per pound. From these figures it appears that phosphorus is the least expensive when purchased in steamed bone meal; it costs more in acid phosphate; and is the most expensive in the so-called mixed fertilizers. [Director's Office and Department of Chemistry; fertilizer fees.]

INVESTIGATIONS IN THE PLANT INDUSTRIES

Something of the importance of the plant industries in the state is indicated by the fact that the gross value of the products of these industries is now in the neighborhood of four hundred million dollars per annum. The principal plant industries are the wheat, corn, alfalfa, and oats industries. There are many smaller, more localized plant industries which have importance somewhat in excess of their direct monetary value. The conduct of all these industries naturally involves a large number of problems, both of production and of distribution, and many of these problems are being attacked by the experiment station. Some of the outstanding features of the work of the station in connection with these problems during the fiscal year, 1918-19, are discussed below.

PHYSIOLOGICAL INVESTIGATIONS WITH DROUTH-RESISTANT PLANTS

The study of plant physiology as related to drouth resistance in plants was begun at Garden City, Kan., in 1914. In the spring of 1918 the work was transferred to Manhattan and the data obtained during the season of 1918 indicate progress along four lines as follows: (1) Water requirement of plants. (2) Plant cytology. (3) Metabolism of plants. (4) Plant anatomy.

1. Water Requirement.—The relative water requirement was determined for five varieties of corn and eleven varieties of sorghum. The results, with but slight exceptions, agree with those previously obtained. They indicate that there is little or no relation between the water requirement of a plant and its ability to withstand severe climatic conditions.

2. Cytology.—A study was made of the distillate spikelet from the appearance of its rudiment to the beginning of the grain of corn. The results have been published in the *Journal of Agricultural Research* under the head, "The Development of the Distillate Spikelet and Fertilization in *Zea mays* L." The following summary taken from the manuscript presents the important facts observed:

(a) *The Embryo Sac.*—In the formation of the embryo sac there is no disorganization of the megaspores and all four of them function. The three antipodal cells rapidly increase in number, apparently by indirect cell division, until they number from 24 to 36 at the time the embryo sac is mature. These cells have rather indistinct cell walls and frequently contain two nuclei. The two polar nuclei come into position just above the egg and remain in close contact with each other but never fuse before fertilization has taken place. The egg becomes reticulate, stains very lightly, and is decidedly balloon shaped.

(b) *The Pollen Tube.*—Practically all the pollen tubes that function come from the pollen grains that lodge on the hairs of the silk. The tubes may enter the hairs directly and through them gain some access to the interior of the silk, or they may follow the hairs to their base and then penetrate the silk. After the pollen tubes are once inside the silk, they work their way between the cells to the fibro-vascular bundles. Each silk has two fibro-vascular bundles. These bundles are surrounded by sheath cells which are characterized by their extremely dense contents and large flattened nuclei. It is between these cells that the pollen tube travels down the silk. Arriving at the base of the silk, the pollen tube works its way between the sheath-like cells that extend from the fibro-vascular bundle of the silk to the cavity of the ovary. The tube enters the ovary cavity and twists and coils in its passage along the ovule

coat until it reaches the micropyle. The tube then pushes between the cells of the ovule until it reaches the embryo sac. The growth of the pollen tubes is very rapid so that they reach the embryo sacs of all the ovules of the ear in 24 hours after pollination. To do this some of the tubes must grow a distance of approximately six inches in the course of 24 hours. The pollen tubes apparently do not extend the full length of the silk at any given time but are absorbed a short distance back of their tip by the cells between which they pass. A great number of tubes start down a given silk but the number of tubes becomes less and less as the base of the silk is approached so that by the time the cavity of the ovary is reached only one tube is to be observed. The two sperm nuclei are formed in the pollen grain before the pollen tube appears.

(c) *Fertilization*.—The pollen tube enters the embryo sac and pushes its way upward until its tip is near the polar nuclei. The tip of the tube expands until it is approximately one-third the width of the embryo sac. The wall of the tube seems to dissolve giving the sperm nuclei access to the embryo sac. One of the sperm nuclei fuses with the egg at about the same time the other fuses with one of the polar nuclei. The two polar nuclei fuse at the time the sperm nucleus enters one of them or shortly afterwards. The pollen tube persists in the embryo sac until it is crowded out by the developing endosperm and embryo. Fertilization occurs in from 26 to 28 hours after the silks have been pollinated.

(d) *Endosperm and Embryo*.—The endosperm nucleus soon divides and in 10 to 12 hours after fertilization the endosperm nuclei may number as high as 30 arranged around the periphery of the embryo sac. Within 36 hours after fertilization the cells of the endosperm completely fill the embryo sac. The nucleus of the fertilized egg does not divide for some time, so that the endosperm may number 20 or more cells before the first division of the egg takes place. When the cells of the endosperm completely fill the embryo sac, the embryo numbers only 14 to 16 cells.

3. Metabolism.—Chemical analyses have been made of the leaves of corn and the sorghums at two-hour periods during the day and night. The purpose of this work is to determine if there is any specific variation in the daily metabolism of these plants. It is hoped to complete the test in 1919-20.

4. Anatomy.—Some progress has been made on the structural differences of the leaves of corn and the sorghums. The number of stomata per unit of leaf area has been determined for five varieties of corn and twelve varieties of sorghum. The results obtained agree with the work of the previous four years; namely, that the sorghum leaves have approximately one-third more stomata per unit of area than the leaves of the corn plant.

[Project 74; Department of Botany; state funds.]

THE SUPERIORITY OF KANRED WHEAT

In an eight-year test Kanred, formerly known as P762, has produced an average yield of 4.5 bushels more per acre than Turkey and 4.7 bushels more than Kharkof, the two standard hard wheats grown in the state. It has outyielded these varieties every year but one and in that year it produced practically the same as the other varieties. In about two hundred and fifty experimental tests with farmers and at the branch experiment stations, Kanred has given an average yield of 3.4 bushels per acre more than Turkey, 4.2 bushels more than Kharkof, and 3.6 bushels more than the local varieties grown by the farmers making the tests. It has outyielded the local varieties in all but 10 tests that have been conducted. This variety has also been shown to be markedly resistant to winterkilling and to rust. Milling tests indicate that it is fully equal to other varieties as a milling wheat. [Project 129; Department of Agronomy; Hatch funds.]

THE FURROW METHOD OF SEEDING WHEAT

Promising results continue to be secured from the furrow method of seeding. The principal advantages are: (1) Protection of the grain against winter injury; (2) prevention of soil blowing; and (3) better germination in dry soils. There is also some evidence to show that grain sown in furrows is more drouth-resistant. An average for nine years for all plots at Manhattan shows a gain of 0.9 bushel per acre for the new method. This probably does not express the full advantage of the furrow method for the reason that the optimum rates, dates, and direction of seeding for the common method have been quite fully determined while practically nothing is known concerning the relation of these factors to the yield of wheat sown in furrows. It seems quite certain that the optimum rate for wheat sown in furrows is lower than for seeding in the usual way, but in experimental tests conducted previous to 1917, all plots were sown at the same rate. It appears also that the difference in yield between the furrow method and the common method is considerably greater if the plots are drilled north and south than if drilled east and west.

A new drill for seeding in furrows has been constructed. This was used in the fall of 1918 for seeding about two hun-

dred acres in eight different fields at the Fort Hays Branch Experiment Station. Conditions for germination were satisfactory, and although there was no injury to the wheat because of winterkilling or soil blowing, the wheat in furrows produced about two bushels per acre more than that sown in the usual way. At the Colby Branch Experiment Station, wheat sown in furrows produced, on fallow land, 3.2 bushels per acre more than that sown by the common method, and 4.4 bushels per acre more on corn ground. In a field previously in kafir there was no noticeable difference, the wheat being practically a failure regardless of the method of seeding. [Project 129; Department of Agronomy; Hatch funds.]

SEEDING SWEET CLOVER

In the sweet clover work good stands were secured when sweet clover was sown alone, but no seed germinated when sown with oats as a nurse crop. The preparation of the soil and time and rate of seeding were identical in both cases. The rate of seeding appeared not to be an important factor in securing a stand, good stands being secured with as little as five pounds of terminable seed per acre. March and April seeding gave better results than seeding on later dates. Sweet clover hay from the second year's crop was very inferior in quality. A large percent of the plants were killed by this second year's cutting except where the stubble was left very high. [Project 129; Department of Agronomy; Hatch funds.]

CROP IMPROVEMENT

This project includes the improvement of varieties of cereal and forage crops through selection and crossing. Its object is to provide improved, high-yielding, adapted varieties of farm crops and to secure additional information on the laws of inheritance as they operate with respect to characters of economic importance in our crop plants. The work pursued may be grouped under the following headings: (1) Wheat Breeding. (2) Oat Breeding. (3) Sorghum Breeding. (4) Corn Breeding. (5) Minor Cereals. (6) Winter and Spring Characters in Small Grains. (7) Breeding for Disease Resistance.

Wheat Breeding.—The variety testing and breeding of winter wheats was continued along the same plan as in previous years. There was no winterkilling and hence the work with the soft

winter wheat varieties is in more complete form than usual. A number of varieties of soft winter wheat from other stations are included in this year's tests, particularly some from Missouri, Wisconsin, and Michigan. Of the hard winter wheat varieties, Kanred is still maintaining its place as a high-yielding variety and this year is particularly outstanding with regard to resistance to leaf rust. Other varieties of hard winter wheat have leaf rust as high as 50 to 80 percent, while all of the Kanred plantings in the Nursery and at the Agronomy Farm are below 10 percent.

Studies have been made of the character of the beaks or short awns on the outer or empty glumes of the spikelets of Kanred, Turkey, and Kharkof. As previously pointed out by Ball and Clark of the United States Department of Agriculture, this character apparently forms a clear-cut morphological distinction which is of value in identification work. The beaks on the outer glumes of Kanred are from 4 to 20 millimeters in length while in Turkey and Kharkof they are from 2 to 8 millimeters. These two characters are practically the only ones which are of value in identifying Kanred and will serve to indicate where there are serious mixtures in fields or where wheat is wrongly named Kanred by unscrupulous seedsmen or careless growers.

Kansas No. 2048 (Alberta Red) has produced grain which is of darker color and harder texture and better milling qualities than other varieties of the Turkey type.

A beardless, hard red winter wheat which is of some promise is C. 1. No. 5170.

A number of pure line selections from Hard Winter Defiance (Kansas No. 373) are being grown this year in rod rows for the first time and some of them are very promising from the standpoint of earliness, being from four to five days earlier than Kanred.

Crosses.—A number of crosses between Ghirka (beardless) and Turkey are being purified, some of them are being grown in eight-foot rows and the pure types in rod rows for the first time. Among these are a number of early, beardless types which it is hoped may prove of some value in parts of the state. No information is yet available, however, on their yield or grain quality.

Head-Row Selections.—In the head-row work there are about seven hundred fifty plantings from selections made in the Nursery in 1918. Of particular interest are rows from Nebraska Hybrid (Kansas No. 34) which is breaking up with regard to the awn character. There are pure awnless, pure bearded, and other rows which are segregating, giving awnless, intermediate, and bearded types. About forty pure lines were also isolated from Illini Chief (Kansas No. 223), which show distinct characters of vegetative habit, earliness, chaff color, pubescence, shape of head, etc.

A new variety is being watched closely known as Clarks Blackhull Hard which was obtained by this station from a grower in Harvey County. This year there are more than a thousand acres of this variety being grown in Harvey County and the distributor claims that the variety yields eight bushels more per acre than Turkey and that it is stiff-strawed and will not lodge where other wheat varieties do. Preliminary tests at the station indicate that the variety is somewhat resistant to lodging and is early. Information as to the yield of this variety is not yet conclusive and little is known as to its winter hardiness, but from the figures available (1919 only) it is evident the variety is one deserving very careful study.

Oat Breeding.—In the testing and improving of oat varieties, distinct progress has been made during the year. Kansas No. 5179 (Fulghum) which was originally received from a seed company in Texas, has maintained its previous record in the matter of high yield, earliness, stiff straw, and high weight per bushel. Its three-year average yield is 87 bushels per acre in comparison with 81 bushels for the highest yielding Burt (Kansas No. 5020), 72 bushels for Kansas No. 5105 (Red Algerian), and 70 bushels for Kansas No. 5177 (Sixty Day). In 1918, the yield of Fulghum (Kansas No. 5179) was 62 bushels in comparison with 59 bushels for Aurora, a variety of white oats selected by C. W. Warburton at Arlington Farm and grown at Manhattan for the first time in 1918. Two other varieties of distinct value received from the Iowa station are Richland (Kansas No. 5209), which yielded 56 bushels in 1918, and Albion (Kansas No. 5208), which yielded 55 bushels in 1918. A small field of Fulghum (Kansas No. 5179) is being grown at the Agronomy Farm in 1919 and the variety is also being given a preliminary test in cooperative experiments over the state.

In 1920, there will be sufficient seed for thorough tests in several counties of the state and it is hoped the variety will be ready to distribute to farmers in a preliminary way in 1921.

Sorghum Breeding.—Sorghum improvement work is being developed gradually as the needs of the work become apparent and the project leader becomes more familiar with the crop and present varieties and their adaptations. A definite program of selection work using the head-row method was started at each of the branch stations in the spring of 1919.

Corn Breeding.—The work in corn improvement occupies a relatively minor part in the project. At the Agronomy Farm, the study of yield of F1 hybrids in comparison with parental varieties was continued in 1918 and the three-year average shows that several of the hybrids exceeded the average yield of the parents. The greatest increase, eight bushels per acre, was in the Pride of Saline X Minnesota No. 13, yellow dent cross. In the Nursery, about two hundred ear-to-row tests were made with particular reference to inheritance studies of endosperm color and the possibility of isolating pure white dent and pure blue dent types from the so-called "Blue and White Dent" variety grown to some extent in southeastern Kansas. From some of these hybrids hereditary dwarf plants have been produced similar to those observed by Emerson and Montgomery of Nebraska and by East and Hayes of Connecticut. Ear-to-row work is also being conducted with Kansas Sunflower, yellow dent corn.

Minor Cereals.—The barley improvement work occupies a minor place in the project because the crop is relatively unimportant in the state. No breeding or selection work is being done with barley with the exception that a number of hybrids received from the South Dakota station selected for earliness and drought-escaping qualities are being tested.

Three varieties of rye (Kansas, Rosen, and Abruzzi) are being tested in replicated rod rows, and several other varieties in single rod rows. The Rosen rye has a heavy straw, large heads, and seems to offer some possibilities as a superior variety for pasture.

An experiment was started in 1918 to test the effect of continued selfing in rye. Several hundred heads were bagged to insure close pollination, and a like number left uncovered, allowing natural cross pollination to take place. The average

number of seed per head was determined for each lot, and the resulting seed planted separately in 1919. It is planned to continue this process three to five years.

Winter and Spring Characters in Small Grains.—An experiment to determine the factors which influence winter and spring types has been in progress during the year. Plantings of winter wheat, spring wheat, winter oats, spring oats, winter barley, spring barley, winter rye, and spring rye were seeded each month throughout the year. Observations were made on winter survival, time of heading, time of ripening, and vegetative characters at the various stages of growth. It is hoped in this way to get some preliminary information on the factors which are present in winter varieties and absent in spring varieties which have to do with winter hardiness and, on the other hand, the factors which are present in spring varieties and absent in winter varieties which control early shooting or jointing and erect habit of growth.

Breeding for Disease Resistance.—The following phases of breeding for disease resistance constitute the chief work of the year in this line: (1) Oat Smut. (2) Sorghum Kernel Smut. (3) Rust Resistance in Wheat. (4) Inheritance of Winter and Spring Habit.

Oat Smut.—It is known that Burt oats carries relatively little smut infection under field conditions and, therefore, about seven hundred fifty head rows of this and other varieties were planted in 1919, seed of which was inoculated with smut. It is hoped by this means to establish pure lines which will be smut-resistant, early, and high-yielding.

Sorghum Kernel Smut.—The work already accomplished by the station Plant Pathologist and the United States Office of Cereal Investigations has shown that certain strains of milo and feterita are not at all infected by kernel smut under natural field conditions. These tests have covered three years' time at two stations (this station and the one at Amarillo, Tex.) and form a safe basis for further breeding work. Plantings have been made of Blackhull White kafir, a standard grain sorghum grown in eastern and east central Kansas, and of Kansas Orange, a commonly grown and high-yielding sweet sorghum, and of the above-mentioned smut, resistant types of milo and feterita. Crosses will be made during the season between milo and feterita as the resistant sorghums, and Black-

hul White kafir and Kansas Orange sorghum, the most important commercial types of sorghum in Kansas, and the smut resistance of the F₁ plants will be studied in 1920. It is hoped by this means to develop a sorghum which will be smut-resistant and still be equal in commercial value to either milo or feterita.

Rust Resistance in Wheat.—The work in testing wheat varieties for rust resistance includes about two hundred rows of winter wheat varieties and about the same number of spring wheat varieties grown in the rust nursery. There were grown in the greenhouse during the winter of 1918-19 about seventeen hundred F₂ plants of crosses between the rust-resistant winter wheat varieties, Kanred, P1066, and P1068, and the rust-susceptible spring wheat varieties, Preston, Marquis, and Bluestem. All of these plants (winter X spring wheat hybrids) were grown as pedigree cultures and individual plant notes were taken on agronomic and botanic characters. Each plant was inoculated with pure cultures of black stem rust and its behavior noted. The segregations with regard to rust resistance were very sharp. These results are very definite inasmuch as every plant was hand inoculated and it is believed that the plants which remained free of infection are actually resistant. These results on the inheritance of rust resistance are believed to be more definite than any yet obtained because of the controlled conditions under which the work was done and the large number of plants grown.

Inheritance of Winter and Spring Habit.—The same group of hybrid plants has also added definitely to our understanding of the inheritance of the winter character.

In addition to the genetic information gained from this series of crosses, there are certain practical possibilities which apparently may be obtained: First, high-yielding, rust-resistant or tolerant spring wheat varieties for the northern states, awnless and similar to the very popular variety, Marquis. Second, a *beardless*, rust-resistant or tolerant hard red winter wheat for the winter wheat states with the grain quality of Marquis, and the yield of Kanred.

There is good evidence that plants having these characters are present in the F₂ population. It is believed that the value of winter and spring wheat crosses has been indicated and further work along this line is intended.

[Project 67; Department of Agronomy; Hatch and state funds.]

THE EFFECTS OF CUTTING ALFALFA AT DIFFERENT STAGES OF GROWTH

The results of four years' work on this project previous to 1918 showed the danger of early cutting and the possibility of delaying cutting as much as desired without permanent injury to the stand. The 1918 results again emphasized these findings. Figures on the yields for the five seasons the experiment has been conducted are given in Table V.

TABLE V.—YIELDS OF ALFALFA IN TIME-OF-CUTTING EXPERIMENT

STAGE OF CUTTING	Yield in tons per acre					
	1914	1915	1916	1917	1918	Average
Bud	3 45	3 86	4 76	3 52	1 89	3 50
One-tenth bloom	3 38	5 31	5 67	4 02	2 26	4 13
Full bloom	2 69	6 35	6 63	3 86	2 00	4 31
Seed	2 13	4 65	5 53	3 27	1 60	3 44

The analytical work in determining the chemical composition of alfalfa hay cut at the different stages of maturity has been done by the Department of Chemistry for each of the five years of the investigation. It is hoped to have the data prepared for publication in the near future. In general it may be said that the percent of protein is greatest in the hay cut in the bud stage and decreases slightly in that cut in each of the later stages. The full-bloom stage, however, gave the highest total yield of nutrients.

The effect of early cutting on the alfalfa plants was strikingly shown by the amount of weeds and grass in the later cuttings in 1918. The hay from the fifth cutting of the bud-stage plots consisted of 85 percent bluegrass, crabgrass, and foxtail, and only 15 percent alfalfa. Only 22 percent of the hay from the one-tenth bloom plots consisted of grass, and there was no grass or weeds in the other plots. [Project 90; Departments of Agronomy and Chemistry; Adams and state funds.]

NUTRIENTS IN FORAGE CROPS

The purpose of this investigation is to study the chemical composition of forage crops as associated with stage of maturity and affected by methods of harvesting and curing. During the year, the work has been limited to alfalfa and sweet clover. It was found that sweet clover cured in the sun has

a higher pure protein content than that cured in the shade. The leaves contain about two and one-half times as much total protein and about three times as much pure protein as the stems, while the stems contain three to four times as much crude fiber as the leaves.

Alfalfa was cut at four stages of maturity; namely, bud, one-tenth bloom, full-bloom, seed-formation. Samples were cured in the sun and in the shade. For each, the process of curing was prolonged by sprinkling. The following chemical changes were most pronounced:

1. Prolonging the period of drying produced a larger amount of water-soluble nitrogen. Samples dried in the shade had a larger percent of water-soluble nitrogen than samples dried in the sun, and sprinkling increased the amount of water-soluble nitrogen for both.

2. Prolonging the period of drying increased the amount of protein nitrogen.

3. The samples dried in the sun had a larger percent of water-soluble carbohydrates than the samples dried in the shade. Sprinkling decreased these water-soluble carbohydrates both for the samples dried in the shade and the samples dried in the sun. The samples dried in the sun and not sprinkled had four to five times as large a percent of water-soluble carbohydrates as the samples dried in the shade and sprinkled.

4. All these changes were more marked in the alfalfa cut in the bud-stage than that cut in the later stages.

[Project 113; Departments of Agronomy and Chemistry; state funds.]

COOPERATIVE EXPERIMENTS WITH FARMERS

Because of the variation in soil and climatic conditions it is desirable to extend the studies made at the regular experiment stations to all parts of the state before the results of these studies can be considered conclusive and directly applicable in farm practice. This state-wide testing of methods which the experiments at the regular stations have shown to be desirable is accomplished through the conduct of cooperative experiments with practical farmers. This cooperative experimental work was begun in 1911. During the season of 1918 this work was under way in 91 counties of the state, and included

193 variety tests of corn; 127 variety tests of sorghums; 80 variety tests of wheat; 120 fertilizer tests with wheat, corn, oats, and alfalfa; 9 rotation and fertilizer experiments; and 39 miscellaneous tests in crop production. The results of this work include: Conclusive evidence that acclimated varieties of corn are superior to introduced varieties; the determination of the local adaptations of a number of varieties of corn and sorghums; demonstrations of the superiority of Kanred wheat for all soil types throughout the hard wheat growing section of the state; and demonstrations of the efficacy of phosphatic fertilizers on shale and sandstone soils for such crops as winter wheat, alfalfa, and clover, and of the relative inefficiency of the same fertilizers on the same soils for such crops as oats, kafir, and corn. [Department of Agronomy; state funds.]

SEED TESTING

During the year a total of 2,730 samples of seed were received at the seed-testing laboratory. Of these samples, 297 were tested for identification and 20 for purity only. The tests on the other 2,413 samples included the germination test. The principal kinds of seed examined were wheat, kafir, sweet sorghum, corn, clover, alfalfa, and the grasses.

The chief results of the purity tests were as follows: Of 169 samples of alfalfa examined, 19, or more than 11 percent, contained dodder. Impurities to the amount of 1 percent or more were found in 62 percent of the samples. The average percent of purity was 96.2. Of 17 samples of meadow fescue examined, 88 percent contained 1 percent or more of impurity. Of 108 samples of millet examined, 89 percent contained 1 percent or more of impurity. Four bluegrass samples averaged 85.9 percent pure.

The germination of the most important farm seeds was better than during the preceding year. It was noticeably low only for the sorghums, alfalfa, sweet clover, and wheat. The average germination test of all samples received was as follows: Sweet sorghum, 73.5 percent; kafir, 76.2 percent; alfalfa, 81.7 percent; Sudan grass, 71.5 percent; sweet clover, 38.8 percent; and wheat, 70 percent. [Department of Agronomy; state funds.]

WHEAT AND FLOUR INVESTIGATIONS

Work to ascertain the factors which determine the gluten quality of wheat was continued during the year. The chief results have been presented in two papers: One, "The Determination of Acidity and Titrable Nitrogen in Wheat with the Hydrogen Electrode" published in the *Journal of Agricultural Research*, January 8, 1919, and the other, "Determination of the Amino Acids by Means of the Hydrogen Electrode," submitted to the *Journal of the American Chemical Society* for publication.

At present the investigations are being confined to a study of (1) the effect of neutral electrolytes on gluten quality; (2) the application of the chlor amine reaction to the determination of the proteins of flour; and (3) the chemical changes which take place during the tempering of wheat. [Project 60; Departments of Chemistry and Milling Industry; state funds.]

MANAGEMENT OF NATIVE PASTURES

The general plan of the work as begun in 1915 was followed during the past year. In the work to determine the effect on the pasture of burning the dead grass in the spring, similar areas were burned at three different dates. The date of appearance, the rate of growth, and yield of the grasses, and also the temperature of the soil on the burned and unburned areas were determined. Burning caused an earlier growth of grass and provided pasture earlier in the season, but the total yield, as shown by harvesting the hay from small plots, was smaller from the burned than from the unburned areas. The soil on the burned areas was warmer than the unburned areas throughout the season.

The results to date seem to show that the deferred system of grazing has not yet materially increased the grass cover, although there is a marked decrease of weeds, especially of the annual weeds. Kentucky bluegrass, side oats, and grama appeared to be favorably affected by the deferred system, but big bluestem and little bluestem showed no response. [Project 96; Department of Agronomy; state funds.]

ORCHARD MANAGEMENT INVESTIGATIONS

This project proposes to ascertain the best methods of orchard management for the stimulation of maximum fruit production. Brief reports on leading phases of the work are as follows :

1. During the season of 1918 many growers omitted the bordeaux spray and other fungicidal sprays because of the light set of fruit of some varieties. As a rule all such trees carried little or no fruit in 1919, whereas other varieties that had a crop of fruit and were well sprayed with bordeaux mixture in 1918 carried good crops the following year. This fact further emphasizes the accumulative effect of spraying. The diseases, apple scab and apple blotch, lessen the vigor of the leaves and leaflets of the fruit spurs.

2. In the Arkansas Valley the set of fruit in orchards that were well irrigated during the dry part of the season, 1918, indicates that it is the growth made during the latter part of the season that is important for the development of fruit buds of the later varieties.

3. The outlook for the control of blister canker is encouraging. The principal requirement seems to be the application of an antiseptic dressing of corrosive sublimate. The work in 1918 indicated that in many instances where cankers were removed in the spring an examination made later in the season showed evidence of the disease and in such cases a second cutting back and disinfection have been quite effective.

4. In the Yaggy orchards near Hutchinson the effects of fertilizers the second and third seasons after the application have been noted. In the second season the fruit in the manured section, for given varieties and on similar soils, stood the drought much better than in the unmanured section.

5. In the Winne orchards the combination of summer and winter pruning is again showing its value over a single operation. [Project 25; Department of Horticulture; state funds.]

POTATO INVESTIGATIONS

Seed tests with seed from various localities have been continued. Home-grown seed, seed grown in the Red River District, and seed grown under irrigation in western Nebraska have been used.

Due largely to the price of commercial fertilizers the ferti-

lizer tests of the year were confined to barnyard manure and green manures. The results are in favor of barnyard manure, although on ground planted repeatedly to potatoes, green manures have given fair returns. [Project 27; Department of Horticulture; state funds.]

GARDEN CROP INVESTIGATIONS

Work in vegetable gardening has been confined to a continuation of varietal experiments, chiefly with cabbage, tomatoes, asparagus, and lettuce.

The tests with tomatoes have included greenhouse tests with different varieties for the purpose of collecting data regarding the advisability of recommending them for forcing purposes. Pruning, pollination, supports, fertilization, temperatures, and marketing have been studied in this greenhouse work. Different varieties of lettuce have been tested with regard to disease resistance, amount of growth, and length of time taken to mature. [Project 26; Department of Horticulture; state funds.]

FOREST TREE INVESTIGATIONS

During recent years the station has emphasized the importance of red cedars and black walnuts as ornamentals, wind-breaks, and shade trees. These species are especially well adapted to Kansas conditions. In southeastern Kansas the plantings of another species, the pecan, should be increased. Assistance has been given by the station in securing and distributing nuts of desirable varieties. Creek bottom-land subject to serious overflow in that section of the state could often be profitably planted to pecans. In many such bottoms it would be well to thin out native species and plant pecans in their places.

The heavy demand for black walnut timber the past four years has greatly increased the interest in walnut planting, and nuts from the best trees, especially trees that have large fruit and therefore a higher market value, are being sought.

The campaign started in the fall of 1918 for thinning shade trees in cities and towns in order to supplement the fuel supply, will be continued for the betterment of street and shade trees and the improvement of parks and grounds throughout the state. [Project 82; Department of Horticulture; state funds.]

DISEASES OF PLANTS

During the fiscal year the principal efforts of the station in connection with plant diseases were devoted to the diseases affecting cereal plants, particularly wheat and corn. Some preliminary work was done in addition to this with reference to diseases affecting potatoes, tomatoes, and apples.

CEREAL DISEASE INVESTIGATIONS

Wheat Stem Rust.—*Puccinia graminis tritici-inficiens* is a new biologic form of stem rust discovered in 1918 and described in circular 68 of the Agricultural Experiment Station. It is different from any other known strain and differs from *Puccinia graminis tritici* in that it attacks Kanred, P1066, and P1068 in the seedling and heading stages. This form was used in the rust nursery in 1918 and 1919 and attacks the above varieties quite vigorously, as well as all other winter wheats tested. In 1918, the heaviest infection was 35 percent, but in June, 1919, the infection on different plants varied from 10 to 85 percent. This new rust has been tested on differential hosts (winter and spring wheats) in the greenhouse and specific physiological studies have been made.

Wheat Leaf Rust.—Leaf rust, as it occurs in Kansas, attacks Kanred, P1066, and P1068 very lightly, as compared to all other winter wheats studied. The average infection for Kanred in all commercial fields over the state for 1919 was less than 10 percent. During this summer leaf rust was present in Kansas in sufficient quantities to be called an epidemic. In the case of Kanred, however, the attack of leaf rust was confined almost entirely to the leaves, while most other varieties had the culms heavily infected.

Corn Smut Investigations.—Isolation experiments and ecological studies of the corn smut organism show that the smut fungus can be isolated from the air a number of weeks before corn is planted. The contamination of the air is more or less constant throughout the corn-growing season. Early isolations of the organism from the air and leaf axils of the corn plant are being experimentally proved to be corn smut.

Sprays applied to the corn plant have reduced the corn smut, but also the yield. It seems that the reduction of smut is probably the result of the reduced plant surface, rather than actual fungicidal control.

Corn Smut and Root Rot.—About one hundred fifty ears of commercial white corn were selected in the field from plants free from corn smut and root rot disease, *Fusarium*. Some ears were selected from plants that showed the presence of corn smut and root rot. It is believed that breeding for resistance to these diseases offers as promising a channel of improvement as breeding for resistance to other diseases.

These ears have been tested for germination in the laboratory. One-half of each is planted in an ear-to-row test for studies in their disease-resistance behavior.

Plant Disease Survey.—A record of the occurrence, prevalence, and injury caused by cereal diseases in Kansas has been kept for reference.

Barberry Survey in Kansas.—A survey of the occurrence of the common barberry in Kansas has been made. out of a total of 2,602 barberries located in the state, 98 showed rust infection. Of these, 2 showed heavy infection: 42, moderate; 23, light; and 31 showed only a trace.

[Project 76; Department of Botany; state funds.]

MISCELLANEOUS PLANT DISEASE INVESTIGATIONS

Under this project, it is proposed to investigate, as occasion arises, diseases of various plants of minor economic importance in the state. Diseases affecting the potato, tomato, and apple crops were studied during the year.

Potato Diseases.—Bordeaux mixture of different strengths was applied at stated times on two standard varieties of potatoes—Early Ohio and Irish Cobbler, to determine differences in effect on tip burn and early blight. On account of the extremely hot weather in early June no definite conclusions could be drawn.

Treatment of seed with corrosive sublimate, to prevent black scurf (*rhizoctonia*) and black leg, has reduced loss in stand as much as 30 percent.

Tomato Diseases.—A few standard varieties of tomatoes are being studied with reference to their susceptibility to blossom-end-rot. Plots of these varieties are being mulched and irrigated to see whether this checks the disease.

Apple Diseases.—The apple tree canker which was observed in Kansas in 1918 for the first time, has been found to be due to the fungus, *Leptosphaeria coniothyrium*. It is the same

disease that causes the raspberry cane blight and is spread from this bramble to the young apple trees in the orchard. Control measures are being tried out. Indications are that the simplest means will be to keep raspberry bushes away from young orchards. The disease is probably spread by insects. [Project 130; Department of Botany; state funds.]

INJURIOUS INSECTS AND OTHER PESTS

The agriculture of Kansas presents a number of very important problems in connection with the control of insects, particularly those affecting the plant industries. - The Department of Entomology during the fiscal year carried on 10 primary investigational projects with reference to the life-histories and methods of control of Kansas insects. The state also has a number of other pests affecting plants or animals, and some of these were under' investigation by the experiment station during the past year.

HESSIAN FLY INVESTIGATIONS

The work during this year was limited by the absence of the fly in many localities of the state. The following lines of investigation were pursued:

1. Life-History in the Field.—There were but two broods of fly present in the field, neither of which was of any consequence. The cold weather of the fall of 1917, together with the late spring and early fall of 1918, resulted in a large mortality, and in a retardation in the development of the fly. A summary of the data on the life-history shows that the life cycle may vary from 20 to 1,283 days.

2. Period of Emergence.—This work has been under way since 1913. Infested wheat is collected at all seasons of the year and from many localities in the state, and is placed under as nearly natural conditions as possible for fly emergence. Emergence from 18 to 24 months after collection is not uncommon and at 12 months is very common. No flies have been reared from threshed straw.

3. Distribution of the Fly in the State.—The area infested by the f y this year coincides with that of last year, the heaviest infestation being in Harvey, McPherson, Saline, and Dickinson Counties.

4. Measures of Control.—The work during 1918 was confined to the date-of-seeding experiment and the results obtained are in accord with those obtained in recent years.

5. Variety Test.—The test, begun in the fall of 1916, to determine the relative resistance or immunity of different varieties of small grain to Hessian fly has been continued. More than 200 varieties and strains of wheat were planted in the fall of 1917, but owing to the cold weather of that fall and the following spring the number of flies present was not sufficient to furnish any reliable data. The Hessian fly is so variable in its life economy that it is necessary to study it for a long period of years in order to attain definite conclusions.

A manuscript on "The Hessian Fly in Kansas," embodying the results of the investigations of the last six years, has been prepared for publication as a station bulletin. [Project 8; Department of Entomology; Hatch funds.]

CORN EARWORM INVESTIGATIONS

Corn earworm investigations were begun in the spring of 1908. In 1918 the project was enlarged to include all insects injurious to corn.

Corn Earworm.—The following lines of investigation were pursued during the year:

1. Time-of-Planting Experiment.—The conditions prevailing during the growing season of 1918 were exceptionally poor for corn. Germination and growth were delayed during the early months, while the extreme drouth of midsummer was detrimental to tasseling and silking. Corn planted April 15 made the best yield, while that planted May 1 had the lowest percent of earworm injury, the accompanying tabulation gives the results in brief.

Date of planting	Percent of ears injured	Yield per acre <i>Pounds</i>
April 15	53.7	267
May 1	50.3	92
May 15	79.2	63
June 1	100.0	7
June 15	100.0	...

2. Egg-Laying in Relation to Time of Planting and Silking.—The results of this year show that the fewest eggs were deposited on the plot planted May 15. This was due to the fact that extreme heat prevented the plants in this plot from silking.

Five varieties were included in each planting in 1918; namely, (1) Boone County White, (2) Commercial White, (3) Pride of Saline, (4) Kansas Sunflower, and (5) Hildreth. For the records one representative plant was selected from each variety. The following tabulation gives the figures obtained regarding the number of eggs laid:

Date of planting	Total number of eggs deposited on one representative plant of each of the five varieties	Average number of eggs per plant
April 15	104	20.8
May 1	28	5.6
May 15	16	3.2
June 1	75	15.0
June 15	868	173.0

This study of egg-laying has been in progress for six years and the data obtained has been summarized for publication. A number of striking results have been obtained. It was found that the moths show a decided preference for the silks for oviposition. When these are not present, the upper surface of the leaves and the stalks are selected. There is a distinct relation between the date of planting and the number and location of the eggs. An analysis of the data indicates that from the standpoint of the number of eggs deposited, Boone County White can be planted from April 15 to May 1; Commercial White about May 1, and Kansas Sunflower and Hildreth from May 1 to May 15.

3. *Variety Test in Relation to Corn Earworm Injury.*—Fifteen varieties of corn were grown in the variety test this year, and complete data were obtained on tasseling, silking, and maturity, together with data on percent of earworm injury and yield. Extreme climatic conditions greatly reduced the yield of all varieties. Sherrod White Dent and Colby Bloody Butcher made the highest yields, while Boone County White and Shawnee White had the lowest corn earworm injury.

Other Insects Injurious to Corn.—During this year much time was devoted to collecting and investigating various insects found in the corn field, or to the making of a general preliminary survey of this phase of the project. On the basis of the results obtained by this preliminary survey a detailed and extended study of other insects injurious to corn will be undertaken.

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

FRUIT INSECT INVESTIGATIONS

The investigations of the year as regards the control of insects injurious to fruit have indicated the following:

1. Apple-Leaf Skeletonizer.—A large number of apple-leaf skeletonizers were secured early in the summer and data gathered throughout the summer on different points in their life-history. Three broods were reared at the station during the year and data secured on the length of the different developmental stages from the egg to the adult. A description of the insect in each of these stages was also made and further data secured on the economy of the insect and methods of control.

2. Raspberry Can Blight.—A serious blight has been attacking the apple trees in northeastern Kansas. The disease having been determined to be the same as the blight attacking raspberry plants and known as raspberry cane blight, it was planned to determine the degree to which insects were instrumental in its spreading. The summer of 1918 was so hot and dry, however, that no cases of blight developed on either the apple trees or the raspberry plants used in the test.

[Project 13; Department of Entomology; Hatch funds.]

SHADE-TREE INSECT INVESTIGATIONS

Tents were placed about some elm trees to capture elm borers with which to further pursue life-history studies. No borers emerged during the season. No further progress was made in the life-history studies of the cedar scale owing to the fact that although a large number of scales were examined all were dead, due evidently to heavy parasitization. [Project 116; Department of Entomology; state funds.]

TERMITE INVESTIGATIONS

Further valuable data were secured on the life-history of termites. It was formerly believed that it took a year from the swarming time before the female began to deposit eggs, but adults which swarmed in March, 1918, and were mated at that time produced eggs in the late summer and early fall. When adult males of the season of 1918 were mated with the females of the season of 1919, eggs were deposited during the summer. [Project 101; Department of Entomology; state funds.]

MISCELLANEOUS INSECTS INJURIOUS TO STAPLE CROPS

A study of the various species of insects of economic importance in the production of staple crops, including experimental work on measures for their control, has been in progress since 1914. Three distinct but closely related projects deal with phases of this problem. They are as follows: (1) Field Crop Insects of Southern Kansas. (2) Insects Injurious to Roots of Staple Crops. (3) Insects Injurious to Alfalfa.

FIELD CROP INSECTS OF SOUTHERN KANSAS

This project was undertaken primarily to study the life economy and methods of control of the maize billbug and the kafir ant, both of these insects having caused widespread damage in southern Kansas during recent years. Data covering the work on each of these insects have been compiled and published.¹

The effects of repellents on the germination of seed developed as an important and distinct phase of the control of southern Kansas field crop insects, especially the kafir ant. The value of crude carbolic acid as a repellent for the kafir ant was fully demonstrated. Its use, however, was found to be detrimental to germination and hence not to be recommended. Some data were collected on the repellent values of other chemicals and the effects of different dilutions on the germination of the seed. An investigation into the causes of injury and noninjury to the seed was also started. [Project 92; Department of Entomology; state funds.]

INSECTS INJURIOUS TO ROOTS OF STAPLE CROPS

The investigations of the year dealing with the control of insects attacking the roots of staple crops may be divided as follows:.

1. May Beetles.—Substantial progress was made on the complete biological study of the May beetles of the state begun in 1915. The life-histories of six species have now been worked out and progress has been made toward working out the biology of several others. Thus far 23 species have been taken in the work and it is planned to work out the life economy of all of them. The year, 1918, was character-

¹ Hayes, W. P. The maize billbug or elephant bug. Kan. Agr. Expt. Sta. Tech. Bul. 6:1-27. Figs. 12. 1920.

Hayes, W. P. *Solenopsis molesta* Say (Hym.): A biological study. Kan. Agr. Expt. Sta. Tech. Bul. 7:1-56. Figs. 11. 1920.

ized by a small flight of beetles and only 8,199 beetles representing 18 species were collected. The data thus secured show the period of flight, relative abundance of the various species, and food preferences. When the collections for the past three years are compared, the data give a good criterion for determining the life cycle. More than two thousand grubs have been collected from various fields and are being reared to determine the food of the grubs, the influence of soil conditions, the places selected by the adults for oviposition, etc.

2. Morphology of *Lachnosterna*.—Since the classification of the different species of the genus *Lachnosterna* is based on obscure external characters and on the genital organs, it has seemed advisable to conduct a morphological study of the various species. The morphology of *Lachnosterna crassissima* was carefully worked out during the year, and the results are being prepared for publication.

3. Muck Beetles.—The work of the year was devoted primarily to confirming studies made during the preceding years on *Ligyris gibbosus*. In addition, the work with *Ligyris relictus* was carried forward as far as material was available.

4. Closely Related Scarabæidæ.—This study has involved the collection of data on a number of species closely related to the May and Muck beetles. Rather extensive notes have been made on various species of *Anomala*, *Cycloceplala*, *Diplotaxia*, *Euphoria*, *Cotalpa*, *Pelidnota*, *Pollyphylla*, and *Cremastochilus*.

5. Wireworms of Kansas.—A complete biological study of the wireworms of the state has been begun. Life-history studies of four species are now under way and minor studies have been made on a number of other species.

6. False Wireworms of Kansas.—During the year the life-histories of three additional species (*Eleodes hispilabris*, *E. obsoleta*, and *E. suturalis*) were started and are now well under way. The work with *Eleodes opaca* and *E. tricostata* was confined to confirming some of the minor points in the life-history, and to a study of the methods of control for *E. opaca*. As a result of field trips into western Kansas and questionnaires much additional information was obtained.

[Project 100; Department of Entomology; state funds.]

INSECTS INJURIOUS TO ALFALFA

In addition to continuing life-history studies in general on alfalfa insects, an exceptionally large amount of valuable data on the alfalfa hayworm were secured. It was ascertained that there are at least three species, the larvæ of which, because of similar habits and appearance, may be called hayworms. The larvæ are so similar in appearance as not to be easily distinguished. The most common of the three near Manhattan is *Pyrallis farinala*, commonly known as the meal snout-moth. The one next in abundance, but much more rare, is the true alfalfa hayworm, *Hypsopygia costalis*. The third species has not yet been identified.

Two species have been found to be of considerable economic importance to alfalfa growers; namely, the garden webworm, *Loxostege similis*, and the cotton cutworm, *Prodenia ornithogalli*. The former species was found to be present in destructive numbers in certain parts of southern and southwestern Kansas, especially in Reno County, and counties west of there, where many farmers were compelled to cut their alfalfa much earlier than they would have done otherwise, in order to save the crop. The latter species was generally present over the state, and in some parts in destructive numbers. One field of about 30 acres near Manhattan, which was being saved for seed, was estimated to have been injured at least 50 percent by this insect. Apparently not a single square foot of the field was free from infestation, and it was not uncommon to find more than a dozen larvæ on a single plant. The larvæ were found on a wide variety of plants, including corn, tomatoes, various other garden plants, and many weeds. One field of sweet potatoes was found near Wamego where the larvæ had entirely defoliated the vines for a distance of from 30 to 50 feet from the edge of the field. They were controlled here by a spray of arsenate of lead.

Due to the grasshopper outbreak in western Kansas in the summer and fall of 1918, one phase of the work on this project merged into the problem of grasshopper control. In this the station worked in cooperation with the Division of College Extension and the Federal Bureau of Entomology. The necessity of cooperation in a large way was emphasized and many townships responded heartily and did effective work. Six counties supplied their farmers with all the ingredients for making poison bran mash and two others furnished the

white arsenic. Two other counties organized to furnish the materials but the supply of arsenic was exhausted. Thousands of acres of alfalfa were saved by these cooperative efforts in grasshopper poisoning. The necessity of fall disking the hard grassy strips adjacent to cultivated fields was widely demonstrated and seven counties organized to carry out this important phase of grasshopper control. [Project 115; Department of Entomology; state funds.]

EMBRYOLOGY OF CESTODES

Studies on the embryology of cestodes (tapeworms) show that the rate at which larvæ develop in the intestines of the final hosts is variable. In the case of a kitten a tapeworm developed to maturity in 20 days. In 31 days fowl tapeworms formed reproductive organs, and in 35 days these large tapeworms, *Davainea tetragona*, were giving off hooked embryos in the intestine of the chicken. [Project 119; Department of Zoology; state funds.]

INJURIOUS MAMMAL INVESTIGATIONS

The station was without a mammalogist during most of the year, and little progress was made in this investigation. In cooperation with the Extension Division of the College and the United States Biological Survey, the rodent poison laboratory furnished about 20,000 quarts (1,000,000 doses) of poisoned bait, or the powdered poison for making it, for pocket gophers, prairie dogs, spermophiles, and ground hogs. Reports of the results have been entirely satisfactory. It is expected that the services of the poison laboratory will be greatly extended during the coming year. A series of experiments have been begun on the food of moles, extent of the damage to alfalfa by pocket gophers, and better means of exterminating these and other mammalian farm pests. [Project 84; Department of Zoology; state funds.]

PARASITOLOGICAL INVESTIGATIONS

This work has been continued during the year along two lines as follows:

1. Life-Histories of Chicken Tapeworms.—Investigations of the life-histories of fowl tapeworms point to the house fly, *Musca domestica*, as the means of transmitting tapeworms from one chicken to another. Conclusive evidence was ob-

tained against one of the most common fowl tapeworms when house flies which had been fed tapeworm embryos were given to young chicks. The chicks became infested with several tapeworms of the species *Davainea cesticillus*. These results were reported before the Kansas Academy of Science at Lawrence, March 15, 1918, and an account of the experiments and discovery has been published.¹

In cooperating with local farmers whose chickens were infested with tapeworms, thousands of house flies were trapped, identified, and fed to chicks reared in the experimental feeding house. Several of these chicks became infested with another species of tapeworm, the first evidence on the *Davainea tetragona* Molin. A full description of this finding, together with the method of experimentation, has been accepted for publication by the *Journal of Parasitology*.

2. Fowl Nematode Transmission.— Studies are in progress on the occurrence, development, and resistance of the large roundworm, *Heterakis perspicillum*, of chickens. Examinations of 424 fowls showed an infestation of 42.4 percent, the average number for each infested chicken being 10.6 worms. The number of deaths of mature fowls due to the toxic and other effects of these worms is not small, but it is too early to make definite statements on the percent of deaths and on several other points. The following facts, however, have been determined: (1) A mature female worm may contain about 1,500 fertilized eggs at one time. (2) The eggs do not begin to develop until they leave the body of the worm. (3) Embryos in eggs can resist at least seven days of desiccation. They resume development when moisture is added. (4) Both fertilized and segmenting eggs (two-celled stage) are resistant to continuous freezing at 11 to 18° F. for 15 hours, but neither can endure 22 hours of such freezing. (5) Unsegmented fertile eggs fail to develop in the digestive tracts of chickens, while eggs containing curved, motile embryos hatch in the small intestine and are half grown in a month.

[Project 79; Department of Zoology; Adams funds.]

¹ Ackert, J. E. On the life cycle of the fowl cestode, *Davainea cesticillus* Molin. *Jour. Parasit.* 5:41-43. 1918.

INVESTIGATIONS IN THE ANIMAL INDUSTRIES

The annual value of animal products in Kansas is now in the neighborhood of one hundred fifty million dollars. All the common animal industries are important in the state; but the beef, dairy, swine, and poultry industries dominate. The sheep industry has only recently begun to develop large proportions, and there are still fewer sheep in the state than there are milk cows. The conduct of the animal industries of the state involves a number of problems which are yet to be solved with reference to the breeding, feeding, management, and marketing of farm animals. Some of the important work done by the experiment station in connection with these problems is briefly described in the following pages.

SEX TYPE AS RELATED TO FUNCTIONAL DEVELOPMENT AND PERFORMANCE

To obtain some positive information on the proper standards for the selection of females in the beef breeds this investigation was begun September 1, 1915, with 20 shorthorn cows each selected for her ability to transmit beef characteristics to her offspring.

The objects of the experiment are to secure some information on the following points: (1) Is the milking tendency in beef cattle transmitted mainly by the dams through the male line of descent? (2) To what extent does the milk-giving function of the dam influence the beef character of progeny? (3) By mating thickly fleshed beef bulls, whose dams were heavy milkers, and beef cows which transmit beef character to their progeny is it possible to establish a heavy-milking strain of beef cattle within a breed, the female progeny of which will be double purpose beef and milk animals and the males strictly of the beef type? In other words, is it possible to retain the typical beef form in the male animals and increase the milking tendency in the females? (4) Is the present standard of selecting beef cows conducive to the production of the best beef type in the breed?

The data thus far secured indicate that it will probably be possible to establish a heavy-milking strain of Shorthorn cattle in which both bulls and cows will be the broad, deep, thick-fleshed, blocky showyard type. If this conclusion proves to be

a correct one then we must admit that the present standard of selecting beef cows is correct and that the fact that champion cows have not produced champions must be explained upon some basis other than type.

Five of the cows in the experiment have met the requirement of the Shorthorn Registry of Merit. These are: (1) Cream Toast 87609; (2) Archduchess 9th 121203; (3) Matchless Queen 180093; (4) Pride's Bessie 206445; and (5) Gwendoline 79th 217427. The butterfat records of the mature cows in this group vary from 366 to 386 pounds. Cream Toast produced the greatest amount of milk. Her record is: Milk, 10,-302.8 pounds; butterfat, 380.57 pounds. These five cows represent some of the best beef-breeding strains of the Shorthorn breed. Cream Toast and Archduchess 9th are cows of acceptable beef type and Pride's Bessie, Matchless Queen, and Gwendoline 79th are cows of exceptionally desirable beef type (broad, deep, thick-fleshed), indicating the possibility of developing a strain of deep, thick-fleshed beef cows that are also heavy milk producers.

Five daughters of the original cows are now officially in the experiment, having taken the places of five cows that failed to maintain the required standards. These heifers are all of excellent beef type and give promise of developing into heavy milkers.

Matchless Dale 291609 is still vigorous and active and since most of his daughters give promise of developing into heavy milkers, as well as splendid beef type individuals, he will be retained at the head of the herd as long as any of the original cows remain in the experiment, providing he remains active and vigorous. [Project 97; Department of Animal Husbandry; Adams and state funds.]

ALFALFA AS A SUPPLEMENT TO CERTAIN INADEQUATE DIETS FOR SWINE

Due to the death of the project leader, the previous work on animal nutrition was somewhat disorganized. It was decided early in 1919 to confine the investigations to the effect of feeding certain specific rations upon three generations of swine. Eight bred gilts were selected and divided into two lots. One lot was fed corn and tankage and the other kafir and tankage. The pigs in each lot, all farrowed in March and April,

1919, were separated into four lots—two of sows and two of boars. These eight lots are fed as follows: One lot of sows and one lot of boars, corn and tankage; one lot of sows and one lot of boars, corn and tankage, and alfalfa meal as a vitamine supplement. One lot of sows and one lot of boars, kafir and tankage; one lot of sows and one lot of boars, kafir and tankage, and alfalfa meal as a vitamine supplement.

Matings will be made in the fall of 1919 for spring farrows. Full chemical analyses are being made of the feeds used, and parallel feeding tests run on rats.

The work has not progressed far enough to indicate more than the most outstanding tendencies. It is of interest to note that the pigs in the kafir and tankage-fed group are larger for their age, more thrifty, and apparently more vigorous, than the other group. [Project 38; Departments of Animal Husbandry and Chemistry; Adams and state funds.]

SILAGE FEEDING INVESTIGATIONS

Two phases of the investigation of the feeding value of silage for fattening cattle were studied during the year. They are: (1) Maximum utilization of silage in fattening two-year-old steers. (2) Corn silage versus sorghum silage for fattening baby beef.

1. Maximum Utilization of Silage in Fattening Two-Year-Old Steers.—To determine the maximum economical utilization of roughage in the form of silage in fattening cattle under Kansas conditions, a 120-day feeding test was carried out, beginning in January, 1919, on 40 two-year-old steers. They were divided into four lots, each lot being uniform in type, size, and quality. The steers in lot 1 received all the corn and alfalfa hay they would eat, three pounds per steer of linseed meal daily, and no silage. Lot 2 was fed in the same manner except that they were also fed all the sorghum silage they would eat. Lot 3 was fed in the same manner as lot 2 except that they received only half as much corn. Lot 4 received no corn, all the sorghum silage and alfalfa hay they would eat, and three pounds per steer of linseed meal daily.

A comparison of the results in lots 1 and 4 shows that, in this particular test, 1,950 pounds of sorghum silage and 2.7 pounds of linseed meal, fed in lot 4, replaced 478 pounds of corn and 311 pounds of alfalfa hay fed in lot 1 in producing

100 pounds of gain. A comparison of the efficiency of a full corn-fed ration without and with silage (lots 1 and 2) shows a decrease of \$0.89 per hundredweight in the cost of gains and an increase of \$4.15 per steer in net returns, including hog returns, when silage was fed.

Details of the experiment are given in Part I of station circular 77, "Cattle Feeding Investigations, 1918-19."

2. Corn Silage Versus Sorghum Silage for Fattening Baby Beef.—A series of tests conducted during the three years previous to the present year have shown that, under normal conditions, sweet sorghum, kafir, and corn silage have practically the same feeding value, pound for pound. Unfavorable seasons, however, cause many questions to be raised regarding the relative value of silage made from corn and silage made from sorghum that have been injured by drouth. The hot winds of 1918 did such serious damage to both corn and sorghum crops that an experiment was planned to test the relative feeding value of silage made from these drouth-injured crops.

Thirty calves, divided into two lots of fifteen each, were used in the experiment. The lots were managed exactly alike except that one was fed corn silage and the other sorghum silage. The lot fed sorghum silage made slightly greater and cheaper gains, dressed a higher percent, and showed carcasses of better quality than did the other lot. It is interesting to note further that the sorghum silage was decidedly more palatable than the corn silage and that the sorghum made a yield of 9 tons of silage per acre as compared with 3.5 tons per acre for the corn.

Details of the experiment are given in Part II of station circular 77, "Cattle Feeding Investigations, 1918-19."

[Project 78; Department of Animal Husbandry; state funds.]

SWINE FEEDING INVESTIGATIONS

The main problems studied in this test were three in number; namely, (1) a comparison of self-feeding and handfeeding methods, (2) the relative value of several available feeds rich in protein that may be used as supplements to corn in fattening hogs, and (3) the possibility of growing fall pigs profitably.

Twenty 75-pound pigs divided into two lots of 10 each were

used in the study of the first problem in this experiment. The pigs of lot 1 were allowed to eat at will from a self-feeder which had been divided into two compartments, one of which was filled with shelled corn and the other with tankage. The pigs of lot 2 were fed twice daily all they would eat of a mixture consisting of 10 parts shelled corn and 1 part tankage. The feeding period was 100 days.

A comparison of lots 1 and 2 reveals the tremendous influence of methods of feeding upon ultimate profits. The hogs in these two lots were fed exactly the same kinds of feeds but the hogs in lot 1 could help themselves to either corn or tankage as they saw fit, while the hogs in lot 2 were fed twice a day, a combination of corn 10 parts and tankage 1 part. The hogs in lot 1 made a gain of 1.83 pounds daily and a profit of \$7.15 a head, and the hogs in lot 2 a gain of 1.25 pounds daily and a loss of 20 cents a head. The results in full are given in Part I of station circular 78, "Swine Feeding Investigations, 1918-19."

The second part of the experiment was a study of the comparative value of several protein supplements when fed with corn alone. Fifty 80-pound pigs of uniform size, condition, and quality, divided into five lots of ten each, were used. All were handfed and the ration was so planned that the feed cost should be the same for each lot. The five protein supplements to corn used were: Tankage, semisolid buttermilk, linseed meal, peanut meal, and alfalfa hay. The tankage-fed lot gave the greatest profit and the lot fed semisolid buttermilk the least.

The third part of the year's investigation was designed to give further information on the question frequently raised by farmers, "Is it possible to grow fall pigs profitably?" Thirty average fall pigs, lacking somewhat in thrift and health, were used. Fully one-half of them were farrowed during the month of October. All were vaccinated December 8, 1918, weaned, and on January 15, 1919, divided into six lots of five pigs each for a 90-day winter-feeding test under dry-lot conditions.

All the lots received shelled corn, and in addition lot 1 received tankage and lot 4 linseed meal as a protein supplement; lot 2 received tankage and shorts and lot 5 linseed meal and shorts as a protein supplement; and lot 3 received tankage, shorts, and semisolid buttermilk and lot 6, linseed meal, shorts,

and semisolid buttermilk as a protein supplement. The feeds were given in self-feeders, each feed separate, except the semisolid buttermilk which was handfed night and morning.

The general plan of the feeding and the results of the experiment are shown in Table VI.

TABLE VI.—GROWING FALL PIGS

(Value of different protein supplements to shelled corn as shown by a 90-day experiment)

Lot No.....	1	2	3	4	5	6
	<i>Pounds</i>	<i>Pounds</i>	<i>Pounds</i>	<i>Pounds</i>	<i>Pounds</i>	<i>Pounds</i>
Initial weight per pig.....	53 5	56 06	55 34	56 4	50 3	56 4
Final weight per pig.....	126 6	152 26	184 34	121 74	139 85	174 66
Daily gain per pig.....	.81	1 07	1 43	.73	.99	1 31
Feed required to make 100 lbs. of gain:						
Shelled corn.....	364 67	297 87	243 06	407 1	269 76	224 21
Protein supplements:						
Tankage.....	47 20	25 36	19 38			
Wheat shorts.....		90 07	94 77		82 4	79 95
Semisolid buttermilk.....			53 02			59 19
Linseed meal.....				65 58	52 03	25 33
Total feed required to make 100 pounds of gain.....	411 87	413 30	410 23	472 68	404 19	389 18
Cost per 100 pounds of gain.....	\$12 63	\$11 61	\$11 78	\$13 33	\$11 41	\$11 17
Final value per pig.....	22 78	27 40	33 18	21 91	25 17	31 44
Feed cost per pig.....	9 25	11 17	15 20	8 71	10 22	13 21
Initial cost per pig.....	9 59	10 09	9 96	10 15	9 05	10 15
Margin over initial cost plus cost of feed.....	3 94	6 14	8 02	3 05	5 90	8 08

Valuation of feeds: Shelled corn, \$1.54 per bushel; tankage, \$5.50 per hundred pounds; linseed meal, \$3.25 per hundred pounds; semisolid buttermilk, \$4 per hundred pounds; wheat shorts, \$2.25 per hundred pounds.

The following conclusions were noted: (1) As a protein supplement to corn, tankage gave greater and more economical gains than linseed meal. (2) There seems to be an advantage in a variety of feeds. Gains increased when shorts was added and again when semisolid buttermilk was added. (3) Fall pigs to be grown profitably should be farrowed in September. They may then be weaned and become accustomed to shift for themselves before winter begins. (4) During severe weather little increase in weight was made. Weather conditions have a marked influence upon the gains made by fall pigs. Warm houses and dry floors and beds free from dust are necessary to prevent pneumonia. Ventilation must be provided so the house will not steam up, but the pigs should not be forced to sleep in a cold draught.

The results of the year's investigations pertaining primarily to swine feeding are reported in greater detail in station circular 78, "Swine Feeding Investigations, 1918-19." [Project 110; Department of Animal Husbandry; state funds.]

FEEDING WESTERN LAMBS

Two hundred forty-five Idaho lambs were purchased on the Kansas City market at \$16 per hundredweight. They were divided into seven lots of thirty-five each, care being taken to have each lot as uniform as possible in weight, conformation, and quality. The feeding period lasted 49 days. The results are given in full in station circular 79, "Lamb Feeding Investigations, 1919." The summary of this publication follows:

The results of these investigations indicate:

1. That linseed meal is more efficient than corn gluten feed as a protein supplement for fattening lambs when fed with shelled corn, alfalfa hay, and corn silage.

2. That the addition of linseed meal or cottonseed meal as a protein supplement to a ration of shelled corn, alfalfa hay, and corn silage increased gains, reduced cost of 100 pounds gain, increased selling price per hundredweight and the ultimate profit. The addition of corn gluten feed as a protein supplement to a ration of shelled corn, alfalfa hay, and corn silage increased gains, reduced slightly the cost of a hundred pounds gain, but failed to produce the desired finish and made less profit than when no protein supplement was used.

3. That the substitution of hominy feed for shelled corn with alfalfa hay and silage increased slightly the gains, but increased the cost of gains. It also failed to produce the high finish that corn did, making the ultimate profit less.

4. That corn silage added to the ration of shelled corn and alfalfa hay did not prove profitable except when linseed meal as a protein supplement was fed with the silage, alfalfa hay, and corn. This combination gave the greatest profit.

5. That linseed meal substituted for corn and fed with alfalfa hay and corn silage produced slightly larger gains than when corn was fed with alfalfa hay and corn silage; but the linseed meal, alfalfa hay, and corn silage ration failed to produce the necessary finish, and the lambs sold for so much less per hundredweight that each lamb made a loss.

[Project 111; Department of Animal Husbandry; state funds.]

STALLION LICENSES

Stallions standing for public service in the state are licensed by the State Livestock Registry Board,¹ a license being issued annually which gives the breeding and description of each stallion. During the fiscal year, 1918-19, 4,416 licenses were issued. of these 2,990 were for purebred stallions, 818 for

¹An ex-officio board consisting of the Dean of the Division of Agriculture, the Head of the Department of Animal Husbandry, and the Dean of the Division of Veterinary Medicine of the Kansas State Agricultural College.

grade stallions, and 608 for scrub stallions. Each year shows an increase in the percent of purebred stallions licensed. During the past year 68 percent of the public service stallions were purebred and 32 percent grades and scrubs. The year previous 64.5 percent were purebreds and 35.5 percent were grades and scrubs, a greater number of grade and scrub stallions having been retired from service than in any previous year. The number of stallions of the draft breeds is considerably greater than of the light breeds. Percheron stallions represent 74 percent of the purebred stallions in the state. The number of standardbred stallions has decreased from 194 in 1917-18 to 116 in 1918-19. The enforcement of the stallion law has eliminated the practice of misrepresenting the breeding of stallions. Very few false pedigrees were found during the course of inspection. State Livestock Registry Board; stallion license fees.]

THE WEIGHT OF SILAGE

For the last five years this station has been collecting data on the weight of silage in silos of different dimensions. These data have been very much in demand, due to the great variation in weights of silage given in published tables, and due also to the fact that so many factors influence the weight of silage. Results obtained at this station in weighing silage from ten silos filled with corn, four filled with sweet sorghum, and three filled with kafir, have been published, together with similar data from the University of Missouri.¹ This work is being continued in order to obtain more data on the weight of sorghum silage as compared with corn.

The following statements are taken from the Summary of the Kansas publication:

1. The tables of silage weights now in use are King's table published in 1893, or modifications of this table. The modification of King's table published by the Nebraska experiment station² gives reasonably accurate results when used, as specified by the author, to estimate the weight of silage at the time filling is completed. No table heretofore published is adapted to estimating the weight of settled silage.

2. The weight of silage is subject to so much variation and is in-

¹These data are published as bulletin 164 of the Agricultural Experiment Station, University of Missouri, "Estimating the Capacity of Silos and Weights of Silage," and bulletin 222 of the Kansas Agricultural Experiment Station, "The Capacity of Silos and Weights of Silage."

²Chase, L. W. Measuring, silage and capacity of silos. Nebr. Agr. Expt. Sta. Cir. 1:1-1.4. 1917.

fluenced by so many factors that no table can be more than approximately correct. The chief factors influencing the weight of settled silage are: (1) Percentage of water; (2) proportion of grain to fodder; (3) depth of silage; and (4) diameter of silo. At the time filling is completed and before settling has taken place, the rate of filling and the thoroughness of packing are also important factors.

3. It was found experimentally that the fineness of cutting did not appear to influence the weight of silage.

4. A new table is given, based upon experimental data, and designed for use in estimating the weight of settled silage.

5. Weights on the contents of four silos containing sweet sorghum and three containing kafir showed no wide variations in weight as compared with corn silage. It is recommended that until more data are available, the table used for corn silage be used also for estimating the weight of silage made from the sorghums.

[Project 34; Department of Dairy Husbandry; state funds.]

DAIRY HEIFER DEVELOPMENT

The work of securing definite data on the influence of the ration on the development of dairy heifers, and the relative cost of raising grade Holstein heifers on alfalfa hay alone, on alfalfa hay and corn silage, and on alfalfa hay, corn silage, and grain, was begun in 1914.

Four lots of heifers are used, their rations being as follows: Lot 1, alfalfa hay alone; lot 2, alfalfa hay and corn silage; lots 3 and 4, alfalfa hay, corn silage, and grain. The heifers in lot 4 were fed the same as those in lot 3, but were bred to calve at 24 months of age instead of 30 months as in the other lots. To date, 29 calves have been dropped in the several lots. Twenty of the calves were first calves and nine were second calves. It is commonly believed that the animals fed on alfalfa hay alone are difficult to get with calf. In only three cases has difficulty been experienced from this source, and this was not confined to any one lot.

The record of first calves in each of the four lots is shown in Table VII.

TABLE VII.—RECORD OF FIRST CALVES

Lot	RATION	Number of calves	Av. weight at birth	Av. weight of cow	Calf's weight percent of weight of cow
1	Alfalfa hay	6	81.6 lbs.	859 lbs.	9.4
2	Alfalfa hay and silage.	4	89.0 "	936 "	9.4
3	Alfalfa hay, silage, and grain.	5	86.0 "	1,092 "	7.8
4	Alfalfa hay, silage, and grain (bred to calve at 24 mos.)	5	91.4 "	968 "	9.4
		20	87.0 lbs.	964 lbs.	9.0

The average cost of feed per heifer for three representative heifers in each lot till freshening was as follows: Lot 1, \$82.76; lot 2, \$85.22; lot 3, \$108.01; and lot 4, \$85.46.¹

These animals were fed no more than is generally fed where good growth is desirable, but it can readily be seen that the cost of the heifers was excessive.

The average milk and butterfat production for 10 months of three representative heifers in lots 1, 2, and 3 and of four heifers in lot 4; also figures on feed costs and value of milk produced, are shown in Table VIII.

TABLE VIII.—COST OF PRODUCTION RECORDS
 (Time, 10 mos.)

Lot	Av. production			Av. daily production per cow	Av. cost of feed per cow	Av. feed cost per 100 lbs. milk	Av. feed cost per lb. of butterfat
	Milk	Butterfat	Percent butterfat				
1	4,167 lbs.	151 lbs.	3.6	13.6 lbs.	\$45.35	\$1.09	30.3 cts.
2	4,918 "	168 "	3.4	16.1 "	35.62	.72	21.1 "
3	6,800 "	259 "	3.8	22.1 "	57.65	.85	22.7 "
4	6,994 "	247 "	3.5	22.9 "	49.74	.73	20.7 "

The poor showing of the heifers in lot 1 is undoubtedly due to the exclusive feeding of alfalfa hay. Feeding alfalfa hay alone is not only a poor method, but is an expensive method. The heifers in lot 4, calving at 24 months of age, made a very good showing, but this is largely due to the exceptionally high production of one heifer which produced 3,000 pounds more milk than any of the others. The heifers in lot 2, fed alfalfa hay and silage, produced milk and butterfat at the lowest feed cost.

The results obtained so far on this experiment would warrant the following statements:

1. The exclusive feeding of alfalfa hay has had no effect upon the breeding power of the animals.

2. The feeding of alfalfa hay alone to dairy cows was more expensive and produced poorer results than the other methods of feeding used.

3. Alfalfa hay and silage are more desirable for body development and cost of products than alfalfa alone. Good animals can be raised by this method.

4. The full-fed lot, calving at 24 months of age, have given very favorable results, but they lack size and mature slowly. [Project 99; Department of Dairy Husbandry; state funds.]

¹ In this calculation feed was figured at the following prices: Alfalfa hay, \$10 per ton; corn silage, \$3.50 per toll; grain, \$1.50 per hundredweight.

**VALUE OF VARIOUS PROTEIN SUPPLEMENTS FOR
GROWING DAIRY HEIFERS**

In the first phase of this investigation it is planned to determine the comparative value of cottonseed meal and linseed meal when fed with alfalfa hay and prairie hay to growing heifers. Seven animals are now on the test, only one of which is giving milk. The heifers are measured the day they are six months old and every 30 days thereafter. Body weight, height of withers, width of hips, width of pin bones, barrel girth, and heart girth are determined, in order that the influence of the different combinations of feed upon body development, milk production, and reproduction may be determined. Six lots of two animals each will eventually be used. [Project 140; Department of Dairy Husbandry; state funds.]

VALUE OF SWEET CLOVER PASTURE

An experiment was conducted in 1917 to obtain some definite data on the value of sweet clover pasture for dairy cows. The pasture used was the second year's growth of common white sweet clover. Holstein cows were kept in a 3.8-acre field day and night and in addition to the sweet clover pasture received one pound of a grain mixture daily for each four pounds of milk produced. The grain mixture consisted of 4 parts corn chop, 2 parts bran, and 1 part linseed meal. The field was pastured by six cows from May 7 till June 16; by three from June 16 till August 5; and by four from August 5 till October 1. Thus the total number of days of pasture obtained amounted to 618 days for one cow, or an average of 154.5 days for four cows. In other words, 3.8 acres of sweet clover pasture kept four cows five months or 1 acre kept a cow 5.3 months. The total amount of milk produced on the pasture was 19,395.3 pounds containing 680.5 pounds of butterfat. The cows consumed 4,602.8 pounds of grain mixture. With milk at 30 cents a gallon and the grain at \$60 per ton, one acre of sweet clover produced \$141.70 worth of milk. With butterfat at 50 cents per pound, one acre returned \$89.50 worth of butterfat, not making allowance for the skimmilk. Three of the cows were on the pasture during the entire 147 days. Their average weight at the beginning of the experiment was 1,284 pounds and at the close, 1,304 pounds. No trouble from poisoning was experienced throughout the season. The re-

suits obtained indicate that sweet clover is a useful pasture crop for dairy cows. [Departments of Agronomy and Dairy Husbandry; state funds.]

OFFICIAL TESTING OF DAIRY COWS

Increasing interest in the official testing of dairy cows is an indication of the steady advance of the dairy industry in the state. In spite of the handicaps of the high price of feed and the shortage of labor, breeders realize that as feed and labor become more valuable the mistake of milking low-producing cows becomes more apparent.

During the year 2,010 two-day tests were conducted, as compared with 1,798 for the preceding year, an increase of 11.8 percent. Fifty-one different breeders did testing, as compared with thirty-four for the preceding year, an increase of 45.9 percent. On June 30, 1919, there were 220 cows on yearly tests, owned by 44 breeders, as compared with 145 cows on yearly tests, owned by 22 breeders, on June 30, 1918.

The seven-day testing has increased more than the yearly testing because it requires a shorter time for completion. In 1917-18, 146 cows were tested for seven days each by 34 different breeders. During the past year, 50 breeders tested 394 cows for seven days each, or longer. During the past year several 30-day records have also been made. [Department of Dairy Husbandry; fees from official testing.]

IMPROVEMENT OF STATE INSTITUTIONAL DAIRY HERDS

By an act of the Kansas legislature, the dairy herds of the state institutions were placed under the advisory supervision of the Department of Dairy Husbandry, Kansas State Agricultural College, on July 1, 1917. At that time there were twelve institutions which were subject to this act. In 1919 a law was passed making the Topeka Industrial and Educational Institute subject to the same act. Regular visits are made to these 13 institutions by representatives of the department, who give assistance in connection with the selection, feeding, management, and breeding of the respective dairy herds. Local problems, especially those involving the production of clean milk, receive due consideration.

A brief summary of the second year's work of the Department of Dairy Husbandry in connection with the management and improvement of these state herds is as follows:

On July 1, 1918, these 13 state institutions owned 697 head of cattle—67 purebreds and 630 grades. The total on hand June 30, 1919, was 804—109 purebreds and 695 grades. Individual milk records are kept of each cow in every herd, four institutions having started the work during the year. All the institutions but one keep breeding records, five having started such records during the year. Identification tags are now used by six institutions and complete herdbook records are being kept by nine. The department has adopted a uniform herdbook and a simple yet comprehensive system of marking cattle and keeping the milk records and breeding records. The department has made an effort to keep in close touch with the herds of the institutions. Monthly dairy reports are required of each institution. A summary of each month's reports is compiled by the department and sent to each institution and the Board of Administration.

The year's total milk production was approximately three hundred thousand gallons. The production would have been larger had not all the institutions fed sparingly. Milk production is one of the most profitable enterprises at each institution, though its importance is usually not fully appreciated because the milk is not sold.

Only two herds, those of the State Penitentiary and the Osawatomie State Hospital, are at the present time in cow-testing associations. It is the purpose of the department to have as many of these state herds as possible in cow-testing associations in the near future. It is also the department's purpose to promote as rapidly as possible the keeping of individual feed and butterfat records throughout all the herds. Without these records the herds can not be culled intelligently and the cost of production reduced.

Besides the visits, monthly reports, and other means of advice and supervision the Department of Dairy Husbandry held a one-week school in dairying at Manhattan, May 12 to 16, 1919, for the benefit of the superintendents and herdsmen of these state institutions. There were 13 men in attendance, representing 10 institutions. [Department of Dairy Husbandry; state funds.]

ICE CREAM INVESTIGATIONS

The work of the year has been confined chiefly to the manufacture of ice cream from "reconstituted" or "remade" cream. Remade cream is a wholesome product made by reconstitu-

ting the various constituents of normal cream, which have been separated for the purpose of storage. Emulsification is accomplished by forcing the mixture through small openings under pressure created by centrifugal force or force pump. The substances used are dried skimmilk or condensed milk, fresh unsalted butter, and water.

The object of the station work has been to identify the various difficulties encountered and to devise methods of overcoming them. Particular emphasis has been placed on the composition of the mix, the ingredients used, the manner of emulsifying the mix, and the effect of these factors on the flavor, body, texture, and overrun obtained.

The work has not gone far enough to make any positive statements, but it is evident that as equally desirable a product can be made from the "remade" cream, as from the fresh article. The ice cream maker must be particular in choosing his brand of skimmilk powder, since there is on the market a great deal of dried milk that cannot be thoroughly dissolved. Such powder entails considerable loss since much of the undissolved portion is centrifuged out in the emulser. There may also be a decidedly disagreeable cooked flavor imparted to the finished ice cream. The "remade" cream must be aged the same as fresh cream, in order to obtain sufficient overrun or swell for quality and profit. Emulsifying the entire mix seems to give uniformly greater swell in freezing and a smoother textured ice cream. [Project 124; Department of Dairy Husbandry; state funds.]

DAIRY INSPECTION

CREAMERY STATISTICS, 1918

Incomplete data (incomplete because it is impossible to get data from all the smaller plants) from the dairy manufacturing plants located in Kansas, and plants obtaining cream from farms within the state, give the following figures regarding the creamery business of the state for the year 1918:

Total amount of creamery butter made from cream produced in Kansas	50,245,709 pounds
Average price paid per pound for butterfat.	\$0.487
Amount paid Kansas farmers for butterfat.	\$19,191,835.78

EXAMINATIONS AND INSPECTIONS

There are approximately 1,600 cream stations, several hundred places where ice cream is manufactured, 86 creameries, and 7 condenseries in the state. During the year 13 examina-

tions for cream buyers were held in Manhattan. Examinations were also held in 41 other cities of the state. In all, final examinations were given to 1,366 applicants and temporary examinations to 797 applicants. Approximately 93 percent of those taking the final examination and 75 percent of those taking the temporary examination passed.

Interest in cream grading declined somewhat during the war. Creameries, however, realize that more attention must be paid to the quality of cream, as better quality means better butter and better butter means higher prices for butterfat. In order to show the operators how to grade cream, this department has conducted practical cream-grading work at the examination points. Each operator who takes the final examination is required to taste and grade samples of cream as a part of the examination. He is also required to taste samples of butter and distinguish between those made from first-grade cream and those made from second-grade cream.

This department collected numerous samples of ice cream during the year. The tests of these go to show that large amounts of ice cream which does not come up to the standard as prescribed by law, are sold in Kansas. Some of it is made in Kansas and some of it is shipped in. The small manufacturer makes ice cream, the test of which varies, because he does not know what he is doing. The large manufacturers know what they are doing. Three manufacturers have been prosecuted. The department is cooperating with the State Board of Health and the Federal authorities in regard to interstate shipments. More prosecutions will be made. More than three thousand letters were written in answer to inquiries addressed to the department during the year and several hundred mimeograph letters were sent out.

The inspection work covered by the department during the year is as follows:

Towns visited	724
Cream stations inspected	1070
Creameries inspected	75
Ice cream factories inspected	84
Dairies and milk plants inspected	19
Condenseries inspected	4
Receiving stations inspected	4
Stores handling ice cream visited	98
Cream stations closed because of insanitary conditions	9
Prosecutions, won by the state	3
Ice cream and cream samples collected	395

Permits canceled	1
Complaints received	130
Complaints investigated	87

[State Dairy Commissioner; state funds.]

IMPROVEMENT AND CONSERVATION OF FARM POULTRY

A full report on the phase of this project having to do with; the use of standardbred males from high-producing strains in grading up mongrel flocks has been published as station bulletin 223, "Improving Farm Flocks Through Selected Standardbred Cockerels."

The work of selecting for high egg production within the standard breeds most common on Kansas farms is being continued with success. Considerable numbers of eggs and breeding stock from high-producing families have been sent out to farmers during the past year. Because of the unsatisfactory results in shipping eggs for hatching and further because it frequently interferes with keeping experimental records, the practice of selling eggs for hatching has been discontinued. Breeding stock may still repurchased.

The study of the inheritance of Andalusian Blue has proceeded satisfactorily. During the past season more than twenty-five hundred chicks have been hatched, recorded, and described. Many of the latter are F² individuals. The results have not yet been fully tabulated.

Feeding tests to determine the comparative feeding value of corn and kafir seem to indicate that kafir is less desirable than corn, but is, nevertheless, a valuable feed for poultry either within or without the corn belt. Sufficient data have not yet been secured to warrant a definite statement of the comparative values.

An experiment has been started to determine the desirability or danger of commercial chick feeds which include weed seeds. It has been found that the chicks refuse the seeds of the following plants even when the amount of feed is limited and the chick kept hungry: Wild oats, wild buckwheat, Indian mustard, lamb's-quarter, hare's-ear mustard, corn cockle, ball mustard, wild pepper grass, stink weed, Mexican tea, sleepy catch fly, quack grass, charlock, large crab grass, stickseed, water smart weed, curled dock, western wheat grass, and cheat. Whether any seeds pass through the chicks undigested is yet to be determined. [Project 77; Department of Poultry Husbandry; state funds.]

DEFICIENCIES OF FEEDS FED HENS AS AFFECTING THE VITALITY OF CHICKS

Six pens of Barred Plymouth Rocks, each consisting of one male and five females, have been fed on differing rations of known composition for the past year as follows: Pen 1 was fed a supposedly adequate diet. The diet of pen 2 was low in protein; pen 3 in fat-soluble vitamine; pen 4 in water-soluble vitamine; and pen 5 in calcium. Pen 6 received no salt. All were housed and handled under as nearly identical conditions as possible.

In all pens the birds became excessively fat and egg production was low. Pen 1, on the supposedly adequate diet, laid the most eggs, and pen 6, lacking only salt, was second. There was evidence, however, that the diet used as adequate, and which was known to be adequate for certain mammals under similar conditions, is not adequate for chickens. The next step will be to formulate a diet of known composition which is adequate.

Birds in pens 3 and 4, lacking the fat-soluble or water-soluble vitamine, showed typical symptoms of these deficiencies. It was noticeable from the first that the males exhibited these symptoms more quickly and more markedly than the females.

A bio-chemical analysis of the vitamine content of the eggs from the general flock at the college Poultry Farm has been begun. Bio-chemical analyses will be made of the eggs from the different experimental pens. These will be compared with the results obtained from the general flock. It is proposed to change from Barred Rocks to White Leghorns for the coming season in the hope that, because of the latter's greater natural activity, they may better stand the conditions of confinement which are necessary for the complete control of the diet. [Project 127; Departments of Poultry Husbandry and Chemistry; Adams funds.]

FEEDINGSTUFFS AND LIVESTOCK REMEDY CONTROL

The Feed Control Office of the station works with manufacturers, dealers, and consumers. Its purpose is to compel each feed or each remedy to be sold for exactly what it is and upon its own merits. A consumer is entitled to know what he is buying. A manufacturer or dealer is entitled to know what is being sold.

The work of the office during the year may be summarized as follows:

STATE REGULATORY WORK

FEEDINGSTUFFS

Inspectors' visits to towns	354
Inspectors' visits to firms or individuals	1,206
Firms or individuals registering feeds	767
Feeds registered	2,013
Official samples of feed analyzed	460
Feeds found not up to guarantee in one or more particulars.	166
Deficient in protein	146
Excessive in fiber	27
Deficient in fat	3
Citations for violation of feedingstuffs law issued but prosecution held in abeyance	9
Prosecutions for violation of feedingstuffs law filed	6
Cases filed but explained and dropped	1
Cases held in abeyance	1
Convictions obtained	4
Known number of rebates paid	4
Known amount of rebates paid	\$364.10
Commercial feed analyses made.	295
Office samples of feed analyzed	48

LIVESTOCK REMEDIES

Additions to livestock remedy registrations	36
Additions to number of firms registering livestock remedies	12
Total number of livestock remedy registrations	467
Total number of firms registering livestock remedies	180
Official samples of livestock remedies analyzed	3
Prosecutions and convictions under livestock remedy law	1

REGULATORY WORK IN COOPERATION WITH FEDERAL AUTHORITIES

Official samples analyzed	306
Found in compliance with the law and dropped	179
Found in violation of law in one or more particulars and prosecution recommended	127
Deficient in protein	71
Short in weight	37
Without statement of net weight or content,	37
Adulterated	6
Misbranded	3
Deficient in fat	1
Citations issued	66
Seizures consummated	14
Placed in permanent abeyance	7
Prosecutions filed in United States courts	27
Known number of rebates paid	23
Known amount of rebates paid	\$2,553.05
Shipments of feed returned to shipper on account of poor quality and cost refunded.	2

[Department of Milling Industry; feedingstuffs fees.]

BEE INVESTIGATIONS

Further data on wintering bees was secured by the repetition of the experiment conducted during 1917-18. Two sets

of three hives each were placed on scales. In each set there was one single-story hive, unpacked; one two-story hive, unpacked; and one packed hive. One set was placed in a protected place and one in the open. On the day of packing the amount of honey and the number of bees in each hive was ascertained. Daily weights were recorded as were also the direction of the wind and the wind velocity. At the beginning of the honey-flow the number of bees in each hive was again computed. The hives were then kept on the scales during the summer months to determine the actual and relative amounts of honey-flow.

The amount of honey consumed by the bees in the sheltered hives differed but little from the amount consumed by the bees in the unsheltered hives. The sheltered hives, however, wintered a larger number of bees than the unsheltered. The hives which were packed wintered the largest number. The number of bees wintered and the increase or decrease during the 150-day winter period in each of the six hives are shown by the following tabulation:

	Number wintered	Increase or decrease
<i>Unsheltered hives</i>		
One-story	11,718	—3,282
Two-story	16,406	—469
Packed	36,718	+22,968
<i>Sheltered hives</i>		
One-story	14,063	+313
Two-story	20,936	+5,936
Packed	38,594	+24,844

[Project 126; Department of Entomology; state funds.]

DISEASES OF FARM ANIMALS

One of the encouraging features of American agriculture during the past 10 years is the marked reduction in the losses of livestock from diseases. This improvement in the animal industries of the country has been due primarily to the discovery of methods of disease prevention and control by the Agricultural Experiment Stations and the United States Department of Agriculture, and to the increased interest which farmers have taken in these methods. Despite the marked recent improvement in connection with the animal disease situation in Kansas, the state still loses large numbers of farm animals annually. During the 12 months ending March 1,

1918, no fewer than 194,000 head of livestock died of diseases in this state. The losses were confined chiefly to swine, of which more than 84,000 were lost, and to cattle, of which more than 76,000 died of disease. The experiment station is carrying on some work in connection with the diseases of farm animals, especially with reference to blackleg in cattle and cholera in hogs. Some of this work is briefly described in the following pages.

BLACKLEG INVESTIGATIONS

During recent years this station has produced a blackleg aggressin which gives greater active immunity against blackleg than can be secured by the use of blackleg spore vaccines. More recently it has developed and produced a blackleg filtrate made by the filtration of cultural media after blackleg organisms have grown upon it. That this laboratory product—the blackleg filtrate—is as efficient as the natural” product—the blackleg aggressin—has been indicated by this year’s investigations. A total of 39,880 doses of the filtrate were distributed during the year and not a single adverse report was made.

A number of calves from four to six months of age were immunized with the filtrate, a corresponding number with the aggressin, and a few animals kept as checks. In from 12 to 14 days all of the animals were given a lethal dose of blackleg virus, with the result that no effects were noticed in those calves immunized by either the aggressin or the filtrate, though the checks succumbed. This indicates that blackleg filtrate is an efficient immunizing agent, comparing favorably with blackleg aggressin.

Attempts were also made during the year to develop a method of standardization of the filtrate. It appears that such standardization may be accomplished if normal horse serum is run against varying doses of filtrate and aggressin, and blackleg virus. This test seems quite uniform, but its value cannot be definitely determined, as so far no bad results have been reported from the vaccination with filtrate. A complete record has been kept of all filtrate, so that it can be traced back to its source should any bad results occur.

An effort was also made to determine whether guinea pigs could be used to test out blackleg filtrate and blackleg aggressin, but these laboratory animals do not react uniformly in such tests and therefore cannot be used for this purpose.

White rats and white mice were also tried out with the same object in view, but both proved to be naturally immune. This phase of the work will be continued in order to determine whether some laboratory animal cannot be found upon which these blackleg vaccines may be tested. At the present time, in so far as our knowledge is concerned, calves alone can be used for this purpose.

A series of tests have been started to determine the most suitable medium for the growth of blackleg organisms. The acidity of brain and liver media has always been tested with phenolphthalein as an indicator. With the assistance of the Department of Chemistry the foregoing reagent was found very inaccurate, and litmus was tried and proved to be more efficient. This phase of the work is in an early stage and will be continued, no positive results having as yet been determined.

[Department of Veterinary Medicine; blackleg receipts.]

STATE SERUM PLANT

At the State Serum Plant anti-hog-cholera serum and virus are produced primarily in the interest of developing a more economical and efficient means of controlling hog cholera. The serum plant is placed on a semi-commercial basis to promote progress in the investigation of methods of controlling hog cholera and to stimulate an educational campaign that will advance the swine industry. During the year more than three million cubic centimeters of anti-hog-cholera serum and 61,900 c.c. of virus were produced; and 2,363,700 c.c. of serum and 61,900 c.c. of virus were sold. The serum is produced by using all the latest laboratory apparatus, and always by using every possible means to avoid contamination. Only perfectly healthy hogs are used for serum production and each bleeding is preserved and put into a separated container until the hog is killed and a post mortem is held on the carcass to detect any disease or infection that could not be detected clinically. If an animal should prove to have tuberculosis or any other infectious or contagious disease, all its blood is destroyed without the contamination of other blood.

The serum is subjected to a careful test before it is mixed and bottled for shipment. It is tested for sterility and potency. The potency test must protect pigs weighing from 45 to 75 pounds by means of one-half the amount of serum given similar pigs in the field, and the pigs are given twice the amount

of strong virus ordinarily used for vaccinating similar pigs. The test involves seven susceptible pigs for each 100,000 c.c. of serum to be tested. Five of the pigs receive 20 c.c. of serum each and 2 c.c. of strong virus and the two remaining pigs receive 2 c.c. of strong virus as a check on the virus and susceptibility of the pigs. To have a passing test, the five pigs given serum and virus must all live, and the two given virus must sicken and die in from seven to fourteen days after injection. Serum which does not stand this test is considered below standard and is not used. During the last two years, every test has come up to the standard. The sterility test is carried on by the Department of Bacteriology.

Serum was sold in 52 counties of the state. The distribution of serum, however, does not indicate the condition of any particular district, as farmers and stockmen usually treat their hogs while in a healthy condition. Trouble cases came from various districts and from many causes. Many of the cases visited were from infection other than hog cholera but which are very confusing. They are sometimes called swine plague, hemorrhagic septicemia, mixed infection, or necrobacillosis. Ofttimes the presence of ringworms in pigs gives the characteristic appearance of hog cholera, till a post mortem is held, which usually shows the exact cause.

The superintendent of the serum plant has also, during the year, answered 110 professional calls, vaccinating 3,780 healthy, and 359 infected hogs. Only 35 of the herds visited contained any but healthy hogs. The cholera situation in the state during the last two years has not been serious and the loss from cholera has not been heavy. Owners are learning the advantages of treating healthy hogs. This has reduced the loss materially each year. The department is cooperating with government officials and the livestock men in the control of hog cholera. Further, demonstrations are put on any place in the state where unsatisfactory work has been done with the use of the serum and virus. [Department of Veterinary Medicine; anti-hog-cholera serum receipts.]

MISCELLANEOUS DISEASES OF FARM ANIMALS

During the winter, 1918-19, many cattle in scattered sections of the state died, apparently from feeding on wheat pasture. Several field investigations were conducted by members of the veterinary staff. Post mortems were held and in some in-

stances there was evidence of hemorrhagic septicemia. Blood samples were collected from all the animals on which an autopsy was held, and in eight cases laboratory examinations of this blood demonstrated that death had been due to the *bacillus bovisepiticus*, which is the cause of hemorrhagic septicemia in cattle. Not all cases, however, were due to this cause. An investigation near Cimarron where cattle were dying on wheat pasture disclosed that the dead animals were recent arrivals from Texas and they were in a very emaciated condition. They were unable to withstand the effects of a severe storm and therefore died as a result of exposure to severe weather.

The work did not indicate that there is anything poisonous in the wheat pasture itself, as believed by many livestock men, but that death is due to the fact that these fields become infected with the organisms of an infectious or contagious disease, and also that the unthrifty condition of many cattle makes them more susceptible not only to disease but also to unaccustomed exposure.

No serious outbreaks of diseases of horses occurred during the year. A few scattered cases were investigated, especially one in the vicinity of Belleville.

An investigation of the cause of deaths in a herd of two-year-old steers near Skiddy, justified a tentative diagnosis of oak poisoning. [Project 102; Department of Veterinary Medicine; state funds.]

POULTRY DISEASE INVESTIGATIONS

The work on this project takes account of the fact that losses in poultry are very high and the low unit value of an individual bird precludes extensive treatment for curative purposes. Infectious diseases must be controlled by prevention, or by curative measures that are cheap and easily applied.

The results obtained in 1917-18 were published in October, 1918.¹ The following cases have been studied during the past year: Roup, 77, white diarrhea, 7; cholera, 7; tuberculosis, 6; vent gleet, 6; tumors, 2; blackhead, 1; and miscellaneous, 17. From typical cases of roup 37 cultures have been isolated and by means of detailed study divided into two distinct groups. One group is very similar to the *B. avisepticus* and the other to *B. dysentery*.

A study of the immunity reactions of these cultures is well

¹ Bushnell, L. D., and Jackley, J. G. Poultry diseases. Kan, Agr, Expt, Sta, Cir, 70:1 21, Figs 1, 1918.

under way. Each culture is being used as an antigen and agglutination tests are being run on the blood serum of each sick bird which arrives at the laboratory. It is hoped by these tests to find a method for diagnosis.

The immune serum is also being used to aid in the classification of new cultures, as they are obtained. Vaccines have been made from each culture. When the serum from a chicken agglutinates a certain group the bird is treated with that specific vaccine. An attempt is also being made to find the proper amount of vaccine to be used so that one treatment will produce an immunity. [Project 85; Department of Bacteriology; state funds.]

RELATION BETWEEN ADEQUACY OF DIET AND IMMUNITY TO ROUP

A six months' test under laboratory conditions was begun in December, 1918, to determine whether feeds lacking in fat-soluble vitamine will predispose chickens to roup. Eight pens, each consisting of six females and one male, were fed on the following rations: Pen 1—Pearl hominy, 70 percent; corn bran, 7 percent; rice polishings, 5 percent; lard, 5 percent; ash mixture, 3 percent; and wheat gluten, 10 percent. Pen 2—Same feed as pen 1 except that butter replaced the lard. Pen 3—Same feed as pen 1 except that the pearl hominy was reduced to 60 percent and 10 percent by weight of oats included. Pen 4—Same feed as pen 3 except that the oats were sprouted. Pen 5 Corn. Pen 6—Corn, 90 percent; alfalfa, 10 percent. Pen 7—Kafir. Pen 8—Kafir, 90 percent; alfalfa, 10 percent.

At the end of each four-week period, two of the birds in each pen were inoculated with the roup organism. A natural virus from a typical case of ocular roup was used. It was pathogenic for rabbits, and one from which the roup bacillus could be isolated. The inoculation was made by sewing a string, saturated with the virus, through the eyelids of the birds. Cases of roup and number of deaths resulting were as follows:

	Pen No.							
	1	2	3	4	5	6	7	8
Jan. 13—Cases of roup.....	0	0	0	0	1	0	1	0
Number died.....	0	0	0	0	0	0	0	0
Feb. 11—Cases of roup.....	1	0	2	1	0	1	1	0
Number died.....	0	0	0	0	0	0	0	0
Mar. 11—Cases of roup.....	2	0	2	2	0	1	2	1
Number died.....	0	0	1	1	0	0	1	0
Apr. 8—Cases of roup.....	2	2	2	2	2	2	2	2
Number died.....	1	1	1	1	1	2	2	1
Apr. 29—Cases of roup.....	2	1	2	2	0	1	1	1
Number died.....	1	1	2	2	0	0	1	1

The greater susceptibility of pen 1, in which seven of the ten inoculations resulted in roup, as compared with pen 2, in which only three of the ten inoculations produced roup, was probably due to the inadequacy of the diet of pen 1, which was very low in the fat-soluble vitamine. Neither the sprouted oats in pen 4 nor the unsprouted oats in pen 3 proved beneficial to the diet, which was otherwise low in the fat-soluble vitamine. Pen 7, which was fed kafir alone, showed a much higher susceptibility to roup than did pen 5, which received only corn. The alfalfa included in the kafir feed in pen 8 seemed to have a beneficial result, but that added to the corn in pen 6 did not seem to be beneficial. There were no spontaneous cases of roup, although the affected birds were allowed to remain with the others. The inadequacy of the diet seemed to affect the male birds more than the females.

With these results obtained under laboratory conditions as a guide the work will be continued on the Poultry Farm under the usual conditions of poultry management. [Project 131; Departments of Bacteriology, Chemistry, and Poultry Husbandry; state funds.]

MISCELLANEOUS INVESTIGATIONS

INHERITANCE IN ORTHOPTERA

Previous to July 1, 1918, the inheritance of 14 multiple allelomorphic characters from nature, a fifteenth, a mutation in the same series in the laboratory, and two other independent characters had been studied in the grouse locusts of the species *Paratettix texanus*. Six characters, five multiple allelomorphs and one independent, have been tested out thoroughly in the species *Tettigidea parvipennis pennata* Bellomy. The results of these experiments have been published in four papers in the *Journal of Genetics*, February, 1914, and October, 1917. Studies have also been made previous to the present year, of parthenogenesis and crossing over (linkage) in the genus *Apotettix*.

During the present year special emphasis has been given to working out the linkage, or crossing over, relations among the eleven characters in *Apotettix*. Large numbers have been bred, and the data are to be assembled during the summer. Thus far, two, three, and four characters have been linked so

that they will breed perfectly true, respectively, and data as to how this has been accomplished are available and being assembled. These data indicate that these linkages take place on a definite percentage basis, and can be predicted as certainly as Mendelian segregation. Application of this principle in animal and plant breeding promises greater benefits economically than the principle of Mendelian segregation itself, possibly being adaptable to the production of double purpose breeds. Parthenogenesis in this group has been further studied, and the data are to be arranged. A preliminary paper, "Parthenogenesis and Crossing Over in the Grouse Locust *Paratettix*," was read before the holiday meeting of the American Society of Naturalists, in Baltimore, and was published in the *American Naturalist*, March-April, 1919. [Project 72; Department of Zoology; Adams funds.]

EFFECT OF VARIOUS CONSTANT TEMPERATURE AND MOISTURE CONDITIONS ON INHERITANCE IN ORTHOPTERA

During the past year several cultures were bred in the controlled breeding chambers, but no positive results were detected. The main effort, however, was devoted to finding out what the normal breeding results show. Till this is fully known, it is futile to try out unusual conditions. The results for several kinds of matings have now been determined and in the future there will be a *large* extension of effort to produce modified inheritance results with the special moisture and temperature conditions. [Project 104; Department of Zoology; Adams funds.]

CLIMATE AND INJURIOUS INSECT INVESTIGATIONS

The past work on this project has been devoted largely to the development of apparatus by means of which life-history studies could be carried on under controlled temperature and moisture conditions. Such studies have been made on the Hessian fly, the chinch bug egg parasite, and two species of aphids, —the corn-leaf aphids, *Aphis maidis* and *Macrosiphum granaria*. It was hoped during the past year to secure definite data on aphids for the causes of the appearance of winged and of sexual forms at certain seasons. War conditions, however, so reduced the available, competent help as to bring the work to a halt. It will be continued next year.

Supplementary life-history studies on the alfalfa hayworm

under four different types of conditions are being carried on at the present time. It is planned to continue these studies on other insects of economic importance. [Project 6; Department of Entomology; Hatch funds.]

THE BACTERIOLOGY OF CANNING

The Division of Home Economics put up 664 pint cans of asparagus in the summer of 1918 processed and treated in various ways. Bacteriological studies were made by the Agricultural Experiment Station to ascertain the influence of treatment upon the amount of spoilage. The data show that the addition of more than 1 percent of salt or 0.05 percent of acid decreased the time of processing necessary to prevent spoilage, but injured the flavor and palatability of the asparagus.

The following treatments prevented spoilage and at the same time gave a product of good flavor and appearance: (1) Asparagus treated with 1 percent of salt and heated for, respectively, 3.25 hours on 1 day; 1.25 hours each day for 2 days; 0.5 hour twice each day for 3 days; 0.75 hour twice each day for 2 days; 1.25 hours two times in 1 day; 0.75 hour twice on 1 day and once on the second day; or 1.25 hours twice on one day and once on the second day. (2) Asparagus treated with 0.05 percent of acid and heated for, respectively, 2.25 hours on 1 day; 0.75 hour each day for 3 days; 1.25 hours each day for 2 days; 0.5 hour twice each day for 2 days; 1.25 hours two times in 1 day; 0.75 hour twice on 1 day and once on the second day; or 1.25 hours twice on 1 day and once on the second day.

From the tests made, 119 cultures of obligate anærobes were obtained and 68 cultures of ærobes. The anærobes may be subdivided into four groups and the ærobes into seven groups. All but one culture of the organisms were spore-producing types. The percent of spoilage due to each type of culture was as follows: Ærobes alone, 17.4 percent; anærobes alone, 51.3 percent; ærobes and anaerobes, 31.3 percent.

Since all these organisms are spore formers they will be difficult to destroy by heat, and since many of them are anærobes proper sealing will not prevent their growth in the jars. [Project 120; Department of Bacteriology; state funds.]

BRANCH EXPERIMENT STATIONS

The branch experiment stations at Hays, Garden City, Colby, and Tribune are maintained for the purpose of supplementing the investigational work conducted at the main station at Manhattan, with particular reference to testing under western Kansas conditions the results secured at Manhattan, and of investigating agricultural problems peculiar to the four western Kansas districts in which the branch stations are located. The work of these stations was continued during the fiscal year, 1918-19, without material modifications in the general plans. A few of the features of the work of these stations are briefly discussed on the following pages.

FORT HAYS BRANCH EXPERIMENT STATION

The Fort Hays Branch Experiment Station consists of 3,600 acres of land equipped for investigational work with both crops and livestock. The principal general lines of work in progress include investigations in dry-land agriculture, cereal investigations, forage crop investigations, the management of a herd of range cattle with special attention to winter maintenance, the management of a dairy herd, the production of sheep, and the operation of the state forest nursery.

Crop Investigations.—The crop investigations are conducted on more than 1,600 experimental plots and on several somewhat larger fields used for the forest nursery and garden work. The dry-land agriculture investigations occupy approximately 300 plots upon which studies are made of various crop production methods, including continuous cropping, alternate cropping, rotations, various tillage methods, and studies of the relationship of moisture, nitrates, and temperature to crop production. The crops grown include wheat, alfalfa, corn, sorghums, and other crops grown in western Kansas.

The forage crop work which has been in progress on substantially its present basis for about six years is producing some particularly valuable results. These investigations include methods of seeding, rate of seeding, date of seeding, and various other cultural tests with alfalfa, forage sorghums, millets, sweet clover, and such annual legumes as Canada field peas, cowpeas, soybeans, and vetch. The work also includes that testing of a large number of varieties of these forage crops. Some of the results of the experiments with alfalfa are included in

Kansas station circular 73, "Growing Alfalfa in Western Kansas."

Range Cattle Work.—The herd of range cattle, which consists chiefly of grade Herefords but includes some Galloways, is maintained on native pasture during the summer months, and used extensively in the winter for the conduct of maintenance experiments. The experiments conducted during the fiscal year, 1918-19, included four lots of cows in an experiment to determine a satisfactory method of winter feeding in the development of breeding cows; two lots of cows and calves in a comparison of Russian thistle hay and alfalfa hay; three lots of heifers and herd bulls in an investigation to determine the cost of wintering; four lots of cows and calves in an experiment comparing linseed meal and cottonseed cake as supplements to feed grown in western Kansas; and two lots of mature cows in a comparison of kafir fodder and kafir silage. These experiments and others like them which are conducted each year are producing a large fund of information which is extremely useful to the agriculture of western Kansas, both with reference to the winter maintenance of range cattle and to the utilization of the waste materials and by-products of the agriculture of that region. During the year, 1918, the Fort Hays station produced 544 tons of alfalfa; 380 tons of wheat straw; 200 tons of sorghum fodder; 50 tons of corn fodder; 30 tons of Russian thistle hay; 25 tons of Sudan grass hay; and 800 tons of silage. The work of the station is developing and demonstrating the practicability of growing in western Kansas most of the feeds required for the satisfactory maintenance of range cattle.

Commercial Application of Results.—In order that the results secured in the experimental work with crops and animals at the Fort Hays station may be tested out on a commercial scale, the farm produces annually about 300 acres of alfalfa, from 300 to 400 acres of grain and forage sorghums, 100 acres of corn, and 600 to 700 acres of wheat. The acreages, together with large areas of pasture available to the station, make it possible to apply on a commercial scale the results secured experimentally. Ten silos, a grain elevator, and a seed barn make it possible for the station to handle its feed and seed situation satisfactorily. All these large scale operations sup-

plement the small scale work of the station in a way which materially increases the effectiveness of the experimental work.

GARDEN CITY BRANCH EXPERIMENT STATION

The work of the Garden City Branch Experiment Station is concerned both with irrigation agriculture and dry-land agriculture, as these two are important in the district represented by the station. The work conducted during the fiscal year, 1918-19, was substantially a continuation of the projects already under way. This work included dry-land crop rotation and tillage experiments, variety tests of crops both with and without irrigation, and investigations of the use of irrigation water.

Dry-Land Agriculture Investigations.—The work in the dry-land agriculture project was continued on substantially the same lines as in 1917. This work includes the testing of a large number of crop rotations, the continuous production of dry-land crops on the same land under various methods of tillage, and determinations of the adaptability of crops for dry-land conditions in southwestern Kansas.

Winter Irrigation.—A series of preliminary experiments in winter irrigation was completed and the results were published as station circular 72. The following table showing the yields of certain crops obtained with winter irrigation as compared with the same crops on adjacent land without irrigation in 1918, is typical of the results secured in the winter irrigation experiments at the Garden City Branch Experiment Station during a five-year period ending with 1918:

	GRAIN, BUSHELS PER ACRE		STOVER, TONS PER ACRE	
	Winter irrigated	Unirrigated	Winter irrigated	Unirrigated
Twentieth Century				
Yellow Dent corn.....	34.6	0.0	1.54	0.51
Colby Bloody				
Butcher corn	41.7	0.0	1.69	0.79
Dwarf Yellow milo.....	72.2	4.0	3.54	0.67
Dwarf Blackhull kafir...	47.8	5.6	3.38	0.85

The winter irrigation consisted of an application of approximately 18 acre-inches of water per acre in the late winter or early spring. No other irrigation was applied. The results of the five-year test show: (1) That very satisfactory yields of corn, mile, and kafir can be secured in the Garden City district with winter irrigation even when no summer irrigation

is practiced; (2) that the practice of winter irrigation is helpful in distributing the available water on a given tract of land over a large proportion of the land in a single irrigation at a time of year when there is no demand for irrigation for growing crops; (3) that the practice of winter irrigation distributes labor in such a way as to relieve materially the need for labor in irrigation during the busy summer season.

New Work.—With the completion of the first series of winter irrigation experiments and of a series of irrigation-frequency experiments, opportunity is afforded for starting new work at this station. The legislature of 1919 appropriated funds for the purchase of new pumping equipment which will add materially to the efficiency of the station and to its ability to serve southwestern Kansas. New experiments contemplated include an extensive test of a number of pasture crops, a series of crop rotation and soil fertility experiments, and a series of pasture tests with cattle and swine. Information which it is expected will result from these experiments can be made very useful in the development of a more satisfactory irrigation agriculture in the upper part of the Arkansas Valley in Kansas.

COLBY BRANCH EXPERIMENT STATION

The Colby Branch Experiment Station occupies 320 acres of land near the town of Colby in Thomas County. The work of this station includes investigations of crop production, tillage methods, conservation of moisture, and the operation of a small dairy. These investigations are of particular importance in the development of agriculture in northwestern Kansas.

Dry-Land Agriculture.—Investigations in dry-land agriculture include a large number of experiments in crop rotation and tillage methods. These experiments, which are planned to continue for a long period of years, are gradually producing very valuable material as to the effects on the soil of practicing different methods of crop rotation in northwestern Kansas.

Results with Dairy Herd.—During the year, 1918, the dairy herd consisted of 11 producing cows. This herd is regarded as being about the proper size for the ordinary farmer in western Kansas, where the grain grower wishes to diversify his agriculture to the extent of including a dairy. During the year, 1918, the highest producing cow in the herd produced 8,839

pounds of milk and 330 pounds of butterfat. The total receipts from the herd averaged about \$200 per month, the milk being sold in the town of Colby at 9 cents a quart. These cows were maintained on native pasture and on feeds produced at the branch station, with the exception of about \$600 worth of cottonseed meal and other concentrated feeds purchased during the year. The results which are being secured with the dairy herd at the Colby station show that it is entirely feasible for a grain farmer in western Kansas to operate a small dairy herd with great advantage to himself. Some of the important points to be considered in this connection are: (1) That the herd should contain only good cows; (2) that the size of the herd be kept small enough so that the dairy work does not present any serious labor problem; and (3) that the cows be bred so that their maximum production will come during the winter months and their minimum production during the harvest season, so as to get the advantage of high prices for dairy products and to reduce the labor difficulties of the mid-summer months.¹

Experiments with Furrow Drill.—The results secured by seeding winter wheat with a furrow drill continued to be satisfactory. The following table shows the yields secured in 1918 by the furrow-drill method as compared with the ordinary method of drilling in three fields, one of which grew a crop of kafir in 1917, one a crop of corn, and a third was fallow:

CROP GROWN IN 1917	—YIELD OF WHEAT, BUSHELS PER ACRE, 1918—		
	Furrow drill	Ordinary drill	In favor of furrow drill
Kafir	5.00	5.20	—0.20
Corn	13.70	9.30	+4.40
Fallow	15.40	12.15	+3.25

TRIBUNE BRANCH EXPERIMENT STATION

The work of the Tribune Branch Experiment Station was conducted on substantially the same lines as during the previous year. This work includes the production of varieties of various crops to test their adaptation to southwestern Kansas conditions, with particular reference to the beef cattle industry which is the major industry in that locality. Particular attention is being paid to the production of silage crops for use in winter feeding of range stock. In this connection experiments are conducted not only with various crop varieties but

¹ For further information write to the Agricultural Experiment Station, Manhattan, Kan, for station circular 81, "Suggestions Regarding Dairying in Northwestern Kansas."

also with different rates of seeding, crop rotation, and seedbed preparation. The results secured already are indicating the suitability of such crops as dwarf mile, dwarf kafir, and freed sorgo. Fairly satisfactory results have also been secured with millet and Sudan grass. The sorghum crops produced at the station are placed in silos and are later fed out during the winter to livestock and in this way much useful information is being secured with reference to wintering livestock in the extreme southwestern districts of the state.

PUBLICATIONS

STATION PUBLICATIONS

Three bulletins, two director's reports, and seven circulars were published and distributed during the fiscal year ending June 30, 1919. They were as follows:-

BULLETINS					
No.	TITLE	EDITION	PAGES	TOTAL PAGES	
219	Growing Wheat in Kansas.....	35,000	51	1,785,000	
220	Soil Fertility	30,000	40	1,200,000	
221	Farm Leases in Kansas.....	30,000	32	960,000	
REPORTS					
	Director's Report, 1916-17.....	2,500	50	125,000	
	Director's Report, 1917-18.....	2,500	63	157,500	
CIRCULARS					
69	Contagious Abortion of Cattle.....	40,000	16	640,000	
70	Poultry Diseases	20,000	21	420,000	
71	Safeguarding Feeders of Cottonseed Products.....	3,000	4	12,000	
72	Winter Irrigation for Western Kansas.....	5,000	8	40,000	
INSPECTION CIRCULARS					
7	Analyses of Inspection Samples of Fertilizers, 1917.....	2,500	16	40,000	
8	Kansas State Livestock Registry Board Report No. 8.....	6,500	149	968,500	
9	The Permit System of Cream-Buying	20,000	57	1,140,000	
Totals		197,000	507	7,488,000	

SUMMARIES OF STATION PUBLICATIONS

BULLETINS

219. *Growing Wheat in Kansas*, L. E. Call and S. C. Salmon. (51 Pp., 11 figs.) This bulletin discusses the various phases of wheat production in Kansas in considerable detail and gives briefly a few suggestions on marketing. The kinds of wheat to grow in the various sections of the state; the value of pure seed; the cause of yellowberry; the time to seed in areas where Hessian fly is abundant; treating seed wheat for smut; methods of seeding; rate of seeding; methods of preparing ground for wheat; rotations for wheat in central and in eastern Kansas; fertilizers for wheat; and marketing wheat are among the subjects discussed.

220. *Soil Fertility*, L. E. Call and R. I. Throckmorton. (40 pp., 11 figs.) This bulletin discusses the relative supply and demand of plant foods in Kansas soils; also methods of storing and applying manure and its value in increasing crop yields. Sections of the state which respond to commercial fertilizers and lime are pointed out by the use of maps, and fertilizer treatments are suggested.

221. *Farm Leases in Kansas*, W. E. Grimes. (32 pp., 9 figs.) This bulletin deals with the more common methods of leasing farms in Kansas, giving comparisons of the relative merits of these methods, undesirable conditions resulting from certain methods, and ways of improving tenancy conditions. The information given is based upon investigational data from farm management surveys.

REPORTS

Director's Report, 1916-17, W. M. Jardine; *Director's Report, 1917-18*, L. E. Call. (Report, 1916-17, 50 pp.; Report, 1917-18, 63 p. 5 figs.) Each report gives a brief summary of the work of the Kansas Agricultural Experiment Station during a fiscal year. The main features of each report are as follows: (1) Changes in the personnel of the station staff; (2) a statement of station publications and a partial list of article: contributed by members of the station staff to scientific journals; (3) statements of the most important lines of research supported by Adams, Hatch, and state funds, respectively; (4) a brief statement of the state control work -carried on by the station; (5) brief reports of the work of the branch experiment stations; and (6) a financial report covering all receipts and expenditures of the station for the fiscal year.

CIRCULARS

69. *Contagious Abortion of Cattle*, Department of Veterinary Medicine. (16 pp.) This circular explains briefly the nature, cause, symptoms, and methods of spread of abortion disease in cattle. It discusses somewhat in detail the control of the disease by (1) preventing the dissemination of infection, (2) developing herd immunity, and (3) treating affected animals. In view of the fact that there are many erroneous ideas in regard to abortion disease, a paragraph is devoted to a discussion of that phase of the subject. The circular as a whole may be considered as a review of established facts about abortion disease.

70. *Poultry Diseases*, L. D. Bushnell and J. G. Jackley. (21 pp.) This circular emphasizes the value of cleanliness and sanitation in the prevention and control of poultry diseases. The discussion of curative measures includes for each of the most important poultry diseases both information regarding symptoms and directions for treatment.

71. *Safeguarding Feeders of Cottonseed Products*, L. A. Fitz and A. E. Langworthy. (4 pp., 1 fig.) This circular gives feeders of cottonseed products brief but specific directions for checking the weight and quality of their purchases. It also gives instructions regarding taking official weights and samples by the Feed Control Office and securing for the purchasers refunds due for shortage in weight or deficiency in protein.

72. *Winter Irrigation for Western Kansas*, G. S. Knapp. (8 pp., 5 figs.) This circular discusses the advantages and requirements of winter irrigation. The statements are based on five years' experiments with corn, kafir, and milo at the Garden City Branch Station, the detailed results of which are given for the years, 1916, 1917, and 1918.

INSPECTION CIRCULARS

7. *Analyses of Inspection Samples of Fertilizers*, 1917, J. T. Willard, C. O. Swanson, and R. C. Wiley. (16 pp.) This circular gives a report of the analyses of 81 inspection samples of fertilizers taken from stocks offered for sale in the open market during 1917. An explanatory statement regarding the value of commercial fertilizers and also of barnyard manure and a financial statement covering receipts and expenditures from July 1, 1916, to June 30, 1918, are included in the report.

8. *Kansas State Livestock Registry Board Report No. 8*, F. W. Bell, Secretary. (149 pp.) After giving a few brief introductory articles, including one on the "Improvement of Public Service Stallions Since 1910," one on "Why Breed Draft Horses," others on the effect of the war on the horse situation in this country, and a chapter giving the Kansas law regarding the registration and licensing of stallions, this publication gives a list of all stallions licensed by the State Livestock Registry Board to stand for public service in' Kansas during the year 1918.

9. *The Permit System of Cream-Buying*, H. M. Jones, J. B. Fitch, and L. D. Bushnell. (57 pp., 24 figs.) This publication is a revised edition of State Dairy Commissioner's Bulletin No. 3. It was prepared especially for persons who are about to engage in the receiving, sampling, grading, and testing of cream. The subjects discussed include those of cream station equipment and conveniences; official instructions for receiving, sampling, testing, and paying for cream; cream grading; and other definite suggestions and instructions regarding the handling of a cream station in accordance with the provisions of the Kansas dairy law. A brief discussion on "Microorganisms in Relation to the Dairy Industry" is given.

PAPERS APPEARING IN SCIENTIFIC JOURNALS

In addition to the official publications heretofore listed, the staff members have prepared numerous papers along the various lines of applied science which make up the research activities of the station. Many of these papers have been presented at meetings of the respective scientific associations; many have appeared in leading scientific periodicals. A partial list of these publications is as follows:

"A Means of Transmitting the Fowl Nematode, *Heterakis papillosa* Bloch," J. E. Ackert, *Science*, n. s., vol. 46, no. 1190, p. 394. 1917.

"On the Life Cycle of the Fowl Cestode, *Davinea Cesticillus* Molin.," J. E. Ackert, *Journal of Parasitology*, vol. 5, pp. 41-43. 1918.

"Another Cestode from the Young Cat" J. E. Ackert and A. A. Grant, *Transactions of the American Microscopical Society*, vol. 36, no. 2, pp. 93-96. 1917.

"On the Transmission of Two Fowl Tapeworms" (Abstract), J. E. Ackert, *The Anatomical Record*, vol. 15, no. 6, p. 341. 1919.

"The Effect of Abnormal Temperatures Upon the Developing Nervous System in the Chick Embryos," Florence M. Alsop, *The Anatomical Record*, vol. 15, no. 6, pp. 307-331. 1919.

"Studies on Inheritance and Evolution in Orthoptera, IV," A. W. Bellomy, *Journal of Genetics*, vol. 7, no. 1, pp. 55-70. 1917.

"The Influence of the Separator Upon Distribution of Bacteria in Milk and Cream," L. D. Bushnell and O. W. Hunter, *Kansas Academy of Science*, pp. 61-69. 1918.

"The Microbial Flora of Graded Cream," L. D. Bushnell and O. W. Hunter, *Kansas Academy of Science*, pp. 69-76. 1918.

"The Control of the Codling Moth in the Arkansas Valley Fruit Belt," Geo. A. Dean and W. R. Martin, *Transactions of the Kansas State Horticultural Society*, vol. 35.

"Grasshopper Control in Kansas," Geo. A. Dean, E. G. Kelly, and A. L. Ford, *Journal of Economic Entomology*, vol. 12, no. 2, pp. 213-217. 1919.

"Insects Destructive to Grain and Grain Products Stored in Bins and Granaries," Geo. A. Dean, *Twenty-first Biennial Report of the Kansas State Board of Agriculture*, vol. 26, pp. 314-321. 1917-1918.

"Parallel Formation of Carbon Dioxide, Ammonia, and Nitrate in Soil," P. L. Gainey, *Soil Science*, vol. 7, no. 4, pp. 293-311. 1919.

"Soil Reaction and the Growth of Azotobacter," P. L. Gainey, *Journal of Agricultural Research*, vol. 14, no. 7, pp. 265-271. 1918.

"Effect of Carbon Disulphid and Toluol Upon Nitrogen-fixing and Vitrifying Organisms," P. L. Gainey, *Journal of Agricultural Research*, vol. 15, no. 11, pp. 601-614. 1918.

"Soil Reaction and the Presence of Azotobacter," P. L. Gainey, *Science*, vol. 48, no. 1232, pp. 139-140. 1918.

"Standardization of Blackleg Vaccines," L. W. Goss and Joseph P. Scott, *Journal of the American Veterinary Association*, vol. 7, no. 3, pp. 234-243. 1918.

"A Case of Superfetation in the Cat," Mary T. Harman, *The Anatomical Record*, vol. 13, no. 3, pp. 145-157. 1917.

"Another Case of Gynandromorphism," Mary T. Harman, *The Anatomical Record*, vol. 13, no. 7, pp. 425-433. 1917.

"A Probable Case of Superfetation in the Cow," Mary T. Harman, *The Anatomical Record*, vol. 14, no. 5, pp. 335-336. 1918.

"Abnormalities in the Chick Embryo," Mary T. Herman. *Science*, n.s., vol. 48, no. 1245, p. 476. 1918.

"The Life Cycle of *Lachnosterna lanceolata* Say," Wm. P. Hayes, *Journal of Economic Entomology*, vol. 12, no. 1, pp. 109-117. 1919.

"Bacteriological Studies on Alfalfa Silage," O. W. Hunter, *Journal of Agricultural Research*, vol. 15, no. 11, pp. 571-592. 1918.

"The Colon-Aerogenes Group of Milk," O. W. Hunter, *Journal of Dairy Science*, vol. 2, no. 2, pp. 108-129. 1919.

"An Electromagnetic Hypothesis of the Kinetics of Heterogeneous Equilibrium, the Structure of Liquids, and Cohesion," H. H. King and W. D. Harkins, *Journal of American Chemical Society*, vol. 41, no. 6, pp. 970-992. 1919.

"The Breed in Poultry, and Pure Breeding," William A. Lippincott, *Journal of Heredity*, vol. 10, no. 2, pp. 71-79. 1919.

"The Relation of Plumage to Ovarian Condition in a Barred Plymouth Rock Pullet," William A. Lippincott and Leon J. Cole of the University of Wisconsin, *Biological Bulletin*, vol. 36, pp. 167-183. 1919.

"The Toad as an Enemy of the Chinch Bug," J. W. McColloch, *Journal of Economic Entomology*, vol. 12, no. 1, p. 124. 1919.

"*Eleodes apaca* Say, an Important Enemy of Wheat in the Great Plains Area," J. W. McColloch, *Journal of Economic Entomology*, vol. 12, no. 2, pp. 183-194. 1919.

"Variations in the Length of the Flaxseed Stage of the Hessian Fly," J. W. McColloch, *Journal of Economic Entomology*, vol. 12, no. 3, pp. 252-255. 1919.

"Providing Winter Stores for Bees," J. H. Merrill, *Sixth Biennial Report of the Kansas Entomological Commission*, pp. 31-32. 1917-1918.

"Increased Consumption of Honey, J. H. Merrill, *Sixth Biennial Report of the Kansas Entomological Commission*, pp. 34-35. 1917-1918.

"Wintering Bees," J. H. Merrill, *Sixth Biennial Report of the Kansas Entomological Commission*, pp. 32-33. 1917-1918.

"Report of the State Apiarist," J. H. Merrill, *Sixth Biennial Report of the Kansas Entomological Commission*, pp. 20-21. 1917-1918.

"Winter Feeding of Bees," J. H. Merrill, *Sixth Biennial Report of the Kansas Entomological Commission*, pp. 33-34. 1917-1918.

"Beekeeping on the Farm," J. H. Merrill, *Twenty-first Biennial Report of the Kansas State Board of Agriculture*, vol. 26, pp. 309-314. 1917-1918.

"Spring Management of Bees," J. H. Merrill, *Circular No. 6. Kansas State Entomological Commission*.

"Methods of Increase," J. H. Merrill, *Sixth Biennial Report of the Kansas Entomological Commission*, pp. 28-31. 1917-1918.

"Making a Start with Bees," J. H. Merrill, *Sixth Biennial Report of the Kansas Entomological Commission*, pp. 25-27. 1917-1918.

"Sweet Clover as a Honey Plant," J. H. Merrill, *Sixth Biennial Report of the Kansas Entomological Commission*, pp. 36-37. 1917-1918.

"Parthenogenesis and Crossing-Over in the Grouse Locust *Apotettix*," Robert K. Nabours, *The American Naturalist*, vol. 53, no. 625, pp. 131-142. 1919.

"Studies on Inheritance and Evolution in Orthoptera, II and III," Robert K. Nabours, *Journal of Genetics*, vol. 7, no. 1, pp. 1-54. 1917.

"Apiculture in Boys' and Girls' Club Work," L. V. Rhine, *Transactions of the Kansas State Horticultural Society*, vol. 35.

"Determination of Acidity and Titrable Nitrogen in Wheat with the Hydrogen Electrode," C. O. Swanson and E. L. Tague, *Journal of Agricultural Research*, vol. 16, no. 1, pp. 1-13. 1919.

"Chemistry of Sweet Clover Silage in Comparison with Alfalfa Silage," C. O. Swanson and E. L. Tague, *Journal of Agricultural Research*, vol. 15, no. 2, pp. 113-132. 1918.

"Life History of the Honey Bee," M. C. Tanquary, *Sixth Biennial Report of the Kansas Entomological Commission*, pp. 37-42. 1917-1918.

PERSONNEL

The following changes in the personnel of the station staff have taken place during the year:

APPOINTMENTS

- F. M. Aiman, State Feedingstuffs Inspector.
- F. W. Atkeson, B. S., Assistant in Dairy Husbandry.
- F. W. Bell, B. S., Associate Professor of Animal Husbandry.
- H. W. Cave, M. S., Assistant Professor of Dairy Husbandry.
- Martha L. Denny, A. B., Assistant in Genetics.
- Hugh Durham, A. M., Assistant to Director.
- F. D. Farrell, B. S., Director.
- E. F. Ferrin, B. S., Associate Professor of Animal Husbandry.
- J. B. Fitch, B. S., Professor of Dairy Husbandry.
- G. C. Gibbons, B. S., Assistant Superintendent, Fort Hays Branch Station.
- C. B. Griffiths, D. V. M., Assistant in Blackleg Laboratories.
- N. D. Harwood, D. V. M., Assistant in Vaccine Laboratories.
- R. C. Jaccard, B. S., Nurseryman, Fort Hays Branch Station.
- C. W. McCampbell, B. S. A., D. V. M., Professor of Animal Husbandry.
- Ivar Mattson, Superintendent, Tribune Branch Station.
- H. B. Mugglestone, Superintendent of Poultry Farm.
- C. W. Mullen, M. S., Assistant Professor of Farm Crops.
- N. E. Olson, B. S., Assistant Professor of Dairy Husbandry.
- W. F. Pickett, B. S., Assistant in Horticulture.
- B. O. Severson,¹ M. S., Associate Professor of Animal Husbandry.
- H. B. Winchester, M. S., Assistant Professor of Animal Husbandry.

RESIGNATIONS

- L. T. Anderegg, Assistant in Agricultural Analysis.
- Clennie E. Bailey, Assistant in Genetics.
- R. K. Bennett, Assistant Professor of Crops.
- W. A. Cochel, Professor of Animal Husbandry.
- L. A. Fairchild, Assistant in Dairy Husbandry.
- George S. Knapp, Superintendent, Garden City Branch Station.
- R. A. Muttkowski, Instructor in Zoölogy.
- O. E. Reed, Professor of Dairy Husbandry.
- H. F. Roberts, Professor of Botany.
- R. W. Titus, Assistant Chemist.
- Ethel Vanderwilt, Instructor in Animal Husbandry.

¹ Deceased.

FINANCIAL STATEMENT

(The Kansas Agricultural Experiment Station in account with federal and state appropriations, 1918-19)

	Federal appropriations	State appropriations and receipts	Totals
Manhattan station	\$30,000 00	\$49,023 40	\$79,023 40
Branch stations		34,037 56	34,037 56
Branch station farm products			52,481 30
Totals			\$165,542 26
Salaries	\$17,108 09	\$24,510 97	\$41,619 06
Labor	7,905 35	38,034 80	45,940 15
Publications		9 32	9 32
Postage and stationery	220 42	834 14	1,054 56
Freight and express	103 58	1,629 93	1,733 51
Heat, light, water, and power	27 67	1,911 26	1,938 93
Chemicals, laboratory supplies	762 00	910 42	1,672 42
Seeds, plants, sundry supplies	684 78	10,028 23	10,713 01
Fertilizers		54 00	54 00
Feedingstuffs	1,245 78	10,691 18	11,936 96
Library	3 25	22 07	25 32
Tools, machinery, appliances	269 63	4,828 60	5,098 23
Furniture and fixtures	105 41	1,073 83	1,179 24
Scientific apparatus, specimens	453 15	163 82	616 97
Livestock	622 88	5,479 03	6,101 91
Traveling expenses	306 60	2,599 30	2,905 90
Contingent expenses		11,499 37	11,499 37
Buildings and land	181 41	2,358 47	2,539 88
Balance, June 30, 1919		18,903 52	18,903 52
Totals	\$30,000 00	\$135,542 26	\$165,542 26

We, the undersigned, duly appointed auditors of the corporation, do hereby certify that we have examined the books and accounts of the Kansas Agricultural Experiment Station for the fiscal year ending June 30, 1919; that we have found them well kept and classified as above, and that the receipts for the year from the treasurer of the United States are shown to have been \$30,000 and the corresponding disbursements \$30,000, for all of which proper vouchers are on file and have been by us examined and found correct.

WILBUR N. MASON
H. J. PENNEY
E. L. BARRIER