

# AGRICULTURAL EXPERIMENT STATION

KANSAS STATE AGRICULTURAL COLLEGE  
MANHATTAN, KANSAS

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## DIRECTOR'S REPORT 1924-1926



FOR THE BIENNIUM  
July 1, 1924, to June 30, 1926

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PRINTED BY KANSAS STATE PRINTING PLANT  
B. P. WALKER, STATE PRINTER  
TOPEKA 1926  
11-5356

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## KANSAS AGRICULTURAL EXPERIMENT STATION

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 W. F. PICKETT, *Orchard Investigations*.  
 ARTHUR H. HELDER, *Landscape Gardening*.

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 J. P. SCOTT, *Blackleg Investigations*.  
 N. D. HARWOOD, *Vaccine Production*.  
 C. H. KITSSELMAN, *Abortion Disease Investigations*.

#### ZOOLOGY.

- R. K. NABOURS, *in Charge*.  
 J. E. ACKERT, *Parasitology*.  
 ISABEL POTTER, *Genetics*.  
 G. E. JOHNSON, *Injurious Mammals*.

### BRANCH EXPERIMENT STATIONS

- |   |  |
|---|--|
| <p style="text-align: center;">FORT HAYS.</p> <p>L. C. AICHER, <i>Superintendent</i>.</p> <p style="text-align: center;">GARDEN CITY.</p> <p>F. A. WAGNER, <i>Superintendent</i>.</p> | <p style="text-align: center;">COLBY.</p> <p>B. F. BARNES, <i>Superintendent</i>.</p> <p style="text-align: center;">TRIBUNE.</p> <p>T. B. STINSON, <i>Superintendent</i>.</p> |
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\*On leave.

## LETTER OF TRANSMITTAL

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OFFICE OF THE DIRECTOR,  
June 30, 1926.

*To His Excellency, Ben S. Paulen, Governor of Kansas:*

I have the honor to submit herewith the report of the Agricultural Experiment Station of the Kansas State Agricultural College for the biennium ending June 30, 1926. The report includes a brief statement of the work in progress during this period, changes in personnel of the station staff, a list of publications of the station and of the scientific contributions of the station staff, and a statement of receipts and expenditures of the biennium under review.

L. E. CALL, *Director.*

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## DIRECTOR'S REPORT<sup>1</sup>

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### INTRODUCTION

The work of the Kansas Agricultural Experiment Station is organized around definite projects which have been carefully selected and planned. During the biennium ending June 30, 1926, these projects comprised investigations in a number of distinct fields as follows: Studies in the economics of agriculture; studies in soil conservation; investigations in the plant industries; investigations in the animal industries; studies in home economics; and a study of a number of miscellaneous agricultural problems. The following report makes brief mention of each of the more important projects in progress during the biennium and summarizes briefly the more important results secured in the conduct of the work.

### COÖPERATION WITH OTHER AGENCIES

The Kansas Agricultural Experiment Station has been fortunate in having cooperative relationships with a number of related agencies. The extensive cooperation that has existed in the past with the United States Department of Agriculture has been increased during the past two years and relationships have become even more cordial.

This cooperative work has included investigations in small grain production and breeding, corn breeding, and the control of cereal and forage crop diseases with the Office of Cereal Investigations; investigations in dry-land agriculture with the Office of Dry-Land Agriculture; and experiments with alfalfa, the sorghums, turf grass, and other forage crops with the Office of Forage Crop Investigations of the Bureau of Plant Industry; a survey of three counties with the Division of Land Classification and Survey of the Bureau of Soils; a study of factors influencing the palatability and quality of meat and other live-stock problems with the Division of Animal Husbandry of the Bureau of Animal Industry; and investigations in farm organization, cost of production, land utilization, wheat marketing, and hay grading in cooperation with the Bureau of Agricultural Economics. Cordial cooperative relations have existed with the Kansas State Board of Agriculture in analytical determinations

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1. Contribution No. 33 from the director's office.

of feeding stuffs, live-stock remedies, and dairy products; in the conduct of the seed-testing laboratory, and in a number of other important projects.

### THE PURNELL ACT

The most significant event affecting the Agricultural Experiment Station during the biennium covered by this report was the passage of the Purnell Act by the Sixty-eighth Congress which authorizes the more complete financial support of the agricultural experiment stations. This is the third specific act of Congress to provide for the support and enlargement of the agricultural experiment stations, the others being the Hatch Act approved by President Cleveland March 2, 1887, to provide for the establishment and maintenance of agricultural experiment stations, and the Adams Act approved by President Roosevelt March 16, 1906, to provide further support for more fundamental research in agriculture. The Purnell Act particularly authorizes investigations in the fields of agricultural economics, rural life, and home economics. The wording of the Purnell Act is as follows:

(PUBLIC—No. 458—68TH CONGRESS)

(H. R. 157)

AN ACT to authorize the more complete endowment of agricultural experiment stations, and for other purposes.

*Be it enacted by the senate and House of Representatives of the United States of America in Congress assembled, That for the more complete endowment and maintenance of agricultural experiment stations now established, or which may hereafter be established, in accordance with the act of congress approved March 2, 1887, there is hereby authorized to be appropriated, in addition to the amounts now received by such agricultural experiment stations, the sum of \$20,000 for the fiscal year ending June 30, 1926; \$30,000 for the fiscal year ending June 30, 1927; \$40,000 for the fiscal year ending June 30, 1928; \$50,000 for the fiscal year ending June 30, 1929; \$60,000 for the fiscal year ending June 30, 1930; and \$60,000 for each fiscal year thereafter, to be paid to each state and territory; and the Secretary of Agriculture shall include the additional sums above authorized to be appropriated in the annual estimates of the Department of Agriculture, or in a separate estimate, as he may deem best. The funds appropriated pursuant to this act shall be applied only to paying the necessary expenses of conducting investigations or making experiments bearing directly on the production, manufacture, preparation, use, distribution, and marketing of agricultural products and including such scientific researches as have for their purpose the establishment and maintenance of a permanent and efficient agricultural industry, and such economic and sociological investigations as have for their purpose the development and improvement of the rural home and rural life, and for printing and disseminating the results of said researches.*

SEC. 2. That the sums hereby authorized to be appropriated to the states and territories for the further endowment and support of agricultural experiment stations shall be annually paid in equal quarterly payments on the 1st day of January, April, July, and October of each year by the Secretary of the Treasury upon a warrant of the Secretary of Agriculture out of the treasury of the United States, to the treasurer or other officer duly appointed by the governing boards of such agricultural experiment stations to receive the same, and such officers shall be required to report to the Secretary of Agriculture on or before the 1st day of September of each year a detailed statement of the amount so received and of its disbursement on schedules prescribed by the Secretary of Agriculture. The grants of money authorized by this act are made subject to legislative assent of the several states and territories to the purpose of said grants: *Provided*, That payment of such installments of the appropriation herein authorized to be made as shall become due to any state or territory before the adjournment of the regular session of the legislature meeting next after the passage of this act shall be made upon the assent of the governor thereof duly certified to the Secretary of the Treasury.

SEC. 3. That if any portion of the moneys received by the designated officer of any state or territory for the further and more complete endowment, support, and maintenance of agricultural experiment stations as provided in this act shall by any action or contingency be diminished or lost or be misapplied, it shall be replaced by said state or territory to which it belongs, and until so replaced no subsequent appropriation shall be apportioned or paid to such state or territory, and no portion of said moneys exceeding 10 per centum of each annual appropriation shall be applied directly or indirectly, under any pretense whatever, to the purchase, erection, preservation, or repair of any building or buildings or to the purchase or rental of land. It shall be the duty of each of the said stations annually, on or before the 1st day of February, to make to the governor of the state or territory in which it is located a full and detailed report of its operations, including a statement of receipts and expenditures for the fiscal year next preceding, a copy of which report shall be sent to each of the said stations and the Secretary of Agriculture and to the Secretary of the Treasury of the United States.

SEC. 4. That on or before the 1st day of July in each year after the passage of this act the Secretary of Agriculture shall ascertain and certify to the Secretary of the Treasury as to each state and territory whether it is complying with the provisions of this act and is entitled to receive its share of the annual appropriations for agricultural experiment stations under this act and the amount which thereupon each is entitled, respectively, to receive. If the Secretary of Agriculture shall withhold from any state or territory a certificate of its appropriation, the facts and reasons therefor shall be reported to the President and the amount involved shall be kept separate in the treasury until the close of the next congress in order that the state or territory may, if it shall so desire, appeal to congress from the determination of the Secretary of Agriculture. If the next congress shall not direct such sum to be paid, it shall be covered into the treasury. The Secretary of Agriculture is hereby charged with the proper administration of this law.

SEC. 5. That the Secretary of Agriculture shall make an annual report to congress on the receipts and expenditures and work of the agricultural experiment stations in all of the states and territories, and also whether the appropriation of any state or territory has been withheld; and if so, the reason therefor.

SEC. 6. That congress may at anytime amend, suspend, or repeal any and all of the provisions of this act.

Approved, February 24, 1925.

Immediately upon the passage of the Purnell Act, the Executive Committee of the Land-grant College Association of America, cooperating with the Secretary of Agriculture, called a conference of executive officers of agricultural experiment stations and investigators in the United States Department of Agriculture to meet at St. Louis, Mo., on April 20 and 21, 1925. The purpose of the conference was to reach a decision upon a number of fundamental investigations of a national character which might be attacked coöperatively by the various agricultural experiment stations and by the federal Department of Agriculture. The following projects were approved:

1. Distribution and marketing of farm products.
2. The problem of surpluses of farm products.
3. The vitamin content of food in relation to human nutrition.
4. Rural home management studies.
5. Rural social organizations and agencies essential to a permanent and effective agriculture.
6. Factors which affect the palatability and quality of meats.

The Kansas Agricultural Experiment Station has already started a number of projects of an agricultural, economic and home economic character under the provisions of the Purnell act.

#### **THE SOIL SURVEY RESUMED**

At the request of the Agricultural Experiment Station, the legislature of 1925 made an appropriation of \$5,000 per annum to provide for the resumption of the state soil survey. Prior to this a reconnoissance survey had been made of the western half of Kansas by the Bureau of Soils of the United States Department of Agriculture; and detailed surveys had been made by the Agricultural Experiment Station cooperating with the Bureau of Soils of about twelve counties in the eastern half of the state. At this time there were 51 counties in the eastern part of the state which had not been surveyed.

With the funds made available as a result of this appropriation,

soil-survey work was resumed in cooperation with the Bureau of Soils, and at the end of the period covered by this report a detailed survey had been made in part of Clay, Labette, and Wilson counties. It is planned to push these fundamental investigations of our soil resources as rapidly as the support for the work will permit.

#### **AGRICULTURAL DEVELOPMENT IN SOUTHWESTERN KANSAS**

The past two years has been a period of rapid agricultural development throughout western Kansas, but especially in the southwestern part of the state. The acreage of land under cultivation in the six southwestern counties, consisting of Grant, Haskell, Morton, Seward, Stanton, and Stevens, more than doubled between 1915 and 1924 and an additional 150,000 acres of sod land was brought under cultivation in this area in 1925. This development is the more remarkable because it has taken place during a period of agricultural unrest, unsatisfactory returns on many agricultural investments in the older, better-established farming regions, and during a time of general farm retrenchment. It undoubtedly is the result of the working out of natural causes which have made possible the development of the region under present economic conditions. The causes which have contributed to this result are: (1) A level tract of fertile, comparatively cheap sod land adapted to the use of power machinery; (2) the development of tractors, combined harvester-threshers, and other large-scale power machinery that has lowered the cost of producing farm crops, especially wheat, under level, dry-land conditions; (3) the introduction and development of varieties of crop plants adapted to the region; and (4) climatic conditions during recent years somewhat more favorable than the average, resulting in fewer crop failures, thus encouraging and providing capital for the purchase of farm machinery.

There is every indication that the rapid development of this territory will continue at least for a few years. This may result in too rapid a change in agricultural practices, thus leading to undesirable economic and social conditions. Meantime, the Agricultural Experiment Station is endeavoring to secure facts which will help to place the agriculture of the region on a permanently safe and sound basis.

### INCREASED INTEREST IN IRRIGATION IN THE ARKANSAS RIVER VALLEY

The upper Arkansas river valley in Colorado is one of the important irrigated regions of the central part of the United States, thus appropriating the natural stream flow before the river enters Kansas. There is, however, an extensive underflow throughout the valley which is capable of being utilized by pump irrigation. It is estimated that more than a million acres of Arkansas river valley land in Kansas may be irrigated in this way.

Public sentiment regarding irrigation agriculture in the Arkansas river valley in the past has fluctuated greatly. There has been an awakened interest in it in the last three years due to a greater appreciation of the need for higher yields per acre and an increased demand for specialized crops which it is thought may be grown successfully under irrigation. A number of pump irrigation units scattered along the valley but centered primarily in the vicinity of Garden City, Dodge City, Larned, Hutchinson, and Wichita have been established.

Irrigation agriculture in the valley presents a number of problems in need of study by the Agricultural Experiment Station. American experience with irrigation has shown that it is usually unsafe for the irrigation farmer to depend exclusively upon the production of crops which are extensively grown on adjacent unirrigated land. As a rule, successful irrigation has developed where there was an opportunity to produce specialized crops. It is thought, therefore, that if irrigation farming in this region is to be successful, it will be necessary to introduce into the farming system a number of specialized crops adapted to the region. To determine the best crops for this purpose presents a problem that will receive the attention of this station. Such a study, it is hoped, may be made in advance of extensive irrigation developments.

#### LAND AND BUILDINGS

Three small tracts of land, totaling in all approximately 22 acres, have been purchased for the Agricultural Experiment station during the past year. The Moseley tract and adjoining land, a total of about seven acres, was purchased to provide increased facilities for the Departments of Botany and Entomology, and to permit these departments to make a more careful field study of diseases and insect pests. The Gish farm, a tract of 12 acres lying north of the present poultry plant, was purchased to provide additional land for

experimental work in poultry husbandry. The Aye tract, of approximately three acres, was purchased to provide a larger area for plant-breeding work in the Department of Agronomy. These tracts replace in part land released by the Departments of Agronomy, Botany, and Entomology for physical education purposes.

Two greenhouses, each 30 by 100 feet, to be divided into several sections are now under construction. These houses will be equipped with refrigeration machinery, brine tanks, low temperature rooms, and hardening rooms, and will provide additional greenhouse facilities for the Departments of Agronomy and Botany for the purpose of enabling these department to investigate the problems of winter hardiness of crop plants and plant diseases.

A college library now under construction, to cost when completed a quarter million dollars, will provide additional library facilities for the Agricultural Experiment Station.

#### PERSONNEL

The resignation of W. M. Jardine as President of the College in July, 1925, to become Secretary of the United States Department of Agriculture, resulted in the advancement of F. D. Farrell, Director of the Agricultural Experiment Station, to President of the College; L. E. Call from Agronomist in charge to Director of the station, and R. I. Throckmorton, of the Department of Agronomy, to Agronomist in charge. Other changes in the station staff which have occurred during the past biennium have been as follows:

#### APPOINTMENTS

- A. E. Aldous, in charge pasture management investigations.
- Lilian Baker, clothing and textiles.
- Harry R. Bryson, in charge staple crop insect investigations.
- E. C. Converse, in charge of meteorological investigations.
- Margaret Chaney, food economics and nutrition.
- F. L. Duley, soils.
- Leila Dunton, food economics and nutrition.
- Harold Hedges, instructor in marketing.
- Katherine Hess, clothing and textiles.
- Harold Howe, instructor in marketing.
- Margaret M. Justin, in charge home economics.
- Martha M. Kramer, human nutrition.
- Allan P. Loomis, superintendent of poultry farm.
- W. H. Martin, in charge dairy manufacturing.
- R. H. Painter, in charge plant resistant insect investigations
- Isabel Potter, assistant in genetics.
- W. H. Riddell, in charge official tests of dairy cows.
- Ralph H. Parker, in charge apiculture.

**RESIGNATIONS**

- Wm. P. Hayes, in charge staple crop insect investigations.
- Harold Hedges, instructor in marketing.
- F. L. Hisaw, in charge of injurious mammal investigations
- P. C. McGilliard, in charge of official tests of dairy cows.
- J. H. Merrill, in charge of apiculture.
- H. B. Mugglestone, superintendent poultry farm.
- N. E. Olson, in charge dairy manufacturing.
- Caroline Perkins, assistant in genetics.
- Pearle Ruby, food economics and nutrition.

## SCOPE OF THE STATION WORK, JULY 1, 1924, TO JUNE 30, 1926

A list of the principal active projects carried on during the biennium ending June 30, 1926, is given below, together with a statement of the source of financial support in each instance and reference to the discussions included in the report:

NAME.	Project No.	Departments.	Funds.	Discussed on page
Studies in Farm Organization and Cost of Production . . . . .	95	Agricultural Economics . . . . .	Purnell and State . . . . .	18
Investigations in Land Tenure and Other Land Problems . . . . .	132	Agricultural Economics . . . . .	Purnell and State . . . . .	21
The Marketing of Kansas Wheat . . . . .	143	Agricultural Economics and Milling Industry . . . . .	Purnell and State . . . . .	22
The Economics of the Poultry Industry on Kansas Farms . . . . .	144	Agricultural Economics . . . . .	Purnell and State . . . . .	27
The Marketing of Kansas Live Stock and Live-stock Products, . . . . .	149	Agricultural Economics . . . . .	Purnell and State . . . . .	28
Soil Fertility Investigations . . . . .	17	Agronomy . . . . .	Hatch and State . . . . .	29
The Residual Effect of Alfalfa on the Soil . . . . .	17	Agronomy . . . . .	Hatch and State . . . . .	31
Tillage Investigations . . . . .	18	Agronomy . . . . .	Hatch . . . . .	32
Plant Nutrition Investigations . . . . .	. . . . .	Agronomy . . . . .	State . . . . .	34
The Relation of the Absolute Reaction of the Soil Solution to the Quantity of Nitrogen Fixed by Azotobacter . . . . .	128	Bacteriology . . . . .	Adams . . . . .	34
A Study of the Soil Solution as Governed by H-ion Concen- tration . . . . .	155	Chemistry . . . . .	State . . . . .	35
Work on the Flora of Kansas . . . . .	137	Botany . . . . .	State . . . . .	36
Chemical Analysis of Important Crops . . . . .	152	Chemistry, Botany and Agronomy . . . . .	State . . . . .	36
Drought Resistance in Crop Plants . . . . .	74	Botany . . . . .	State . . . . .	36
Temperature in Relation to Crop Plants . . . . .	157	Agronomy . . . . .	Purnell . . . . .	37
Small Grain and Sorghum Improvement . . . . .	67	Agronomy . . . . .	Hatch . . . . .	39
A Genetic Study of Aberrant and False Wild Types in Kanota Oats . . . . .	146	Agronomy . . . . .	Adams . . . . .	43
Sorghum Varietal Tests . . . . .	129-1	Agronomy . . . . .	Hatch and State . . . . .	44



SCOPE OF THE STATION WORK—CONTINUED.

NAME.	Project No.	Departments.	Funds.	Discussed on page
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Alfalfa Production Experiments . . . . .	129-3	Agronomy . . . . .	Hatch and State . . . . .	45
The Production of Soy Beans and Cowpeas . . . . .	129-4	Agronomy . . . . .	Hatch and State . . . . .	46
Corn Production and Improvement . . . . .	156	Agronomy . . . . .	Purnell . . . . .	46
Turf and Lawn Grass Experiments . . . . .	167	Agronomy and Horticulture . . . . .	State . . . . .	47
Bindweed Eradication with Chemical Sprays . . . . .	166	Chemistry and Agronomy . . . . .	State . . . . .	48
Coöperative Experiments with Crops . . . . .		Agronomy . . . . .	State . . . . .	50
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The Quality of Wheat as Influenced by Cropping Systems and Fertilizer Treatments . . . . .	60B	Milling Industry . . . . .	State . . . . .	52
The Quality of Wheat as Affected by Seedbed Preparation and Tillage Methods . . . . .	60C	Milling Industry . . . . .	State . . . . .	52
The Relation of Variety to the Quality of Wheat . . . . .	60D	Milling Industry . . . . .	State . . . . .	53
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A Study of the Protein Content of Some Common Kansas Wheat Varieties . . . . .	60F	Milling Industry . . . . .	State . . . . .	54
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Flour Chemistry Investigations . . . . .	60	Chemistry and Milling Industry . . . . .	State . . . . .	57
Orchard Investigations . . . . .	25	Horticulture . . . . .	State . . . . .	58
Small Fruit Investigations . . . . .	26	Horticulture . . . . .	State . . . . .	62
Experiments with Vegetables . . . . .	27	Horticulture . . . . .	State . . . . .	64
Tree Investigations . . . . .	82	Horticulture . . . . .	State . . . . .	64
Cereal and Forage Crop Disease Investigations . . . . .	76	Botany . . . . .	State . . . . .	66
Fruit and Vegetable Disease Investigations . . . . .	130	Botany . . . . .	State . . . . .	70

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### STUDIES IN THE ECONOMICS OF AGRICULTURE

The Department of Agricultural Economics under whose direction the studies in this field have been conducted has continued to make the same rapid and substantial growth that has characterized its work in the past. Increased financial support as a result of the passage of the Purnell Act has made it possible to strengthen and enlarge those projects which were in existence before the passage of this act and to add other projects, thus strengthening this phase of investigational work. During the past two years, work has been prosecuted along five major lines, each of which is briefly discussed on the following pages.

#### **Studies in Farm Organization and Cost of Production.**

The year 1924 completed a five-year study on cost of production routes in McPherson and Jackson counties. The field work was ended as soon in 1925 as was practicable and the records for both counties were summarized. Preparation for publication of the major portion of the data covering the first four years in McPherson county which had already been begun, was completed. Mimeographed material showing the cost of producing corn, wheat, and oats for five years in both counties, except wheat in Jackson county for 1924, has been prepared. Another route was started about March 1, 1925, in Bourbon county where dairying is the chief enterprise. The first year's records are now being summarized and analyzed.

After an analysis of the McPherson and Jackson county data it has been possible to suggest standard labor and material requirements for crop and live-stock production which are applicable over a much wider territory than that from which the data were collected. The standards for crop production in the McPherson county area may be illustrated by the requirements for wheat as shown in Table I.

TABLE I.—Standard requirements for wheat operations in McPherson county.

OPERATION AND SIZE AND TYPE OF EQUIPMENT .	Hours of man labor per acre.	Hours of horse work per acre.	Acres per 10-hour day.
Plowing:			
2-bottom gang plow and 5 horses	1.80	9.00	5.6
2-bottom gang plow and 4 horses	2.25	9.00	4.4
16-inch sulky plow and 3 horses	3.00	9.00	3.3
Disking:			
8-foot disk and 4 horses (single disking)	.50	2.00	20.0
Harrowing:			
3-section harrow and 5 horses	.29	1.43	35.0
Drilling:			
8-foot drill and 4 horses.	.50	2.00	20.0
Listing:			
1-row lister, 4 horses	1.00	4.00	10.0
Working down ridges:			
2-row sled, 4 horses	.50	2.00	20.0
Binding:			
7-foot binder, 4 horses (14 bushels)	.75	3.00	13.3
Shocking:			
14-bushel yield	.75		13.3
Stacking bundles:			
3 men and 2 teams (14-bushel yield)	1.50	2.00	20.0
Heading:			
6 men and 10 horses, 10-foot header (14-bushel yield)	2.00	3.33	30.0

The usual range for seed was from three to five pecks per acre. Twine varied with the yield of straw but was approximately two pounds per acre.

For the Jackson county area, corn may be taken as an illustration. These data are shown in Table II.

TABLE II.—Standard requirements for corn operations in Jackson county.

OPERATION AND SIZE AND TYPE OF EQUIPMENT	Hours per acre one time over.		Usual times over.	Acres per 10-hour day, one time over
	Man.	Horse		
Plowing:				
2-bottom 14-inch gang and 5 horses	2.0	10.0	} .60	{ 5.0
2-bottom 12-inch gang and 4 homes	2.5	10.0		
16-inch sulky and 3 horses	3.5	10.5		
Listing for:				
1-row lister and 4 horses	1.25	5.0	.25	8.0
Disking:				
16-disk and 4 horses	.60	2.40	} .90	{ 16.6
14-disk and 4 horses	.67	2.68		
Harrowing before planting:				
3-section and 4 horses	.40	1.60	} 75	{ 25.0
2-section and 4 horses	.50	2.00		
Planting:				
2-row furrow opener and 4 horses	.80	3.20	.25	12.5
2-row planter and 2 horses	.67	2.68	.15	15.0
1-row lister and 4 horses	13.5	5.4	.60	7.4
Harrowing after planting:				
3-section and 4 horses	.30	1.20	} .75	{ 33.0
3-section and 3 horses	.40	1.20		
2-section and 3 horses	.50	1.50		
Monitoring:				
2-row and 4 horses	.80	3.20	} .50	{ 12.5
1-row and 2 horses	1.35	2.70		
Cultivating:				
2-row and 4 horses	.80	3.20	} 2.50	{ 12.5
1-row and 2 horses	1.35	2.70		
Husking from standing stalk.				
1 man and team—30-bushed yield	3.00	10.00	75	2.0
Cutting:				
Corn binder and 3 horses	1.70	5.0		6.0

The quantity of seed used was about 7.5 pounds per acre. Twine required for binding was approximately two pounds per acre.

Standards for live stock may be illustrated by work horses for both counties. This shows how differences may exist in different regions. (Table III.)

TABLE III.—Standard requirements for work horses in McPherson and Jackson counties.

	McPherson county, 1,200-lb horse working 700 hours	Jackson county, 1,200- to 1,400-lb horse working 1,000 hours
Grain	2,000 lbs.	3,000 lbs
Alfalfa hay	800 lbs.	1,500 lbs
Clover and timothy hay	.....	1,000 lbs
Prairie hay	1,400 lbs	.....
Sorghums, forage	.....	750 lbs
Fodder	2,000 lbs	500 lbs
Pasture	150 days	100 days
Cash costs: Veterinary, medicine, shoeing, etc	\$0 50	\$1.00
Man labor	50 hours	60 hours
Horse labor	15 hours, free access to straw in winter.	10 hours, little straw utilized by work horses

With standards of production for each enterprise within a farming area and with typical labor distributions, it becomes much easier to point out strong and weak points in present farm organizations. Reorganization for efficiency and profit is greatly facilitated. Several farms have been reorganized to illustrate how these standards may be used.

Additional phases of the McPherson county data are to be prepared for publication. Especial emphasis is to be placed upon the importance of live stock in the farming systems of central Kansas. Effects of diversification by this means upon the various factors of the farm organization, such as distribution of labor and receipts, will be emphasized and standards of production will be presented.

The Jackson county material is in such a form as to be of much value as an office reference upon many phases of crop and live-stock production for the corn belt section of Kansas. Analysis of certain phases of these data will be continued. An important use of this material is for comparison with similar data from different sections of the state. A complete analysis of these data will form the basis for important publications on farm organization problems. [Project 95; Department of Agricultural Economics; Purnell and state funds.]

#### **Investigations in Land Tenure and Other Land Problems.**

The work during the last biennium has consisted of a continuation of the studies in taxation, especially land taxation. Following publication of Bulletin 232, "Assessment and Equalization of Farm and City Real Estate in Kansas," in July, 1924, the work was continued and the results published, December, 1924, in Bulletin 234, "Tax Revision in Kansas."

In the meantime, work was continued on data and other material for Bulletin 235, "The Trend of Real Estate Taxation in Kansas from 1910 to 1923." This manuscript was completed in the spring of 1925 and the bulletin published in September of the same year. This probably constitutes the most fundamental study of the taxation series issued to date.

The work for the past year is embodied in a manuscript entitled "Federal Aid as a Part of a Long-Time Agricultural Policy, with special reference to the distribution of tax levies." This manuscript has been submitted for publication as a station bulletin, and as a part of the taxation series. Project 132; Department of Agricultural Economics; Purnell and state funds.

**The Marketing of Kansas Wheat.** The work on this project is divided into seven phases. Phases I and IV were inactive during the past biennium. The five active phases are briefly discussed below.

*The Availability of Short-time Bank Credit and Its Effect on the Marketing of Wheat.* Work during the past biennium has consisted of the tabulation and classification of data obtained through the State Board of Agriculture in 1924 for the purpose of checking the 1922 and 1923 data obtained by the Agricultural Experiment Station. The per cent of the wheat crop marketed early because of farmers' inability to get local bank credit is shown in Table IV.

TABLE IV.—Relation of farmers' ability to secure local bank credit to time of marketing wheat.

YEAR.	Total number of farms reporting	Total crop	Crop sold because of credit needs	Per cent
1922 (a).....	251	<i>Bus.</i> 361,413	<i>Bus.</i> 37,342	10 3
1923 (a).....	443	510,863	63,977	12 5
1924 (b).....	643	1,634,610	180,481	11 0

(a) Data collected by Agricultural Experiment Station  
(b) Data collected by State Board of Agriculture.

The study to date indicates that, taking the state as a whole, approximately 10 to 12 per cent of the wheat crop is being marketed, earlier than it otherwise would be, because of inability on the part of some farmers to get local bank credit. The movement of wheat from central, south central, and southwestern Kansas counties seems to be more influenced by the credit factor than that of other sections of the state.

*Local Elevator Costs in Handling Wheat.* During the last biennium data on the cost of operating country elevators for the three seasons, 1920-'21, 1921-'22, and 1922-'23, were assembled into bulletin form under the title "Country Elevator Margins and Costs in Marketing Kansas Wheat." The study has attempted to answer the following questions bearing on the local market for wheat: (1) Is the margin on which country elevators in Kansas buy grain too large? (2) Do costs of operating local elevators justify any such margin as that taken? (3) Are costs of operation themselves reasonable or are they the result of inefficiency? (4) What can be done to keep this

local buying margin at as low a figure as is consistent with safe business?

A summary of data leads to the following general conclusions: That in ordinary years margins and expenses seem to be fairly closely adjusted to each other. They permit of an average net profit of about two cents a bushel, but under these conditions perhaps one-third of the elevators of the state earn no profit and many of them suffer losses.

The local buying margin for wheat must be set at such a figure as will in some way take into account a number of accidental factors which constitute the element of risk in local elevator operation. These factors are violently fluctuating terminal market prices, fluctuations in the size of crop, amount of competition to be met, and quality of crop.

Aside from these accidental factors, certain fixed operating costs, of which salaries and wages are about 75 per cent, very largely determine what the local buying margin must be. A line of elevators, in locations selected with a view to lessening the risk from local crop failure has some advantages, since cost of operation is influenced so largely by volume of grain handled.

The elevators with low costs of operation are not always the most profitable elevators.

Elevators with high operating costs but obtaining a high average price for the season are able to pay as good prices to the producer as some elevators with low costs but averaging a lower price for the season on their sales.

The ability to choose the sales method that gives best results, knowledge of the milling quality of wheat, and some attention to seasonal price trends are important elements in the local elevator manager's sales ability.

The advantage which cooperatives generally have in a larger volume of business is sometimes offset by the selling ability of private competitors. No further work is planned on this phase of the project.

*High and Low Protein Wheat Areas.* The work on this phase of the project during the past biennium has consisted in the preparation of a manuscript in cooperation with the Department of Agronomy and the Department of Milling Industry entitled, "How to Grow and Market High-protein Wheat." Data for the 1924 crop

were obtained from the books of one Kansas City grain firm. No 1925 data were collected.

The variation in protein content of wheat in an extensive area in central Kansas is shown in Table V. This table shows the average protein content by counties for each of seven crop years, 1917-'18 to 1923 -'24. It also shows the range in protein content from county to county (reading up or down columns) and the range from season to season in the same county (reading across the table). The average range in protein content from county to county any one year has been found to be about as great as the range from one crop year to another. There is likely to be as much variation in any one county as there is from season to season. This makes the geography of quality wheat of importance to any marketing organization handling wheat in quantity for mill trade.

It will be seen by examining the data presented in Table V that there are no invariably low or high protein areas in the principal wheat belt. There is a certain variation dependent upon the season that keeps any county or group of counties from always ranking at the top or the bottom. Regardless of this shifting, however, there is a certain consistency on the part of some counties to rank above or below the average. For instance, only once in seven years did Comanche county fall below the average of 12.5 per cent, and in three years out of the seven the county average was the highest of the seventeen representative counties.

Apparently a section beginning with Comanche county and extending west to Seward, thence north to Trego and east to and including Russell county, then southwest to and including Ford county, contains a considerable area where soil and climatic conditions are frequently favorable to the production of high quality wheat.

*Shrinkage and Damage in Farm Storage.* During the past biennium a study has been made of all the wheat harvested with combine harvesters on five farms near Stafford, Kan. The purpose of the study was (1) to determine in so far as possible under field conditions the extent to which heating takes place with varying moisture, with different types of storage bins, and with different degrees of protection from outside temperatures; (2) to determine to what extent heating is due to immature grain and to what extent it is due to rain or dew on the wheat at time of storage; and (3) to study the extent to which there is heating of combine wheat when it is stored under ordinary farm conditions, the temperatures reached under dif-

TABLE V.—Showing average protein content of wheat by counties and crop years.  
 (Central Kansas)

COUNTY	1917-'18	1918-'19	1919-'20	1920-'21	1921-'22	1922-'23.	1923-'24	Average	Range
Barber	12.6	14.7	12.9	13.1	12.7	11.0	12.3	12.8	3.7
Barton	12.2	14.2	12.5	11.8	13.4	11.8	12.1	12.6	2.4
Butler	11.7	14.1	12.9	12.9	12.1	12.5	12.9	12.7	2.4
Cloud	10.8	15.2	12.5	11.7	12.3	12.9	12.5	12.6	4.4
Cowley	10.4	12.8	12.8	13.2	12.2	13.0	12.3	12.4	2.8
Comanche	14.3	14.6	13.2	13.4	12.5	12.4	13.0	13.3	2.2
Harper	11.9	13.7	12.6	13.7	11.3	11.7	12.5	12.5	2.4
Harvey	11.0	14.2	12.8	14.1	11.6	12.1	12.2	12.6	3.2
Kingman	12.3	13.5	12.4	13.6	11.8	12.3	12.6	12.6	1.7
Marion	12.3	12.5	13.1	13.2	11.9	12.5	12.7	12.6	1.3
McPherson	11.4	13.5	12.6	13.5	11.7	11.5	12.3	12.4	2.0
Pratt	12.7	13.8	12.5	12.5	11.4	11.8	11.9	12.4	2.4
Reno	11.3	13.4	12.0	13.6	12.0	12.2	12.2	12.4	2.1
Rice	11.3	12.8	12.3	12.6	12.4	11.9	12.0	12.2	1.5
Sedgwick	11.6	12.7	12.1	13.4	11.7	11.8	12.2	12.2	1.1
Stafford	11.5	12.2	12.4	11.9	11.2	11.8	11.8	11.8	1.2
Sumner	11.2	12.5	12.0	12.5	11.5	11.6	12.5	12.0	1.3
Average	11.8	13.6	12.6	13.0	12.0	12.0	12.4	12.5	2.2
Range	3.9	3.0	1.2	2.4	2.2	2.0	1.2	2.3	

ferent conditions of storage, and the extent of damage from heating as shown by milling and baking tests. The data collected the past two years combined with that collected during the summer of 1923 lead to the following interesting observations:

1. Wheat stored in farm bins with more than 14 to 14½ per cent moisture is very likely to heat under temperature conditions prevailing in the wheat belt at harvest time.

2. Wheat with as high as 15 per cent moisture was stored two consecutive years in a protected barn bin without heating. This bin was protected by hay in a loft overhead.

3. Green wheat carrying 16 to 17 per cent moisture showed signs of heating and was beginning to cake at the end of five days though the temperature of the wheat was only 86 degrees F. Samples taken at this time, however, did not show inferior baking qualities. After 52 days wheat from the same bin was materially damaged showing a decrease of about one-fourth in loaf volume of the bread baked from the grain.

4. Samples of wheat taken from the heating bins before heating had progressed far actually showed an increased loaf volume and gave no evidence of injury to texture and color.

5. Wheat with 16 to 17 per cent moisture because of green berries, had in 10 days after storage caked in parts of the bin to such an extent that it was difficult to push a grain probe through the caked layers. Extremely high temperatures developed after the formation of these layers.

6. Wheat with 14.2 per cent moisture stored in the same bin with wheat having 16 per cent moisture showed some damage from contact with the latter.

7. Wheat containing 12 to 13½ per cent moisture and going into a bin 32 feet by 11 feet by 8 feet high at a temperature of 102 degrees F. remained at a temperature of 95 degrees or above for five days without any damage to the wheat or any signs of heating. Air temperature at time of storing was 95 degrees but in five days was down to 79½ degrees F.

Competitive Factors in the Marketing of Wheat. During the last biennium a study of Kansas wheat prices for a period of 32 years was made for the purpose of determining the character and frequency of seasonal price fluctuations. Monthly exports from competing countries and monthly imports by consuming countries have been compiled.

Data on mill consumption month by month, monthly mill purchases, and stocks of wheat on hand the first of each month were secured from about 30 Kansas mills. These data for the most part cover the last ten-year period. Data have also been collected from a number of elevators showing for a five-year period the monthly distribution of carlot shipments and the principal market destinations of these shipments.

During next year an analysis will be made of the mill and elevator data to determine to what extent local movement of wheat and mill buying and consumption affect the Kansas City price and to what extent movement and mill buying is influenced by changes in the Kansas City price. [Project 143; Department of Agricultural Economics; Purnell and state funds.]

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

The work on this project has consisted of a study of the following phases of the project: The effect of size of flock upon other factors influencing production; cost of maintaining general farm flocks; changes in average production for farms in the state; changes in region of high and low production; distribution of poultry on farms by counties and regions of high or of low numbers per farm; and proportion of total production consumed on the farm.

The following conclusions were drawn from the data secured:

1. On average farms medium-sized flocks, around 125 hens per year, are to be preferred if the object is high production per hen.
2. If high production with low feed cost is desired, the small or medium-sized flock is preferable to the large flock.
3. Heavy feeding (70 pounds per hen and up) as a rule gave no better financial results than medium feeding (40 to 50 pounds per hen). The hen getting 40 to 50 pounds picked up sufficient grain to make a full ration. Heavy feeding usually was rewarded by large production.
4. Large flocks return the greatest total profit. Medium flocks were the most profitable when based on production per hen. Small flocks were more profitable per hen than large flocks.
5. The small flocks have the highest investment per hen for buildings and equipment. Large flocks have the least.
6. Feed cost is the largest item of expense. The labor charge is the next largest item.
7. The interest charge varies from 7 cents to 9 cents per hen.
8. The building charge varies from 9 cents to 12 cents per hen.
9. The expense per hen in the groups studied varied from \$1.50 to \$1.80.
10. The overhead expense amounts to 3 to 4 per cent of all other expenses for small and medium flocks, and less than 3 per cent for large flocks.
11. Slightly more than two-thirds of the meat produced was sold. The rest was used on the farm.
12. The value of eggs and poultry sold was practically always greater than the cash expenses incurred.
13. The value of eggs and poultry used on the farm was usually greater than the charges for labor, interest, use of buildings, etc.
14. For the farms studied, the poultry furnished an average of 43 per cent of the live stock and live-stock products used on the farm.

New phases of the project started during the past year include a study of the per capita consumption of poultry and eggs in Kansas,

and of the factors influencing variations in consumption. [Project 144; Department of Agricultural Economics; Purnell and state funds.]

**The Marketing of Kansas Live Stock and Live-stock Products.** The work of this project was devoted to three phases of the general subject. Each phase is briefly discussed below.

*Organizations Engaged in Marketing Live Stock and Live-stock Products.* Questionnaires were sent to all known cooperative organizations in Kansas handling live stock. Satisfactory replies were received from more than half of the organizations. It has developed from this work that: (1) There are approximately 175 cooperative organizations handling live stock from at least 200 shipping points in Kansas. (2) Two sections of the state show the greatest development of cooperative live-stock shipping. They are the northern tier of counties and a group of counties in southeastern Kansas. (3) The greatest development of cooperative live-stock shipping has been since 1919. (4) Of 98 organizations reporting, 53 gave live-stock shipping as their principal business; and 45 concerns were engaged principally in other lines of business—the grain business mainly. (5) Of 95 organizations reporting, 51 were incorporated and 44 were not. Only 9 of 50 concerns handling live stock exclusively were incorporated while 42 of 45 concerns handling live stock as a side line to the grain or other business were incorporated. (6) The average number of cars of live stock shipped in 1923 by 84 organizations reporting on volume was 44 cars. The number of cars per organization varied from 5 to 342 cars. (7) Of the 97 organizations reporting, 75 handled live stock on a commission basis while 8 concerns bought outright and 14 gave the patrons the option of selling or shipping on commission, (8) In computing commission charges, the hundred-weight basis was most commonly used, with the “per cent” basis second in favor. (9) In carrying losses due to crippling or killing in transit, the sinking or insurance fund method was used by more than half of the organizations reporting. Commercial insurance was used by slightly less than a third of the concerns.

*Price Trends and Price Making Factors in the Live-stock Industry.* Work on this phase of the project has consisted in the collection and analysis of statistics on trend of prices by types, grades, and classes of live stock in various markets. From these data, tables, charts, and diagrams showing long time production, and seasonal

tendencies in prices have been constructed. The price statistics have been secured from a number of sources, including the United States Census, the Price Current Grain Reporter Yearbook, the Kansas City *Drovers Telegram*, and others.

The conclusions reached from the statistics on hog prices briefly stated are that hog raisers can, to their advantage, study two price movements in particular: (1) The long-time price tendency which corresponds to the production period for hogs having an average length of about 5½ years; and (2) the short time or month to month fluctuation. There are other factors behind hog prices but these two are more nearly under farmers' control.

The size of the corn crop has been shown to have a pronounced influence upon hog receipts and prices. The normal trend of receipts is subject to considerable readjustment in years when the corn crop is abnormally large or small. Consequently the seasonal fluctuations in price are closely correlated with the size of the corn crop.

*Economic Factors Influencing the Time and Place of Production and Marketing of Live Stock and Live-stock Products.* Work on this phase of the project has consisted of summarizing data obtained from the United States Census; the United States Department of Agriculture; the Kansas Office of the Bureau of Crop Estimates, United States Department of Agriculture; and the Kansas State Board of Agriculture. The investigation includes a study of when and where Kansas live stock and live-stock products are produced; when Kansas live stock and live-stock products move to market; and where Kansas live stock and live-stock products are marketed. [Project 149; Department of Agricultural Economics; Purnell fund.]

#### CONSERVATION OF THE SOIL

The soil constitutes the most important source of agricultural wealth of the state. Soil conservation is, therefore, of fundamental importance. This problem is one that is receiving careful consideration by the Agricultural Experiment Station. A brief report of the investigations in soil conservation during the past biennium is given on the following pages.

**Soil Fertility Investigations.** The work on this project during the past biennium has consisted chiefly of a continuation of the investigations that have been in progress since 1910. A complete summary of the results obtained during the progress of the work is being made, so that the results on the various phases of the project may be

put in shape for publication in the near future. In the 16-year rotation, one full round of the rotation has been completed, which means that from now on all crops in that rotation will be on land that has had alfalfa or brome grass.

The yields of corn during the past two years have been much higher in the 16-year rotation than on the other plots. The difference has been greater than that shown by the average yields. This would seem to indicate that the 16-year rotation including alfalfa may prove more effective in maintaining a high yield of corn through along period of years than the shorter 3-year rotation including cowpeas as the legume. The land which is kept in corn each year has given an average yield of only 20 bushels per acre, or 11.2 bushels less than the corn in the 16-year rotation. The influence of the cropping system on yield of corn is shown in Table VI.

TABLE VI.—The influence of the cropping system on the yield of corn.

CROPPING SYSTEM.	Yields of corn in bushels per acre.		
	1924	1925	Average, 1911-1925.
16-year rotation—alfalfa, 4 years; corn, wheat, wheat	49.05	35.05	31 21
3-year rotation—corn, cowpeas, wheat . . . . .	35.16	19.14	29.19
3-year rotation—corn, corn, wheat . . . . .	22.87	9.46	25.08
Continuous corn . . . . .	14.56	26 54	20.01

The yields of wheat in the 3-year rotation following cowpeas has been slightly higher than the wheat in the 16-year or in the other 3-year rotation where wheat follows corn. This would indicate that the wheat will follow cowpeas slightly better than corn, but in either case the yield is probably greatly reduced by following a late maturing summer crop as compared with what might be secured after a crop such as wheat or oats which matures early in the summer and thus permits early preparation of the ground. This is further brought out by the yields obtained in the 16-year rotation for the second crop of wheat, where the average yield in 1925 was 5.8 bushels greater than for the first crop after corn. The yield of grain from the continuous wheat has averaged 0.91 bushels greater than in a rotation where wheat follows two years of corn. That the cropping system has had a marked influence on the yield of wheat is shown in Table VII.

A summary of the results for the entire period, 1911-1925, shows

TABLE VII.—The influence of the cropping system on the yield of wheat.

CROPPING SYSTEM.	Yields if wheat in bushels per acre.		
	1924	1925.	Average, 1911- 1925.
16-year rotation—wheat after corn	11.02	16.10	16.95
16-year rotation—wheat after wheat (a)	16.06	21.10	22.75
3-year rotation—corn, cowpeas, wheat	14.61	19.14	17.60
3-year rotation—corn, corn, wheat	9.81	9.46	14.36
Continuous wheat	12.19	14.32	15.27

(a) In 1922 the rotation was changed from alfalfa, corn, corn, wheat, to alfalfa, corn, wheat, wheat

that certain soil treatments have been very effective in increasing yields while others have given increases of little or no practical value. Manure has increased the yields of all crops but has been most effective on alfalfa and wheat. Acid phosphate has given fairly good returns on alfalfa and it seems advisable for this crop. When applied directly to corn it has given a decrease in yield in all cropping systems except with continuous corn and this is partially explained by irregularities in plots. Potash given slight increases on all crops but in most cases they have been too small to pay for the cost of the fertilizer. Sodium nitrate has also given considerable increase in crop yields but the cost of the material has been too high to justify its use under the conditions in these experiments. Lime has been of some value on alfalfa and since the rate of application was increased to two tons per acre in 1923 there is some indication of greater returns.

Since these experiments have been in progress for about 15 years, the various soil treatments have undoubtedly had sufficient time to exert a considerable effect upon the physical, chemical, and biological conditions in the soil. It is planned to begin during the next biennium a number of special investigations to determine these changes and also to study the conditions of the soil and soil solution that afford the most favorable environment for the development of the various crops. Some work on the effect of different rotations and soil treatments upon the soil moisture and nitrate supply for wheat and corn crops is already under way. [Project 17; Department of Agronomy; Hatch and state funds.]

The Residual Effect of Alfalfa on the Soil. This project, which was begun in the fall of 1922, consists of several plots of alfalfa which are allowed to remain for varying numbers of years, together

with the plots growing continuous wheat as comparison plots. Each year following the second cutting of hay duplicate plots of alfalfa are plowed and seeded to wheat each year thereafter.

The questions being studied are: The influence of growing alfalfa on soil nitrogen, soil organic matter, and soil nitrates; the influence of growing alfalfa on yield, protein and test weight of wheat following alfalfa together with several minor factors; and the length of time alfalfa will affect the above factors. That the growing of alfalfa has had a marked effect on the protein content of wheat is shown by the data presented in Table VIII.

TABLE VIII.—The influence of the cropping system on the protein content of wheat

PLOT TREATMENT	Yield wheat per acre	Per cent protein in wheat.
<b>Season of 1924.</b>		
First year, wheat following alfalfa 1 year	36.7	12.6
Wheat continuously 2 years	33.5	10.8
<b>Season of 1926.</b>		
Second year, wheat following alfalfa 1 year	17.2	14.7
First year, wheat following alfalfa 2 years	22.2	17.0
Wheat continuously 3 years	19.6	12.7

The plots which have grown alfalfa contain more nitrate nitrogen at wheat seeding time than plots which have been in wheat continuously. [Project 17; Department of Agronomy; state funds.]

**Tillage Investigations.** The continuous wheat portion of the wheat seed-bed project established in 1909 was temporarily abandoned after the harvest period of 1923 because of foot rot which was first observed in 1921. In the fall of 1923 each plot was given its respective tillage treatment and in the spring of 1924 soy beans were planted. Oats were planted on the disked soy-bean stubble in the spring of 1925. After the harvest of the oats the plots were given their respective tillage treatments and again planted to wheat. Several plot treatments were changed in order that a better comparison could be made between the effects of deep and shallow July plowing.

The rotation portion of the project has been continued without interruption. Foot rot has not appeared on these plots.

The average yields of the various crops grown in this rotation for the period 1913 to 1923, inclusive, and for the seasons of 1924 and 1925 are shown in Table IX.

TABLE IX.—The influence of the time and depth of plowing on the yield of wheat.

TILLAGE PREPARATION FOR WHEAT.	Average for 11 years, 1913 to 1923.			Yields for 1924.			Yields for 1925.		
	Wheat.	Corn (a).	Oats (b).	Wheat.	Corn (a).	Oats (b).	Wheat.	Corn (a).	Oats (b).
Plowed July 12 inches deep . . . . .	25.7	29.5	20.4	26.3	23.0	22.0	22.6	50.9	24.3
Plowed July 7 inches deep . . . . .	26.7	30.7	31.8	29.0	22.5	22.0	25.3	41.6	24.0
Plowed July 3 inches deep . . . . .	26.8	28.8	32.0	24.3	18.7	24.2	19.3	52.5	16.4
Plowed August 7 inches deep . . . . .	23.2	28.0	31.8	11.3	17.5	21.4	21.4	52.3	19.7
Plowed September 3 inches deep . . . . .	17.0	29.3	31.8	7.2	19.0	19.7	11.4	54.3	21.5

(a) Corn is surface planted on fall-plowed wheat stubble.

(b) Oats are planted on disked corn stubble.

The tillage project, established in 1919, was discontinued after the harvest of 1925 because of the spread of foot rot. Most of the area will in the future be devoted to rotation studies including alfalfa. A part of the foot-rot infested land will be used for investigations of the foot-rot disease of wheat. [Project 18; Department of Agronomy; Hatch and state funds.]

**Plant Nutrition Investigations.** The relation of the molecular proportion of calcium nitrate to potassium dihydrogen phosphate was studied in salt nutrition experiments with wheat in the greenhouse. The plants were carried through to maturity. The solution containing the high molecular proportion of calcium nitrate produced the best growth of wheat. The experiment is being repeated using larger containers.

Greenhouse experiments were conducted on some of the soil types from the Agronomy Farm. The soils all responded to nitrogen fertilization. For any single treatment a nitrogen fertilizer gave the greatest increase, but the largest yields were secured by combining the nitrogen carrier with acid phosphate. Nitrogen was found to be absorbed by the plant more readily when applied to the soil as sodium nitrate than as calcium nitrate. Plants responded better to applications of calcium phosphate than to sodium phosphate.

A study was made during the winter of 1924-'25 of the growth of alfalfa and sweet clover in an acid soil from southeastern Kansas treated with varying ratios of lime to acid phosphate. The maximum yields of alfalfa and sweet clover were secured when acid phosphate was used in addition to lime. The liming rate apparently need not exceed 4,000 pounds per acre when acid phosphate is used at the rate of 300 pounds per acre. [Department of Agronomy; state funds.]

**The Relation of the Absolute Reaction of the Soil Solution to the Quantity of Nitrogen Fixed by Azotobacter.** A study of the cylinder experiments begun in 1923 for the purpose of determining the effect of *Azotobacter* upon the nitrogen balance of the soil has been continued. These cylinders were planted to wheat in the fall of 1924 and again in the fall of 1925. In certain cylinders the organisms are supplied annually with sources of energy in the form of dextrose or wheat straw. Certain cylinders are maintained at a favorable reaction for *Azotobacter* while others are left in their normal acid condition which is believed to be too acid for *Azotobacter*. The soil has been examined from time to time to ascertain

the presence or absence of *Azotobacter* in those cylinders where an effort is being made to maintain them.

The work has not progressed to the point where definite information is available. It will be continued.

Work was begun on a study of the relationship, if any, existing between the energy content, or heat of combustion, of food materials utilized by *Azotobacter* and the quantity of nitrogen fixed by the organisms. These studies have been continued.

During the past year a comprehensive biological survey of the organisms collectively known as *Azotobacter* was undertaken. Cultures have been obtained from a large number of investigators and in addition isolations have been made from soils from all parts of this country and from a number of foreign soils as well. These cultures are now being studied culturally, morphologically, and biologically. [Project 128; Department of Bacteriology; Adams fund.]

**A Study of the Soil Solution as Governed by the H-ion Concentration.** The work on this project has been developed along the line of base (Ca, Fe, Al, Mg, K, Na, etc.) adsorption in soils as affected by various ions as Cl, SO<sub>4</sub>, PO<sub>4</sub>, Acetate, etc. Preliminary work consisted of the development of methods; one for leaching the soil which would allow rapid leaching and at the same time keep the leachings relatively free from colloids; and other methods for determining the bases leached in extremely minute amounts. Primary attention has been given to iron and aluminum and their progressive exchangeability at various H-ion concentrations induced by different acids and by a series of SO<sub>4</sub> salts, such as Ca. NH<sub>4</sub>, K, etc. Derby silt loam has been used as a type soil.

The principal results obtained seem to indicate that in small concentrations the SO<sub>4</sub> radical favors the separation of Fe and Al from the soil complexes and therefore favors their leaching from the soil.

During the coming year it is planned to continue the work in much the same manner as in the past, extending the study to other soil types and including the effect of other fertilizing and soil amendment materials upon the volubility and leachability of Fe and Al. [Project 155; Department of Chemistry; state funds. ]

#### INVESTIGATIONS IN THE PLANT INDUSTRIES

The plant industries are the most important in Kansas agriculture. In 1924 the value of the crop plants produced in the state was in excess of 375 million dollars as reported by the State Board of Agriculture, wheat alone representing a value of more than 160 million,

while the combined value of corn, hay, and the sorghum crops was in excess of that of wheat. The following pages contain a brief summary of some of the work that the Agricultural Experiment Station has done during the past two years relating directly to the problems of these industries.

**The Flora of Kansas.** During the past biennium the herbarium was maintained and about 2,900 sheets were added to it, About 700 grasses from various parts of the world were received by donation from the National Museum. About 150 miscellaneous specimens were received from Kansas; and 451 miscellaneous specimens from Vermont were received by exchange.

During the past year a bulletin on Kansas trees has been brought to completion and is ready to submit for publication.

Some 2,500 specimens are to be mounted and put in the herbarium during the coming year; and a series of Kansas collections consisting of more than 2,000 collection numbers will be studied. [Project 137; Department of Botany; state funds.]

**Chemical Analysis of Important Crops.** Samples of corn, kafir, and oats were collected during several stages of growth. These samples were divided into the various parts of the respective plants. The amount of dry matter was determined and the samples prepared for chemical analyses. Analyses for ash, sand, silicon, manganese, calcium, magnesium, nitrogen, sulfur, phosphorus, iron, aluminum, and potassium, have been completed for corn and kafir. No chemical work has been started as yet on the samples of oats. [Project 152; Departments of Chemistry, Botany, and Agronomy; state funds.]

**Drought Resistance of Crop Plants.** The work on this project during the past two years has been carried on along four general lines of study: (1) The effect of Bordeaux mixture on the rate of transpiration and temperature of the leaves of potato and tomato plants; (2) the comparative rate of transpiration of corn, sorghum, pumpkin, cowpea, and soy-bean plants under the same environmental conditions; (3) the daily variation of the total nitrogen in the leaves of crop plants; and (4) studies on the weekly rate of growth of corn as expressed by the increase in dry weight and leaf surface.

The results obtained in these investigations are not sufficiently complete to draw definite conclusions, since for the most part data have been assembled for only one year. General indications, however, are as follows:

1. Bordeaux mixture (4-8-50) seemed to have no significant effect on the rate of transpiration of potato plants, but the rate of transpiration of sprayed tomato plants was in both years approximately 6 percent higher than that of the unsprayed plants. During the year, 1925, 40 plants each of tomatoes and potatoes were used. The work is to be continued with a larger number of plants. The temperature of potato leaves sprayed with Bordeaux mixture was consistently 0.1 to 0.2 degrees C. higher than that of the unsprayed leaves. The experimental results with sprayed and unsprayed tomato leaves showed that Bordeaux mixture did not affect the temperature sufficiently to be detected by the apparatus used.

2. The results of the comparative transpiration experiments indicate that under like conditions there is a specific difference in the transpiration rate of corn, dwarf yellow milo, pumpkin, cowpea, and soy-bean plants and that this difference will depend upon the age of the plants and upon other factors not as yet determined.

3. The daily variation of the total nitrogen content of the leaves of corn, sorghums, soy beans, and cowpeas has been determined with varying degrees of completeness. A large amount of material has been collected, but owing to the lateness of the installation of some of the necessary apparatus, the analyses are as yet not complete. The preliminary work indicates that there is a rise of the nitrogen content in the leaves of the legumes during the day and a fall at night, but that this change does not take place in the leaves of corn and the sorghums.

4. The rate of growth of the corn plant during the growing season was obtained by determining the average dry weight of five representative plants selected at random in the field at seven-day intervals. The leaf area of these plants was determined as well as their transpiration rate. The average dry weight, leaf area, and amount of water transpired by a single plant during each seven-day period of the growing season of 1924 is shown in Table X. [Project 74; Department of Botany; state funds.]

**Temperature in Relation to Crop Plants.** It is coming to be recognized that economical production of crops and especially the improvement of crop plants by breeding is limited and determined to a very large extent by a knowledge of environmental factors. Temperature, although generally recognized as one of the most important of these factors, has perhaps been studied less than any other. The object of this new project is to make such a study.

TABLE X.—Dry weight, leaf area, and amount of water transpired by a corn plant during each seven-day period during the growing season of 1924. (Average of 5 plants.)

DATE.	Dry matter per plant.	Leaf area per plant.	Transpiration per plant
	<i>Gms.</i>	<i>Sq. in.</i>	<i>Gms.</i>
May 19 to 26	.27	11.00	37.6
May 26 to June 2	.62	22.53	173.1
June 2 to 9	2.85	85.12	328.7
June 9 to 16	12.30	279.23	1,146.8
June 16 to 23	37.20	606.02	5,420.0
June 23 to 30	78.20	1,265.16	9,822.0
June 30 to July 7	143.60	1,505.54	15,544.0
July 7 to 14	224.20	1,940.38	17,650.0
July 14 to 21	332.7	2,300.82	22,934.0
July 21 to 28	376.0	2,313.80	30,267.5
July 28 to August 4	490.0	Full	27,817.5
August 4 to 11	535.8	.....	17,067.5
August 11 to 18	593.4	leaf	17,090.0
August 18 to 25	661.0	.....	18,057.5
August 25 to Sept 1	745.4	development	12,635.0
September 1 to 8			5,647.5

It is proposed to secure equipment so that crop plants may be exposed to any desired temperature to which they are likely to be subjected in nature and study their reaction thereto. It is proposed especially to expose winter annuals such as different varieties of wheat, and perennials such as Bermuda grass, Buffalo grass, varieties of alfalfa, etc., to temperatures below freezing in order to determine their relative ability to survive such conditions. It is also hoped that there will be an opportunity to study the effects of high temperatures (100 degrees to 110 degrees F. or higher) on varieties of corn, kafir, wheat, and oats, during or near the blossoming period.

Among the specific problems which it is expected will be attacked may be mentioned the following: (1) Relative ability of different varieties of wheat to survive low temperatures; (2) relative ability of different varieties and regional strains of alfalfa to survive low temperatures; (3) relation of hardening off and conditions (temperature and moisture) of hardening off to ability to survive low temperatures; (4) relative rate of growth of corn and sorghums at low temperatures; (5) relative rate of growth of different varieties of sorghum at low temperatures; (6) relative ability of corn and

sorghums to survive high temperatures during the blooming period; (7) relative ability of bearded and beardless wheat to survive high temperatures (*a*) with a deficient and (*b*) with an ample supply of moisture; and (8) relative ability of Kanota, Red Texas, and Kherson oats to survive high temperatures.

Delay in getting the new greenhouse constructed and lack of sufficient space in the old one has so far prevented any extensive work on this project during the past year. Some preliminary observations regarding the ability of different varieties of wheat to survive low temperature were made. It is expected that greenhouse space and equipment will be available for proceeding with this work the coming year. [Project 157; Department of Agronomy; Purnell funds.]

**Small Grain and Sorghum Improvement.** The experiments in crop improvement have included trials of varieties, selections, and crosses of winter wheat and rye, spring oats and barley and sorghums.

In the winter wheat nursery, more than 200 varieties have been grown in replicated rod rows each year.

A large number of winter × spring crosses grown in previous years have been tested extensively. Approximately 100 strains have been grown in the regular variety tests, and many more grown in single and triplicated rod rows. From 20 to 60 strains have been grown in cooperative yield tests at the following stations: Hays and Colby, Kan, North Platte and Lincoln, Neb., Denton, Tex., and Ames, Iowa. A limited number have been tested for winter hardiness at University Farm, Minn., and tests for rust resistance have been carried on at Lafayette, Ind., Knoxville, Term., and Arlington Farm, Va.

A number of strains have been produced which outyield Kanred slightly at Manhattan and which produce a better quality of grain, and of these, Tenmarq is perhaps the most promising. No strain has been tested thus far which outyields Kanred consistently at other stations.

A limited number of these strains are being continued in the variety tests and a large number of head selections are being tested further. Some of the more promising strains are being grown in plots at the Agronomy Farm.

Preliminary work on a study of the inheritance of earliness in wheat was started in 1925. Crosses were made between Kanred and Nebraska No. 28 in an effort to develop a strain of Kanred which

matures a few days earlier. Approximately 2,500 individual F<sup>2</sup> and parental plants were grown in the 1925 nursery and individual plant notes taken. About 20,000 F<sup>3</sup> plants are being grown in the 1926 nursery for further study, from which selections will be made for further trial. Detailed greenhouse studies on a limited number of families were made during the winter of 1925-'26.

A soft-wheat nursery was planted on the experimental field at Columbus, Kan., in the fall of 1924. Among the more important problems to be studied at Columbus are (1) resistance to Hessian fly, (2) rust resistance, and (3) lodging. A varietal survey is being made, and this will be followed by such selection and hybridization experiments as may prove necessary. More than 200 strains are being grown at Columbus each year. In 1925, Indiana Swamp, a rust resistant sort, made the highest yield. Nigger, Minturki, Currell, and Blackhull were other varieties which appeared especially promising in 1925.

Breeding experiments with winter rye are limited to tests of a few varieties. Common Kansas has consistently outyielded all introduced varieties with the exception of Advance, which has a slightly higher four-year average. The yield of Kansas rye for the period, 1919-1925, is significantly higher than that of Rosen rye for the same period.

Oat variety tests for the past two years have included about 90 strains grown in replicated rod rows and about 1,000 additional strains grown in single and triplicated rod rows. A number of Australian varieties have been introduced and are being tested in comparison with the standard varieties, and in addition a large number of Kanota and Burt selections have been grown. The outstanding feature of yield tests for 1924-'25 is the evident superiority of Kanota over most other strains. The average yield of the Kanota checks is 49.9 bushels. No variety other than Fulghum or Kanota selections exceeded the checks in 1925, and only one variety, Glenn Innis, made a higher yield for the two-year period (53.5 bushels). A number of the Kanota selections not only outyield the unselected stock but they also are less variable. Two Kanota selections have an average yield of more than 56.5 bushels. Most strains of Burt were low-yielding and the Albion checks had an average yield of but 36.4 bushels.

Studies in smut resistance have been conducted in cooperation with the Department of Botany. Smut counts were made in all

strains of oats grown in the nursery. A number of strains of Burt and Kanota are now available which have a "zero" smut count over a period of years. A most interesting observation was the great susceptibility to smut of a strain of Fulghum oats received from a Texas seed company. This particular strain had 54.9 per cent smut in 1924 and 13.5 per cent smut in 1925, while comparable Kanota checks were smut free or had less than 1 per cent smut. These and other data obtained in nursery and plot experiments at the Kansas station indicate very clearly that there are distinct strains within the Fulghum varietal group, some of which are superior and some inferior, though perhaps morphologically very similar.

The main barley nurseries are located at the Hays and Colby branch stations. They are identical in the number of rows and in the varieties grown, thus furnishing a good test of the adaptation and yielding ability of the different varieties. In general a variety which yielded well at Hays also yielded well at Colby and vice versa. A thorough varietal survey is being made in order to obtain adapted strains for future breeding work. More than 500 strains have been tested in preliminary trials. These tests indicate that strains can be selected which are superior to the varieties commonly grown. Yields of a few of the more promising varieties grown in replicated rod rows are given in Table XI.

TABLE XI.—Two-year average yield of barley at Hays and Colby, 1924 and 1925.

Kansas No.	VARIETY.	Yield.		Av., both stations
		Hays.	Colby.	
163	Hero	36.9	38.15	37.53
232	Forsythe*	38.9	33.55	36.23
112	Tripoli	40.9	30.20	35.55
220	Black Smyrna*	35.5	33.65	34.58
202	Caesar*	32.1	32.60	32.35
223	Ernest*	34.7	29.55	32.13
145	Venez	30.6	31.6	31.1
121	Vaughn	31.5	29.0	30.25
199	Pandora*	38.9	21.4	30.12
	Average of Club Mariout checks	26.6	23.4	25.0

\* Two-row barley.

The yields of these nine varieties are significantly higher than the check yields, and in addition there are a number of other varieties which have also outyielded the checks. It is also of significance to note that five of the nine high-yielding strains are two-row barleys. These varieties are somewhat earlier than most two-row sorts. Hero is a smooth, awn type and appeared especially promising in 1925.

The sorghum breeding work for the biennium consisted of four main phases: (1) Studies of Red Amber X *feterita* crosses with special reference to smut resistance; (2) chinch bug resistance and susceptibility; (3) a nursery containing miscellaneous new introductions, selections, and hybrids; and (4) yield studies on a Blackhull X Sourless sorgho cross. Approximately 400 rows have been grown each year and 3,000 heads self-fertilized.

The Red Amber X *feterita* crosses have been carried through to the eighth generation and most of the undesirable types have been discarded. The 40 selections remaining have white seeds, juicy stalks, and are smut resistant.

Chinch bug resistance and susceptibility was studied in general on the miscellaneous sorghum varieties, and in particular on segregates of the cross Dwarf Yellow milo (very susceptible) X Kansas Orange (partially resistant) and the cross Hegari (partially resistant) X Dwarf Yellow milo (susceptible).

The infestation was so severe in 1924 that all of the Kansas Orange X milo hybrids were destroyed with the exception of one plant, although some plants withstood the attack much longer than others. In general, such varieties as *feterita*, milo, amber, and shallu are severely injured, while durra, kaoliang, sumac, kafir, and the crosses, milo X kafir, hegari X milo, and Kansas Orange X milo are distinctly resistant. It is particularly interesting to note that plants showing the most hybrid vigor were apparently the most successful in withstanding chinch bug attack.

The miscellaneous nursery was all treated with smut in order to study the smut resistance of varieties. The experiments revealed that *feterita*, Kansas Orange, sumac, and hegari X milo were resistant to smut with the exception of a few susceptible strains. Dwarf Yellow milo, kafir, and some natural milo hybrids are generally susceptible.

Probably the most interesting new type is the cross, Blackhull X Sourless sorgho, which was grown in a small increase plot in 1925. Plants of this type are leafy, have juicy stalks, while the head is of

the kafir type. Excellent yields of grain and forage were produced in 1925. (Project 67; Department of Agronomy; Hatch funds.)

**A Genetic Study of Aberrant and False Wild Types in Kanota Oats.** About 1,100 headrows of Kanota oats were grown in the 1924 nursery from panicles previously described. Seed for all of these rows was smutted before planting, and smut counts were made. The false wild types do not seem to differ materially from normal Kanota in smut reaction, that is, they seem to carry similar genetic factors for smut resistance. This fact may lend support to the mutation hypothesis as to the origin of the false wild types. Mutations might occur with respect to factors or genes governing awn type, basal hairs, kernel base, plant height and other characters without in any way altering the factors concerned in smut resistance or susceptibility. On the other hand, if the false wild types arise through natural crossing as certain European workers believe, there probably would be more susceptible segregates among the false wild types, unless the parent with which Kanota crossed was also smut resistant, which is unlikely.

The distinct differences in plant height previously observed were again apparent in the 1924 greenhouse and nursery plantings. The typical or extreme false wild types are ordinarily somewhat shorter than either the heterozygous false wild or the normal Kanota plants.

A very large number of individual panicle or plant selections were made in 1924. These have been carefully hand threshed, and kernel notes on the bulk samples from the rows and on the kernels from the individual panicles will be obtained.

These data when tabulated and analyzed will go far toward establishing the following points: (1) The frequency of mutation in lines of normal Kanota; (2) the frequency of reverse mutations, if any, that is, from false wild to normal; and (3) the segregation ratios obtained by planting kernels from heterozygous false wild plants.

In addition to the false wild types discussed above, a number of other aberrant forms were under observation in 1924. Perhaps the most interesting of these were several lines which have a more erect habit of early growth than Kanota, head and ripen earlier, and which differ considerably in the characters of the kernels, which are longer, more pointed, resembling the Burt type of kernel more than normal Kanota.

Several true winter or spreading forms were also isolated and studied as were forms differing in awn type, kernel color, articulation, adherence of glumes, and other characters.

Numerous crosses involving the false wild type as one parent were attempted in the greenhouse during the winter of 1923-24 and again in 1924-'25. Very few crossed seeds were obtained. This may be due to incompatibility of the types used as parents or to faulty technic. Efforts to secure crosses of false wild X normal Kanota, false wild X *Avena sterilis*, false wild X *Avena fatua*, normal Kanota X *Avena sterilis*, normal Kanota X *Avena fatua* will be continued. [Project 146; Department of Agronomy; Adams fund.]

**Sorghum Varietal Tests.** In the sorghum variety test an early variety of Red kafir has produced the highest average yield for the six years it has been grown but the difference is small as compared with Blackhull, the standard variety for this area. Darso and Shrock have also given larger yields than Blackhull but the feeding value of the grain is such that they are not recommended. Aside from these no other varieties promise better yields than Blackhull. Pink kafir is a desirable variety for thin upland soils and may be safely recommended for such conditions.

Attempts to secure white seeded sorgos equal to Kansas Orange, the leading sorgo for eastern Kansas, have proved unsuccessful. A recently acquired variety, the result of a cross between sourless and kafir appears promising but has not been grown for a sufficient length of time to determine its value. [Project 129; Department of Agronomy; Hatch funds.]

**Small Grain Tests.** This project consists of a varietal test of wheat and oats, and a study of cultural practices with these cereals. In the wheat varietal test, the Kanred variety produced higher yields than any of the other standard hard wheats for the season of 1925, the yield being 39.0 as compared with 34.5 for Turkey. The average yield for a period of 16 years is 30.4 bushels for Kanred as compared with 27.3 for Turkey. Blackhull which has attracted so much attention in recent years produced 37.4 bushels for the season. Its average for seven years is 34.9 bushels per acre as compared with 31.6 bushels for Turkey. A beardless hybrid, seed of which was supplied by the United States Department of Agriculture, grown for the first time this year, produced 40.9 bushels, or the second highest yield for the season and slightly more than Kanred.

This result is of special interest in view of the low yields usually recorded for beardless wheats.

In the oat varietal tests Kanota was slightly exceeded in yield by Red Texas No. 5085 and for all practical purposes equalled by Red Texas No. 5015 because of timely rains which favored the later maturing varieties. As an average for the nine years that Kanota has been grown in field plots it has produced 15 per cent more than the best Red Texas with which it has been compared, and 20 per cent more than the average of two typical strains of Red Texas. It has also averaged about 10 per cent more than typical Fulghum strains with which it has been compared.

A date-of-seeding test with three varieties, Kanota, Burt, and Red Texas, gave a marked reduction in yield from seeding March 17, as compared with February 25. Further losses in yield were sustained from April seedings. Burt seemed to be injured less than the other varieties by the late seeding. [Project 129-2; Department of Agronomy; Hatch funds.]

**Alfalfa Production Experiments.** A new project relating to time of cutting alfalfa was begun in the spring of 1924. The object is to determine the possibility of taking the first or the first and second crops off early and permitting the other crops of the season to reach a more advanced stage of growth without injury to the stand. By so doing it is believed that better quality of hay may be secured and a better distribution of farm labor effected. Results for the two seasons afford considerable evidence to support the belief that some such practice will prove profitable.

A variety test including 15 varieties and regional strains of alfalfa has been conducted for three years. Dakota Common, Kansas Common, Utah Common, Grimm, and Cossack have given approximately equal yields. Spanish, Cape Lucerne (Africa), Provence and Ladak (India) gave low relative yields. Cape Lucerne, Ladak, and Argentine showed marked deterioration in stand and encroachment of grasses. Considering the cost and certainty of getting good seed, permanence of stand, and yield, it seems that Kansas common will prove more satisfactory than any of the others.

Bacterial wilt made its appearance during the season and so many of the plants in the stage of cutting experiment have been killed or are dying that it is questionable whether the experiment can be carried through the present (1926) season. A new set of plots has been laid out to continue the work next year.

Technical Bulletin 15, "Experiments Relating to the Time of Cutting Alfalfa," was published in April, 1925. [Project 129-3; Department of Agronomy; Hatch funds.]

**The Production of Soybeans and Cowpeas.** Twenty-six varieties of soybeans were grown in 1925. Yields of both hay and seed were obtained. A. K. has proved to be the most productive both as a hay and as a seed crop. Increase plots of four promising varieties were planted to provide seed for cooperative tests with farmers. In addition to the variety tests and increase plots, a test of corn and soybeans grown together was also made. This consisted of one plot each of corn and soybeans grown separately and four plots planted to both corn and soybeans with different rates of seeding of each crop. In this test it was found that the yield of corn was reduced in proportion to the amount of soybeans produced, as is shown below:

STAND		YIELD	
Soybeans	Corn	Soybeans Tons	Corn Tons
One-fourth . . . . .	Full . . . . .	.51	6.6
Half . . . . .	Full . . . . .	.81	5.3
Full . . . . .	Full . . . . .	1.04	4.6
Half . . . . .	Half . . . . .	1.17	3.4

Three varieties of cowpeas were grown with the soybeans for comparison in 1925. The best variety of soybeans yielded 20 per cent more hay and three times as much seed as the standard varieties of cowpeas. [Project 129-4; Department of Agronomy; Hatch funds.]

**Corn Production and Improvement.** During the past two years the seasonal conditions have been such as to favor late planted corn, in each of the two years the highest yielding dates falling on May 10 in the time-and-method-of-planting experiment.

As an average for a ten-year period, the optimum date of planting is April 20 to May 1. Planting corn with a furrow opener on plowed land has given more than the average increase during the biennium over listing and surface planting.

In the rate-of-planting experiment for 1924, the 16-inch spacing in 42-inch rows gave the highest yield with Pride of Saline; and for 1925 the 12-inch spacing was first with the 16-inch spacing a close second. As an average for a period of years, 16 to 20 inches has been shown to be optimum for this type of corn,

A promising new yellow variety called Bill Day and developed in Greenwood county led by a comfortable margin in the variety

yield test in 1925. If further trials confirm its performance the past year it will be a valuable addition to the varieties for this section.

The method-of-cultivation test was dropped with the close of the 1924 season as it has been conclusively shown that the main purpose of cultivation is to control weed growth and that stirring the ground with a one-horse cultivator after the corn is laid by is wasted time and effort.

A series of 515 single row plots was grown in 1925 to test in a preliminary way a group of hybrids between selfed lines. An outstanding result of this trial was that the highest yielding combinations were crosses between lines of locally adapted sorts, although many rows represented crosses in which one or both parents were from exotic varieties in the hopes that the more distant the relationships the greater would be the hybrid vigor. Ten of the higher yielding combinations gave the following yields in comparison with the nearest checks (Pride of Saline):

Row No.	YIELD IN	
	Hybrid	Check
36.....	100.7	76.1
38.....	110.4	76.1
55.....	97.1	72.9
64.....	108.6	72.9
76.....	98.9	72.1
225.....	79.6	56.4
264.....	97.1	59.3
302.....	100.4	61.4
336.....	97.1	72.1
341.....	104.6	72.1
Average.....	99.5	69.2

It is expected to continue this project along similar lines for the coming year. Greater emphasis is being placed on selection within selfed lines and the production of superior hybrids of their recombinations. [Project 156; Department of Agronomy; Purnell funds.]

**Turf and Lawn Grass Experiments.** In the fall of 1924, experiments were started in cooperation with the United States Golf Association Green Section with three purposes in view, namely: (1) To determine the adaptability of certain grasses, the bent grasses in particular, for putting greens on golf courses and for lawns; (2) to ascertain the best cultural methods for establishing and maintaining turf of these grasses; (3) to observe the influence of various fertilizer treatments on the control of weeds and maintenance of the turf.

Fifty-two plots, 10 feet square, of turf grasses were started in the fall of 1924. These consisted of 36 plots to be used for fertilizer

tests which were planted to Kentucky bluegrass, Chewing's fescue, and German mixed bent. In addition 16 plots were planted to different species and strains of bent grasses. In the spring of 1925, one plot of buffalo grass was started. Most of these grasses came through the summer of 1925 in fair condition with the exception of Chewing's fescue and velvet bent which suffered severely from the effects of the summer heat and most of which had to be planted again in the spring. Three of the grasses; namely, Virginia, Metropolitan, and Washington strains of creeping bent seem promising for golf greens or for lawns where plenty of water is available and occasional applications of compost and ammonium sulfate fertilizer can be applied.

The work for 1926 will be a continuation of that of the preceding year. In addition, 16 new plots have been planted to eight strains of creeping bent and two plots to bluegrass. Half of each variety will be cut with a lawn mower and the other half will be cut very close with a greens mower; the object here is to determine whether close mowing influences the resistance of various grasses to adverse weather conditions. [Project 167; Departments of Agronomy and Horticulture; state funds.]

**Bindweed Eradication With Chemical Sprays.** Experiments to eradicate bindweed (*Convolvulus arvensis*) were started in 1925. The purpose of the experiments is to determine the value of various chemicals used as sprays for the eradication of bindweed and to compare results from the chemical treatments with fallow.

The increasing recognition of the seriousness of bindweed as a pest in this state and the limited knowledge of methods of control make additional work along this line desirable. The methods now in use are either injurious to the soil, expensive, involve serious erosion problems on rolling land, or are ineffective. These facts emphasize the need of other methods of control. It is hoped that by the use of chemical sprays a cheaper and better method may be discovered.

The following chemicals in two dilutions were used in the experiments conducted in 1925:

Sodium arsenite.....	1 and 2 per cent.
Sodium chlorate.....	.12½ and 25 per cent.
Zinc chloride.....	6¼ and 12½ per cent.
Copper sulphate.....	6¼ and 12½ per cent.

These chemicals were sprayed on one one-hundredth acre plots at the rate of 1 gallon of solution to each plot, Three applications of

the sodium chlorate spray and four applications of the others were applied. In addition to the above chemical treatments, clean cultivation or fallow was used on two plots for comparison.

This work was started August 18, 1925. Quadrats, 9 square feet in area, were located in each plot and all weeds within the quadrat areas counted.

In Table XII are recorded the bindweeds in the quadrat area of each plot at the beginning of the experiment, immediately preceding each treatment, and after growth started in the spring of 1926.

TABLE XII — Weed count in 9 square feet quadrat areas on pots treated in various way-s to control bindweed.

Plots, 1-100 TREATMENT. acre	Plot No	Aug. 19	Sept 2.	Sept. 16.	Sept. 29.	Apr 30, 1926.
Copper sulphate, 12.5 per cent	1	31	25	40	54	70
Fallow, cultivated with a hoe	2	27	25	42	56	77
Zinc chloride, 12.5 per cent	3	44	35	47	56	67
Sodium arsenite, 2 per cent.	4	25	23	38	47	65
Check, no treatment	5	22	23	17	23	49
Sodium chlorate, 25 per cent	6	27	23	19	4	0
Sodium chlorate, 12.5 per cent	7	35	24	10	4	0
Fallow, cultivated with a hoe	8	25	35	58	36	50
Sodium arsenite, 1 per cent	9	43	28	30	46	73
Zinc chloride, 6.25 per cent	10	65	45	47	59	79
Check, no treatment	11	33	30	29	32	101
Copper sulphate, 6.25 per cent	12	41	27	29	31	45

No consistent decrease in the number of bindweed was observed as a result of any of the treatments with the exception of the plots sprayed with the sodium chlorate solution. The number of bindweeds on these plots gradually decreased from the time of the first spraying on August 19. After the second spraying on September 2, the bindweeds became yellow and looked sickly and some plants seemed to be dying. There was some doubt as to whether a third application of the spray would be necessary; however, a third application was made. At the time of the fourth treatment of all other plots the few remaining weeds on the sodium chlorate plots were in such a weakened condition that an additional spray was considered unnecessary. That these plants were weakened was evident by their lack of resistance to frost, and further by the total

absence of stored food in the root as determined by a microscopic study of microtome sections taken at various depths. Final evidence of the weakness of the few plants which survived after spraying was their failure to survive the winter.

Since there was some evidence that the sodium chlorate spray as used was stronger than necessary, new plots using weaker dilutions were started in 1926. The fact that sodium chlorate gave promising results suggested the use of sodium hypochlorite, a much cheaper chemical. The application of sodium chlorate at various periods during the growing season will be undertaken to find, if possible, the most critical period in the life of bindweed, or the period at which the spray will be the most effective. [Project 166; Departments of Chemistry and Agronomy; state funds.]

**Cooperative Experiments With Crops.** In the crop seasons, 1924 and 1925, a total of 802 cooperative crop and soil tests were conducted on farms in all parts of the state. Of these, 390 were located in 77 counties in 1924 and 412 in 79 counties in 1925. The work consisted largely of variety tests of practically all crops grown in the state, fertility, rotation, and tillage tests, and studies in the adaptation of new crops and varieties.

Kanred made the highest average yield in cooperative wheat variety tests in the hard wheat belt in 1924 and Blackhull yielded highest in 1925. For several years these varieties have been close competitors for first place in the yield comparisons, one or the other having outyielded all other varieties during the past seven years.

Kanred outyielded Turkey the last two years as it has done consistently for 12 years, the average difference for the whole period being 2.5 bushels.

In the eastern part of the state where soft wheats are adapted, Blackhull averaged highest in yield each of the last two years. Harvest Queen and Fulcaster averaged about the same in 1924 and also in 1925 and have made consistently good yields for 11 years. Harvest Queen is especially well suited in the northeastern part and Fulcaster in the southeastern part of the state.

High test weight or weight per measured bushel is characteristic of Blackhull. It averaged about 2 pounds heavier than Turkey and Kanred last year.

Kanota oats outyielded other varieties in cooperative tests both in 1924 and 1925, as was the case also in each of the five preceding seasons. During the seven years it has been grown in comparison with Red Texas in 177 tests and outyielded Red Texas 158. The

average yield of Kanota for the period was 39.4 bushels whereas Red Texas averaged 29.0 bushels, a difference of 10.4 bushels to the acre in favor of Kanota. Burt is the second best variety of oats tested in cooperation with farmers. Its average yield for a period of seven years is approximately 3 bushels less than that of Kanota.

Kanota oats grown in the cooperative tests weighed an average of about 3 pounds per bushel more than any other variety tested.

Pride of Saline corn was the highest yielding variety in cooperative tests in eastern and central Kansas. Kansas Sunflower was the highest yielding yellow variety in northeastern Kansas for the last two years and was exceeded only by Pride of Saline. Midland Yellow and Kansas Sunflower did equally well in southeastern Kansas in 1925 while in 1924 Midland Yellow was superior in that section. Freed, Cassel, and Colby, which are early maturing, hardy varieties, averaged higher in yield in western Kansas than the larger types such as Pride of Saline or Kansas Sunflower.

A. K. soybean has made the highest average yield of seed in each of the last three years. It is also one of the best varieties for hay since the quality is good and the yield near that of the highest yielding variety both in 1924 and 1925.

About 35 varieties of cotton were tested to determine their adaptation and production in southern Kansas. The average yield of the ten best varieties in each test for the two years was about one-half bale per acre. [Department of Agronomy; state funds.]

#### **Chemical Factors Influencing Quality of Wheat and Flour.**

In the spring of 1925, a new dough mixer was designed which produces a mechanical action which may be described as a pack-squeeze-pull-tear action. The purpose was to provide a machine that could be used to determine quickly and with a reasonable degree of accuracy the difference in strength of gluten of different samples of flour. As the machine is now constructed and used, a strong flour will produce a well developed dough after from five to seven minutes of mixing and the baked bread will have a large volume and good texture, while a weak flour handled in the same manner will go "slack" and the baked bread will have a smaller loaf volume and poorer texture.

It is hoped that this mixer will provide a direct method of measuring the viscosity of dough. Certain improvements are contemplated which it is hoped will make it possible also to measure the electrical operating energy and thereby the resistance of the dough. If these efforts prove successful, a very quick method of testing dough

quality with the personal equation eliminated will be provided. [Project 60-A; Department of Milling Industry; state funds.]

**The Quality of Wheat as Influenced by Cropping Systems and Fertilizer Treatments.** Samples of wheat from all the fertility plots on the Agronomy Farm for the crop of 1924 were analyzed, milled, and baked, but in 1925 the work was reduced to 17 representative samples from these plots and 12 samples from the rotation plots of wheat and alfalfa.

In general, applications of nitrogenous fertilizers were found to have increased slightly the protein content of the wheat. Nitrogen added in the form of barnyard manure and cowpeas plowed under for green manure have not increased the protein content. The highest per cent of phosphorus was obtained from those plots fertilized with acid phosphate. It seems, therefore, that when phosphorus is added to the soil in available form it will be taken up and stored in the kernel of the wheat plant. The phosphorus content of the flour has been found to bear no relation to the phosphorus content of the grain due to the fact that the bran which is removed in milling contains about eleven times more phosphorus than the endosperm. Consequently the per cent of phosphorus in the flour is influenced more by the closeness of milling than by difference in the phosphorus content of the wheat.

It has been found that the ash in wheat as well as the acidity of wheat and flour does not vary with the different fertilizer and rotation treatments, hence these determinations have been discontinued. Two technical papers relative to the work of this project have been published in chemical and milling journals. [Project 60-B; Department of Milling Industry; state funds.]

**The Quality of Wheat as Affected by Seedbed Preparation and Tillage Methods.** On account of foot rot no samples from the crop of 1925 were submitted for tests from the plots on which wheat was grown continuously. Five samples from plots on which wheat is grown in rotation and 62 samples from the crop of 1924 were tested.

The data obtained on wheat grown on the 20 plots devoted to seedbed preparation and tillage methods have been summarized for the years, 1912 to 1924, and the results published in Technical Bulletin 19, "Tillage in Relation to Milling and Baking Quality of Wheat." In general, it may be said that these tillage methods which gave the best yields also produced wheat of the best quality.

The most notable effect of tillage treatment on quality was on the loaf volume. Thus the average loaf volume from the wheat grown on the September worked plots was 1,827 c. c. and that from the wheat grown on plots worked earlier in the season was 1,878 c. c. This difference would not be significant in a single test but when it is the average of all tests made throughout a period of 12 years, it is very significant.

The average ash content of the September worked plots was 2.18 and that of the wheat from the plots worked earlier was 1.96. This is a significant difference. The higher per cent of ash in wheat is usually due to a shriveled condition of the grain resulting in a higher proportion of bran to the endosperm. However, in this case the test weight of wheat from the September treated plots was higher than that of the wheat from the plots worked earlier. Thus the higher ash content of the wheat from the plots worked late was not due to a shriveled condition of the kernels. While size of kernel was not determined it is very probable that the wheat from plots of lower yield had kernels of smaller average size, in which case the proportion of bran would be somewhat higher than in the larger kernels, resulting in a higher per cent of ash. [Project 60-C; Department of Milling Industry; state funds.]

**The Relation of Variety to the Quality of Wheat.** Milling, baking, and chemical tests were made on 34 varieties and strains from the crop of 1924 and on 41 from the crop of 1925.

The flour samples from the crop of 1924 were baked according to the standard method. The results failed to show any superiority for the new varieties. Those from the crop of 1925 were tested with the new dough mixer previously described. Poor results were obtained with Blackhull, Nebraska No. 28, and one selection of Turkey. These three appeared to have a weak gluten while all others gave results indicating a strong gluten.

The varieties grown at the Fort Hays Branch Experiment Station averaged 4 to 5 per cent more protein than those grown at Manhattan. This higher protein content was not, however, reflected in correspondingly better baking qualities. Apparently the protein content was too high as the dough was very tough. Such flours have their greatest value for blending with weaker flours. [Project 60-D; Department of Milling Industry; state funds.]

**A Comparison of the Quality of Wheat Varieties Grown in Different Parts of Kansas.** Milling, baking, and chemical tests were made on 201 samples from the crop of 1924 and 195 samples from the crop of 1925 of the four varieties of wheat, Kanred, Turkey, Blackhull, and Fulcaster, grown under comparable conditions in different part of Kansas. The summarized results for the season of 1925, grouped on the basis of protein content, are given in Table XIII. The protein content of all four varieties was higher in 1925 than in 1924 but not as high as in 1923.

No marked varietal differences were observed in the crop of 1924. In 1925 Blackhull was distinctly poorer than the others. In testing the 1925 samples, the new dough mixer was used. This gives the flour a much severer test. Blackhull gave a smaller volume and a poorer texture for all ranges of protein. This makes it appear that this variety has a gluten of distinctly weaker quality than the other variety under observation. [Project 60-E; Department of Milling Industry; state funds.]

**A Study of the Protein Content of Some Common Kansas Wheat Varieties.** During the past biennium, 749 samples representing 20 varieties of wheat grown in Kansas were analyzed for protein. The results of these analyses for the nine more common varieties are given in Table XIV.

The general averages as well as the range in protein content were greater in 1924 than in 1925. The range in protein of any one variety is so much greater than the differences in protein between different varieties that protein content does not appear to be a variety characteristic as far as shown by the data in Table XIV. Soil and climatic factors are so dominant that the influence of variety on protein is obscured by them. The special value of any variety, therefore, lies in its adaptation to environmental conditions. [Project 60-F; Department of Milling Industry; state funds.]

TABLE XIII.—A comparison of the quality of four standard varieties of Kansas wheat, grouped on the basis of protein content.  
(Season of 1925.)

Number of samples.	VARIETY.	Average per cent protein.	Average yield, bushels.	Range in yield, bushels	Average test weight.	Per cent flour	Loaf volume, c c	Texture
11	Kanred	10.6	21.9	9.9 to 43.5	58.9	69.5	1,877	95
15	Kanred	11.5	17.9	8.7 to 26.6	59.0	69.2	1,871	98
9	Kanred	12.4	18.9	11.7 to 31.3	58.0	69.2	1,901	96
7	Kanred	13.3	18.5	9.3 to 39.5	58.7	70.5	1,890	95
6	Kanred	16.1	11.7	8.7 to 16.0	56.5	68.9	2,010	96
2	Turkey	9.7	14.6	10.2 to 18.9	58.5	69.3	1,820	94
9	Turkey	10.5	20.5	11.8 to 35.0	59.6	68.9	1,886	95
18	Turkey	11.4	18.4	8.2 to 30.2	60.0	69.6	1,806	93
8	Turkey	12.4	14.1	7.7 to 24.7	59.2	68.6	1,840	94
2	Turkey	13.2	26.3	15.8 to 36.7	59.9	68.9	1,885	94
8	Turkey	15.4	12.1	7.4 to 18.9	57.8	68.1	1,991	97
1	Blackhull	9.9	9.4	9.4 to	61.1	68.0	1,660	88
10	Blackhull	10.6	22.7	12.0 to 44.1	61.7	69.1	1,653	88
22	Blackhull	11.5	21.5	12.7 to 35.2	62.1	69.6	1,665	88
7	Blackhull	12.4	16.9	7.6 to 37.6	60.6	69.6	1,663	88
2	Blackhull	13.6	11.7	11.5 to 11.8	60.2	69.6	1,770	93
6	Blackhull	14.9	13.7	6.4 to 21.7	59.8	68.8	1,733	90
2	Fulcaster	9.8	37.9	35.6 to 40.2	60.1	68.1	1,830	96
5	Fulcaster	10.5	18.6	8.6 to 27.2	60.4	68.5	1,778	91
15	Fulcaster	11.5	18.8	13.0 to 24.9	60.3	68.0	1,871	95
11	Fulcaster	12.3	18.0	8.0 to 33.1	58.4	66.8	1,837	93
5	Fulcaster	13.5	13.4	5.2 to 24.3	57.9	67.4	1,826	93
7	Fulcaster	15.5	12.6	5.8 to 20.7	57.0	65.7	1,959	96

TABLE XIV.—The protein content of some Kansas wheat varieties.

VARIETY.	Number samples.	Protein average.	Per cent range.
Crop of 1924.			
Kanred	55	11.2	8.1 to 16.4
Turkey	70	11.4	8.1 to 16.0
Blackhull	76	11.7	8.7 to 17.2
Fulcaster	70	11.8	8.9 to 18.1
Kharkof	57	11.4	8.4 to 19.2
Harvest Queen	27	12.0	9.4 to 18.7
Fultz	24	11.8	9.7 to 15.1
Currell	23	12.0	9.7 to 19.3
Poole	23	12.1	10.1 to 19.0
Crop of 1925.			
Kanred	68	13.00	10.4.5 to 18.95
Turkey	69	12.77	9.90 to 17.75
Blackhull	70	12.43	10.15 to 17.55
Fulcaster	54	13.03	10.00 to 18.10
Kharkof	43	13.11	10.30 to 17.70
Harvest Queen	22	12.33	10.65 to 15.85
Fultz	22	12.71	10.50 to 15.60
Currell	18	12.65	10.58 to 16.00
Poole	22	12.39	10.75 to 17.70

**Milling Work on Wheat Shrinkage, Loss, and Damage in Farm Storage.** During the biennium the Department of Agricultural Economics has submitted 282 samples of wheat for moisture tests; 16 for protein tests; and 63 for milling, baking, and chemical tests.

From the results obtained so far it seems that there is little danger of heating and damage to combine wheat if it is fully ripened when cut and if it is not wetted by rain. In 1924, the wheat ripened unevenly, and some was cut too green. Consequently, several lots were damaged or bin burned in storage. This damage was so serious that even when some of this wheat was mixed with sound wheat the baking results were unsatisfactory, as is indicated by the data presented in Table XV.

TABLE XV.—The influence of varying quantities of bin-burned wheat upon baking qualities of sound wheat.

Per cent bin-burned wheat mixed with sound wheat	Per cent ash in flour.	Loaf volume (c. c.).	Texture per cent.	Color per cent.
0.0	.49	1,800	93	92
2.5	.47	1,730	91	90
5.0	.49	1,815	90	91
10.0	.52	1,645	85	88
15.0	.53	1,545	83	86
20.0	.56	1,500	80	84
25.0	.57	1,540	80	80
50.0	.69	1,175	40	40
75.0	.76	1,010	30	20
100.0	.90	1,070	20	20

These figures show that when more than 5 per cent of bin-burned wheat was mixed with the sound wheat unsatisfactory results were secured.

No samples of the 1925 crop suffered any serious damage. One sample showed a small amount of heating in the bin which appeared to improve its baking qualities. Another was obtained from the first round of the combine after rain. This also showed better baking qualities than the check.

The three years' work has shown that heating which causes damage to wheat results from excess of moisture due to an immature condition of the grain or moisture from rain or dew. The former appears to be the more serious and frequent cause of damage. [Project 143; Department of Milling Industry; Purnell funds.]

**Flour Chemistry Investigations.** The work on this project for the past two years includes (1) a study of the acidic and basic strengths of different flours; (2) the behavior of flours at different degrees of acidity and alkalinity; (3) the increase of acidity in different flours with age; (4) the properties of the proteins of flour; a determination of the physical and chemical properties of leucosin; and (5) the working out of a method for determining the hydration capacity of flour.

The following papers were completed and published during the biennium:

The Iso-electric Points of Gliadin and Glutenin. Jour. of Amer. Chem. Soc., Vol. XLVII, No. 2, pp. 418-422. 1925.

The Volubility of Gliadin in Acids, Bases, and Neutral Salts. *Cereal Chemistry*, Vol. II, No. 3, pp. 117-127. 1925.

Gluten Quality and the Iso-electric Point. *Cereal Chemistry*, Vol. II, No. 4, pp. 202-208. 1925.

The following lines of work have been completed and papers presenting the results are ready for publication: (1) Changes in the acidity of flours with age; (2) A comparison of the neutralization curves of different grades of flour; and (3) The influence of the proteins of flour on the acidity. [Project 60; Departments of Chemistry and Milling Industry; state funds.]

**Orchard Investigations.** In the spring of 1925 several plots were selected in the Winesap section of the station orchard to determine the fungicidal and insecticidal values of combinations of lime-sulfur solution and dry lime-sulfur with certain arsenical compounds.

The fungicidal efficiency of the various mixtures was judged by their effectiveness in controlling apple scab. In addition to the data recorded on apple scab an accurate record was made of the insecticidal value of calcium arsenate and lead arsenate in controlling the codling moth.

The combination sprays were applied as follows: the "pink" spray on April 13, 1925, the calyx cup spray on April 23, and the "14-day" spray on May 4, and again on May 19. On June 8, July 1, July 14, and August 3 arsenical sprays were applied for the control of codling moth. All sprays were applied at 275 pounds pressure through a rod and disk nozzles.

Unfortunately for the experiment, apple scab did not produce enough damage in the orchard on the unsprayed or check row to make the experiment of value. There is a possibility that the comparatively dry winters of 1923-'24 and 1924-'25 were unfavorable to the overwintering of the fungus in the fallen leaves. Undoubtedly the methods of soil management involving a clean cultivation cover crop combination and the general orchard sanitation practices followed are also unfavorable for the development of the apple scab fungus. The work will be repeated in 1926.

In 1925, six rows on the east side of the experimental cherry orchard were sprayed three times with summer strength lime-sulfur, and seven rows on the west side were sprayed three times with Bordeaux mixture, 3-4-50. The spray dates were April 25, May 6, and July 6. The same spraying equipment and crew were used in both plots. The applications were made through a standard spray gun at a working pressure of 275 pounds.

No separate check or unsprayed block was left because the proximity of a windbreak near the north row of cherry trees made it inconvenient to spray the north half of this row. This row transverse both spray plots. A large proportion of leaves on the unsprayed branches became badly infected with cherry leaf spot. There was no apparent difference in the effectiveness of the sprays in controlling the disease. The control was practically perfect in each plot.

In order to observe if the fungicide used had any influence upon the size of the fruit, representative two-pound samples of cherries from each of four Early Richmond, four Montmorency, and two English Morello trees in each plot were selected at harvest and the cherries were counted. They were harvested on June 9, June 22, and July 4, respectively. The data showing the number of cherries per pound in the various samples are presented in Table XVI.

TABLE XVI.—Number of cherries per pound in Bordeaux and lime-sulfur sprayed plots, 1925.

VARIETY.	Date harvested and counted.	Number of cherries per pound.	
		Bordeaux plot	Lime-sulfur plot.
Early Richmond	June 9	230	151
Montmorency	June 22	173	144
English Morello	July 4	159	197

These data show that the cherry fruits from the lime-sulfur plot were larger than those from the Bordeaux plot with the Early Richmond and Montmorency varieties. However, with the English Morello variety the fruit from the plot sprayed with Bordeaux mixture was larger than that from the plot sprayed with lime-sulfur. No reason is assigned for this difference.

The statement has been made that length growth is greater from terminal buds on sour cherry twigs than from the end lateral bud following the removal of the terminal bud. A test was made to determine this point during the seasons of 1924 and 1925 with the following result:

YEAR.	Treatment.	Number measured.	length in c. m.	
1924	Headed back . . . . .	28	28.4	Growth from distal end buds
1924	Not headed. . . . .	78	26.1	Growth from terminal buds.
1925	Headed back . . . . .	69	47.5	Growth from end distal buds.
1925	Not headed . . . . .	41	43.0	Growth from terminal buds.

These records indicate that, as far as the extension in length of the sour cherry twig is concerned, heading back is a stimulating process. In addition, the lateral twigs arising on headed back twigs averaged 10 centimeters greater in length than those from unheaded twigs. The numbers of each measured were 284 and 315 respectively. It would seem that heading back the twigs on newly transplanted Montmorency cherry trees is a desirable practice.

The experimental study of the effect of partial disbudding at planting time of one year apple whips which was begun in 1923 was extended to include 48 Jonathan trees in 1925. These trees were all headed back to a height of 65 centimeters immediately following planting. After the buds had started growth, April 16, 1925, the trees were divided into groups of 12 and given the following disbudding treatments:

GROUP 1. The terminal, that is the highest, and five lateral buds were left on the upper 25 centimeters of the stem. These were spaced approximately 5 centimeters apart, which required the removal of alternate buds in most cases. Buds lower on the trunk were not removed.

GROUP 2. The terminal, that is the highest, and three lateral buds were left on the upper 25 centimeters of the stem. These buds were thus spread about 8 centimeters apart. Lower buds were not removed.

GROUP 3. Check trees. No disbudding.

GROUP 4. The terminal and three lateral buds were left on the upper 25 centimeters of the stem. These buds were spaced approximately 8 centimeters apart. All lower buds, including those which appeared to be latent, were removed.

The values of these treatments are to be judged on the basis of their effect on the vigor of the plant during its juvenile period and the desirability of form exhibited by the plant. Increase in trunk diameter and length of twig growth are to be taken as representing the vegetative vigor of the plants.

Any detailed analysis of the data will be postponed until further data are collected, but it may be observed that no striking differences were found at the end of the first year. The trees of Group 4 seem to show the effects of the removal of the low buds in reduced trunk diameter. However, this same group was first in total twig growth. It is proposed to continue the observations on these trees for three more years.

The experimental work in orchard soil management during 1924 followed much the same line as during the preceding year, but was interfered with somewhat in 1925 because of the cessation of all cover crop work on the west half of the apple orchard and the inauguration of a bindweed eradication campaign on this area.

In addition to the bindweed work, three phases of soil management experimentation were prosecuted during the biennium; namely, (1) the use of commercial fertilizers; (2) the use of cover crops; and (3) the straw mulch system of management. Both the vegetative response of the trees and, in 1925, the yield of fruit, were recorded as measures of the effects of these varied treatments.

As has been the case heretofore, plot 9, barnyard manure without phosphate, exceeded in vegetative development and in production of fruit plots 7 and 8 which received barnyard manure and phosphates. The trees in plot 9 average younger than in the other two plots, five of them being 1921 or 1922 replants compared with three replants in plot 7 and but one in plot 8. Evidence accumulates that, under these conditions, applications of phosphorus produce a negative result. On the Jonathan plots (46-47-48) plot 47 to which rock phosphate was applied replaced the check plot as the most rapid grower by both twig measurement and trunk growth although the check, 48, excelled in the former in 1924. In these plots the differences were small. In the other commercial fertilizer plots the differences in vegetative response were small and possibly not significant.

Plots 16 and 20 have now been under the straw mulch method of soil management for five years. The results secured from this method with Delicious trees during the past two years are given in Table XVII.

Except for the item of twig growth the superiority of the straw mulch system is less marked during seasons of adequate rainfall. In fact, the check plot yielded more fruit in 1925 than did plot 16 under straw. The heavy crop of fruit, 41.25 bushels, on the trees of plot 20 seemed to depress their vegetative growth, the twig growth being less than on the check plot.

TABLE XVII.—A comparison of the rate of growth and yield of Delicious apple trees under straw mulch.

Plot No.	TREATMENT.	1924.		1925.		Yield
		Average increase in trunk girth.	Average twig growth.	Average increase in trunk girth.	Average twig growth.	
16	Straw mulch. . . . .	<i>Cm.</i> Not recorded	<i>Cm</i> 37.1	<i>Cm</i> 6.08	<i>Cm.</i> 25.5	<i>Bus.</i> 18.5
20	Straw mulch. . . . .	8.6	36.86	5.9	23.5	41.25
17	Check. . . . .	6.6	25.42	5.25	24.2	24.5

The cover crop tests were curtailed in 1925 due to other uses for the west 15 acres of the experimental apple orchard. The only cover crops used were rye and winter vetch with which studies of the optimum date for plowing under were continued.

Closely related to the study of date of plowing under cover crops is the question of the rate of growth of the orchard trees. The study of this problem made during the past year was of a preliminary nature but data collected on twig growth rates are of value and a method of determining the time or rate of trunk expansion was developed and tested. Five of these home made "Dendrographs" are in use this season and are so placed as to record trunk growth of the same trees which are affected by the cover crop studies. The rates of twig growth data confirm previous records. When the trees have been exposed to a certain sum total of heat units, twig growth is very rapid for a period of about 40 days, after which extension ceases on nearly all of the twigs. In contrast, the increase of trunk circumference is fairly even throughout the growing season, April to September. [Project 25; Department of Horticulture; state funds.]

**Small-fruit Investigations.** The grapes in the station vineyard reached bearing age during the biennium and produced a light crop of fruit during the summer of 1925. This crop would have been more abundant except for the frost of April 30 and the heavy winds of the latter part of the same month, both of which destroyed many shoots.

Following the frost damage of April 30, special pruning practices were followed with vines of the Niagara and Moore Early varieties. These practices consisted of (1) removing the frozen shoots, (2) removing part of them, and (3) the check vines which received no

treatment. The subsequent growth of shoots from the secondary buds and the production of fruit on these vines indicated that pruning off the frozen shoots was of no measurable value to the vines. Unpruned canes on the same vine did as well as pruned ones and unpruned vines were equally vigorous and productive as those from which the frozen shoots had been removed.

A study has been inaugurated to determine the diameter of the grape cane that is most productive. The cane growth of grapes can readily be divided into two groups on this basis; namely, (1) large or "bull" canes up to thirty sixty-fourths of an inch in diameter, and (2) medium canes sixteen to eighteen sixty-fourths of an inch in diameter. At pruning time canes in these groups were selected on 28 Concord vines, all under the two-cane Kniffin system of training, and on 15 Worden vines, 13 of which are two-cane Kniffin and two the Munson system of training. The original lengths of these canes were recorded as well as the diameter and they were headed back to 18 buds each, all other canes on the vine being removed. Records will be kept of the yield from these vines and from the individual canes in an effort to determine whether the medium size is preferable as is frequently stated in the literature but not supported by definite evidence.

This experiment will not interfere with the tests of the various methods of trellising which are under way. The vines trained according to the four-cane Kniffin system gave the largest yield of Concord, 307 pounds, in 1925. The Munson system led in the Worden block with 408 pounds. Second place went to the Munson system in the ConCORDS and to the four-cane Kniffin system in the Wordens with records of 270 and 291 pounds, respectively. The "fan" system ranked third in both blocks.

None of the hybrid varieties, Brighton, Agawam, Diamond, and Niagara, found in the vineyard has suffered winter killing of the canes during the past two winters but they all suffered from the frost of April 30, 1925, and so gave but light yields of fruit that season.

Lucile, a new commercial variety, which is being tested in the vineyard, will produce a light crop this season (1925). It has shown excellent vine characteristics so far. The trellis for this row was built during the past winter. A manuscript, "Grape Growing in Kansas," is in course of preparation. [project 26; Department of Horticulture; state funds.]

**Experiments With Vegetables.** The project on the effect of steam soil sterilization in the greenhouses has been continued. The first crop grown indicated that a 20-minute treatment was sufficient. Subsequently it was found that the time was too short. During the summer and fall, 40-minute treatments were tried and the results were more satisfactory. This spring 60-minute treatments were given and these, so far, seem the most practical.

The cost of a 60-minute treatment is estimated at \$45 to \$50 per greenhouse unit with coal at \$9 a ton. At these figures it costs about 10 cents per square foot for the treatment.

The value of the treatment may be measured by the returns. Lettuce plants of the same age were set in two beds; one treated one hour with the steam, the other untreated. In other respects all conditions were alike. At the end of eight weeks, the crop was harvested.

One thousand three hundred and fifty plants were set in each bed. There was a perfect stand in the treated bed and the plants weighed 1,815 pounds. In the untreated bed about 10 per cent of the plants were unsalable, having been attacked by lettuce drop. The salable plants weighed 607.5 pounds. On January 15, the beds were reset with lettuce and tomatoes. At the end of eight weeks the lettuce drop had spread throughout the soil in the untreated bed and none of it was salable. The plants in the treated bed reached a salable size and weighed 1,041.5 pounds or .89 pound per plant.

All of the ground beds in the Horticultural greenhouses have been equipped to permit of soil sterilization. The cost of installation is repaid in the labor saved by using the same tile installation for irrigation purposes.

The variety tests with tomatoes in the greenhouse have been continued. They indicate that the Louisiana Red tomato which has been seed selected for seven generations is superior to the imported and domestic strains of various greenhouse tomatoes in yield and quality of fruit. These tests will be continued. [Project 27; Department of Horticulture; state funds.]

**Tree Investigations.** *Pinus ponderosa*, a native of northwestern Nebraska, the Dakotas, and the northwest is proving the most desirable species of the pine genus. The older trees under observation, now about 50 years old, show greater vigor and less injury from varying weather conditions than does the Austrian pine and form more uniformly straight trunks than the Scotch pine. The greater

difficulty of transplanting is being overcome by balling and bur-lapping for spring handling and, even better, by handling them in freezing weather.

For a large part of upland Kansas, the Red Cedar is valuable. The fungus occurring on the Red Cedar which is so injurious to apples is not common and the hardiness of the tree makes it one of the very desirable species. It recovers from serious hail injury more readily and certainly than any other conifer. Its propagation is dependent upon favorable conditions for seed production, the crops of seed in different years varying greatly in viability. This makes it necessary to grow large numbers of seedlings in years when viability is high.

For woodlot improvement the increase in the proportion of young walnut and the better species of oak is gratifying. Walnut is not so successful in pure stands as in mixed species. Success is best assured by preparing hills and planting, in early spring, seed that has been stored in wet sand and exposed to the winter's freezing. Many woodlots may be made much more valuable by changing from low value species of willows and elms to nut trees and valuable wood species.

The interest in pecan culture increases. Some of the groves in southeastern counties have required thinning as a thick stand causes tall trunks with small tops. The nuts are produced from terminal buds and a large number of terminals is necessary for large crops. On the farm of Sebastian Hahn near Coffeyville, pecan trees planted in well enriched hills have made unusual growth and came into bearing at an early age, some nuts being produced on eight-year-old trees. Pecans are finding a place in the northern part of the state. Trees in Jefferson and Nemaha counties are proving hardy and productive and the species is worthy of more general planting. [Project 82; Department of Horticulture; state funds.]

#### DISEASES OF PLANTS

Kansas is fortunate in having fewer serious diseases to menace her plant industries than many agricultural regions, nevertheless, plant diseases exact a heavy toll from many crops. The Agricultural Experiment Station is active in its efforts to safeguard Kansas crops against disease. Some of the important features of work along this line are discussed below.

**Cereal and Forage Crop Disease Investigations.** One of the phases of this project relates to the leaf rust of wheat. Several thousand spaced F<sub>2</sub> and F<sub>3</sub> plants of a Kanred X Fulcaster cross have been studied in the field and some promising leaf rust resistant lines with good grain quality and stiff straw have been selected for increase and further study.

The inheritance of resistance to leaf rust has been studied in a number of different crosses in the greenhouse, using a single known physiologic form of leaf rust. A detailed study was made of the Kanred X Fulcaster cross. It was found in both F<sub>2</sub> and F<sub>3</sub> plants that while resistance was recessive in the seedling stage, it was apparently dominant in the heading stage. An analysis showed that heterozygous plants were responsible for this change. Plants immune in the seedling stage did not change later in their reaction to rust. Thus it was found that true immunity, that is, immunity in all stages of growth was recessive and apparently due to a single main factor difference.

The effect of leaf rust on yield is also being studied, using potted plants grown in the greenhouse. One hundred plants of each of two varieties of wheat are grown, namely, Malakof C. I. No. 4898 which is susceptible to rust, and Fulcaster No. 6 which is resistant. Half of the plants of each variety are inoculated while the others are not. The seed is harvested and detailed data taken on number of heads, number of grains, weight of grain, and quality. In general a reduction in yield due to leaf rust has been noted, but the nature and cause of the reduction has not been fully determined.

Dusting wheat with sulphur both in the greenhouse and in the field has been found to prevent leaf rust infection. The frequency and rate of dusting necessary to give satisfactory control have not been determined.

A grass garden of about eighty species of wild and cultivated grasses has been maintained for several years in connection with the rust nursery. Notes on the date of appearance of rust have been secured each year. Considerable rust has been noted on species of *Hordeum*, *Elymus*, *Bromus*, *Avena*, *Agropyron*, and *Dactylis*, but the date of appearance has been later than the appearance of leaf and stem rust on wheat in the adjoining nursery. Goat grass, *Aegilops cylindrica*, has been found in wheat fields of 10 counties in Kansas and has become a serious weed in some localities. Natural crosses of wheat and goat grass have been found to be extremely susceptible to leaf rust of wheat where the parental wheat variety is a susceptible one.

In the stinking smut (bunt) phase of the project, a study has been made of the effect of date of planting on smut infection and of the effect of recontaminating treated seed with smut by soil and seed inoculations. It has been definitely proved that early plantings in September while the soil is warm resulted in little or no smut, while planting in October and up to the middle of November gave the highest infection. Generally speaking soil temperatures between 40 degrees and 60 degrees F. produce heavy infection.

The brands of copper carbonate with 50 to 55 per cent copper have given the best smut control, being more dependable than those grades containing only 18 to 20 per cent copper. This is especially the case when seed wheat is badly infected. If seed wheat, which has been treated with copper carbonate, is heavily recontaminated with smut spores by dusting the seed with smut or applying large amounts of smut to the soil before planting, heavy smut infection occurs. This shows that copper carbonate treated seed is not necessarily protected against recontamination. Undoubtedly the spore load which the seed carries is an important factor in this connection.

The wheat foot-rot disease has assumed a more serious aspect during the last two years. Many of the fields attacked may properly be said to be affected with "take-all," since the organism *Ophiobolus graminis* is definitely known to be present in fields where wheat foot rot occurs. The other organisms, *Helminthosporium* spp. and *Wojnowicia graminis* have been isolated much more commonly, however, from infected plants. In the wheat seedbed and tillage plots at the Agronomy Farm, five seasons' observations show that early deep plowing favors the spread of the disease, while late shallow plowing, disking, or merely removing the weeds suppresses the disease. An effort is being made to secure varieties resistant to the disease. Many strains and varieties of wheat have been planted in the field in naturally infested soil. These same varieties are being artificially inoculated in the greenhouse with a pure culture of *Ophiobolus graminis*. To date the work has not demonstrated the presence of resistance in any variety.

In the oat smut investigations, a number of treatments were used on both hulled and hull-less varieties. Fairly satisfactory smut control for both groups was secured with Uspulum, Semesan, Kalimat, Corona No. 620, Germisan, Pythal, Seed-O-San, and Chlorophol. They have not proved to be as reliable as the formaldehyde soaking treatment, however. Furfural gave no smut control in hulled oats and copper stearate failed to control smut in either hulled or hull-less varieties. Dusting treatments with copper carbonate and vari-

ous forms of sulphur gave excellent smut control in hull-less oats, but were ineffective when a hulled variety was used.

Periodic sowings of six varieties of heavily smutted oats were made for two years to determine the effect of date of sowing on smut infection. The sowings began the first week in March and were continued through the first week in May. The moisture content and temperature of the soil at the time of sowing were determined. Smut infection in all sowings of all varieties was higher in 1925 than in 1924. The data secured show that soil temperatures of 62 degrees to 66 degrees F. and a soil moisture of about 30 per cent of the water-holding capacity of the soil were most favorable for smut infection.

In 1924 and 1925 an experiment was conducted to determine the effect of dehulling the oat kernels on smut infection. Both hulled and dehulled samples of five varieties of oats were inoculated and sown each year and the smut percentages determined. The efficiency of the glumes as a protection against smut infection is shown in Table XVIII.

TABLE XVIII.—Effect of dehulling oat kernels on smut infection.

VARIETY.	Kansas No.	Reaction to smut.	Per cent of heads smutted.			
			Seed hulled.		Seed dehulled.	
			1924	1925	1924	1925
Aurora . . . . .	5206	Susceptible . . . . .	15.1	30.6	56.7	67.5
Richland . . . . .	5209	Moderately susceptible. . .	3.8	27.8	55.0	49.0
Burt . . . . .	6004	Moderately susceptible. . .	12.4	48.2	74.6	84.9
Burt . . . . .	6090	Resistant . . . . .	3.0	4.0	12.7	27.4
Kanota . . . . .	5179	Resistant . . . . .	2.7	2.1	4.5	1.9

These results indicate that the glumes of oats are a great natural protection to susceptible varieties such as Aurora, Richland, and Burt (Kan. 6004). Burt (Kan. 6090) and Kanota are physiologically and inherently more resistant and their reaction to smut is evidently not due to the protection afforded by the glumes.

Kernel smut of Dwarf Yellow milo was found at the Colby Branch Experiment Station in 1923. It occurred again in 1924. This is the first time a kernel smut has been reported on milo. Extensive cooperative experiments with the Office of Cereal Investigations of the United States Department of Agriculture have been conducted

for two years in which this kernel smut of milo and the ordinary kernel smut of sorghum have been used for artificial inoculations. The results of these studies show that all varieties of sorghum with the exception of feterita may be attacked by milo smut.

A number of materials for treating for the control of the common kernel smut of sorghum have been studied for several years. For four years Blackhull kafir, Pink kafir, Red Amber sorgo, and Kansas Orange sorgo have been used in these experiments. Thirty treatments were used in 1924 and forty-two in 1925. Soaking and dusting treatments were compared. Dusting experiments have given excellent reports, Copper carbonate in various forms and several brands of superfine sulphur have been found to give nearly as good smut control as the formaldehyde treatments. No seed injury results from the use of the dust treatments, the germination being sometimes increased by their use. Copper Stearate and Colloidal copper failed to give satisfactory smut control, but some of the organic mercury compounds seem promising.

In the corn smut investigations, a large number of inbred lines of Commercial White, Pride of Saline, Kansas Sunflower, Colby, Dawson County, and Freed's White Dent corn have been studied from the standpoint of resistance to smut. In all approximately 400 inbred and hybrid lines have been used in these studies. Several inbred lines have been secured which are resistant to smut while others are extremely susceptible.

Extensive studies now in the fifth year are in progress in which the corn smut organism *Ustilago zae* is being studied physiologically. Data on the possible existence of physiologic forms of the organism have been secured. Studies are in progress to determine why differences appear to exist in the pathogenicity of the organism.

Results have been secured which indicate that copper carbonate and sulphur dusts of various brands have some effect on the control of sweet corn smut, the smut being very appreciably reduced by certain treatments. The time, amount of dust, etc., for the best control are yet to be determined.

Several root-rot diseases of alfalfa have caused serious damage in Kansas in the past biennium. One has recently been described as a bacterial disease commonly known as wilt. It is widespread in Kansas and surrounding states. The disease becomes noticeable in the spring when affected plants fail to sprout, or if sprouting occurs the growth is weak and spindly. The woody portions of the roots of

diseased plants are discolored, showing a tan or brown and watery appearance when the bark is removed. The disease frequently reduces the stand of alfalfa 25 to 50 per cent in a single season.

A careful investigation of the disease should be made to determine (1) how it is transmitted; (2) what agencies are involved in its spread; and (3) how long the disease remains in the soil after the alfalfa is plowed up. [Project 76; Department of Botany; state funds.]

**Fruit and Vegetable Disease Investigations.** During the past two years experiments have been continued on the comparative value of the hot formaldehyde method versus the corrosive sublimate method treatment of seed potatoes for the control of *Rhizoctonia*.

Over eighteen thousand sclerotia taken from potatoes treated by different methods have been plated and examined in the past two years. The results indicate that three minutes in the hot formaldehyde solution in sacks is just as effective for the control of *Rhizoctonia* as corrosive sublimate for 90 minutes.

Several sulphur, copper, and organic mercury dusts have been used as dust treatments for the control of *Rhizoctonia*. Sulphur dusts did not materially reduce the amount of *Rhizoctonia* on the stems. Copper dusts as a group gave slight control, but all caused a stunting of the plants. One of the organic mercury dusts gave excellent control. Two others were valueless.

Potato scab experiments for the biennium have consisted of a study of the effect of sulphur and green manuring crops upon control. The results indicate that neither sulphur alone nor green manure crops alone can be relied upon to economically control potato scab. Both have reduced the per cent of scab on potatoes grown on some soils while they have been ineffective on other soils. In one experiment a combination of rye plowed under for green manure plus 400 pounds of sulphur per acre reduced the infestation from 82.9 to 5 per cent. The per cent of clean tubers was increased from 11.8 to 62.3.

Degeneration diseases of the potato, such as mosaic and spindle tuber, have been under investigation for two years. The symptoms of mosaic are masked in Kansas due to the high temperature during the growing season. Nevertheless plants carrying this disease although appearing healthy are greatly reduced in yield.

Of greater economic importance than mosaic is spindle tuber, It causes, in Kansas, a greater reduction in yield than all other virus diseases.

The work of past years to obtain varieties or strains of tomatoes resistant to wilt, a disease caused by *Fusarium lycopersici* has been continued. Varieties found to be most resistant are Louisiana Red, Louisiana Pink, Marvana, Marvelosa, Marvel, Norton, Norduke, and Kanora. The Kanora variety, previously reported as Kansas hybrid No. 9B or as White's No. 9, is a new wilt-resistant variety. It is a hybrid between Norton and John Baer. The results of seven years' work upon this subject have been published as Technical Bulletin 20, "Tomato Wilt Investigations." Future work upon this phase of the project will be directed toward the production of a wilt-resistant forcing tomato for the greenhouse.

Rhizoctonia crown rot of carrots has been observed to be locally severe and destructive in trucking areas near Kansas City. It was found to be a weak parasite causing serious loss only under very humid conditions and fairly high temperatures.

A disease of apple trees known as root rot has appeared in the northeast section of the state. The cause has been determined as *Stereum purpureum*. Methods of infection, overwintering, and possibilities of control are points still to be determined.

Results of the work in cabbage yellows investigations have shown that such varieties as All Season, Iocope, and Brunswick, while resistant to the disease, are not entirely desirable from the standpoint of type and date of maturity. Commercial Copenhagen and Golden Acre, therefore, continue to be the most popular varieties although they are both susceptible to yellows. Further work upon this sub-project will be directed toward the production of an early wilt-resistant Copenhagen type cabbage. [Project 130; Department of Botany; state funds.]

#### INJURIOUS INSECTS AND OTHER PESTS

There are given below some of the more important features of the work of the Agricultural Experiment Station on injurious insects and other pests that menace the plant industries of Kansas.

**Climate and Injurious Insect Investigations.** During the past two years an effort has been made to accumulate data on insect abundance and weather conditions for the last 20 or 30 years. The purpose was to ascertain whether there was any correlation between insect outbreaks in this state and the weather. Records of insect abundance and weather conditions have been studied from the reports of the State Board of Agriculture at Topeka, from the United States Weather Bureau stations, from records of farm pa-

pers, and from records of the more important insect outbreaks as recorded by the Department of Entomology.

Severe chinch bug outbreaks have occurred in Kansas in 1871, 1874, 1875, 1881, 1887, 1910 to 1913, 1920, and 1924. All of these outbreaks occurred during hot, dry years. There was a light infestation in 1880 in some of the eastern counties, but heavy rains in August ended the trouble. In 1881, the chinch bugs were reported from nearly all counties in the eastern two-thirds of the state, except some in the northeast and southwest corners. The rainfall in May was 2½ inches above normal, but was preceded by a dry April. It was followed by three extremely hot and dry months—June, July, and August. The peak of the injury occurred in July, indicating that the bugs required the hot, dry weather to recover from the wet May. In 1889, the peak of the chinch bug injury came in May, which was a wet month.

When May and June were wet, or had a normal rainfall as occurred in 1876 to 1879, 1882 to 1885, 1888, 1892, 1894, 1897 to 1899, 1914, and 1915, there were very few reports of chinch bug damage. There were some exceptions, as in 1896, during which chinch bugs were generally distributed over the state and some damage occurred regardless of a cool, wet spring. Apparently the chinch bug does not reproduce rapidly under wet, cool conditions; but the most important factor is the chinch bug fungous disease which thrives best with warm moist conditions. Therefore, the rainfall of May and June apparently has a most important influence on the abundance of this insect.

Hessian fly outbreaks occurred during the years of 1891, 1900, 1903, 1908, 1915, and 1916. These were years of normal rainfall or above during the summer months. It, therefore, appears that high rainfall during July and August is especially favorable for the development of the Hessian fly.

The pea aphid, *Illinoia pisi* Kalt, has become a major pest of alfalfa in the last decade. The first outbreak occurred during the spring of 1921, as a result of which over 100,000 acres of alfalfa in Kansas were killed. Apparently this insect is controlled largely by climatic factors. Rearings were conducted in the greenhouse during 1923 to December, 1924, to determine the effects of temperature and humidity on the general life cycle of the insect with a view of explaining its activity in the fields, especially prior to and during outbreaks.

Nineteen generations were reared with peas as the host plant, and

twenty-one generations with alfalfa as host plant. The average age of the female when the first young were born was, on alfalfa, 8.3 days, and on peas, 8.9 days. The average length of the reproduction period was, on alfalfa, 10.8 days, and on peas, 5.4 days. The total number of young produced was, on alfalfa, 41 and on peas, 19.7. The average length of life was, on alfalfa, 21.3 days, and on peas, 14.5 days.

These data indicate that, other conditions being equal, the pea aphid reproduces longer, has more young, and lives longer with alfalfa than with peas as the host plant.

Another experiment was conducted in the air chambers in the greenhouse. In this experiment, the daily average temperature was maintained at 65 degrees for 40 days, and 70 degrees for 60 days. Alfalfa was used as the host plant. The average periods of development and reproduction for 30 individuals were as follows:

Age of female when first young was born. . . . .	9.7 days
Length of reproduction period. . . . .	16.6 days
Number of young. . . . .	54.3
Length of life. . . . .	30 days

A field laboratory situated at the edge of an alfalfa field was used to represent field conditions to check the insectary rearings. The averages of the rearings for the summer of 1924 were as follows:

Age of the female when first young was born. . . . .	10.8 days
Length of reproduction period. . . . .	3.3 days
Number of young. . . . .	13.7
Length of life. . . . .	16.0 days

These data show that these aphids live longer and have more young when under constant temperature, or temperatures of small fluctuations between 55 degrees and 80 degrees F. than they do under uncontrolled field temperatures. They indicate further that the lower temperatures are more favorable than the higher ones. The largest number of young were produced at an average temperature of 65 degrees. As the average temperature increases, the number of young produced decreases.

This is especially important in explaining the seasonal activity of these aphids in the field. They are most abundant and injurious in the field in April and May. The average temperatures for these months for the 37-year period was 54.6 degrees and 63.6 degrees, respectively. These temperatures are not far from the optimum indicated in the experiments mentioned above. [Project 6; Department of Entomology; Hatch funds.]

**Hessian Fly and Other Wheat Insects.** The study of the distribution of the Hessian fly in Kansas has been continued. It is gradually spreading westward across the state. The western limit at present is Meade, Gray, Finney, Scott, Logan, Sherman, and Cheyenne counties.

Studies on the life history of the Hessian fly under field conditions have been continued. Four broods were noted in 1924; namely, first spring brood, second spring brood, main fall brood, and supplementary fall brood.

The season of 1925-'26 presented a number of interesting features. There was a heavy emergence of the main fall brood about September 26, 1925, over most of the state. Owing to the exceptionally low temperatures of October, this brood developed slowly and many went into winter as partially grown maggots. Spring conditions were characterized by alternate periods of warm and cold weather, so that emergence was very irregular and prolonged, and the mortality was high.

The study of the resistance of wheat to Hessian fly injury was greatly expanded during the biennium. Over 700 varieties and strains of wheat were grown in the fly nursery. A good infestation of the fly was secured and a representative sample of each variety was examined. The results of this work are now being summarized. Marked differences were noted in the degree of infestation in the different varieties. Many varieties, as Illini Chief and Dawson Golden Chaff, were free from injury, while most of the Turkey and other hard wheats had 50 to 75 per cent of the plants infested. The spring infestation on these varieties was also determined. A study was also made of the per cent of fallen straw in the variety plots at the Agronomy Farm and the results conform with those obtained in the fly nursery.

Preliminary studies were begun to determine whether there are biologic strains of the Hessian fly. This work was suggested by the fact that two varieties of wheat which are resistant to the fly in Kansas are susceptible in areas where these varieties of wheat have been grown for many years. Also, in eastern Kansas, soft wheat is more susceptible than hard wheat; while in central and western Kansas, hard wheat is the most susceptible. The preliminary work consisted of introducing fly from Illinois and placing in cages containing Illini Chief, a resistant wheat, and Kanred, a susceptible variety. Under these conditions the Illini Chief wheat was heavily infested. This preliminary work is suggestive and will be continued.

An extensive series of time-of-planting experiments have been conducted during the past two years in cooperation with the county agents. Thirty-three date-of-seeding tests were conducted in 17 counties in 1924-'25, and 23 tests in 12 counties were conducted in 1925-'26. The infestation in these plots were determined late each fall. In every case during both years, the safe seeding date fell on or before the computed date. The experiments also emphasized the importance of fall rains on the emergence of the fly. This was brought out in 1925 when a general period of rainy weather ending about September 26 brought out practically all of the fly in a very few days; so that taking the state as a whole, wheat planted on or after September 26 was practically free from fall injury.

In order to determine the influence of cultural measures on fly injury, a study was made of the per cent of fallen straw in the different cropping plots at the Agronomy farm. These included seedbed preparation plots, rotation plots, soil fertility plots, and time and rate-of-planting plots. A total of 108 plots were studied. The results for a single season indicate that the cultural system may have some influence on the ability of the wheat plant to withstand injury.

The plots which were plowed shallow, had barnyard manure applied, had been in wheat two or more years, or were planted early, suffered the heaviest lodging due to fly infestation. [Project 8; Department of Entomology; Hatch funds.]

**Corn Earworm and Other Insects Injurious to Corn.** The corn earworm investigations during the past two years have consisted of a study of the relation of time of planting and variety of corn planted to earworm injury and of a study of the plant characteristics of corn that may be associated with earworm injury.

Plantings of corn were made at 10-day intervals from about April 1 to June 10, three methods of planting being used; namely, listing, surface planting, and planting in open furrows. The results coincide with previous studies in that corn planted about May 1 showed less earworm injury than that planted on earlier or later dates.

Twenty-four varieties of corn were under observation in 1924 and 19 varieties in 1925. The infestation of 1925 was light, but in general the results are in accord with the work of previous years. Data are now available on earworm injury to different varieties of corn for a period of about ten years. These data will be brought together, analyzed, and published in the near future.

In 1923, it was observed that ears showing male florets were re-

markedly free from earworm injury. A number of selections and crosses were made in order to study this further. Some of these crosses produced ears with male florets and in the face of the severe infestation of 1924 remained comparatively free from injury. Further studies were made in 1925, but the infestation was not severe enough to warrant any definite conclusions.

The heavy infestation of chinch bugs in the wheat in the spring of 1924 offered an excellent opportunity to carry on a series of barrier experiments to protect corn. Seven different types of barriers were constructed and studied. The results of these experiments have justified recommending a new type of barrier for Kansas conditions. This consists of a line of creosote with postholes every rod to trap the bugs. The addition of one-fourth to one-half ounce of calcium cyanide in each posthole daily serves to destroy the bugs. Considerable attention was paid to the migratory habits of the chinch bug, their abundance, and methods of determining the efficiency of the different types of barriers. The work of 1925 was concentrated on the efficiency of the creosote-posthole barrier. Approximately two miles of this type were under observation. The results obtained confirmed the work of 1924 and justified the recommendations that it is the most efficient and practical for Kansas conditions.

Studies on the resistance of corn to migrating chinch bugs were made in 1924 and 1925. Thirteen varieties of corn were planted in a small plot adjoining wheat. A heavy migration of chinch bugs occurred both years and all varieties finally succumbed to the attack. Marked differences were noted in the ability of the different varieties to withstand injury. Chlorophyll deficient plants were the first to die. Pride of Saline and Champion White Pearl survived much better than most other varieties but all were eventually killed.

Further studies on insects injurious to corn consisted of a biological study of the corn leaf aphid and the southern corn root worm; a study of the influence of cultural systems on insect injury with special reference to wireworm injury; and of a study of the protection of seed corn in storage against insect injury. [Project 9; Department of Entomology; Hatch funds.]

**The Control of Fruit and Vegetable Insects.** The work of the past biennium on the control of fruit and vegetable insects has consisted of (1) a test of various commercial lead arsenates; (2) a test of various poisons and methods of application; and (3) a study of an outbreak of the clover mite (*Bryobia pratensis* Garman) which

for the first time severely injured orchards in the Arkansas River valley.

An unusual outbreak of the clover mite occurred in 1924. The spring of 1924 was not noticeably different from many previous springs in Kansas; however, early weeks were cool with very little rain until late in May. The long spell of dry weather may have had an influence on the mite, for it became very abundant on apple trees by the latter part of June, and by the first week in July trees in some of the orchards in the Arkansas valley were seriously damaged. The serious condition of the orchards was discovered July 5 when an inspection was made of the orchard of Ralph Dixon near Arkansas City. A survey of the valley below Wichita was made at once and the pest was found in injurious numbers in several orchards.

Flowers of sulphur which had been found to be effective in controlling red spider was recommended for dusting the orchards. Mr. Dixon immediately made an application to the infested portion of his orchard and two days after the dust was applied no living mites could be found.

Some very valuable information regarding the injury to different varieties of apples by the mite was secured. A very decided preference was shown for certain varieties. The Missouri Pippin was most severely injured with Ben Davis second. The Winesap, Grimes Golden, and Delicious were very lightly infested and the Jonathan was uninjured. Since a satisfactory control measure has been discovered, work on this insect will be discontinued. [Project 13; Department of Entomology; Hatch funds.]

**Control of Insects Attacking the Sorghums.** The work on sorghum insects during the biennium has had to do with (1) Sudan grass in relation to chinch bugs, (2) the resistance of sorghum varieties to chinch bugs, (3) a study of an infestation of southern corn root worm on rye following Sudan grass, (4) a study of the life-history of the southern corn root worm, (5) a study of the biology and economic importance in Kansas of the corn leaf aphid, *Aphis maidis* Fitch, as a pest of sorghum, (6) a study of insects infesting sorghum seed, and (7) a survey of the insects of the sorghum field.

The principal investigation in relation to Sudan grass was a continuation of the hibernation studies made during the winters of 1922-'23 and 1923-'24. It was found that the number of bugs in clumps of Sudan grass decreased rapidly throughout the winter in

each instance. The results show that chinch bugs can hibernate in Sudan grass stubble, and that as the acreage of this crop increases, it will probably become an important factor in chinch bug control. Bunches of grass from Sudan fields, in close proximity to small grain fields where heavy infestations occurred during the summer, contained a greater number of bugs than bunches from other fields. Further observations show that the bugs did not migrate from fields other than those adjacent to the ones in which the counts were made.

Further studies have been made of the resistance of sorghums to chinch bug injury. The migration of the chinch bugs into the plot of sorghums in 1925 was ideal for a comparative study of varietal resistance. A summary of the injury done in 1925 confirms the work of Parker and Hayes of previous years in which milo was found to be more susceptible than other varieties.

The data recorded for the milo check rows showed a range in injury from 78 to 100 per cent, with an average loss of 92 per cent. Feterita, Shallu, Kaoliang, and Hegari ranked next in susceptibility. The kafirs showed little difference in their abilities to withstand chinch bug injury, with a range of 67 to 75 per cent. Kansas Orange sorgo proved fairly resistant.

Two crosses of Kansas Orange X milo from resistant plants from the summer of 1924 showed an injury of 78 per cent, which loss was higher than Kansas Orange but lower than for the mile. Blackhull X Sourless also was significant in its ability to withstand the attack. A number of factors, such as those affecting the color of leaves, number of suckers, and the amount and arrangement of lignin, that may be associated with the resistance factor were also studied. The lignin tests were again especially significant.

Studies were made of the biology and economic importance of *Aphis maidis* Fitch in Kansas. These insects prefer sorghums to corn, as indicated by the fact that they are found on the sorghums in early, summer, leave the sorghums for the corn in mid-summer and return to the sorghums later where they stay until frost kills the plants.

The relative importance of the various types of injury was determined and it was found that, in numbers, the rank from greatest to the least was discoloration of the infested parts, failure of the head to emerge from the boot, rotting and breaking of the stem, and a sterility of the lower branches of the head. Blackhull suffered more injury than Pink or other varieties of kafir. That the sorghum

heads selected for injury, due to *Aphis maidis*, consistently showed a decrease in the amount of grain produced in 1924-'25 is shown by the following table.

Variety	Loss in weight of heads	
	1924 Gms.	1925 Gms.
Dwarf Hegari. . . . .	63.90	43.61
Blackhull. . . . .	51.55	18.61
Kansas Orange. . . . .	33.71	24.69
Feterita. . . . .	8.77	Unavailable

Grain produced by injured heads was found to be shriveled, inferior in quality, and subject to molds. The germinating power was reduced and the development of plants from injured seed was retarded. [Project 92; Department of Entomology; state funds.]

Insects Attacking the Roots of Staple Crops. The studies on the life history of Kansas May beetles and white grubs were continued, emphasis being laid on those species on which data are meager. The work on the white grub was devoted principally to closing up the various lines of investigation, analyzing the data, and planning new lines of study. Life histories of 20 species of *Lachnosteria* have been worked out and five other species have been studied. Ecological studies have also been made and records on over 200,000 individuals are at hand. Some progress has been made in bringing these data together and summarizing them.

Considerable attention has been paid to the various species of *Scarabæidæ*, closely related to the true white grubs. Life histories of 15 or 20 species have now been completed and others are being studied. Ecological studies have also been carried on with these species of *Scarabæidæ* and a large amount of the data are at hand relative to their habitat, abundance, food, enemies, etc.

An extensive study of the wireworms of Kansas has been undertaken. During the biennium, over 3,500 wireworm larvae have been collected for rearing to adult in order to determine the length of the life history and the species that occur in Kansas. The collections were made over various types of habitats. Counts were made on the corn plots at the Agronomy Farm to determine the infestation in various plots under different farming practices. The records show considerable injury to some of the plots and fields following wheat. Much time has been required in an attempt to work out a suitable technique for rearing the insect from the egg stage to the adult. A systematic plan for collecting adults and larvae is under way, so that the occurrence and abundance of species may be ascertained.

An attempt has also been made to list as many species of the *Elateridae* known to be in Kansas as published in the literature with the hope that in the future the list maybe completed.

Studies have been made for some time, but chiefly the past two years throughout the winter, to determine the hibernation habits of white grubs and wireworms, The records show that the various species of grubs go below the frost line when winter begins. Digging indicate that the larvae are stratified as to species. Seventy-five per cent of the white grubs were taken within the first foot of soil. One species was taken at a depth of 40 inches. The wireworms seldom go deeper than six inches.

The burrowing habits of soil-inhabiting insects were studied and observations made of the uses which insects make of the soil. An attempt was also made to ascertain the effect of burrowing upon the soil, the amount of organic matter incorporated into the soil by certain species of insects, the interchange of soil and subsoil through the process of burrowing, and the factors which influence the distribution of insects. Data on 500 samples of soil, as well as on the burrows and the insects that made the excavations are available and ready to be summarized.

The use of calcium cyanide and carbon disulphide as soil insecticides proved injurious to Kentucky bluegrass, alfalfa, and corn, while paradichlorobenzine showed no injurious effects. In the preliminary investigations, carbon disulphide and calcium cyanide proved effective against white grubs while paradichlorobenzine proved of no value. [Project 100; Department of Entomology; state funds.]

**Insects Injurious to Alfalfa and Allied Plants.** Biological studies on the pea aphid have been completed and a paper on this insect has recently been published. A practical method of controlling the insect has been devised and has been tested with thoroughly satisfactory results. It consists of the following steps: (1) Location of infested areas or spots in fields in March and April, and their destruction by sowing calcium cyanide granules at the rate of about 30 pounds to the acre. (2) Where the areas are larger or the aphids scattered over the field, collecting with the aphidozer. (3) Harrowing infested areas where the alfalfa is not too tall to cultivate.

While collecting in alfalfa on the Agronomy Farm, July 3, 1925, a gravid female and two males of a very rare Chrysopid (*Eremochrysa punctinervis* McLach) were taken. The female deposited two eggs and the larvæ were reared. No member of this genus had

previously been reared. The larvæ were trash carriers; that is, they carried the small hemispherical packets of debris upon their backs. These insects feed upon plant lice, but since they are so scarce they are of negligible importance.

The work on the green clover worm has been completed. Rearing data on instars, measurements of stages, and general habits of larvæ and adults have been recorded. A difference of opinion exists in the literature as to whether this insect overwinters as adult or pupa. It overwinters in Kansas in both stages, but predominately as pupæ

There was a rather widespread outbreak of the army cutworm (*Euxoa auxillaris*) over the state in the spring of 1926. Severe damage was done to fall-sown alfalfa in many cases. Poisoned bran mash sown in the evening of hot, clear days, or during the afternoon of cool or cloudy days in the early spring when the worms were feeding most rapidly gave good control. Life history studies of this insect are being continued.

A study has been made of the clover root curculio (*Sitones hispidulus*), which is abundant over the state, judging by correspondence and local injury. A possible means of control in lawns was discovered by accident. Some rugs were left out in the yard over night. In the morning, practically the entire population of beetles of these and allied species were clinging to the under side of the rug. The beetles were readily collected and destroyed. This will be tried as a control measure this year and also as a practical way of determining the abundance of these insects in a given area.

Several sowings of grasshopper bait prepared with sodium arsenite were made and satisfactory results obtained. The arsenite severely injured sweet potatoes but the effect on alfalfa and corn was negligible. Results so far tend to prove amyl acetate the best attractant, and sodium arsenite the most satisfactory lethal agent for these insects.

A study of 15 alfalfa varieties at the Agronomy Farm with respect to their possible differences in insect abundance was completed. The relative attractiveness of the varieties was determined by making 50 sweeps with the regular insect net once or twice a month and then counting each species of insect in the sweepings. The results give no hope of immune varieties. It was early observed that the varieties having the best stands and heaviest growth had the most insects on them. These are likewise the best varieties to grow for yield.

Overwintering studies on insects hibernating in alfalfa fields have been carried on for two years. A square foot of soil three to five inches deep was removed from each of nine plots five times during 1925 and from seven plots during 1926. The soil and vegetation were worked over very carefully and all insects listed. Some accurate information regarding the species which overwintered, the stage in which they overwinter, and the influence of the kind of cover on hibernation was obtained.

The summary indicates that chinch bugs overwinter successfully in fair numbers in grassy alfalfa fields. The tarnished plant bug, flea beetles, cutworms, grasshopper eggs, elaterid adults, and ants occurred also in fairly large numbers. Among beneficial insects the following were the most numerous: *Carabidæ*, especially ground beetle larvae, *Staphylinidæ*, certain dipterous and hymenopterous parasitic forms in cocoons and larval stages. This phase of the work will be discontinued. [Project 115; Department of Entomology; state funds.]

**Shade Tree Insects.** A number of trees were banded as usual and observations taken as in previous years.

The total number of spring canker worm adults taken in 1925 was 41 females and 42 males, and in 1926, 138 females and 152 males. The maximum emergence was on February 21, 1925 (4 males and 6 females), and on March 11, 1926 (14 males and 8 females).

Work the past two years with the woolly aphids attacking the elms has shown that there are heavy infestations of these insects in Kansas. Aphids seriously impair the vigor and value of elms used for shade, but the extent of such injury is hard to ascertain.

Present known control measures are inadequate because for the most part liquid and dust sprays are ineffective against aphids found within the leaf-galls, and unless the insects are attacked in the egg stage they become numerous. The planting of immune or resistant elms and apple stocks offers the most hopeful means for combating the elm aphids.

At least three species of elm aphids, namely, *Erisoma lanigera*, *Erisoma americana*, and a third unidentified one, possibly a new species, figured in these studies.

*Erisoma lanigera*, woolly apple aphid, instead of migrating to *Pyrus* as noted by Patch and others may remain upon *Ulmus americana* throughout the entire summer.

Infestations of *Erisoma lanigera* are more widely distributed than either *Erisoma americana* or the unidentified species which attacks

*Ulmus glabra* and *Ulmus fulva*. [Project 116; Department of Entomology; state funds.]

**Investigations in the Control of Injurious Rodents.** The work of this project during the past biennium has included: (1) A study of the physiology of hibernation of the 13-lined ground squirrel, *Citellus tridecemlineatus*. (2) The effect of cold temperatures upon the pocket gopher, *Geomys bursarius*; the prairie dog, *Cynomys ludonicianus*; and the pocket mouse, *Perognathus* sp. (3) Experimental work on poisoning pocket gophers, prairie dogs, and moles; and (4) the problem of specificity of protoplasm is being attacked by means of ovarian grafting.

Extensive records of temperature, heart beat, and respiration of normal and torpid ground squirrels during hibernation have been taken. The rate of rise of temperature, heart beat, and respiration in waking from hibernation was studied in many individual animals. A starvation diet, cold and confined air have been found to favor the production of hibernation. Darkness appears to play no part in its production. The activities of the thyroid gland and of the pituitary body appear to have little effect on the production of torpidity. Ground squirrels hibernating in late spring show a greater mortality than in winter. The causes for this are being investigated.

Pocket gophers appear not to become torpid when subjected to cold temperatures. Prairie dogs become sluggish, but only in two instances has there been found the distinct stupor of hibernation. The pocket mouse hibernates less readily and recovers its normal condition more quickly than the ground squirrel.

Twenty-one preliminary experiments with unpoisoned grain showed that gophers have practically no preference when fed wheat and oats simultaneously. Experiments with poisoned grain showed approximately 35 per cent mortality of 17 animals each of which ate from 9 to 16 kernels of poisoned oats, but approximately 82 per cent mortality of 11 animals each of which ate from 10 to 15 kernels of poisoned wheat. The lower efficiency of the oats is explained by the rejection by the gophers of an average of about 50 per cent of the oats eaten.

Calcium cyanide has been found to kill prairie dogs, but it does not equal strychnine-treated grain for effectiveness, economy, and ease of treating. For pocket gophers, tests thus far show that the oats is much less effective than poisoned wheat.

Barium carbonate, lye, poisoned corn, and calcium cyanide dust have been used on moles in the vicinity of Manhattan, all without

marked success, Experiments on feeding strychnine poisoned corn to 18 captive moles showed that moles can eat from 5 to 20 kernels of poisoned corn in the course of 24 hours without fatal results. The moles usually reject the pell-like outer portion of the corn. On the other hand some favorable results have been obtained from treating seed corn with a strychnine paste. This experiment is being repeated.

The grafting of ovaries in guinea pigs has thus far resulted in the birth of one young, showing the characters of the guinea pig from which the ovaries were taken. [Project 84; Department of Zoology; state funds.]

### INVESTIGATIONS IN THE LIVE-STOCK INDUSTRIES

The live stock of Kansas ranks high among the agricultural industries of the state. In 1924 the total value of the sales of live stock and live-stock products as reported by the State Board of Agriculture amounted to more than 117 million dollars. Kansas ranks ninth among the states of the Union in the number of pigs, twelfth in the number of dairy cattle, and fourth in the number of other cattle. A brief report of the work which the Agricultural Experiment Station has done during the past two years on problems relating directly to the animal industries of the state is contained in the following pages.

**The Nutritive Requirements of Swine.** During the past biennium this experiment has been divided into two phases. Phase I consisted of a study of the chemical and histological changes brought about by avitaminosis A. Three groups of hogs fed a basal ration of ground white corn, tankage, and bone ash, have been used for this phase of the work. One group of six pigs was placed on experiment January 1, 1924. The last of this group was killed for analysis December 23, 1924. Another group of four pigs was placed in the lot December 26, 1924, and the last of this group was killed for analysis December 11, 1925. A third group was then placed on the experiment of which none had developed the advanced stages of avitaminosis A at the time of this report. A chemical analysis has been made of the blood, bones, and brains of the hogs which developed a vitaminosis A and also of normal hogs. They have shown no significant difference between hogs in the advanced stages of avitaminosis A and normal hogs,

Some preliminary experiments were carried out on the electrical conductivity of the optical nerves of hogs which were blind as a re-

suit of avitaminosis A. Similar determinations were made on the optic nerve of normal hogs. The results of this work were not consistent, due no doubt to poor technic.

Phase II of the experiment consisted of a study of the adequacy for reproduction of three feeds which varied in their vitamin content. This phase of the project was begun January 1, 1924. Lots 2, 3, and 4 were used for this work.

In the four years prior to 1924 during which this experiment had been conducted, three supplements had been used with the basal ration of white corn, tankage, and bone ash. These supplements were butter, sprouted oats, and alfalfa hay. Normal reproduction was not obtained with any of these supplements. The question arose as to whether this failure was due to a faulty diet or to a lack of exercise. In order to secure information on this point, four gilts were started in Lot 2 January 1, 1924, and were given a feed calculated to contain all the necessary vitamins. For this purpose the basal ration was supplemented with butter, sprouted oats (green alfalfa during summer months), alfalfa hay, and cod liver oil.

Lot 3 was continued, as it had been, with the exception that the basal ration was supplemented with cod liver oil in addition to sprouted oats. This feed contains all the necessary vitamins but does not contain as much Vitamin A as Lot 2, as no butter or alfalfa hay is used.

Lot 4 was continued as it had been with the exception that the basal ration was supplemented with cod liver oil in addition to alfalfa hay. This feed contains no Vitamin C. The purpose was to determine whether or not hogs need Vitamin C for reproduction.

The results of this phase of the project have not been conclusive. Lot 2, fed the basal ration supplemented with an abundance of Vitamin A, has given erratic results. Two sows farrowed good litters and two poor. One sow farrowed a litter of 10 pigs and raised 10 and the other raised eight out of a litter of nine. One of the other two sows farrowed a litter of eight, all of which died before they were three days old, and the other raised only one out of a litter of four. These results serve to emphasize the fact that the individuality of the experimental animal is an important factor in all experimental work involving animals. Four gilts representing the second generation on this feed are in Lot 2 at the present time.

Three sows in Lot 3 and three in Lot 4 are due to farrow. Results for these lots can not be reported until after the farrowing records

are obtained. [Project 38; Departments of Chemistry and Animal Husbandry; Adams funds.]

**Investigations in the Use of Silage in the Fattening of Beef Cattle.** The work of this project for the past biennium has consisted primarily of two features: (1) An attempt to determine to what extent one may depend upon silage as the roughage portion of a ration to fatten baby beef for market, and (2) an attempt to find a substitute for alfalfa to feed with silage as the roughage portion of a ration to fatten baby beef for market.

During 1924-'25 six lots of steer calves of 10 head each were fed. The principal results secured may be summarized as follows:

1. Fairly satisfactory baby beef can be produced on a ration consisting of cane silage, shelled corn, and cottonseed meal. The calves fed this ration gained 2.08 pounds per head per day for 195 days.

2. A high degree of finish and economy of gains are influenced by the length of time a limited amount of alfalfa hay is fed with cane silage, shelled corn, and cottonseed meal. The longer a limited amount of alfalfa is fed with this ration the greater the finish and economy of gain.

3. It is more satisfactory to add a limited amount of cottonseed meal to a ration of shelled corn, cane silage, and alfalfa hay than it is to depend upon shelled corn, cane silage, and alfalfa hay only.

4. Alfalfa hay alone is a satisfactory roughage to feed with shelled corn in fattening baby beef for market in so far as gains are concerned, but in many localities the price of alfalfa prohibits its use as the sole roughage.

During 1925-'26 six lots of steer calves of nine head each were fed in an attempt to find a substitute for alfalfa to feed with silage. It was found that the addition of approximately one-ninth of a pound of calcium carbonate per head per day to a ration consisting of prairie hay, sorgo silage, shelled corn, and cottonseed meal produced slightly greater gains at less cost per hundred pounds of gain than alfalfa hay, sorgo silage, shelled corn, and cottonseed meal. However, the yearlings receiving alfalfa hay were valued at \$0.25 per hundred more than those receiving prairie hay, which resulted in slightly greater profits for the lot fed alfalfa hay. Apparently the addition of calcium carbonate to prairie hay and silage enables it to compare favorably with alfalfa and silage as the roughage

portion of a ration to be used for fattening calves to be sold as yearlings. [Project 78; Department of Animal Husbandry; state funds.]

**The Relative Value of Corn and Cottonseed Meal for Fattening Cattle.** An opinion prevails in Kansas and other southwestern states that a given amount of cottonseed meal will produce more fat than the same amount of corn when fed to cattle. To secure information on this question two lots of yearling steers of 10 head each were placed on feed. One lot was fed all the cottonseed meal it would eat as the grain portion of the ration and the other was fed 1 pound of cottonseed meal and enough ground corn to make the concentrate portion of the ration equal to the amount of cottonseed meal fed in the first lot. The daily ration consumed by each steer for a period of 140 days was as follows:

Lot 1: Cottonseed meal, 11.04 pounds; alfalfa hay, 2.01 pounds; and sorgo silage, 20 pounds.

Lot 2: Cottonseed meal, 1 pound; ground corn, 10.04 pounds; alfalfa hay, 2.01 pounds; and sorgo silage, 20 pounds.

Lot 1 weighed 546 pounds at the beginning of the test and gained 384 pounds, an average of 2.39 pounds per day. Lot 2 weighed 552 pounds and gained 342 pounds, an average of 2.43 pounds per day. There was practically no difference in the degree of fatness of the two lots. This test indicates that a pound of ground corn and a pound of cottonseed meal have practically the same fattening value when fed with alfalfa hay and silage. [Department of Animal Husbandry; state funds.]

**Methods of Utilizing Native Pasture in Beef-cattle Feeding.**

In the late fall of 1924, three lots of light weight yearling steers were started on a test for the purpose of securing data relative to:

(1) The amount of flesh coming two-year-old cattle should carry when they go to grass in the spring if they are to be given short full-feed beginning about August 1; (2) the comparative returns from full-feeding on grass and in a dry lot two-year-old steers that have been well wintered (half-fed), grazed without grain from May 1 to August 1, and then full-fed from August 1 to November 1. The following results were obtained.

The two-year-old steers fed a limited grain ration during the winter of 1924-'25, grazed without grain from May 5 to August 3, 1925, and full-fed in a dry lot from August 3 to November 1, 1925, gained 51.27 pounds more, brought \$0.50 per hundred more, and made a profit of \$5.61 per head more than steers fed and handled in

the same manner except for full-feed on grass instead of in a dry lot from August 3 to November 1, 1925.

The most of the difference in gain occurred during the last 90 days on full-feed, the steers in the dry lot gaining 255.2 pounds while those on grass gained but 198.6 pounds. Both lots were fed practically the same amount of grain during this period.

The two-year-old steers fed no grain but given a heavy feed of silage and 1 pound of cottonseed meal per head per day during the winter of 1924-'25, grazed without grain from May 5 to August 3, 1925, and full-fed on grass from August 3 to November 1, 1925, gained 57.07 pounds less, sold for \$0.50 a hundred less, but made a profit of \$4.60 per head more than the two-year-old steers fed a limited grain ration during the winter of 1924-'25, grazed without grain from May 5 to August 3, 1925, and full-fed on grass from August 3 to November 1, 1925.

These results indicate: (1) That, in the case of yearling steers, a ration of 5 pounds of corn in addition to 1 pound of cottonseed cake, 2 pounds of alfalfa hay, and all the silage they will consume contains more grain than is necessary where they are to be run on grass without grain during the first half of the grazing season and are full-fed on grass the last half of the grazing season. (2) That in the case of yearling steers, a gain of around 200 pounds during the winter is desirable when they are to be grazed without grain the first half and full-fed on grass the last half of the grazing season and that well-bred, thrifty yearlings will make from 1 to 1.2 pounds gain per day on all the good silage they will consume and 1 pound of cottonseed cake per head per day. However, the cattle that were fed a limited corn ration would have returned a profit at the end of both the winter feeding season and at the end of the first half of the grazing period, whereas the cattle that were fed no grain during the winter showed a loss at the end of both these periods. (3) That two-year-old steers will fatten faster on the same amount of grain in a dry lot than they will on grass from August 1 to November 1. [Project 151; Department of Animal Husbandry; state funds.]

**Swine-feeding Investigations.** The primary object of the work of this project for the past biennium has been to determine whether a combination of linseed oilmeal and tankage is preferable to tankage alone as a protein supplement in rations for fattening hogs.

During the winter of 1924-'25 five lots of 10 pigs each were fattened in a dry lot on corn and a protein supplement consisting of

tankage and linseed oilmeal ranging from all tankage in lot 1, three parts tankage and one part linseed oilmeal in lot 2, two parts tankage and two parts linseed oilmeal in lot 3, one part tankage and three parts linseed oilmeal in lot 4 to all linseed oilmeal in lot 5. All lots received alfalfa hay. This experiment showed that the greater the proportion of tankage and the smaller the proportion of linseed oilmeal used as a protein supplement the greater the gains and finish and the cheaper the gains.

During the summer of 1925, three lots of 15 pigs each were fattened on alfalfa pasture, on corn, and a protein supplement consisting of tankage and linseed oilmeal in different proportions, lot 1 receiving tankage, lot 2 tankage 50 per cent and linseed oilmeal 50 per cent, and lot 3 linseed oilmeal. This experiment showed that there was very little difference in the rate of gain and the feed required to make a given amount of gain for pigs receiving tankage and those receiving equal parts of tankage and linseed oilmeal as protein supplements to corn on alfalfa pasture. The costs of grains were practically the same in each case. The substitution of linseed oilmeal for all the tankage as a protein supplement did not increase the feed required to produce a given amount of gain but it did decrease the rate of gain 14 per cent and the pigs receiving linseed oilmeal had less finish than those fed tankage.

During the winter of 1925-26, six lots of eight pigs each were fattened in a dry lot on corn and a protein supplement consisting of tankage or linseed oilmeal fed with and without both alfalfa hay and salt. These six lots received rations as follows:

Lot 1: Corn, tankage, and salt.

Lot 2: Corn, tankage, and alfalfa hay.

Lot 3: Corn, tankage, alfalfa hay, and salt.

Lot 4: Corn, and equal portions of tankage and linseed oilmeal.

Lot 5: Corn, alfalfa hay, and equal portions of tankage and linseed oilmeal.

Lot 6: Corn, alfalfa hay, salt, and equal portions of tankage and linseed oilmeal.

The principal results secured from these different tests may be summarized as follows: All lots fed tankage as a protein supplement made more rapid and cheaper gains than those receiving equal parts of tankage and linseed oilmeal as a protein supplement. The pigs receiving alfalfa hay maintained a more vigorous and thrifty condition. The addition of salt to rations containing alfalfa hay reduced the rate of gain and increased the feed required to produce a given amount of gain.

The results of all three tests taken together indicate that it is not

advisable to substitute linseed oilmeal for any part of the tankage as a protein supplement, that better results will be secured if this substitution is made when pigs have access to alfalfa hay, that it is not necessary to feed salt when tankage is fed as a protein supplement, and that corn, tankage, and alfalfa hay is the most satisfactory ration known at this time for fattening hogs during the winter in this section of the country.

Another phase of this project consisted of a comparison of corn, tankage, and alfalfa pasture with kafir, tankage, and Sudan pasture for fattening hogs. The hogs receiving corn, tankage, and alfalfa pasture made an average daily gain of 1.47 pounds for 105 days and required 341.42 pounds of corn and 3.80 pounds of tankage to produce 100 pounds of gain. The hogs fed ground kafir, tankage, and Sudan pasture made an average daily gain of 1.37 pounds for 105 days and required 354.44 pounds of ground kafir and 17.52 pounds of tankage to produce 100 pounds of gain. Both lots made excellent and economical gains. The ground kafir, tankage, and Sudan pasture proved to be almost as satisfactory as corn, tankage, and alfalfa pasture. [Project 110; Department of Animal Husbandry; state funds.]

#### **A Comparison of Different Methods of Feeding Spring Pigs.**

During the past two years a study has been made of the following methods of feeding spring pigs. (1) Deferred full-feeding versus immediate full-feeding; (2) growing feeder pigs on alfalfa pasture; and (3) fattening feeder pigs on new corn.

One group was full-fed from weaning time until ready for market. A second was grown on alfalfa pasture until fall and full-fed on new corn. These latter averaged approximately 60 pounds each at the beginning of the test, that is, June 15, 1924. Lot 1 was fed one pound of corn and one-fifth of a pound of tankage on alfalfa pasture from June 15 to September 28, a period of 105 days. It was then fed an average of 8.24 pounds of corn and one-fourth of a pound of tankage for 60 days. Lots 2 was fed an average of 4.96 pounds of corn and one-fifth of a pound of tankage from June 15 to September 28, a period of 105 days.

Lot 1 gained 0.53 of a pound per head per day from June 15 to September 28 on a ration consisting of one pound of corn and one-fifth of a pound of tankage and alfalfa pasture. These pigs averaged 115.63 pounds on September 28. In other words it required approximately 2 bushels of old corn and 20 pounds of tankage besides alfalfa pasture to make 115-pound feeder hogs out of 60-pound pigs.

It then required 9 bushels of new corn and 15 pounds of tankage fed in a dry lot to make 115-pound feeder hogs into 238-pound finished market hogs. Growing the pigs on alfalfa pasture and then full feeding on new corn required 11 bushels of corn and 35 pounds of tankage to produce 238-pound finished hogs out of 60-pound pigs.

Lot 2, full fed from June 15 to September 28, gained 1.51 pounds per day on an average daily ration of 4.96 pounds of corn and one-fifth of a pound of tankage in addition to alfalfa pasture. This method required approximately 9½ bushels of new corn and 20 pounds of tankage to make 218-pound finished hogs out of 60-pound pigs.

Whether to grow spring pigs chiefly on alfalfa and a light feed of concentrate and then full feed on new corn or full feed on old corn will depend upon (1) the price of old corn and hogs during the summer and the probable price of new corn and hogs the following fall, and (2) the ability to make a marketable finish and weight on spring pigs by September. [Department of Animal Husbandry; state funds.]

**Lamb-feeding Investigations.** The work on this project for the past biennium consisted of two phases: (1) An attempt to determine the maximum time silage may be fed as the roughage portion of a ration to lambs that are being fattened for market; and (2) an attempt to determine the minimum amount of alfalfa necessary to balance a corn ration in such a way that the most satisfactory gains and finish may be secured when fed to lambs that are being fattened for market.

The first was attempted in 1924-'25 when six lots of 24 lambs each were fed on various rations. The results indicated that silage may be used satisfactorily as a part of the roughage portion of a lamb-fattening ration for the entire feeding period but as the sole roughage for only a comparatively short period of time, probably not longer than 30 days.

The second phase of the experiment was conducted in 1925-'26. The results indicated that more rapid gains and a more desirable finish can be secured when the ration consists of comparatively small amounts of alfalfa hay and large amounts of shelled corn than when large amounts of alfalfa hay and comparatively small amounts of shelled corn are fed. Lot 1, which consumed an average of 0.5 pound of alfalfa hay and 1.22 pounds of corn per head per day, made the most rapid gains and the most desirable finish, whereas lot

3, which consumed an average of 1.49 pounds of alfalfa hay and 0.83 pound of shelled corn per head per day, made the least rapid gains and the least desirable finish. Lot 2, which consumed an average of one pound of alfalfa hay and 1.13 pounds of corn per head per day, made slightly smaller gains than lot 1 but greater gains than lot 3. Lot 2 also made a slightly less desirable finish than lot 1 but a decidedly more desirable finish than lot 3. [Project 111; Department of Animal Husbandry; state funds.]

**A Study of Pasture Values and Pasture Methods for Horses, Cattle, Sheep, and Swine.** During the past biennium the work on this project has consisted as previously of a study of different kinds of tame pasture crops when grazed by different types of live stock.

Sweet clover proved to be less valuable than alfalfa for hogs, but entirely satisfactory for both sheep and cattle. Very little trouble was experienced with bloat.

Sudan grass has proved to be the most satisfactory summer pasture crop for all classes of live stock. It retains its succulence in dry weather and withstands drought better than any other pasture crop under observation.

Orchard grass has proved to be one of the most satisfactory permanent pasture grasses. It is easy to start, stands grazing well, and all classes of live stock relish it throughout the entire grazing season. [Project 142; Department of Animal Husbandry; state funds.]

**The Influence of Different Quantities of Salt Upon the Palatability and Keeping Qualities of Hams and Bacon.** The work of this project during the past two years involved (1) an attempt to determine the effect of less salt than is ordinarily used upon the palatability and keeping qualities of both hams and bacon, (2) to secure data relative to the comparative value of Kansas and Michigan salts in curing pork products, and (3) to secure data relative to the value of smoked salt in curing hams and bacon.

The work was begun in 1924-'25 with five lots each containing six hams and six sides of bacon cured as follows:

Lot 1: Twelve pounds of salt, 3 pounds brown sugar, 3 ounces of salt petre dissolved in 6 gallons of water was used for each 100 pounds of meat. The meat was left in cure for a period of two days per pound per piece for bacon sides and three days per pound per piece for hams, then smoked for 24 hours with hickory smoke.

Lot 2: Same as lot 1, except that the amount of salt was reduced to 11 pounds.

Lot 3: Same as lot 1, except that the amount of salt was reduced to 10 pounds.

Lot 4: Same as lot 1, except that the amount of salt was reduced to 9 pounds.

Lot 5: Same as lot 1, except that the amount of salt was reduced to 8 pounds.

During 1925-'26 part of the work from the preceding year was duplicated with some changes in technique. Six lots of meat each containing three bacon sides and five hams were cured as follows:

Lot 1: Twelve pounds Kansas salt, 3 pounds brown sugar, 3 ounces of salt petre, dissolved in 6 gallons of water, was used for each 100 pounds of meat, cured for a period of two days per pound per piece for bacon sides and three days per pound per piece for hams, and then smoked for 20 hours with hickory smoke.

Lot 2: Same as lot 1, except 10 pounds of Kansas salt was used.

Lot 3: Same as lot 1, except 10 pounds of Michigan salt was used.

Lot 4: Same as lot 1, except 8 pounds of Kansas salt was used.

Lot 5: Smoked salt was used for dry cure as directed by the manufacturers.

Lot 6: Smoked salt was used for brine cure as directed by the manufacturers.

The results of the first trial indicate that: (1) The use of 9 and 10 pounds of salt (70 to 76 degrees by the salinometer) is the most satisfactory from the standpoint of palatability. Chemical analysis showed an average salt content of 3.05 per cent and 2.82 per cent for the bacon sides in lots 3 and 4, respectively, while the hams had an average salt content of 4.45 per cent and 4.68 per cent, respectively. (2) The amount of salt used in curing has no effect upon the development of moulds. (3) The use of less than 12 pounds of salt per 100 pounds of meat will not result in spoilage. No spoilage occurred in any of the lots either in cure or during the period of storage. (4) The sugar content of both bacon sides and hams was only about 50 per cent of that present in standard commercial products. The salt petre content was also lower than in commercial products. No definite cause could be allocated for the shortage but it is thought that the calcium content of the salt and water may have had some influence upon the absorption of the sugar and salt petre.

The results of the second trial indicated that: (1) Eight pounds of salt per 100 pounds of meat (brine strength 65 degrees by salinometer) is an adequate amount for satisfactory curing of hams and bacons. (2) The amount of salt used in curing has apparently very little if any effect upon the shrinkage of hams and bacons in smoking or in storage. (3) Kansas salt is the equal of Michigan salt in so far as the physical appearances and palatability are concerned. (4) The shrinkage on hams and bacon sides cured with Kansas salt was

slightly larger than on those cured with Michigan salt. (5) The use of smoked salt proved a fairly satisfactory method of curing hams and bacons when material for smoking or a smoke house are not available. (6) The color of the hams and bacons cured by the smoked salt process is inferior to that produced by the regular method. (7) The shrinkage of the hams and bacons cured by the smoked salt process is lower than in the regular method and results in the bacons holding their shapes better. (8) Bacons cured by the smoked salt method are inferior in flavor and cooking quality than those cured by the regular smoke-house method. (9) Dry cure with smoked salt is inferior to the brine with smoked salt.

The work on this project will be discontinued. [Project 153: Department of Animal Husbandry; Purnell and state funds.]

#### **Factors Influencing the Mineral Metabolism of Dairy Cows.**

The first phase of this project consists of a study of the influence of the ovaries on calcium retention in lactating dairy cows.

Four lactating dairy cows were selected. A complete mineral balance was determined on these cows for four periods of one week each. At the end of this time, the ovaries were removed from two of the cows and the other two received injections of ovarian extract during four periods of one week each. Each of the four cows showed a positive calcium balance during the first four weeks of the experiment. The injection of the ovarian extract had no effect on one of the cows and caused the other to go from a positive to a negative balance; at least she showed a negative calcium balance during the four weeks she was receiving the ovarian extract.

One of the cows showed a negative balance after the ovaries were removed. She did not recover promptly after the operation for removing the ovaries; in fact, she was in very bad condition for about ten days, probably due to infection following the operation. This may have been responsible for the negative balance. The other cow changed from a positive to a negative balance both before and after the removal of the ovaries.

A second phase of the project consisted of a study of the influence of ultra-violet light on the mineral metabolism of dairy cows. In this experiment four cows were used that had been kept in the barn out of direct sunshine and fed a winter ration. The calcium, phosphorus, sulphur, and magnesium balance was determined during two one-week periods; then the cows were treated 15 minutes each day with light from a quartz mercury arc lamp, during which time the balance was again determined.

This was followed by two other one-week periods without the light, during which time the balance was again determined.

It was thought from work of other investigators that the cows kept indoors on winter feed would be in a negative balance. Each of the four cows, however, showed a positive balance during the first two one-week periods. The light treatment did not increase this balance. If the cows had been kept under condition such as to have produced a negative balance, the ultra-violet light treatment might have shown a beneficial result. No future work is planned on this phase of the project.

A third phase of this project which has been recently inaugurated consists of a study of the influence of sunshine and green feed upon the nutritive value of milk. The milk from two cows which have been kept in darkness and deprived of green feed since December 1, 1925, is now available. These cows, an Ayrshire and a Jersey, freshened April 6 and March 31, 1926, respectively, and will be continued under the above conditions until the close of the experiment. Likewise the milk is also available from two other cows, an Ayrshire and a Jersey, which freshened March 6 and 4, respectively, and which have had access to pasture and sunlight since freshening.

The anti-rachitic value of the milk from these two lots of cows kept under the above conditions is at present being tested by feeding four lots of baby chicks. Two lots were started April 29, but owing to the presence of white diarrhea it was thought wise to start two other lots on May 4.

In testing the Vitamin C content of the milk from these cows, it is planned to feed two lots of 10 guinea pigs each a basal ration plus 30 c. c. milk per pig daily, one lot getting the milk from cows kept inside and deprived of green feed while the other lot will receive milk from cows having access to sunshine and pasture.

In the same way two other lots of 10 pigs each will receive 60 c. c. of milk per pig daily, while a fifth lot of 10 pigs will receive the basal ration plus 30 c. c. of boiled milk per pig daily. This will serve as a check lot. This will duplicate work previously done which at the time seemed conclusive, but in the light of work reported from other stations seems desirable to repeat. [Project 147; Departments of Dairy Husbandry, Chemistry, and Veterinary Medicine; state funds.]

**Sunlight in Relation to the Growth of Calves.** Two lots of four grade Holstein heifer calves each were fed and housed under similar conditions with the exception that one had access to direct

sunlight while the other was housed in a darkened shed. The calves were fed whole milk until six weeks of age and skim milk until five months of age. Prairie hay and grain mixture of 400 pounds of white corn, 200 pounds of wheat bran, and 100 pounds of linseed oil meal were fed. A sample of blood from each calf was taken for determination of calcium and of phosphorus content at the beginning of the experiment and at 60-day intervals thereafter. Two of the calves in the sunlight lot refused to drink milk consistently and became stunted, gaining less than one-half as much as the other two in the same lot. One of the calves in the darkened pen scoured badly and died of neurotic pneumonia at the end of two months. The results of the experiment, therefore, were unsatisfactory,

Excluding the two stunted calves of the sunlight group, the average gain was 292 pounds in weight and 28.5 cm. in height, thus averaging 12.2 per cent more gain in weight and 6 per cent less gain in height than the three calves in the darkened shed.

There was very little difference in the physical appearance of the two lots and no visible evidence of rickets at the close of the experiment. Neither lot made normal growth on the ration of prairie hay skim milk and grain. The blood of both lots was normal according to the chemical analysis. The experiment has been discontinued. [Project 148; Departments of Dairy Husbandry and Chemistry; state funds.]

**Dairy Cattle Feeding Investigations.** One phase of this project has consisted of a study of the comparative value of ground soybeans and linseed meal as a protein supplement in the ration of dairy cows.

One lot of nine cows was fed by the double reversal method through three 30-day periods, the first 10-days of each period being used as preliminary. Alfalfa hay and topped cane silage were used as a basal ration together with a grain ration consisting of 4 parts corn chop and 1 part of protein supplement.

Linseed meal was used as a supplement during periods one and three and ground soybeans in period two.

No great differences in the efficiency of the two supplements were observed. Slightly more milk was produced while the cows were on linseed meal but the fat production was slightly higher while on soybeans. The quality of the soybeans used in this trial was distinctly inferior to the quality of the beans used in previous tests. This undoubtedly had some influence on the results obtained. The test will be repeated next year.

A second phase of the project consisted of a study of the effect of feeding sorgo seed upon the per cent of fat in milk.

One lot of six cows was started on this trial, but due to udder trouble one had to be dropped, so data were secured from only five. The basal ration consisted of alfalfa hay and topped sorgo silage, in addition to a grain ration consisting of five parts of grain to one part of linseed meal. Corn chop was used in the grain mixture during periods one and three, and ground sorgo seed in the second period. Samples were taken for butter-fat tests from each milking of each cow throughout the experiment.

No appreciable difference appeared in the ability of the two feeds to influence the per cent of fat in the milk. The greatest production of both milk and fat occurred while the lot was receiving corn but the length of periods was too short to draw conclusions as to effect on production.

In a third phase of the project, ground kafir and ground sorgo seed were compared with corn chop for feeding growing heifers.

Three lots of four heifers each were fed through a six-months period. The basal ration used in all lots was alfalfa hay. Lot one received corn chop, lot two, ground kafir, and lot three, ground sorgo seed.

The daily gain was somewhat greater for those fed the corn ration. On sorgo the heifers made a somewhat more satisfactory growth than on kafir. The lot receiving sorgo made a slightly greater increase in height than the other lots. It was interesting to note that the salt consumption of the heifers on corn was much less and they showed less tendency toward a depraved appetite than did the others. The work will be continued. [Project 34; Department of Dairy Husbandry; state funds. ]

**Dairy Calf Feeding Investigations.** The dairy calf feeding investigations recently started consist of two phases: (1) A study of the utilization of ground grain and forage sorghums in a grain ration; and (2) a study of the utilization of dried buttermilk.

Two lots of four heifer calves each were fed in the same manner as those in the dairy herd except that ground kafir or ground sorgo replaced ground corn in the grain ration. The ration consisted of 300 pounds ground corn, 100 pounds ground oats, 100 pounds bran, and 100 pounds of linseed oilmeal. Alfalfa hay and silage was fed according to appetite. The calves were maintained on this experi-

mental ration until six months of age. Individual feed weights were recorded.

The calves fed on ground kafir and ground sorgo made slower gains than those fed on corn. In height, however, they were slightly above the corn fed calves at six months of age.

In the second trial recently started, some difficulty has been experienced in getting one calf in the sorgo lot to drink milk and another in this lot died of pneumonia. One calf in both the kafir and sorgo lots is above normal in weight while the others are slightly below normal. The test is being continued.

During the past two years all available grade Holstein calves in the station herd have been reared on dried buttermilk as a substitute for milk. The dried buttermilk is diluted with nine times its weight of cold water and fed at the same rate as skim milk.

Considerable difficulty was experienced in getting the calves to drink the buttermilk mixture. Some digestive disturbances were also encountered. The experiment will be continued as calves are available for the work. [Project 154; Department of Dairy Husbandry; state funds.]

**Silage Investigations.** This work has consisted of a study of the influence of moisture upon the chemical composition of sorgo silage, the influence of the hour of the day that the sorgo is cut upon the sugar and carbohydrate content of the silage, and of the loss of material during silage formation and the nature of such loss.

The differences in the moisture content of the green sorgo going into the silo were small and, therefore, it had no marked influence on the composition of the silage.

The hour of day that the sorgo was harvested had a noticeable influence on its composition. The sugar content was noticeably lower in those samples cut in the early morning as compared with those cut at a later hour of the day. This different in sugar content reaches a maximum of approximately 50 per cent in a sample cut at 2 p. m. as compared with one cut at 6 a. m. The greater amount of sugar in the green sorgo did not appreciably affect the cured silage. It is of interest to note that: (1) The starch content of the green sorgo is unchanged in the silo. (2) The sugars in the green soro almost entirely disappear, being replaced by acids. It is evident that there is a loss in the transfer from sugars to acids, the per cent ranging from 1.14 to 3.33. (3) There is very little difference in the quantity of protein ether extract, and crude fiber found in the

cured sorgo silage, as compared with that found in the green sorgo. (4) The loss of material resulting from siloing varies from 1.07 to 4.77 per cent. (5) The moisture content of the cured silage is about 1 per cent higher than that found in the green sorgo. [Project 34; Departments of Dairy Husbandry and Chemistry; state funds.]

**Normal Growth of Dairy Cattle.** As was reported in the biennial report of 1922-1924, it is the plan of this experiment to weigh and measure each dairy calf dropped in the station dairy herd at intervals of 30 days from birth to one year of age in case of bull calves and two years of age in case of heifer calves. The object is primarily to secure sufficient data to determine the normal size of calves of the four major dairy breeds.

In this project, started in January, 1922, and extending to May 20, 1926, the number of individuals of each breed which have been weighed and measured is shown in Table XIX (page 100).

The table shows that 85 females and 12 males have been carried through the entire year with an average weight of 537 pounds for the females and 635 pounds for the males. This work will be continued until enough data are available to establish a definite normal size for each of the four dairy breeds. [Department of Dairy Husbandry; state funds.]

**A Study of the Use of Fly Repellents for the Control of Flies on Dairy Cattle.** During the summer of 1924, five lots of four cows each were used in trials with five kinds of fly sprays. Unsprayed animals immediately adjoining were used as checks. The fly repellent was applied twice daily for two five-day periods with an intervening five-day period without a repellent. In order to further check the efficiency of the spray, counts of the number of flies on the left side of alternate animals were made before spraying and at intervals of one-half hour, one hour, and one and one-half hours after spraying.

In the summer of 1925, the work was repeated using only two kinds of repellent sprays.

The results obtained indicate a marked and practically uniform reduction in number of flies by the use of all repellents. Table XX shows a progressive increase in the number of flies as the time interval after spraying increased. However, the animals sprayed had less flies than those not sprayed even in the afternoon, eight hours after the morning spray.

TABLE XIX.—Data on the weight of dairy calves at different ages.

BREEDS	At birth				At six months.				At twelve months.			
	Female		Male		Female		Male		Female.		Male	
	Number	Weight.	Number	Weight.	Number	Weight.	Number	Weight	Number	Weight	Number.	Weight
	<i>Lbs</i>		<i>Lbs</i>		<i>Lbs.</i>		<i>Lbs.</i>		<i>Lbs</i>		<i>Lbs</i>	
Holsteins	33	92	34	97	29	359	23	403	30	642	2	732
Ayrshires .	28	69	28	80	25	306	17	324	22	542	4	606
Guernseys	17	66	22	65	11	285	12	310	15	499	3	662
Jerseys .	16	47	23	56	17	249	12	279	18	467	3	539

TABLE XX.—The effect of fly repellents on the number of flies on dairy cattle.

LOT	Number of flies, no spray	Number of flies before spraying each afternoon	Number of flies one-half hour after spraying	Number of flies one hour after spraying	Number of flies one and one-half hours after spraying
1	36	24	4	8	11
2	16	24	8	10	11
3	10	15	3	11	4
4	12	15	7	7	8
5	35	28	7	8	8
Average	22	21	6	7	8
Check lot, no spray	20	26			

As an average for the two seasons with five repellents used on 32 milking cows, it was found that 4,089 pounds of milk were produced during the time that the repellents were used and 4,070 pounds during the check periods. This increase of 19 pounds of milk is well within the experimental error. However, all sprays were successful in reducing the number of flies and increasing the comfort of the milker. The cost ranged from 1½ to 2½ cents per cow per day. The work will be continued [Department of Dairy Husbandry; state funds.]

**The Relation of Type of Construction to the Winter Temperature of the Floors of Dairy Barns.** A study has been started to determine the temperature during the winter months of the floors of dairy barns constructed of different kinds of material. Six types of floor construction are being compared as follows: Solid cement, solid cement over building paper, cement on hollow tile, wood on cement base, cork brick on cement base, and wood block on cement base. Thermographs are being used to record the temperature of the floor, of the temperature of the soil beneath the floor materials, and of the air inside and outside the barn. The experiment is being conducted in cooperation with the Department of Agricultural Engineering of the Engineering Experiment Station. The work is still in progress and the data have not been summarized. [Project 162; Department of Dairy Husbandry; state funds.]

**Ice Cream Investigations.** The work the past year has consisted of a comparison of the butyl alcohol and Mojonnier test for butterfat in ice cream and of the use of corn syrup in the manufacture of ice cream.

Twenty-four samples of ice cream mix were tested in duplicate by the Mojonnier method and in triplicate by the butyl alcohol test for butterfat.

The average butyl alcohol test on 24 samples was 12.29 per cent and the average Mojonnier test was 12.20 per cent. The maximum variation on individual readings was 0.2895 per cent and the minimum variation was 0.01 per cent, the average variation being 0.0936 per cent.

Results obtained in these trials would indicate that the butyl alcohol test checks the Mojonnier method very closely and that plants which are not equipped with Mojonnier tester may use the butyl alcohol test for testing and standardizing their product.

In order to test the comparative value of corn sugar and cane or beet sugar in the manufacture of ice cream, ice cream mixes were prepared in which various amounts of corn sugar were used and a study was made of its effect on the freezing point, rate of freezing, amount of overrun and quality of the ice cream.

Twenty-eight 50-pound mixes were made. The freezing points of the control mixes which contained 14 per cent cane sugar were found to be between 27.554 degrees F. and 28.445 degrees F., while the freezing point of mixes containing corn sugar ranged from 25.736 degrees F. to 27.88 degrees F. depending on the amount of cane sugar which was replaced by the corn sugar.

Mixes which contained corn sugar froze at a slower rate than the control mixes. In every case the increase in freezing time was in direct proportion to the amount of corn sugar present. Overrun was obtained with more difficulty in the corn sugar mixes, the larger the amount of corn sugar the greater the difficulty.

The flavor, body, and texture of the ice cream containing corn sugar was very satisfactory except when excessive amounts of it were used. Thirty per cent of the cane sugar may be replaced with corn sugar without serious injury to the quality. [Project 124; Department of Dairy Husbandry; state funds.]

**Bacteriological Studies of Ice Cream.** The work on this project during the past biennium has consisted of two separate phases: (1) A practical demonstration in six ice cream plants in various parts of Kansas of the methods of sanitary control; and (2) a detailed study of the "pin point" colony problem which presents a practical difficulty in bacteriological determinations with all dairy products and particularly with ice cream.

The results secured in the first part of the work prove conclusively the reliability of bacteriological analysis as an index to the sanitary condition of ice cream. In the selection of the ice cream plants for this study it was intended to choose two large plants with extensive equipment, two medium-sized plants, and two small ice cream plants with relatively poor and inadequate equipment.

The regular procedure of manufacture of each plant was followed for two days and routine samples were taken. No suggestions were offered by the supervisor during the first two days of the experiment, but a careful study was made of the sanitary practices. On the third and fourth days of the experiment, such changes were made as were deemed advisable to improve the sanitation. These suggestions were based largely on the results secured in previous years' experience with this project. In all but one plant the suggested changes resulted in a very marked reduction in the bacterial content of the product.

During the past summer (1925) a study of the organisms producing "pin point" colonies has thrown considerable light on the characteristics of these bacteria. It has been found that they are thermotolerant, but not themophilic, that is, they survive pasteurization but do not grow at the pasteurizing temperature. They are 'obligate saccharophils in that the development on agar is only in the presence of sugar. The small amount of sugar introduced into the plain agar plate by the low dilutions (1 to 100) of ice cream suffices for their development. They do not appear in plain agar plates containing dilutions of 1 to 1000 or greater. They may not be observed in the plates before pasteurization, if the higher dilutions are used for counting and the lower dilutions are crowded with other larger colonies, which would mask their presence or inhibit their growth. After pasteurization, the lower dilution plates are used since most of the other bacteria have been killed and the presence of "pin point" colonies will be more readily detected. Close examination of these plates sometimes reveals hundreds and perhaps thousands of very small colonies, visible with a hand lens, but too small and frequently too numerous to count with the naked eye. Five manuscripts based on the work of this project have been published. [Project 124; Department of Bacteriology; state funds.]

**A Comparison of the Feeding Value of Milo, Cane, Kafir, and Mixed Feed for Poultry.** This experiment which was started in the fall of 1920 was concluded in the fall of 1925. In the beginning,

10 unrelated White Leghorn pullets were used in each pen annually. However, there was so much variation in production in each pen that beginning with the year 1922-'23 half sisters only were used, that is, all were from one sire. After the pullets completed the first year's production they were kept for a second or hen-year production.

The rations and average production of the related birds for the pullet years and the hen year are given in Table XXI.

TABLE XXI.—Effect of ration on egg production, 1922-1924.

Pen No.	RATIONS.	Production	
		Pullets, av. 2 years.	Hens, av. 1 year.
8	Grain MILO Mash: Ground milo, 75 lbs Meat scraps, 25 lbs	125	135
9	Grain CANE Mash Ground cane, 75 lbs Meat scraps, 23 lbs	79	113
10	Grain: KAFIR Mash: Ground kafir, 75 lbs Meat scraps, 25 lbs	150	133
11	Grain: CRACKED CORN, 75 lbs WHEAT, 25 lbs Mash: Ground corn, wheat, and oats, 80 lbs Meat scraps, 20 lbs	157	133

The last year of this experiment the rations were changed so that the lot which was reared and fed on milo the first laying year was fed kafir the second year; the cane pen was fed corn and wheat, etc. The average production to August 1, 1925, is given in Table XXII.

TABLE XXII.—Effect on production of changing rations.

Pen No.	RATIONS.		Average production as hens, Nov 1, 1924, to Aug 1, 1925.
	First year.	Second year.	
12	Milo	Kafir	80
13	Cane	Corn and wheat	72
14	Kafir	Milo	96
15	Corn and wheat	Cane	80

The five years' work on this experiment will be prepared for publication during the coming year and the project concluded. [Project 77-2; Department of Poultry Husbandry; state funds.]

**Inheritance of Standard Characteristics of Breeds of Poultry.**

The work on this subject has included the study of inheritance of eye color and chick down color variations in Single Comb Rhode Island Reds. The "downy toed" condition in Single Comb White Leghorns has also been studied.

In the study of variations in eye color, matings were made between individuals having bay red eyes. Another mating was made of birds having pale eyes (red practically lacking). The two matings utilized the two extremes of eye color found in the experiment station flock of Rhode Island Reds. The offspring resulting from these matings were classified as to eye color. The grades used were pale, medium, and red. The offspring of the two matings when classified showed practically identical distribution among the grades. The results would thus indicate that the variations studied in these crosses were not heritable.

In Rhode Island Red chicks wide variations in color of down are found. All grades of color from a cream to a deep brownish red may be seen. Individuals possessing very light-colored chick down were mated together as well as were those showing the darkest grade of down. Sample chick skins were prepared showing five grades of down ranging between the lightest and the darkest extremes. These were used in classifying the offspring of the matings. The results clearly show that the variations in down color were heritable, but it remains for succeeding generations of the cross to demonstrate the mode of inheritance.

It is planned to continue selection for more nearly pure breeding strains with respect to the characteristics studied and to follow the behavior in inheritance into the  $F_2$  and  $F_3$  generations. [Project 77-3; Department of Poultry Husbandry; state funds.]

**A Study of the Inheritance of the Characteristics in Which the Single Comb White Leghorns and the Jersey Black Giants Differ.** During the past two breeding seasons nearly one thousand offspring have been hatched from the various matings made between the Jersey Black Giant and the Single Comb White Leghorn breeds. At three periods during the life of the growing chicks, detailed descriptions have been recorded, making it possible to follow the inheritance of all characteristics in which the two breeds differ.

Weight records were also taken making it possible to study the inheritance of size in its relation to other characteristics.

The results of the study of inheritance of plumage color indicate that white and black probably do not compose an allelomorphic pair. Thus the appearance of only predominately white birds in the  $F_1$  generation is due to the epistatic rather than the dominant behavior of white to black.

A difference in shank color involved in this cross was found to be due to two independently acting genetic factors. The yellow shank of the White Leghorn is dominant to the slaty shank color of the Black Giant and exhibits the sex linked type of inheritance.

Although the two breeds are quite uniform with respect to earlobe color (white in the Leghorns and red in the Giants) the factorial basis seems to be rather complex. Complex dominance is lacking, although there is more of a tendency toward white than red in the  $F_1$  generation. The data are not yet completely analyzed, but it appears that the major determiner is autosomal in location. Factors in the sex chromosome may also condition to a slight degree the earlobe color.

Considerable data have also been collected upon the inheritance of body size and egg color. They are not yet sufficiently analyzed to draw conclusions concerning the mode of inheritance of these characters. [Project 77-4; Department of Poultry Husbandry; state funds.]

**The Inheritance of Egg Production in Single Comb White Leghorns.** The foundation stock for this project was obtained from an exhibition strain which had never been trapnested. By selections it was hoped to establish a low producing strain which might be used in crosses with high producing individuals for the study of inheritance of fecundity. Low intensity of production was particularly emphasized in selection. Since the foundation stock consisted of one male and five females, the first generation offspring were all full or half brothers and sisters. To avoid too close inbreeding only half brothers and sisters were mated to produce the third generation. In the next season's matings no full-brother-sister matings were made. The fourth generation is now being reared.

The four females of the foundation stock that completed a full year's record had an average production of 151 eggs. The 12 daughters in the second generation averaged 156 eggs. The females of the third generation have not yet finished their first year of production. Many of the third generation females were destroyed by a

fire which burned a large laying house on May 6, 1926. The mothers of the fourth generation chicks were also eliminated by this accident, so that their production will not be known. The strain is showing many evidences of low vitality and it is not known whether this is due to the necessarily close inbreeding which is being followed or whether, by selecting for low intensity of production, low vitality has also unconsciously been preserved.

If the vitality of the strain will permit, it is planned to continue the selection. [Project 77-5; Department of Poultry Husbandry; state funds.]

**Poultry Flock Management.** This project is a continuation of work begun in the fall of 1923, the object of which is to develop a practical system of managing the farm flock to obtain maximum egg production from the pullets during the fall and winter when the price is high, and maximum fertility and hatchability from the hens during the spring.

High winter egg yields are accomplished by placing March or April hatched pullets in the laying house October 1, leaving them confined until April 15, and forcing for egg production during that period. Good fertility and hatchability is secured by allowing the hens which have completed one or more year's production, free range all winter and spring. From November 1 to January 1, they are fed sparingly grain and bran as a maintenance ration. January 1 they are given a laying mash and brought into egg production. When a 40 to 50 per cent production is reached, the eggs are saved for hatching purposes and a sufficient number set in February and March to raise 75 good pullets for the following year. In the late fall, 50 of the best individuals from both groups are selected as the breeding flock for another year and so the system repeats year after year.

Single Comb Rhode Island Reds have been used the past two and one-half years. The average production of eggs for this period is given in Table XXIII.

**Effect of Feeding White and Yellow Corn and Supplementary Feeds on Egg Production and Hatchability.** The object of this experiment was to find, if possible, a supplementary feed which when used with white corn would give it a feeding value that would approach or equal that of yellow corn.

The work was begun in the fall of 1924 when 40 Rhode Island Red pullets were confined in four pens of 10 each. One male was alternated daily from pen to pen to assure uniform fertility and hatchability.

TABLE XXIII.—Average egg production of each group by monthly periods.

GROUP	Oct	Nov	Dec.	Jan.	Feb.	Mar.	Apr	May.	June.	July.	Aug	Sept.
Hens	5 2	4.1	3.8	4 6	10.2	14 4	14 6	11.8	8 8	8.0	7.5	7.5
Pullets	2 5	5 9	10.6	12 8	14 1	18 9	18 1	17.6	12 2	9 4	10 0	9 1

The results from the three-years' work with Rhode Island Reds will be prepared for publication, and a flock of 125 White Plymouth Rocks will be used for the next period of three years. [Project 77-6; Department of Poultry Husbandry; state funds.]

In the fall of 1925 the experiment was enlarged to eight pens of 10 birds each and White Leghorn pullets were used. A male bird was placed in each pen and these were alternated twice weekly. Two pens were used to test each of the four rations.

The results from the two flocks are listed in Tables XXIV and XXV. None of these pens received green feed and the grain ration was fed ad libitum, [Project 77-9; Department of Poultry Husbandry; state funds.]

TABLE XXIV.—Results from feeding yellow and white corn and supplementary feeds to Rhode Island Red pullets, 1924-'25.

Pen No	RATIONS	Average number eggs, Nov 1 to June 1	Per cent fertility.	Per cent hatched of fertile eggs
8	White corn and meat scraps .	50	82	38
9	White corn, soybean meal, and 3 per cent mineral mixture (a)	58	82	61
10	White corn, meat scraps, and alfalfa litter	77	44	56
11	Yellow corn and meat scraps .	89	74	60

(a) The mineral mixture consisted of 60 parts bone ash, 20 parts calcium carbonate, and 20 parts sodium chloride.

TABLE XXV.—Results from feeding White Leghorns yellow and white corn and supplementary feeds, 1925-'26.

Pen No	RATIONS	Quantity	Average number eggs Nov 1 to May 1	Number eggs set	Per cent fertility.	Per cent hatched of fertile eggs	
51 and 55	Scratch Yellow corn	Lbs	58	242	91	76	
	Mash: Ground yellow corn	80					
	Meat scraps	15					
	Dried buttermilk	5					
52 and 56	Scratch: White corn	80	37	100	85	65	
	Mash: Ground white corn						
	Meat scraps						15
	Dried buttermilk						5
53 and 57	Scratch: White corn	75	14	42	79	61	
	Mash: Ground white corn						
	Soybean meal						20
	Mineral mixture						5
54 and 58	Scratch: White corn	80	74	250	90	86	
	Mash: Ground white corn						
	Meat scraps						15
	Ground alfalfa leaves						10
	Dried buttermilk	5					

**The Effect of an Inadequate Ration on the Production and Hatchability of Eggs.** The work on this project during the past two years can best be described by dividing it into three phases.

In Phase I, a study was made of the relative value of certain Vitamin A carrying substances as supplements to a feed which consisted of white corn, wheat, meat scraps, and buttermilk, which are low in Vitamin A. During the first of the two years, yellow corn and green sprouted oats were used as Vitamin A carrying feed. During the second year, in addition to the yellow corn and sprouted oats, alfalfa leaf meal and yellow soybean meal were used.

The results, in general, agree with the results which were obtained in previous years, which show the importance of Vitamin A for egg production and hatchability. The results are not conclusive in regard to the relative value of the various Vitamin A supplements. The inconsistencies in the results are no doubt due to the great variation in the individuality of the hens used. Although the results are not very significant, it is of interest to note that in each of the two years, the lot receiving white corn supplemented with sprouted oats produced eggs of the highest fertility and hatchability. The hatchability on this pen was 74 per cent the first year and 73 per cent the second, as compared with 55 per cent the first and 57 per cent the second year for birds which received an adequate standard ration including yellow corn and sprouted oats.

In Phase II, a study was made of the influence of ultra-violet light and Vitamin D on egg production and hatchability. Ultra-violet light from direct sunshine and from a quartz mercury arc light (Uviarc Poultry Treater) were used. Cod liver oil and irradiated feed were used as a source of Vitamin D.

Biological analysis showed that the eggs from the hens which received the ultra-violet light either from the direct sunshine or from the light from the Uviarc Poultry Treater contained more Vitamin D than eggs from hens receiving light through window glass.

Phase III of this project consisted of a study of the relative antirachitic value of various sources of ultra-violet light and various substances containing Vitamin D as measured by the development of growing chicks fed the Kansas adequate ration.

Seven comparisons were made, as follows: (1) Relative antirachitic value of light from a mercury arc in a quartz tube (Uviarc Poultry Treater); (2) light from a mercury arc in a glass tube (Cooper Hewitt Factory Lamp); (3) sunlight through an open window; (4) sunlight through a glass window; (5) the Vitamin D content of cod liver oil; (6) irradiated cottonseed oil; and (7) irradiated Wesson oil.

Two lots were treated with ultra-violet light in a glass tube, one for 8¼ hours and the other for 9½ hours, making a total of eight comparisons.

The effect of the different treatments on the rate of growth of chicks is shown in Table XXVI.

TABLE XXVI.—The effect of irradiated oil, diffused sunlight, direct sunlight, ultra-violet light. Wesson oil, and of cod liver oil on the weight of chicks.

Pen No	Days old	Weight in grams				
		2	16	30	44	56
	<b>Treatment of</b>					
65 a	2 per cent irradiated cottonseed oil	32	61	123	184	210
65 a	Sunlight diffused through window glass	31	58	105	139	158
67 a	Ultra-violet light, glass tube, 8¼ hours	33	61	136	283	441
68 a	Ultra-violet light, quartz tube, one-fourth hour.	32	59	139	291	442
69 b	Direct sunlight through open window	35	86	210	402	585
70 b	One-half per cent cod liver oil	33	79	200	429	628
71 b	Ultra-violet light glass tube 9½ hours	34	88	223	425	651
72 b	2 per cent irradiated Wesson oil	34	78	141	175	204

The direct sunshine through the open window proved to be adequate for the prevention of rickets in growing chicks kept in the brooder house.

The inclusion of 2 per cent of irradiated cottonseed oil in the feed showed some beneficial results but did not prevent rickets. The light from the mercury arc in a glass tube proved to be adequate for the prevention of rickets in growing chicks when they were irradiated 8 hours per day. How much shorter time would have been adequate was not determined. This result is of importance as this is the first experiment run with the mercury arc in a glass tube for the purpose of studying the health-giving quality of the light produced. [Project 127; Departments of Poultry Husbandry and Chemistry; Adams funds.]

**Vitamin Content of Feed and the Use of Light in Relation to Immunity to Roup and the Production and Hatchability of Eggs.** Prior to the beginning of this biennium, the work on this experiment had shown that of the three vitamins, A, B, and C, Vitamin A only had any influence on immunity to nutritional roup. During this biennium the experiment has been planned to show the

relation of Vitamin D (ultra-violet light) and mineral content of the feed to nutritional roup.

In this work, White Leghorn pullets in lots of 12 each were used to test the feed. The pullets were started on the experiment November 1 and were continued until all in the pens receiving the adequate feed died.

In 1926 two pens were included to study the influence of iron content of the diet on the iron content of the blood and eggs. Egg records were kept and a chemical analysis of the blood of the hens of the various pens was made. The composition of the feeds as far as the substances under test are concerned and their influence on production is shown in Table XXVII.

Neither minerals nor ultra-violet light had any effect in preventing the condition which has been called nutritional roup, since ultra-violet light has the same effect in nutrition as Vitamin D, we may conclude that this vitamin has no influence on the development of nutritional roup.

Since Vitamin A seems to be the only dietary factor involved in the development of nutritional roup, the term avitaminosis seems to be a better term to use for designating this condition.

TABLE XXVII.—The influence of light, Vitamin A, and minerals on egg production.

YEAR	Pen No	Ultra-violet light	Vitamin A.	Mineral.	Eggs produced
1924 and 1925	1	+	+	+	620
	2	—	+	+	432
	3	+	—	+	107
	4	—	—	+	18
1925 and 1926	1	+	—	+	175
	2	—	—	+	129
	3	—	—	—	96
	4	+	+	+ and } iron }	539
	5	+	+	{ and } no + } iron }	498

The only difference in the blood brought about by the lack of Vitamin A, as far as chemical analysis shows, is a sharp rise in the uric acid content a few days before the hen dies. The work seems to indicate that the rapid rise in uric acid is due to fasting and not to a lack of Vitamin A. More work, however, is needed to clear up this point.

The indications are that the iron content of the feed influences to some extent the iron content of the blood and eggs. A technical

bulletin reporting the results of this project is in preparation. [Project 131; Departments of Bacteriology, Chemistry, and Poultry Husbandry; state funds.]

**Studies in Animal Reproduction and Inheritance.** Progress has been made in the study of inheritance of various color factors in guinea pigs. Some of the problems studied are: (1) A number of factors affecting the distribution of white spotting; (2) the inheritance of the white tipping factor which affects only chocolate hairs; (3) two factors affecting eye color, "salmon-eye" and "pigmentless eye;" (4) factors affecting the intensity of pigmentation at the base of black hairs; (5) a modifying factor affecting the expression of agouti; (6) a recessive factor affecting the intensity of red; and (7) the "kodak" factor occurring as yet only in pink-eyed, non-yellow tortoises.

New data have been collected on the linkage relations of six different factors. The results obtained indicate that none of these factors are linked to each other. These tested are pink eye (*p*), non-extension (*e*), non-yellow (*Cr*), non-agouti (*a*), chocolate (*b*), and smooth (*r*). A few animals recessive for the six factors above enumerated and in addition for long hair have also been produced recently and in the near future appropriate matings will be made to determine whether or not the long hair factor (*l*) is linked to any of the other six. A third linkage experiment in progress is a determination of the linkage relations of salmon-eye (*sm*) with the six previously mentioned.

From 1914 to 1925, inclusive, approximately 19,000 guinea pigs have been born in the laboratory. Almost all of those have been weighed at birth, together with the weights of the mothers at the sametime. In a great many cases the length of the gestation period is known and exact records are kept of the size of the litter and the sex. An analysis with respect to the sex ratio indicates that 9,711 males and 9,177 females have been born. This is 105.8 males to 100 females. A biometrical analysis of these data indicates that the excess of males is not due to chance.

In an analysis of the sex ratios based on data secured previous to 1922, it was found that 15-months old mothers produced 145 male offspring and 87 female. An analysis of the data secured in 1922 to 1925 inclusive, shows that 15-months-old mothers produced 197 males and 159 females, again showing a rather large preponderance of males. The combined results are 342 males and 246 females.

The excess of males in this case is much more pronounced than that found in the offspring of females of other ages.

In the experiment on size inheritance in rats, it was found that the F<sub>2</sub> generation was considerably more variable than the F<sub>1</sub> generation, thus indicating that size is probably inherited in Mendelian fashion. In attempting to make a more thorough analysis, matings were made with the idea of producing five different strains, different from each other in size. It was hoped eventually by selection to make these strains practically uniform and therefore homozygous for the factors affecting their size. It later developed that too much was being attempted in the laboratory space available for the work. Because of the limited number of matings which was possible under these conditions, sterility appeared in all of the larger strains. Another factor which probably contributed to sterility was that the animals were not mated until they were approximately 200 days old in order to determine their size before mating. Later experience indicates that greater productiveness can be obtained when the animals are mated at a younger age. Work is being continued with the smaller strains.

In the study of the production of Giant Chinchilla rabbits, a number of characteristics were noticed, especially in the pure-bred Chinchillas. The standard of perfection for Chinchilla rabbits calls for brown eyes, but animals with blue eyes showing brown spots are quite common. Enough work has been done to prove that the "blue" eyes are recessive to brown. Other evidence obtained from cross breeding experiments indicates very strongly that blue-eyed is linked with *Cr*, the factor responsible for the absence of red in the coat of the Chinchilla. Flemish Giants are all brown-eyed. It was noticed, however, that there was considerable variation in the depth of this color. A few matings have been made to test the inheritance of the variation in shade and in one mating of light brown to light brown all of the offspring were light brown. On the other hand, dark brown-eyed parents produce light brown-eyed offspring in addition to dark brown-eyed, thus indicating that the light brown eye is due to a recessive factor.

Preparations are being made to study the linkage relations of the factors producing blue eye and the variation in the expression of agouti with other factors whose inheritance already has been studied. In this experiment it is planned to produce animals that are small in size and at the same time recessive for five or more

color factors. These will be mated to Flemish Giants which are large and at the same time carry all the dominant color factors. By matting back the heterozygotes to the small animals carrying the recessive factors, it is hoped not only to determine the linkage relations of the color factors but also their linkage relations with those affecting size. [Project 93; Department of Animal Husbandry; state funds.]

**Studies of the Inheritance of the Grouse Locusts (Tettigidae).** The work on this project has been continued. This includes breeding and recording as many as possible of the characteristics of the following species of the grouse locusts (Tettigidae), in the order given: (1) *Paratettix texanus*, (2) *Apotettix eurycephalus*, (3) *Telmatettix aztecus*, (4) Praying mantis, and (5) *Acridium* sp.

During the period 1918 to 1924 *Paratettix texanus*, which is the original species used in the experiments, was relegated to a subordinate place and *Apotettix eurycephalus*, which had hitherto held second place, was emphasized. Since 1923-'24 *Paratettix texanus* has been taken up again in a large way. Numerous generous suggestions and criticisms which the published papers, and those read before scientific bodies have provoked, have become available. This additional information, together with 10 or 12 new factors for color characteristics, makes it feasible now to conduct the work in a much more comprehensive and effective manner than has been possible heretofore.

During the past two years, many thousands of records have been added to the fund of data on the inheritance of the color characteristics of this species. However, the most interesting development has been the discovery of parthenogenesis in this group and the accumulation of considerable data on this phenomenon. Briefly, they behave in parthenogenetic breeding as follows: (1) They produce less than one-third as many offspring parthenogenetically as they do bisexually. (2) Segregation of factors occurs in parthenogenesis to the same extent as in bisexual breeding. (3) Crossing over of factors occurs in parthenogenesis the same as among mated individuals. (4) The parthenogenetic individuals, with possibly two exceptions, have been found, when tested, to be homozygous for all characteristics observed. (5) Potent males, homozygous for all characteristics, occur in the ratio of about 1 to 250 among the parthenogenetic offspring.

These facts regarding the genetics of *Paratettix texanus* have never

been reported for any organisms, except for *Apotettix eurycephalus* and *Telmatettix aztecus*, also reported from this laboratory.

Several specimens of *Apotettix eurycephalus* were collected near Tampico, Mexico, in August, 1911, and others from Texas have been added, from time to time.

A preliminary paper dealing with this group was published in 1919. From this date until the fall of 1925, efforts were concentrated on securing additional data and the preparation of an extensive bulletin which was published in 1925.<sup>2</sup> The breeding work with *Apotettix eurycephalus* has been continued and considerable new data acquired. Since the publication of the bulletin one additional factor has been definitely located on the factor diagram or chromosome map.

Several specimens of *Telmatettix aztecus* were secured in Austin, Texas, a few years ago. The factors studied are found to segregate and behave in all respects in parthenogenesis as well as when they mated. An abstract recently published was the second report of this kind of inheritance ever to have been made (*Apotettix eurycephalus* from this laboratory being the first).

A breeding experiment with the common praying mantis, *Phasmomantis carolina*, an orthopteran, was begun in 1925. This is among the most difficult of animals to breed. Two full generations were obtained and some data were secured on the inheritance of their characteristics.

*Acridium* sp. is a group of grouse locusts found in Kansas. They are extremely varied in pattern and there are indications that if they could be bred successfully much valuable genetic information would be obtained. However, only one, or at best, two generations a year can be secured and no way has yet been found to carry them over their hibernation period in the winter. The work on this group will be carried to the point at least of determining their usefulness. [Project 72; Department of Zoölogy; Adams funds.]

**Influence of Climate on Inheritance and Parthenogenesis in the Grouse Locust (Tettigidæ).** Efforts made to change the lines of inheritance in the grouse locusts through the influence of environmental conditions have almost entirely failed. It was intended from year to year to take up the work of this project in a more intensive way. Due, however, to mechanical difficulties with the tempera-

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2. Nabours, Robert K. Studies of Inheritance and Evolution in Orthoptera. V. The Grouse, Locust, *Apotettix eurycephalus* Hancock. Kan. Agr. Expt. Sta. Tech. Bul. 17; 1-231; 4 figs, 1 pl.

ture and humidity control machinery, inadequate funds, and the urgently increasing demand upon time and funds for other phases of investigation, the work on this project has been inactive. It is planned to repair the machinery and to resume work on this experiment within another year. [Project 104; Department of Zoölogy; Adams funds.]

**A Study of the Inheritance of Eye Defects in Rabbits.** An attempt to duplicate the work on inheritance of eye defects in rabbits as reported by Guyer at the University of Wisconsin has been made during the past biennium. The work has been pursued along two lines. (1) The use of serum of hens which had been immunized against rabbit lens protein; and (2) the breaking up (needling) of the lens (*in vivo*) of females on about the ninth day of pregnancy. The immune serum was injected intravenously into female rabbits on alternate days during a period covering the seventh to the fourteenth day of pregnancy.

During the biennium 59 offspring from female rabbits receiving anti-lens-protein serum from immunized hens and 110 offspring from females with needled lenses were examined with but one possible abnormality. Numerous young from untreated females have been examined with one animal showing a slight abnormality in one eye. Seven young from females treated with serum from untreated lenses were all normal.

The results of the experiments so far conducted lead to the following conclusions. (1) The introduction into pregnant rabbits of hen-serum containing precipitins for rabbit lens protein, as recommended by Guyer, will not cause abnormalities to develop in the eyes of the offspring. (2) The breaking up of the lens protein in the eyes of living rabbits will not cause the development of much precipitin in the blood serum of the treated animals. (3) Such treatment will not lead to the development of abnormalities in the eyes of the offspring of the treated animals. [Departments of Animal Husbandry, Bacteriology, Poultry Husbandry, and Zoölogy; state funds.]

**Bee Investigations.** Valuable data have been gathered on nectar flow and climatic conditions associated with it. The data at present are not sufficient, however, to indicate any relationships.

The amount of brood in colonies was determined every 24 days, after which the queens in these colonies were interchanged to determine the brood-rearing power of colonies.

There is a direct correlation between the brood power and the amount of brood reared to maturity. There is no correlation be-

tween the rate of egg-laying and the amount of brood reared. This indicates that the strength of a colony depends more upon its brood-rearing power than upon the queen. This does not lessen the value of the queen, however, because unless a queen can perform satisfactorily, the brood power of the colony will become lowered. When two colonies were united, their brood power was increased; consequently, a larger amount of brood was reared. The work is to be continued.

A study of the causes which affect the granulation of honey have been made and indicate that (1) diffused light does not influence crystallization, (2) low temperatures combined with extreme variations in daily temperatures hasten the beginning of crystallization and also shorten the period of time of crystallization, (3) air incorporated into honey has a tendency to hasten the beginning of crystallization and shortens the period required, (4) crystallization of a blend of two or more honeys is influenced by the ratio of crystallization and shortens the period required, (5) crystallization of a blend of two or more honeys is influenced by the ratio of crystallizable to non-crystallizable sugars which it contains, (6) a correlation exists between the percentage of dextrose in honey and the number of days from extraction until crystallization begins, and (7) a correlation exists between the percentage of dextrose in honey and the length of time required for the completion of the crystallization process. This latter phase of the project has been discontinued. [Project 126; Department of Entomology; state funds.]

#### DISEASES OF FARM ANIMALS

Some of the more important features of the work of the Agricultural Experiment Station on animal diseases and parasites during the past two years are discussed below.

**Miscellaneous Animal Disease Investigations.** This project is concerned with the investigation of various animal diseases as they occur from time to time in different parts of the state. The work consists of post mortem and laboratory examinations of diseased animals and tissues, and a study of methods of controlling new diseases. During the past biennium, 2,990 laboratory examinations have been made consisting of 268 post mortem examinations of large domestic animals; 790 post mortem examinations of rats; 505 rabies examinations; 34 abortion suspect examinations; 610 agglutination tests for contagious abortion; and 470 examinations of blood, feces, skin scrapings, organs, etc. [Project 102; Department of Veterinary Medicine; state funds.]

**Abortion Disease Investigations.** During the first part of the biennium, the work consisted of observations on the herd at the serum plant. The animals have been sold and that part of the experiment discontinued. Some work on cytost has been started. Twelve pregnant guinea pigs were injected with guinea pig cytost to determine whether or not abortion would result. At the same time, 11 control pregnant guinea pigs were injected with an equal volume of physiological saline solution. All injections were made into the heart. Seventy-five per cent of the cytost injected pigs aborted at from 1 to 16 days (average being 6½ days), but 25 per cent of them carried fetuses full time. Of those injected with physiological saline solution, 63.6 per cent aborted in from 5 to 18 days (average being 10 1/3 days) and 36.4 per cent carried fetuses full time.

Cytost has been prepared from cattle, swine, dogs, cats, guinea pigs, and rabbits and has been found to be most active on the animals from which it has been prepared. However, rabbit cytost readily kills guinea pigs, but the reverse is not true. Rabbit cytost kills cats and cat cytost kills rabbits. It is not certain at present whether this is a reaction that has to do with specialization or whether it is a simple quantitative reaction. Technical Bulletin No. 14 based on the results of this work has been published. [Project 135; Department of Veterinary Medicine; state funds.]

**Blackleg Investigations.** The work of this project has consisted of studies of the virulence of blackleg cultures; of the toxicity of filtrates and aggressins produced from typical blackleg cultures; of methods of differentiating blackleg strains from strains of closely related organisms; of comparative tests on blackleg filtrate and aggressin; and of examinations of material sent in for blackleg diagnosis.

It has been found that the virulence of blackleg cultures depends upon the presence of three substances: (1) living cells, (2) aggressins produced by these cells, and (3) a "lethal substance" found in virulent *Clostridium chauvei* cells.

It has been suggested that the use of iron salts stimulates the cellular activities of *Clostridium chauvei*. Ferric sulfate, ferric chloride, and ferrous sulfate were added to various media and it was found that ferric sulfate greatly increased the virulence of a number of strains of *Clostridium chauvei*. One strain which had been a virulent since 1921 was stimulated to such a degree that it again killed guinea pigs and calves.

No toxins could be found in filtrates of blackleg cultures or in filtered muscle extracts from spontaneous cases of blackleg or from cases produced by the use of blackleg cultures. Guinea pigs were inoculated subcutaneously with 25 cubic centimeters of these products, intracardially with 2 cubic centimeters, intraperitoneally with 4 cubic centimeters, and intravenously with 1.5 cubic centimeters with no ill effects; all animals inoculated lived for at least four days.

Potency tests on guinea pigs and reports from the use of blackleg filtrate and aggressin in the field show that the two products are of equal value in the prevention of blackleg.

Impotency tests on 11 serials (Nos. 209-219) of blackleg aggressin and 21 serials (Nos. 197-219) of blackleg filtrate it was found that the average aggressive strength of the 11 serials of aggressin was 19.65 and of the 21 serials of filtrate, 19.19 aggressive units. Field reports during the past nine years on the use of 240,000 doses of blackleg filtrate and 170,000 doses of blackleg aggressin show that there is no difference in the results obtained from these two products, losses being less than 1 in 10,000 for each. Four manuscripts based on this project have been prepared for publication. [Department of Veterinary Medicine; state funds.]

**Studies in Hog Cholera Immunity.** The work of this project consists of attempting to produce permanent immunity in natively immune pigs by the use of hog cholera virus. Thirty-four pigs from immune sows and five pigs from a susceptible sow were inoculated with 2 cubic centimeters of active hog cholera virus. All pigs from the susceptible sow died and 10 pigs from an immune sow that had stopped lactating also died. Fourteen pigs from immune sows lived and survived the test inoculation administered six months later, showing that immunization of suckling pigs is possible under favorable conditions. These sows immunized at three weeks of age with virus alone have been bred to farrow this summer. The immunity of pigs from these sows will be compared with pigs farrowed from sows immunized with anti-hog-cholera serum and virus. [Project 150; Department of Veterinary Medicine; state funds.]

**Poultry Disease Investigations.** The work of this project has been divided into four phases. The first is a general study of poultry diseases and consists of examining diseased birds sent to the laboratory for diagnosis; the second, a study of bacillary white diarrhea; the third a study of *Pasteurella avicida*, the causative organism of fowl cholera; and the fourth a study of avian tuberculosis. A

record has been kept of all post mortem examinations made during the past biennium. These records show that an examination was made of 5,761 birds from 1,992 flocks. The kind of diseases represented and the number of flocks and birds examined for each disease are given in Table XXVIII.

TABLE XXVIII—A list of poultry autopsies for the biennium, 1924-1926

DISEASE	1924-'25		1925-'26		Total birds for biennium
	Number out-breaks	Number birds examined	Number out-breaks	Number birds examined	
Bacillary white diarrhea	108	511	169	956	1,467
Miscellaneous chick diseases	53	313	55	494	807
<i>Coccidiosis</i>	62	215	29	109	324
Large round worms	97	120	136	340	460
Intestinal Cecum worms	37	65	177	446	511
Gizzard worms	8	8	9	14	22
Tape worms	44	81	89	179	260
Fowl cholera	66	130	69	174	304
Fowl typhoid	35	69	41	69	138
Adult <i>S. pullorum</i> infection (acute)	6	8	12	22	30
Tuberculosis	20	40	57	83	123
Infectious bronchitis	66	117	12	51	168
Avian diphtheria			14	25	25
Infectious ophthalmia	22	29	24	55	84
Chicken pox	1	5	9	20	55
Botulism	13	25	17	37	62
Blackhead	3	3	8	14	17
Ovarian infection ( <i>S. pullorum</i> )	11	31	11	26	67
Ruptured ova			36	71	71
Avitaminosis "A"	12	51	32	170	221
Avitaminosis "B"	1	7			7
Avitaminosis "D"	1	1	9	64	65
Air sac mites	12	13	5	7	20
Scaly leg	4	4	8	11	15
Sod disease	3	12	2	4	16
Paralysis	8	12	6	8	20
Injuries	6	6	5	20	26
Internal hemorrhages	7	12	8	16	28
Poisoning	24	33	14	37	70
Bumble foot	3	5	3	4	9
Vent gleet	6	6	3	3	9
Tumors	12	12	12	15	27
Paratyphoid			2	2	2
Favus			1	1	1
Miscellaneous	88	89	68	180	269
<b>Totals</b>	<b>830</b>	<b>2,033</b>	<b>1,153</b>	<b>3,728</b>	<b>5,761</b>

One new disease which has been tentatively diagnosed as infectious bronchitis has been studied during the past two years. It is a disease primarily affecting young fowls, which have been exposed to adverse conditions. During the fall and winter of 1924-'25, considerable losses were experienced at feeding stations throughout the state and on farms where birds had been exposed at poultry shows. The disease is one affecting the pulmonary system, and no definite cause has been determined.

Two outbreaks of paratyphoid in chicks was diagnosed, the basis of the diagnosis being an isolation of an organism which culturally and morphologically resembles *Salmonella schotmulleri*.

A number of samples of feed suspected of causing the death of chicks are sent to the laboratory each year. No attempt has been made to isolate poisonous fungi from these samples, but each one is fed to chicks, or guinea pigs, to determine whether the feed in question is not poisonous. In not a single case have chicks or other laboratory animals died from eating such feed. In most cases birds were also received and a positive diagnosis of the cause of losses usually could be given, the disease most often being of an infectious nature. No doubt commercial chick feeds do cause some losses, but these losses are not so great as is usually supposed.

The work on bacillary white diarrhea consisted of studies of the agglutination test for detection of *S. pullorum* infection carriers; of the preparation and preservation of test fluids; of the preservation of blood serum; of the distribution of bacillary white diarrhea in Kansas; of the mortality of chicks in bacillary white diarrhea outbreaks; in complement fixation for *S. pullorum* infection in adult birds; and the transmission of bacillary white diarrhea in incubators. During the biennium 9,440 agglutination tests were made and in addition 300 complement fixation tests to compare the relative efficiency of the agglutination and complement-fixation tests. To date a close correlation of results has been obtained by the two methods.

During the past year an attempt has been made to determine the mortality in outbreaks of bacillary white diarrhea. Only cases which could be personally observed have been considered and in every case diagnosis has been confirmed by bacteriological examination. The high mortality from the disease is shown in Table XXIX.

TABLE XXIX.—Summary of studies on mortality in outbreaks of bacillary white diarrhea

OUTBREAK.	Number chicks in brood.	Losses began.	Largest number of losses.	Losses stopped.	Total losses.	Per cent mortality.
		<i>Day.</i>	<i>Day.</i>	<i>Day.</i>		
1.....	33	2d	5th	14th	21	66.6
2.....	46	6th	9th	13th	11	23.9
3.....	30	7th	12th	12th	7	23.3
4.....	39	11th	11th	11th	1	2.6
5.....	12	10th	10th	13th	4	33.3
6.....	30	4th	5th and 10th	11th	22	73.3
7.....	55	4th	7th	11th	26	47.3
8.....	81	7th	8th	14th	51	62.9
Totals.....	326				143	40.8

No attempt has been made to determine the relationship of breed, care, etc., to mortality. The work to date indicates that losses seldom start before the fourth day after the chicks are hatched and that the heaviest losses occur from the fourth to the tenth day. Losses are seldom observed from the acute type of the disease after the fourteenth day.

A series of experiments to determine the possibility of transmitting bacillary white diarrhea in incubators have been conducted. Artificially infected chicks were used as a source of infection. It was found possible to transmit the disease to healthy chicks hatching in a forced aircraft type of machine. The work will be repeated using naturally infected stock. Other types of incubators were not used in these experiments.

The work on the problem of developing a vaccine against chicken cholera has been continued. Recently it has consisted of a study of the value of bacterins made from different strains of *P. avicida*; the development of a seriological test for demonstrating immunity; the development of immunity, as expressed by the complement-fixation test, and as determined by injection of virulent cultures; the influence of the method of preparation upon the antigenic properties of this organism; and a study of the cause of death as produced by the fowl cholera organism.

The results to date indicate that bacterial vaccines prepared from the organism of chicken cholera are far from perfect in their protective action; that there is a close correlation between the complement-fixing antibodies in the blood stream and resistance to virus; that ultra-violet light irradiation causes a marked reduction in the antigenic properties of the bacterins made from the organism under study; and that the introduction of the antigen into the skin, trachea, or intestine produced no antibodies in the blood stream or protection against the virus.

During the past two years, 123 cases of avian tuberculosis were secured for diagnosis. A study of the distribution of the lesions shows the liver, spleen, and intestines most frequently infected. [Project 85; Department of Bacteriology; state funds.]

**Relation of Adequacy of Diet to Disease.** During previous years, this project has been confined to a study of the disease commonly called roup. New developments in the field of nutrition have indicated that it would be desirable to study other purely deficiency diseases. Consequently in 1924-'25 the influence of ultra-violet

light upon the development of these diseases was studied, and in 1925-'26 a pen of adult chickens was included to determine the effect of deficiency of minerals on the development of vitamin deficiency diseases. Also, during the year one experiment was made to determine the effect of fasting on the development of urate-like deposits in various tissues of the body.

The results secured in 1925-'26 from the study of a deficiency in the diet upon diseases are shown in Table XXX.

**Parasitological Investigations.** During the last two years the work has been centered upon the biology of the large round worm of chickens, *Ascaridia perspicillum*. The developments in the work during this period have been an extension of the results during the previous biennium on the effects of these parasites on chickens. In addition to muscular deficiencies, anæmia and a mortality of 24.6 per cent (in chicks one month of age), it has been found that the thymus glands of parasitized chicks become reduced in size.

It has also been found that the blood-sugar content of growing chicks is reduced during parasitism. This is the first time that the blood-sugar content of any animal has been found to be affected by the presence of a parasitic worm.

While studying the effect of the nematode, *Ascaridia perspicillum*, upon the blood-sugar content of chickens, it was necessary to remove blood from the live chickens. It was found that the bleeding affected the resistance of the chickens to these parasites, repeated bleeding making young chickens more susceptible. The removal of large amounts of blood by cardiac puncture was also found to make adult chickens less resistant to the growth of parasites. This seems to be the first record of a carefully controlled experiment of this kind.

It has also been found that chicks from five to one hundred days of age became progressively more resistant to parasitism. In chicks one hundred days old, the parasites were not able to make a growth of more than 0.1 mm. during the first 10 days, while those in five-day-old hosts made a growth of over 5 mm.

Experiments to determine the relation between the presence of Vitamin B in the diet to resistance to *Ascaridia perspicillum* were conducted by using different lots of chickens from the same hatch, giving all an adequate ration during the first seven weeks, then separating into lots and giving one lot a ration lacking only in Vitamin B. At the end of two weeks time, all lots are parasitized

TABLE XXX.—Effect of feed deficiency upon disease of adult chickens.

Lot No.	Number birds.	Feed deficient in—	Number died	Per cent died	Average days to death.	Causes of death			
						Avitaminosis.			Miscellaneous
						A	D	A and D	
1..	12	Vitamin A	11	91.6	131	10	0	0	1
2.....	12	Vitamin A and D	11	91.6	142	10	0	0	1
3..	12	Vitamin A, D, and minerals	10	83.3	134	7	0	2	1

The above results indicate that there is little relationship between the losses due to avitaminosis "A" in adult chickens and the mineral content of the feed, or the presence or lack of Vitamin D. No typical clinical cases of avitaminosis "D" developed in lot 2 which lacked Vitamin D. In lot 3, two birds showed typical bone lesions seen in avitaminosis "D" and the lack of minerals may have something to do with the lesions seen in these cases. Both of these birds showed typical beading of the ribs and crooked sternums. The legs of one became very weak and the long bones showed marked curvature at the time of autopsy. This bird assumed a penguin-like attitude two months previous to its death. Both of these birds also showed typical lesions of avitaminosis "A." The three deaths reported as miscellaneous include two from unknown causes and one from an internal hemorrhage. At the time this experiment was reported all four of the birds remaining alive showed typical symptoms of avitaminosis "A." [Project 131; Department of Bacteriology; state funds.]

and in three weeks all chickens are killed and autopsied. The number and size of the worms constitute the measure of resistance to parasitism. Five different experiments were conducted with the result that those chickens whose diet lacked Vitamin B were much less resistant to parasitism than were those whose diet contained Vitamin B.

Additional studies have been made on the viability of the worm eggs (*Ascaridia perspicillum*) when placed out-of-doors in the soil under conditions similar to those of a poultry yard. During the period between July 21 and August 20 all eggs on the surface and those buried two and four inches, respectively, were killed by heat from the sun in unshaded soil but many of the eggs placed similarly in shaded soil survived. Temperatures of 20 degrees below zero F. were found to be sufficient to kill embryonated eggs (eggs with coiled embryos) when placed on the surface, but burial of four inches afforded sufficient protection to enable large numbers of eggs to survive such freezing. [Project 79; Department of Zoölogy; Adams funds.]

**Studies on the Embryology of Parasitic Worms.** During the past biennium the work has been centered upon a study of the behavior of nematode larvæ in the host. Studies were made on larvæ of nine nematodes belonging to three families.

In the family *Ascardæ* the larvæ upon hatching from the eggs in the intestine of the host bore through the wall of the intestine and migrate to the liver, lungs, and trachea and back to the intestine again before settling down to grow to maturity. Previous work has shown that such migrations, in pigs for example, have a very deleterious effect upon the host. The studies showed that the larvæ belonging to the family *Heterakidæ* have a tendency to migrate but they seldom bore through the wall of the intestine.

Larvæ of the nematodes which belong to the family *Oxyuridæ* appear not to have the migratory habit. Prior to 1924, it had been assumed that the larvæ of the human hookworm, *Necator americanus*, could penetrate the skin of man and other hosts so long as the larvæ were alive. A large number of hookworm larvæ were brought from Trinidad, British West Indies, to the Parasitology Laboratory at the Kansas State Agricultural College and there kept alive for 18 months, equalling the world's record for viability of hookworm larvæ. At the end of that time tests were made to ascertain if the hookworm larvæ could enter the skin of a host. Re-

peated tests showed that these larvæ had become so weakened with age as to render them incapable of boring into the skin, thus dispelling the idea that all live hookworms are dangerous.

The large roundworm, *Ascaris lumbricoides*, of man and the large roundworm of the pig have the same structure and are, therefore, according to the present rules of nomenclature, of the same species. As children and young pigs are frequently very intimately associated, it is very desirable to ascertain whether the eggs from the pig *Ascaris* will develop in man and vice versa. Experiments to determine these points were begun in Trinidad, British West Indies, in 1921 and will be completed at the Kansas State Agricultural College.

By feeding embryonated eggs of the human *Ascaris* to young pigs and by giving embryonated eggs of the pig *Ascaris* to one monkey and two human subjects, all tests showed that the worms could not mature in the opposite hosts. But when large numbers of human *Ascaris* eggs were swallowed by young pigs the latter developed an *Ascaris* pneumonia from the larvæ in the lungs. These experiments indicate that children eating fruit from orchards where pigs run may be in danger of pulmonary troubles from pig *Ascaris* eggs.

Studies are being made on filaria nematodes occurring in poll evil and fistulous withers in horses which affords strong evidence that this worm is a possible cause of these two important disorders. [Project 119; Department of Zoölogy; state funds.]

#### STUDIES IN HOME ECONOMICS

The Purnell Act particularly emphasized those economic investigations which have for their purpose the development and improvement of the rural home. Accordingly the Kansas Agricultural Experiment Station has expanded its investigations to include those in the field of home economics. During the fiscal year ending June 30, 1926, work in this field was conducted along five major lines, each of which is briefly discussed below.

**Factors Affecting the Seasonal Variation in the Growth Curve of Children.** This work has consisted of a study of the development, as indicated by monthly determinations of height and weight of the children in the following institutions in Kansas: Boys' Industrial School, Topeka; School for the Blind, Kansas City; and School for the Deaf, Olathe. All the children between the ages of 6 months and 12 years were studied. In all 137 children were under observation, consisting of 83 boys and 54 girls. A group of 76 chil-

dren in the School for the Deaf were divided into three sections as follows:

- Group I—Control. . . . . 16 boys, 12 girls
- Group II—Light treatment. . . . . 12 boys, 12 girls
- Group III—Diet treatment. . . . . 12 boys, 12 girls

These three groups were planned to be as nearly alike as possible in point of age distribution and in relation to normal weight. The children in Group I received the ordinary diet and activities of the institution. The children in Group II, in addition to the regular diet and activities of the institution, were exposed daily under a mercury vapor quartz lamp. The children in Group III received, in addition to the regular institutional diet, two oranges a day.

The height and weight of all children were recorded from December, 1925, to May, 1926. The light treatment began on February 20, 1926, and the diet treatment on April 2, 1926. Table XXXI shows the gain or loss in weight for each child for each group and institution calculated monthly.

TABLE XXXI.—Monthly gain or loss in weight of children in several state institutions of Kansas.

INSTITUTION	Treatment	Gain or loss in weight, pounds						
		Jan	Feb	Mar	Apr	May	Total	Av gain per month
School for Blind . . . . .	Control	1 32	0 77	0 87	0 27	0 35	2.83	0.57
Boys Industrial School . . . . .	Control	1 28	37	.46	27	.59	2.33	.46
School of Deaf . . . . .	Control	1 71	78	1 60	.55	.96	4.39	.88
School of Deaf . . . . .	"Light"	1 40	1 16	1 21	.69	.83	3 91	.78
School of Deaf . . . . .	"Diet"	1 33	.99	83	12	1.16	4 04	.81

The data are not sufficient to justify any definite conclusions. [Project 158; Department of Home Economics; Purnell funds.]

**The Vitamin Content of Some Common Fruits and Vegetables.** It is proposed to determine the vitamin content of cabbage, sauerkraut, and relishes; celery cabbage; cherries; peaches; pears; rhubarb; and string beans. During the past year the work has been confined to a study of the Vitamin B and Vitamin C content of yellow peaches, home-grown cherries, and pears.

The pears which were tested for Vitamin C were purchased on the local market in September, Part of these were canned by the "cold pack" method and were processed for 20 minutes. Another portion

were canned by the "open kettle" method and were cooked for 15 minutes. A third portion were stored under refrigeration at a temperature of 40 degrees F. and used raw. In February, the supply of fresh fruit was exhausted and a new lot of California pears was purchased to complete the experiment. The three kinds of pears were fed in amounts varying by 5 grams from 5 to 35 grams to guinea pigs fed on a basal ration deficient in Vitamin C. Negative control animals were given the basal diet alone to make sure of the absence of Vitamin C and positive control animals were given a bad diet with 5 c. c. of tomato juice to secure normal growth. The following conclusions seem warranted from the results to date:

1. The minimum protective amount of raw pear is about 10 grams daily, although this amount is not sufficient to provide for good growth. Larger amounts gave better growth, while 30 and 35 grams gave better growth than 5 c. c. of tomato juice.
2. The antiscorbutic factor of pear is destroyed in canning by either the "cold pack" or "open kettle" method.
3. Storing pears under refrigeration seemed not to affect their antiscorbutic content.
4. The substitution of California for home-grown pears did not affect the growth curve of the experimental animals. [Project 158; Department of Home Economics; Purnell funds.]

**Utilization of Calcium and Phosphorus from Fresh, Dried, and Canned Milk.** During the past biennium studies have been made of the utilization of calcium and phosphorus from fresh, dried, and canned milk with four adults and five children as subjects.

Simple diets were used, so planned that as large a portion as possible of the calcium would come from the milk. The milk was given, in supposedly equivalent amounts of the various forms, at less than optimum level in order that differences in utilization and storage might be determined.

The work with children was carried on in the Topeka home of the Kansas Children's Home Society, using three girls and two boys between seven and twelve years of age. Fresh milk was used during the first, second, and seventh periods of three days each. Powdered whole milk was used during the third and fourth periods. Unsweetened condensed milk was used during the fifth and sixth periods.

Four adults, graduate students and faculty members of the Department of Home Economics, were subjects in a similar experiment with adults. Fresh milk from the college dairy herd was used during the third and fourth periods. During the seventh and eighth periods,

fresh milk was used from two cows kept in the barn and deprived of sunlight for more than four months. Powdered whole milk was used during the first and second periods and unsweetened condensed milk during the fifth and sixth periods.

Calcium and phosphorus determinations were made for food, feces, and urine. From these figures intake, output, and balances were calculated for each subject, period by period.

It was found for the children that the fresh and dried milk each furnished not less than 75 per cent and condensed milk not less than 63 per cent of the total calcium. During the periods in which dried milk replaced fresh milk, the retention of calcium per kilo was only 50 to 75 per cent as much as the average retention during the fresh milk periods. The children did not utilize the calcium of dried milk as efficiently as that of fresh milk. The condensed milk, upon analysis, showed a calcium content about 25 per cent lower than an equivalent of fresh milk in calories or protein. The retention of calcium from condensed milk was less than 50 per cent as great as from fresh milk. This would indicate that the calcium of the condensed milk was not as efficiently utilized by the child as the calcium in either fresh milk or dried milk.

It was found with the adults that the milk furnished about half the total calcium. For all four subjects, the calcium balances per kilo were low for the dried-milk periods, with decided increases for the fresh herd-milk periods. Apparently the calcium from the fresh herd milk was very much better utilized. Results for the condensed-milk periods were not so decisive, showing for two subjects utilization as good as for fresh herd milk while for the other two subjects the utilization seemed much inferior to that of the fresh milk. Two subjects only were on the diet during the periods when fresh milk was used from cows deprived of sunlight. These subjects each showed a drop in the calcium balance during these periods, indicating a lessened utilization of the calcium. Roughly, the calcium from this milk was about as well utilized as was that from the dried milk.

Phosphorus balances were also calculated, but the results are not conclusive. The general trend was much the same as for the calcium. Utilization seemed better on fresh herd milk than on dried milk. The inferiority of the utilization of phosphorus is marked for the periods when milk was used from cows deprived of sunlight. [Project 159; Department of Home Economics; Purnell funds.]

**A Time Study of Infant Care.** The purpose of this project was to study through carefully made records the time spent by the mother and other persons in caring for children under one year of age and in good physical health.

Certain mothers, having babies under one year of age and in good health and normal mental and physical development as shown by physical examination, were asked to keep records on the "minute clock" furnished by the Agricultural Experiment Station of the time spent in caring for the child, the time being recorded under the headings of feeding, bathing, dressing, preparing for bed, diaper changing, laundry, playing, holding, rocking, outings, exercise, and additional care, that is, hot water bottles, medicine, etc.

Accuracy of records was safeguarded through personal visits to the home by the investigator, telephone calls, and through contacts at the baby clinics and other places.

Data were secured for periods of 10 days of 15 babies from homes of professional families. This study shows that 33 per cent of the mother's waking hours was spent in the care of one child. Since the care was not consecutive but spread out over the 24 hours, the strain and adjustment is really greater than the hourly rate would indicate. Due to a change in personnel, this project will be discontinued. [Project 160; Department of Home Economics; Purnell funds.]

**The Protective Value of Certain Clothing Fabrics.** The work of this project consists of two phases: (1) A study of the protective value of clothing fabrics against cold as measured by the quantity of electrical energy necessary in varying environments to kept a fabric-covered body at a temperature of 36 degrees C. in still air; and (2) a study of the comparative protection afforded the skin against sunburn by different textile fabrics and to determine whether the difference in coefficient of protection depended upon the nature of the fiber or depended wholly or in part upon the construction of the fabric.

In the study of the protection afforded by different fabrics against sunburn, woven fabrics of plain weave were used thus permitting determinations of the per cent of interspace. The lightest weight wool fabric was analyzed as to weight and thread count and used as a standard of comparison. This piece was matched as nearly as possible with silk, linen, and cotton materials. The problem of the

absorption of color was avoided by choosing only white materials. A detailed physical analysis was made of each fabric.

The screening effect of the different fabrics was determined in four different ways: (1) by action of direct sunlight on the skin; (2) by action of ultra-violet light on sensitized paper; (3) by means of a photometer; and (4) by spectrographic analysis. The coefficient of protection of the four different kinds of fabric under study is shown in Table XXXII.

TABLE XXXII.—Coefficient of protection of different textile fabrics.

MANNER OF DETERMINATION.	Wool.	Silk.	Linen	Cotton
Direct sunlight . . . . .	2.0	20	3	4
Ultra-violet light on sensitized paper . . . . .	8.5	13.0	3	4
Photometer . . . . .	7.07	7.11	4.39	8.6
Spectrographic analysis . . . . .	20.00	20.00	3.00	4.0

The per cent of interspace for the various fabrics was found to be 8.8 for wool, 12 for silk, 5.5 for linen, and 5.3 for cotton.

The data tend to show that the protection from sunburn afforded the skin by fabrics depends principally upon the per cent of interspace due to weave. The vegetable fibers, cotton and linen, however transmit some of the rays that burn and hence have a small coefficient of protection. Animal fibers, silk and wool, on the other hand absorb a portion of the rays thus having a large coefficient of protection. [Project 161; Department of Home Economics; Purnell funds.]

**BRANCH EXPERIMENT STATIONS**

Four branch experiment stations located at Hays, Garden City, Colby and Tribune are maintained primarily for the purpose of supplementing the work at the main station with special reference to the conditions that prevail in the western part of the state. The work at these stations has progressed very satisfactorily during the biennium. Improvements have been made to the physical equipment; the research projects have been more generously financed; and the results have been more adequately presented to the farmers of western Kansas than at any time in the past. Something of the character and extent of the work of the branch stations is presented below.

FORT HAYS BRANCH EXPERIMENT STATION

The Fort Hays Branch Experiment Station consists of 3,600 acres of land, about 2,000 acres of which are under cultivation, the remainder being used as pasture, campus, and park. The station is equipped to conduct field experimental work with soils, crops, and live stock. Brief statements regarding the principal projects follow.

**Dry-land Agriculture.** The work on the dry-land project during the past two years has been a continuation of the experimental work established in former years, some of which has been in operation since 1906.

The first objective of the work is to determine the best cultural methods by which the largest and most economical yields of the farm crops adapted to this section can be produced. In connection with these studies, investigations are being made of the value of sod crops and green manure crops in rotations and the value of barnyard manure and commercial fertilizers. Tillage experiments with both winter and spring grain are being conducted.

For spring grains, the ground is prepared by spring plowing, fall plowing, fall listing, and subsoiling. For winter wheat, the tillage methods include late fall plowing, early fall plowing, subsoiling, early fall listing, double listing, disking previous to plowing, double disking and stubbling in without any tillage.

One of the outstanding results of practical importance in the tillage experiments is the increased yield of winter wheat secured by early fall listing or early plowing as compared with late plowing. The data presented in Table XXXIII illustrate this point.

TABLE XXXIII.—Data showing increased wheat yields due to early fall tillage.

METEOD OF SFEDBED PREPARATION.	Late fall plowed.	Early fall plowed.	Early fall listed.
Average yield, 1907 to 1925	<i>Bus.</i> 10.8	<i>Bus.</i> 16.3	<i>Bus.</i> 19.6

A study of the relation of yield to climate shows that the character and distribution of the rainfall is of much more importance than the total amount. This may be illustrated by the results obtained during the seasons of 1924 and 1925. Although the precipitation for the calendar year 1924 was only 13.57 inches, the third lowest in 57 years, the extremely favorable distribution together with the mois-

ture stored in the ground during the fall of the previous year made 1924 the best crop year on record. The average yield, for example, from a group of 34 plots of winter wheat representing all methods of seedbed preparation, except fallow, was 41.5 bushels, which is the highest yield of wheat yet secured on the project. The average grain yield of all the other crops, except milo, was nearly double the average yield. The precipitation for 1925 was 22.15 inches, but an unfavorable distribution together with a dry subsoil made 1925 one of the poorest crop years on record, as is illustrated by the fact that the same 34 plots made an average yield of only 3.3 bushels per acre. Other small grains were almost a complete failure except on fallow. The row crops, however, benefited by late rains sufficiently to make slightly better than normal yields. [Fort Hays Experiment Station; state and federal funds.]

**Cereal Investigations.** The work in cereal investigations is a continuation of varietal and cultural tests with wheat, barley, oats, sorghums, and corn which has been in progress since 1912. Improvement of barley, oats, and sorghums through selection and hybridization has received increased emphasis since 1920.

Seven hundred and twenty-six selections of barley from foreign and domestic sources were received in 1923. The 1923 crop was destroyed by hail, but yields were obtained in 1924 and 1925. The 10 highest yielding selections of the six-row type of barley for the two-year period, 1924 and 1925, were as follows:

	Bushels.		Bushels
Tripoli . . . . .	40.9	Sea of Azov . . . . .	31.9
Club Mariout . . . . .	36.5	Vaughn . . . . .	31.5
Hero . . . . .	36.9	Nitar . . . . .	31.6
Squarehead . . . . .	34.2	Venez . . . . .	30.6
Ramsey . . . . .	33.4	Black barbless . . . . .	30.2
Columbia . . . . .	32.1		

The yields of the best two-row types of barley were:

	Bushels.		Bushels.
Pandora . . . . .	38.9	Ernest . . . . .	34.7
Forsythe . . . . .	38.9	Chevalier . . . . .	32.0
Black Smyrna . . . . .	35.5	Stavropol . . . . .	23.3
Pryor . . . . .	35.2		

In the spring of 1925, 290 foreign introductions were received from the Office of Cereal Investigations of the United States Department of Agriculture. Many of these selections resemble Club Mariout and are of promise.

It was observed that early-maturing, six-row or two-row bearded types of barley seem to be best adapted to the section. It has like-

wise been observed that bearded wheats are superior to beardless strains, so the function of awns is apparently of some significance in this region.

Four hundred selections from Fulghum C. I. 708 oats were made in 1923 and grown in 1924 and 1925. Several high-yielding strains were isolated with sufficient differences to distinguish them from the parent stock.

With the advent of the combine and modern machinery for harvesting wheat has come the demand for grain sorghums suitable for harvesting in a like manner. Two such types of sorghums have been isolated which are of promise: (1) a Dwarf Freed sorgo; and (2) Modoc Pink Freed, a cross between Pink kafir and Freed sorgo. These selections are early-maturing, have a dwarf stature, and well exerted heads, which hold the grain with fair tenacity. The search for a straight-necked milo is still in progress. A cross between Pink kafir and Dwarf Yellow milo has been made with this objective in mind. Strains with somewhat higher yielding ability than Dwarf milo, with brighter seed color and more resistance to chinch bug injury have been isolated but the somewhat pendent heads have not yet been eliminated.

A selection of Feterita known as C. I. No. 182-1 and which originated from Row 8-2 in 1919 was increased and distributed to farmers in 1926.

The results obtained from spacing tests with Dawn kafir are presented in Table XXXIV for a five- and seven-year period.

The distribution of rainfall is the most important factor governing the degree of tillering, time of heading, and the production of seed of

TABLE XXXIV--Five- and seven-year average yields in spacing experiment with Dawn kafir in rows 40 and 80 inches apart and with varying distances between plants in the rows.

WIDTH OF ROW	Row spaces per plant	5-year average 1919-1923		7-year average 1919-1925	
		Total crop	Grain bushels (a)	Total crop.	Grain bushels (a).
40	6	Lbs. 7,590	34 1	Lbs 7,595	35 4
40	12	6,613	33 9	6,878	35.4
40	18	5,658	28.7	6,104	32.2
80	3	6,100	31 8	6,356	37.3
80	6	4,631	25 8	5,299	35.1
80	9	4,412	27 8	4,811	34.1

(a) Fifty-six pounds per bushel.

grain sorghums grown in variously spaced rows. In 1924 and 1925 a drouth preceding the heading period, but followed later by excessive rainfall, was more favorable for the production of seed in the wide-spaced rows than in the single-spaced rows. In years of normal distribution of rainfall, the grain yields from single-spaced rows have exceeded those obtained from the double-spaced rows. The total crop yields, however, have always been greater in single-spaced rows than in rows of wider spacing. [Fort Hays Experiment Station; state and federal funds.]

**Forage Crop Investigations.** This project consists of field experiments with cultivated forage crops under dry-land conditions, principally on upland, for the purpose of determining the best varieties and cultural methods. In 1925, the project occupied 324 plots and included also 416 single-row and square-rod plots primarily for testing new selections.

The sorghum variety tests of the forage and the cereal investigations projects, formerly conducted separately, were reorganized and combined in 1924. This test in 1925 included 48 varieties grown in 40-inch rows on each of three dates, early, medium, and late seeding dates.

Single-row tests have included many newly introduced sorghums from China and Egypt, and crosses and selections from many common varieties.

Early sumac sorgo is a new variety developed as a result of the work of this station. It is the outcome of selections begun in 1916. It was first grown for increase in 1920 and since 1924 has very largely replaced Red Amber which until that time was a popular forage sorghum.

The sorghums receive the largest amount of attention in this project since they produce a greater tonnage than other crops, have high feeding value, and offer a wide range of forms. They are also least likely to fail under adverse seasonal conditions or through lack of skilful management. The heavy tonnage of feed obtained from the sorghums as compared with other representative forage crops is clearly shown by the data presented in Table XXXV.

Changes have recently been made in the alfalfa investigational work, The unpromising work with row alfalfa on upland discussed in the report for 1922-1924 was reduced in December, 1923, to one-fourth former scope. A new alfalfa experiment was begun in April, 1926, on an 18-year-old alfalfa field where the stand

TABLE XXXV.—Data on the yields of different forage crops at the Fort Hays Branch Equipment Station, 1924 and 1925.

Crops	Variety	Tons per acres, air-dry basis.			Ratios, 1914- 1925.
		1924	1925	Averages, 1914-1925	
<b>Close-drilled Seedings.</b>					
Sweet sorghum	Red Amber	2 65	4 42	3 51	100
Sudan grass . . .	. . . . .	2 08	3 04	2 71	77
Millet . . . . .	German . . .	0 86	3.00	2 16	62
Sweet clover . . .	Biennial White	.	0 98	1 33	38
Alfalfa . . . . .	Kansas . . .	0 75	0 61	1 21	34
<b>Seedings in 40-inch Rows.</b>					
Sweet Sorghum . . .	Red Amber . . .	2 88	3 71	3 47	99
Kafir . . . . .	Pink . . . . .	2 94	3 51	2 91	83
Corn . . . . .	Bloody Butcher	1 24	3 25	2 06	59
Cowpeas . . . . .	Early Buff . . .	1 10	1.98	0 91	26
Soy beans . . . . .	. . . . .	0 76	1 43	0 67	19

is fast deteriorating. The plans contemplate breaking up 10 plots, annually, and handling each plot in a different way preparatory to reseeding alfalfa. This problem is especially important, since the acreage of alfalfa declined 53 per cent in the 46 western Kansas counties from 1910 to 1924, and farmers insist that it is impossible to obtain new stands on old alfalfa land. [Fort Hays Experiment Station; state and federal funds.]

**Bindweed Eradication.** Experimental work with bindweed was continued in 1924 and 1925 on a new area of land thickly infested with bindweed adjacent to the experiment station. Studies were made of methods of fallow, the use of sorghum as a smother crop, and the rate of salting.

Tests with fallow indicate that the best time to start work is in April and May. An apparent explanation is that spring-plowed fallow encourages a more rapid growth of the weed. Sorghum smother crops were most successful when seeded about July 1 following a period of intensive fallow.

Salt was applied to a number of plots in 1924 at rates varying from 4 to 28 tons per acre. The weather was extremely dry at the time the salt was applied. Various combinations of mulching, watering, and preliminary cultivation were included in the test in an attempt to discover means of making the salt effective at rates below the standard recommendation of 20 tons. One promising lead

obtained was that effective eradication appears to have resulted from all rates down to and including 8 tons where no mulching or watering was done. Where salting was supplemented by watering or mulching the salt was less effective. In a second experiment begun in May, 1925, under moister soil conditions, all rates under 20 tons were ineffective. [Fort Hays Experiment Station; state and federal funds.]

**Swine Investigations.** A swine unit has been established at the station with the expectation of starting in the near future feeding experiments with hogs. There is a large field in western Kansas for the swine industry. Just how long the breeders and feeders can economically afford to carry hogs toward maturity before disposing of them is an important problem needing investigation. Grain is not always available. The problem is, therefore, one of developing economical methods of producing light stockers. [Fort Hays Experiment Station; state funds.]

**Dairy-cattle Feeding Investigations.** The dairy-cattle feeding trials were a continuation of two previous years' work to determine the relative value of alfalfa hay and Sudan hay for milk and butterfat production,

The eight cows used in the test averaged 575 pounds of milk and 21.5 pounds of butter fat daily while fed alfalfa hay and 511 pounds of milk and 19.17 pounds of butterfat daily on Sudan hay. The body weights of the cows remained practically constant during the feeding trials. Alfalfa hay was consumed in larger amounts than the Sudan hay.

A pasture trial with dairy cattle on Sudan grass was conducted during 1925. Thirteen and nine-tenths acres of Sudan provided pasture for 14 cows from June 26 to September 21, a period of 88 days. In addition to the pasture, the field produced 6½ tons of hay. [Fort Hays Experiment Station; state funds.]

**Seed Distribution.** This work has consisted of producing and distributing seeds of crop varieties adapted to western Kansas conditions.

Since 1922, the following quantities of sorghum seed have been produced and distributed.

<i>Year.</i>	<i>Pounds.</i>
1922 . . . . .	44,489
1923 . . . . .	57,822
1924 . . . . .	32,801
1925 . . . . .	121,906
1926 . . . . .	235,565

Seed was distributed in the spring of 1926 to 95 counties of Kansas and 10 surrounding states. The sorghum seed distributed in 1926 planted at the average rate of 5 pounds per acre is sufficient to plant 47,000 acres. [Fort Hays Experiment Station; state funds.]

**Beef-cattle Feeding Investigations.** The beef-cattle feeding experiments for the past biennium were planned to study (1) the feasibility of selling western Kansas feeds through feeder steers, (2) the relative value of alfalfa hay and Sudan hay as winter ration for calves, (3) the relative value of whole stover and cut stover for stock cows, (4) the relative value of cottonseed cake and cold pressed cottonseed cake as a protein supplement for silage when fed to calves as a wintering ration, and (5) the relative value of both kafir and cane in the form of dry roughage and in the form of silage for wintering stock cattle.

The feeds used in these experiments included kafir, sorgo, Sudan, and alfalfa. The kafir and sorgo feeds consisted of silage and dry feeds, with heads on and heads off, kafir hay and sorgo hay.

The average gain per steer in all lots where silage was fed was 150.4 pounds; where no silage was fed, 85.4 pounds. The average increase in value per hundredweight of all steers receiving silage was \$1.15; where no silage was fed, \$0.40. The average return per acre for feed consumed by all lots receiving silage was \$18.13; where no silage was fed, \$5.18. Those trials clearly indicate the value of silage as a ration for beef cattle.

Calves receiving 13.67 pounds of alfalfa hay and 1 pound of cottonseed cake per day gained 0.73 pounds per day, while calves fed the same quantity of Sudan hay and 1 pound cottonseed cake daily gained but 0.47 pounds daily. The Sudan hay was only of fair quality.

Stock cows receiving 24.61 pounds whole kafir butts and 4 pounds alfalfa hay daily lost 8 pounds during the feeding period while the same kind of cows fed cut kafir butts at the same rate with 4 pounds of alfalfa daily gained 1.3 pounds per animal. Cows receiving the same ration of whole sorgo butts and alfalfa hay gained 13.8 pounds and cows receiving cut sorgo butts and alfalfa hay in the same proportions gained 24.1 pounds. These gains, however, are not sufficient to pay the cost of cutting the feed.

Heifer calves receiving a daily ration of 31 pounds of sorgo silage and 1½ pounds of high-protein cottonseed cake gained 0.86 pound daily while heifer calves receiving cold pressed cottonseed cake with

the same quantity of silage gained but 0.74 pound daily. Steer calves similarly fed gained 0.99 pound daily on high-protein cottonseed cake and 0.71 pound daily on cold pressed cottonseed cake.

These results indicate that as a protein supplement for silage for feeding calves for the purpose of maintaining thrift and securing satisfactory growth, 100 pounds of 43 per cent cottonseed cake is worth approximately as much as 130 pounds of 32 per cent protein cold pressed cottonseed cake. For mature cattle a pound of kafir or sorgo fodder or stover with heads on was found to be worth from one-third to one-half more than a pound of kafir or sorgo silage with the heads off. An acre of kafir or sorgo silage, with heads on, was found to be worth from two to two and one-third times as much as an acre of kafir or sorgo in the form of fodder with heads off. An acre of kafir or sorgo silage, without heads, was found to be worth from two to two and one-half times as much as an acre of kafir or cane stover, without heads. Kafir hay was found to be worth more, pound for pound and acre for acre, than kafir fodder for mature steers; but sorgo fodder is worth more, pound for pound and acre for acre, than sorgo hay for the same kind of cattle. Sorgo as roughage is worth more than kafir as roughage, pound for pound and acre for acre, in all forms except hay as a feed for mature stock cattle. The chemical analysis of the feeds used in these tests and the gains secured indicate that a pound of dry matter of either sorgo or kafir in the form of silage is worth from two to two and one-third pounds of the dry matter of either sorgo or kafir in the form of dry roughage for mature cattle. [Fort Hays Experiment Station; state funds.]

**The State Forest Nursery.** The work in the forest nursery has been a continuation of the previous years' work in experimental planting of new and untried trees and in the propagation and distribution of the hardy types adapted to western Kansas. A few new shrubs have been added in order that the demands of patrons may be more nearly supplied. A new greenhouse and service building is practically completed which will provide facilities for producing Chinese elms and other varieties of trees and shrubs best propagated from cuttings. A Chinese elm grove has been started and will be given close attention in order that the adaptation of this excellent tree for western Kansas conditions may be demonstrated. During the past biennium 53,591 trees and shrubs were distributed in western Kansas. The distribution reached 68 counties in 1925 and 65 counties in 1926. Forty-two varieties of trees and shrubs were distributed. [Fort Hays Experiment Station; state funds.]

**The Vegetable Garden.** Many new and established varieties of garden vegetables have been grown during the past biennium. Owing to the drought practically all of these have been artificially irrigated. It has been definitely established that the Early Ohio is the best variety of potato to grow in the western half of Kansas. A manuscript on vegetable gardening at the Fort Hays Experiment Station is in preparation. [Fort Hays Experiment Station; state funds.]

**GARDEN CITY BRANCH EXPERIMENT STATION**

The Garden City Branch Experiment Station contains 320 acres of upland five miles northeast of Garden City, Finney county. The station is equipped for investigational work in dry-land agriculture, irrigation agriculture, and in a limited way for experimental work with irrigated pastures for dairy cows and pigs. Water for irrigation purposes is supplied by a deep-well irrigation pumping plant. The three principal lines of work pursued by this station are discussed briefly in the following paragraphs.

**Dry-land Agriculture.** The work with slight modifications is a continuation of that started in 1907. The project now consists of 196 tenth-acre plots and 37 twenty-fifth-acre plots. The tenth-acre plots embrace 29 rotations ranging in length from two to five years, four continuously cropped wheat plots, six continuously cropped corn plots, three each of continuously cropped milo and kafir plots, 20 plots in a method of fallow for winter wheat and milo, and 36 plots in a seedbed preparation for sorghums. The 37 twenty-fifth-acre plots are being used in date-of-planting tests with the sorghums and winter wheat.

During the 11 years for which data are available, winter wheat has failed six times regardless of the methods of growing. During the same period wheat growing on fallow in rotation produced an average yield of 10.8 bushels to the acre. The highest yielding continuously cropped plot was one which was early fall listed. It produced an average annual yield of 7.6 bushels to the acre as compared with 6.1 bushels for early fall plowing and 4.8 bushels for late fall plowing.

Variety tests are being conducted with corn, sorghums, and cotton. A spacing test with Dwarf Yellow milo in which planting in rows of ordinary width is being compared with planting in rows twice the regular width has been conducted since 1918. The average acre yield of grain for the period has been 21.12 bushels for the ordinary width rows and 17.79 bushels for the wide rows.

Cassel White Dent, Freed White Dent, and Colby are proving to be the highest yielding varieties of corn. Corn at its best, however, will produce but approximately one-half the grain secured from Dwarf Yellow milo. Dwarf Yellow milo, Sunrise, Dawn, and Pink kafirs have been the highest yielding varieties of grain sorghums; and Honey, Kansas Orange, and Sumac sorgos have been the most satisfactory forage crops. Four varieties of cotton were included in the work for 1924. The number was increased to eight in 1925. All varieties were total failures in 1924. Two of the earlier varieties produced at the rate of approximately one-fifth bale to the acre in 1925. The remaining six varieties produced very little. [Garden City Experiment Station; state and federal funds.]

**Irrigation Investigations.** The work on the irrigation project includes variety tests with corn, sorghums, small grains, and cotton; fertility experiments with milo, winter wheat, and alfalfa; rate- and season-of-watering experiments with alfalfa; continuous cropping of sorghum, sugar beets and barley; irrigated rotations in which alfalfa is grown for periods varying from three to fifteen years and followed by forage sorgos, grain sorghums, sugar beets, and barley; a pasture experiment with dairy cows in which a mixture of nine varieties of grasses is used in comparison with biennial white sweet clover alone and a pasture experiment in which young pigs are grazed on alfalfa.

Three varieties of corn are regularly grown on winter irrigated ground. They rank in order of yield as follows: Freed White Dent, Colby, and Pride of Saline. Freed White Dent has produced an average of 26.6 bushels to the acre for the past five-year period. Of 10 varieties of sorghums grown on winter irrigated land, Dwarf Yellow milo ranked first in yield among the grain sorghums with an average yield of 44.1 bushels and Honey sorgo with a yield of 13.88 tons of silage is the highest yielding variety of the forage producing sorgos.

Five varieties each of winter wheat, spring wheat, oats, and barley are grown on winter irrigated land. Kanred winter wheat, Mariout barley, and Kanota oats are the leading varieties in their respective classes.

Data secured from the fertility experiments during the past five-year period do not show any material benefit from the use of commercial fertilizers. The lowest average yield of alfalfa in the rate-of-watering experiment was obtained from land receiving 24 inches and the highest average yield from land receiving 64 inches of irriga-

tion water annually. The optimum amount, however, appears to fall between 36 and 42 inches for average years.

Average yields produced by the various feed, grain, and row crops in the irrigated rotations show that considerable benefit has resulted from the use of alfalfa in rotation with these crops. The average yield of alfalfa during the past five-year period has been 6.8 tons per acre. These averages include yields from one-year old alfalfa which does not produce as heavily as the older and better established stands. Kansas Orange sorgo has produced an average yield of 19.7 tons of silage when grown on alfalfa sod as compared with 17.1 tons when grown in a two-year rotation with milo. Land continuously cropped to Kansas Orange sorgo has produced an average yield of 16.6 tons per acre for the same period. Milo has averaged 77.0 bushels when grown in rotation with alfalfa and 63.7 bushels when grown in a two-year rotation with Kansas Orange sorgo. Sugar beets grown on land the second year after alfalfa have averaged 15.5 tons as compared with 13.1 tons when grown on the same land year after year. Maximum yields thus far obtained from crops grown in the irrigated rotations are 9 tons of alfalfa, 28.2 tons silage, and 113.5 bushels of milo per acre. Data available to date indicate that the growing of alfalfa in rotation with row crops on irrigated land will result in materially increasing the yield of the row crops. This is especially interesting since neither milo nor winter wheat has responded favorably to the use of barnyard manure or commercial fertilizers.

The work with irrigated pastures includes an experiment in which spring pigs weighing 50 to 60 pounds each are pastured on alfalfa from about June 20 to October 8. A total pasture period of approximately 108 days is thus secured. Two separate pens are maintained. One is fed a daily ration of 2 pounds of ground milo for every 100 pounds of live weight as determined by weighing all of the pigs at regular intervals of 10 to 14 days; the other pen is self-fed on ground milo in addition to the alfalfa pasture. The pigs receiving the 2 per cent ration make a fair growth but are never fat enough to sell as killers until after they have been full fed in a dry lot following the pasture season. Those that are self-fed, however, are fat enough by the close of the pasture season to go onto market without further feeding. They have made good use of irrigated alfalfa pasture and have made very economical gains. Data are available for three years and are as follows: Average daily gain per pig in the 2 per cent ration pen, 0.55 pound; milo required to produce 100 pounds

of gain, 286.8 pounds; gross returns, less cost of milo fed, per acre of alfalfa, \$75.37, which is equivalent to \$12.56 per ton for the alfalfa. The same data for the self-fed pen are: Daily gain, 1.20 pounds; milo required for 100 pounds of gain, 392.7 pounds; gross returns per acre, \$109.18, or approximately \$18 per ton for the alfalfa. At the close of the pasture period, the pigs are transferred to the dry lot and both pens put on self-feeders of ground milo and tankage. The pigs that had received a 2 per cent ration while on pasture made the most economical gains while in the dry lot.

The dairy pasture work recently started is conducted on three one-half acre lots, two of which are seeded to a mixture of nine varieties of tame grasses. The third pasture is seeded to sweet clover alone. One of the grass mixture pastures is fertilized with barnyard manure while the other and the sweet clover pasture are untreated. During the 1925 season the grass mixture plots supplied 143 days of pasture at the rate of two cows per acre and the sweet clover pasture furnished 140 days pasturage at the rate of two cows per acre. The net return from the untreated grass mixture pasture was approximately \$37.50, from the manured grass mixture pasture, \$51.75, and from the sweet clover pasture \$54.70. [Garden City Experiment Station; state funds.]

#### COLBY BRANCH EXPERIMENT STATION

The Colby Branch Experiment Station contains 314 acres of land adjacent to and lying southwest of Colby, Thomas county. The work of the station is divided into three major phases: Dry-land agriculture investigations, a study of varietal adaptation of crops, and dairy herd management.

The dry-land agriculture work embraces 180 one-tenth acre plots. A study is being made of the storage and use of water by winter wheat under the following cultural methods: Continuous late fall plowing; continuous early fall plowing; alternate cropping and fallow; continuous "stubble in"; wheat after corn; early fall plowing in rotation; and "stubble in" in rotation.

The varietal tests include 20 varieties of corn, 22 of sorghum, 22 of barley, 7 of winter wheat, 9 of spring wheat, and 7 of oats. Nursery work with 240 strains of corn and 500 strains of barley in addition to extensive studies relating to smut resistance, rust resistance, and winter hardiness of wheat have been conducted. Several promising head selections from the Stavropol type barley have been made. The leading corn varieties are Colby and Freed White Dent. Colby has been grown for seed for distribution in northwestern Kansas.

Dwarf Yellow milo and feterita are the most valuable grain sorghums. Sumac has taken the lead among the forage sorghums. Club Mariout, Flynn, and Stavropol have been the highest yielding types of barley. Seven-year average yields of winter wheat show that Kanred ranks first with 32.8 bushels per acre, while for the same period of time, Blackhull has ranked second with 30.2 bushels per acre, and Turkey, third with a yield of 26.9 bushels per acre.

Of the spring wheats, Prelude holds the lead with 10.8 bushels per acre for a five-year average. Kanota has the lead in oat varieties with a six-year average of 28.0 bushels per acre. Burt ranks second; Kherson, third; and Red Texas, fourth.

A dairy herd of grade and pure-bred Ayrshires is maintained for the purpose of disposing of the surplus feed grown on the station farm; to demonstrate that dairying is practical on the farms of north-western Kansas; to demonstrate the feasibility of breeding up common dairy cattle by using a pure-breed sire; and for minor feeding experiments. The herd is composed of 12 cows with necessary young replacement stock of which, at the present time, 10 are grades and two pure breeds. The grades consist of first, second, and third cross Ayrshire on common Shorthorn cows. The uniformity of production of the third cross heifers was a very striking feature of the work during the past biennium.

#### TRIBUNE BRANCH EXPERIMENT STATION

The Tribune Branch Experiment Station contains about 100 acres of land situated one mile west of Tribune, Greeley county. While the average annual precipitation is low, being 16.7 inches, nearly four-fifths comes during the six summer months, April to September. Thus with 13 inches of rain during the growing season, satisfactory yields of feed crops are usually obtained where good cultural methods are practiced. The annual as well as the summer precipitation in both 1924 and 1925 was below normal; however, the distribution was fairly favorable except for an extended dry period in the spring of 1925.

The projects under way at the station include variety tests of grain and forage sorghums, corn, oats, wheat, barley, potatoes, and beans; experiments with time and methods of seeding winter wheat, sorghum, and corn; trials of trees, ornamental shrubs, and vegetables; breeding experiments with Freed Pink sorgo; rotation experiments; and a test of methods of seeding and utilizing Sudan grass and sweet clover as pasture for dairy cows.

Good results were secured in both 1924 and 1925 with Dwarf Yellow milo, feterita, Dawn kafir, Early Sumac, and Red Amber sorgo. For the two years, both feterita and milo averaged approximately 25 bushels of grain and 3 tons of cured forage an acre. Sudan grass averaged 4,100 pounds of field-cured hay to the acre and when pastured provided pasture from July to killing frost in September.

The breeding work with Pink Freed sorgo is yielding results which promise to be of practical value. Ten headrows were considered of sufficient promise to justify trial in plots in 1925. One of these strains has been named Weskan. It combines the earliness of Freed sorgo with the heavier head and better quality of grain of Pink kafir.

Among the small grains grown for feed, barley has given best results. The average yield during the last two years was 940 pounds or nearly 20 bushels per acre, which was about 200 pounds higher than oats. With good moisture conditions barley may be depended upon to produce a satisfactory crop. In the dry spring of 1925, the yield of barley on fallow was 23 bushels while that planted after corn was but 8 bushels. In 1924 when there was more moisture the yield of barley after corn was 21 bushels and after fallow 27 bushels.

#### **SOUTHEASTERN KANSAS EXPERIMENTAL FIELDS**

The work for the past biennium on the soil and crop experimental fields located on five important soil types in southeastern Kansas has consisted of plot tests of the use of lime, acid phosphate, potash, rock phosphate, barnyard manure, and green manure in rotations of corn, oats, wheat, clover, alfalfa, and kafir.

The most notable results obtained have been the increases in yield of alfalfa on the Moran field (Oswego silt loam) resulting from the applications of lime. Marked increases have also been obtained from manure, acid phosphate, and rock phosphate as indicated in Table XXXVI.

A comparison of Grimm and Kansas Common alfalfa on five experimental fields in southeastern Kansas resulted in almost identical yields on all fields where a comparison could be made. The yield of Grimm was usually higher than the Common for the first cutting but less for later cuttings.

Cowpeas grown and plowed under for green manure on the Columbus field (Cherokee silt loam) resulted in increases in the yield of wheat greater than that secured from the use of any commercial fertilizer, as is indicated by the data presented in Table XXXVII.

TABLE XXXVI.—The effect of soil treatment on the yield of alfalfa.  
 (Moran field, 1925.)

TREATMENT	Yield of alfalfa, tons per acre.
No treatment . . . . .	0 38
Lime, 3 tons . . . . .	2.00
Lime, 3 tons; acid phosphate, 150 pounds . . . . .	3 03
Lime, 3 tons; manure, 8 tons . . . . .	3.09
Lime, 3 tons; manure, 8 tons; acid phosphate, 150 pounds . . . . .	3.48

TABLE XXXVII.—The influence of phosphatic fertilizers and green manure on the yield of wheat.  
 (Columbus field, 1925.)

TREATMENT	Yield of wheat; bushels per acre.
Green manure, rock phosphate . . . . .	32.4
Acid phosphate . . . . .	16.0
Green manure; acid phosphate . . . . .	31.2
Green manure . . . . .	27.4

Light application of barnyard manure applied to corn has resulted in a general increase in the yield of corn and the succeeding crop of oats on all fields. [Experimental work in southeastern Kansas; state funds.]

**STATION PUBLICATIONS**

The results of investigations by the Agricultural Experiment Station are reported in three series of publications: Bulletins, research bulletins, and circulars.

*Bulletins.* The reports of specific investigations for popular distribution are published as bulletins. The material is presented in such a manner as to be readily understood by the average reader. Five new bulletins were printed during the biennium.

*Research Bulletins.* Reports of detailed scientific investigations too technical for the average reader but of value to the investigational and technically trained reader are published in this series. Seven were issued during the biennium.

*Circulars.* Brief popular reports of experimental results and popular summaries of the best information available on various agricultural problems are published as circulars. Twenty circulars were published during this biennium.

The following are the regular station publications listed by series and showing the title, size of edition, and number of pages issued during the biennium:

GENERAL BULLETINS			
No.	Title.	Edition.	Pages. <span style="float: right;"><i>Total pages.</i></span>
232.	Assessment and Equalization of Farm and City Real Estate in Kansas . . . . .	15,000	70 1,050,000
233.	The Relation of Feeding and Age of Calving to the Development of Dairy Heifers . . . . .	15,000	38 570,000
234.	Tax Revision in Kansas . . . . .	15,000	95 1,425,000
235.	The Trend of Real Estate Taxation in Kansas from 1910 to 1923 . . . . .	10,000	94 940,000
236.	Dairy Buildings for Kansas . . . . .	20,000	45 900,000
TECHNICAL BULLETINS			
14.	Infectious Abortion Investigations . . . . .	4,000	23 92,000
15.	Experiments Relating to the Time of Cutting Alfalfa. . . . .	5,000	50 250,000
16.	A Comparative Study of the History of Certain Phytophagous Scarabeid Beetles . . . . .	3,500	146 511,000
17.	Studies of Inheritance and Evolution in Orthoptera. V: The Grouse Locust, <i>Apotettix eurycephalus</i> Hancock . . . . .	3,400	231 785,400
18.	Tillage Investigations Relating to Wheat Production . . . . .	5,000	55 275,000
19.	Tillage in Relation to Milling and Baking Qualities of Wheat . . . . .	5,000	16 80,000
20.	Tomato Wilt Investigations . . . . .	5,000	32 160,000
CIRCULARS			
106.	Prevention and Control of Poultry Diseases. . . . .	50,000	78 3,900,000
107.	The Copper Carbonate Dust Method of Controlling Bunt of Wheat . . . . .	15,000	14 210,000
108.	Some Lamb Feeding Results Secured by the Kansas Agricultural Experiment Station . . . . .	10,000	8 80,000
109.	Lamb Feeding Investigations, 1922-'23 . . . . .	10,000	4 40,000
110.	Ground Sorgo Seed as a Feed for Dairy Cows . . . . .	10,000	8 80,000
111.	Information Regarding Recent Publications . . . . .	15,000	4 60,000
112.	Swine Feeding Investigations, 1922-'23 . . . . .	15,000	8 120,000
113.	Chinch Bug Barriers for Kansas Conditions . . . . .	25,000	6 130,000
114.	How to Grow and Market High-Protein Wheat . . . . .	25,000	21 525,000
115.	The Loco Weed and Its Effect on Livestock. . . . .	10,000	4 40,000
116.	Strawberry Growing in Kansas . . . . .	10,000	16 160,000
117.	Cattle Feeding Investigations, 1923-'24 . . . . .	15,000	11 165,000
118.	Swine Feeding Investigations, 1923-'24 . . . . .	15,000	6 90,000
119.	Ground Kafir as a Feed for Dairy Cows. . . . .	10,000	8 80,000
120.	Control of Mammals Injurious to Agriculture in Kansas. . . . .	10,000	10 100,000
121.	Seasonal Fluctuations of Wheat Prices. . . . .	20,000	11 220,000
122.	Poultry Management on the Farm. . . . .	50,000	50 2,500,000
123.	Lamb Feeding Investigations, 1923-'24 . . . . .	10,000	6 60,000
124.	Information Regarding Recent Publications . . . . .	15,000	4 60,000
125.	Spraying Fruit Plants . . . . .	10,000	15 150,000
DIRECTOR'S REPORTS			
	Director's Report, 1922-1924 . . . . .	1,500	145 217,500

**SOME INFORMATION REGARDING EACH PUBLICATION ISSUED**

**GENERAL BULLETINS**

**BULLETIN 232: ASSESSMENT AND EQUALIZATION OF FARM AND CITY REAL ESTATE IN KANSAS.** The purpose of the investigation reported in this bulletin is to determine whether there are major departures from the intent of the law

in the valuation of farm and city real estate for taxation in Kansas. The law requires uniform valuation according to "true value in money."

The following types of inequalities in the valuation of real estate were studied: (1) Inequalities between large and small properties. (2) Inequalities between individual real-estate properties, farm real estate and city real estate being compared separately. (3) Inequalities among townships. (4) Inequalities among cities. (5) Inequalities among counties in farm real estate and in city real estate, the two classes being considered separately.

The study covered a period of 10 years, 1913 to 1922. Apart of the bulletin is based on all recorded *bona fide* sales of farm and city real estate in all counties of the state. The principal part deals with inequalities between large and small properties, and is based on 10,307 *bona fide* sales of farm real estate, and 10,231 *bona fide* sales of city real estate, in 15 representative Kansas counties over a period of 10 years. These data show that small parcels of real estate are generally assessed at a higher per cent of true value than large properties. (By Eric Englund, Department of Agricultural Economics. 70 pages; 26 tables; 5 figures.)

BULLETIN 233: THE RELATION OF FEEDING AND AGE OF CALVING TO THE DEVELOPMENT OF DAIRY HEIFERS. This bulletin reports the results of six years' work on the raising of 24 grade Holstein heifers from birth through two lactation periods under different methods of feeding and management. The chief factors under consideration were: (1) The effect of the exclusive feeding of alfalfa hay, and alfalfa hay and corn silage on heifer development, and (2) a comparison of the size and milk production of heifers calving at 24 months of age with those calving at 30 months of age. The effect of the above conditions upon growth, reproduction, and milk production are recorded. Cost figures are also given for the animals kept under the different conditions. (By O. E. Reed, J. B. Fitch, and H. W. Cave, Department of Dairy Husbandry. 38 pages; 11 tables; 8 figures.)

BULLETIN 234: TAX REVISION IN KANSAS. This bulletin is divided into two parts, (1) "The Need for Tax Revision in Kansas" and (2) "A Tax Program for Kansas." It is further subdivided into twelve sections including: The Increase in Taxes; Economic Change and the Need for Tax Revision; Tax Revision Versus Curtailment of Appropriations; Improvement, in the Valuation of Property; Classification of Property for Taxation; Personal Income Tax; Gross Production Tax on Oil and Minerals; Excise Tax on Certain Nonessentials; Gasoline Tax for Roads; Separation of State and Local Revenue, with principal arguments for and against separation, and an appraisal of these arguments.

The publication is intended primarily for the general public in Kansas. It is written in a nontechnical style, with a liberal use of prominent paragraph heads and topic sentences. (By Eric Englund, Department of Agricultural Economics. 90 pages; 19 tables; 8 figures.)

BULLETIN 235: THE TREND OF REAL-ESTATE TAXATION IN KANSAS FROM 1910 TO 1923. The purpose of the investigation reported in this bulletin is (1) to determine the trend of taxes relative to selling value of farm and city real estate in Kansas, and (2) to show to what extent each of the various levies caused the increase in real-estate taxes.

The bulletin is divided into five sections: I. Introduction. II. The Trend of Taxes on Farm Real Estate. III. The Trend of Taxes on City Real Estate. IV. Farm and City Real Estate Compared. V. Conclusion. Methods of calculating and supplementary data are given in an appendix. (By Eric Englund, Department of Agricultural Economics. 97 pages; 48 tables; 28 figures.)

**BULLETIN 236: DAIRY BUILDINGS FOR KANSAS.** In this bulletin is found a discussion of the essential features to be incorporated in convenient and sanitary dairy buildings and equipment. Types and sizes of barns and typical floor plan arrangements are discussed and shown in drawings, as are also details of roofs, walls, foundations, floors, stalls, mangers, windows, doors, and ventilators. Such other equipment as feed bins, feed and litter carriers, milk houses, and manure pits are treated briefly. An appendix lists dairy barn and dairy equipment plans that may be obtained for a nominal price. (Prepared in cooperation with the Engineering Experiment Station of K. S. A. C. By J. B. Fitch, Department of Dairy Husbandry, and V. R. Hillman, Department of Agricultural Engineering. 45 pages; 40 figures.)

**TECHNICAL BULLETINS**

**TECHNICAL BULLETIN 14: INFECTIOUS ABORTION INVESTIGATIONS.** Studies of the causes of abortion and the behavior of *Bacterium abortum* (Bang), including physiological and serological reactions and aerophilic relations of the organism, are discussed in this bulletin. A report of an experiment dealing with an attempted production of immunity in cattle is presented. Four groups of animals were used and abortions occurred in groups I, II, and III in which attempts at immunization were made by using either bacterins or vaccines. In group IV (control group) no attempts at immunization were made and no abortions occurred; therefore, the efficacy of the three supposed preventives used must be doubted. A study of agglutination tests in experimental animals, including weekly tests on adult cows, tests on young animals at birth, and a comparison of the agglutination reaction of milk and serum are also presented. (By H. F. Lienhardt, C. H. Kitselman, and C. E. Sawyer, Department of Veterinary Medicine. 23 pages; 7 tables.)

**TECHNICAL BULLETIN 15: EXPERIMENTS RELATING TO THE TIME OF CUTTING ALFALFA.** The purpose of the bulletin is to present the results of experiments conducted for 10 years relating to the effect of time of cutting on the yield, chemical composition, and feeding value of alfalfa. Alfalfa was cut at four different stages of growth; namely, bud stage, tenth bloom, full bloom, and seed stage. The yields, chemical composition, and feeding value of the hay are reported and the application of the results to farm practice is discussed. (By S. C. Salmon, Department of Agronomy; C. O. Swanson, Department of Milling Industry; and C. W. McCampbell, Department of Animal Husbandry. 50 pages; 25 tables; 3 figures.)

**TECHNICAL BULLETIN 16: A COMPARATIVE STUDY OF THE HISTORY OF CERTAIN PHYTOPHAGOUS SCARABAEID BEETLES.** This bulletin is an attempt to compare the life cycles of certain species of the subfamilies, *Melolonthinae*, *Rutelinae*, *Dynastinae*, and *Cetoniinae* of the coleopterous family *Scarabaeidae*. In all, 16 species are considered and the life cycles as observed at Manhattan,

Kan., are compared with the life cycles of other members of the family. Each of the species, in so far as possible, has been considered in relation to its distribution, relative abundance at Manhattan, the attraction to lights, period of flight, food habits both in the adult and larval stages, the proportion of sexes, mating, oviposition, and the length of the various stages. (By William P. Hayes, Department of Entomology. 133 pages; 10 plates.)

TECHNICAL BULLETIN 17: STUDIES OF INHERITANCE AND EVOLUTION OF ORTHOPTERA. V. THE GROUSE LOCUST, *APOTETTIX EURYCEPHALUS HANCOCK*. Technical Bulletin 17 deals with the inheritance of a small group of grasshoppers, commonly called grouse locusts, which have numerous color patterns, such as stripes and spots of various kinds. Over one hundred thirty-five thousand of these grasshoppers were reared and recorded, and more than five hundred thousand reactions of the factors for the color patterns with each other, such as segregation and crossing over were recorded. Considering that each one of these reactions represents also the reactions of the normal allelomorph, more than one million reactions were recorded. These reactions permit the working out of the laws that govern the behavior of these characters. The laws of inheritance are as definite as those which govern chemical reactions. (By Robert K. Nabours, Department of Zoology. 231 pages; 5 tables; 4 figures; 1 color plate.)

TECHNICAL BULLETIN 18: TILLAGE INVESTIGATIONS RELATING TO WHEAT PRODUCTION. This bulletin presents the results of tillage experiments at Manhattan for a 13-year period in regard to the effect of tillage on soil moisture, weed growth, nitrates, and yield. Ways are pointed out by which wheat production costs can be decreased. (By M. C. Sewell, Department of Agronomy, and L. E. Call, Director, Agricultural Experiment Station. 55 pages; 24 tables; 6 figures.)

TECHNICAL BULLETIN 19: TILLAGE IN RELATION TO MILLING AND BAKING QUALITIES OF WHEAT. The relation between methods of seedbed preparation and the milling and baking qualities of wheat based on 10 years investigation is discussed in this bulletin. The results show that early tillage markedly increases the yield and the per cent of protein in the wheat, and improves the loaf volume and texture of the bread. (By M. C. Sewell, Department of Agronomy, and C. O. Swanson, Department of Milling Industry. 16 pages, 3 tables; 8 figures.)

TECHNICAL BULLETIN 20: TOMATO WILT INVESTIGATIONS. This bulletin reports the results of seven years' investigations upon the tomato-wilt disease caused by *Fusarium lycopersici* Sacc. The report includes a study of environmental factors as influencing the severity of tomato wilt and the results of the testing of varieties for wilt resistance; also the relative commercial values of a few of the proved wilt-resistant varieties. A brief discussion of the development through hybridization and the characteristics of a new variety, named Kanora, wilt-resistant for Kansas conditions, is presented. (By R. P. White, Department of Botany. 32 pages; 1 table; 17 figures.)

CIRCULARS

**CIRCULAR 107:** THE COPPER-CARBONATE DUST METHOD OF CONTROLLING BUNT OF WHEAT. The copper-carbonate dust method for controlling bunt of wheat is described in this circular. Instructions regarding the kind of copper carbonate to use, how it should be applied, precautions that the operator should take, and the selection of equipment are presented. The possibilities of commercial machinery are considered and complete directions given for building home-made equipment consisting of a churn smut-treating machine and a barrel mixer. Advantages of the dust method over the old formaldehyde treatment are discussed. (By L. E. Melchers and H. B. Walker, Departments of Botany and Agricultural Engineering. 14 pages; 5 figures.)

**CIRCULAR 108:** SOME LAMB-FEEDING RESULTS SECURED BY THE KANSAS AGRICULTURAL EXPERIMENT STATION. This circular asks and answers, with the results of carefully conducted tests, questions regarding the feeding value of many different feeds when used in a ration fed to lambs that are being fattened for market. The following feeds are discussed: Shelled corn, barley, whole kafir, ground threshed kafir, ground kafir heads, linseed oilmeal, cottonseed meal, silage, alfalfa hay, and sweet clover hay. The proper method of using a self-feeder is also discussed. (By A. M. Paterson, Department of Animal Husbandry. 8 pages; 7 tables.)

**CIRCULAR 109:** LAMB-FEEDING INVESTIGATIONS, 1922-'23. This circular reports data relative to the comparative feeding values of (1) alfalfa hay and sweet clover hay as protein roughages in rations for fattening lambs; (2) whole threshed kafir, ground threshed kafir, and unground kafir heads; (3) well-balanced rations in which silage is apart, and well-balanced rations in which silage is not a part. (By A. M. Paterson and H. W. Marston, Department of Animal Husbandry. 4 pages; 1 table.)

**CIRCULAR 110:** GROUND SORGO SEED AS A FEED FOR DAIRY COWS. THIS publication reports the results of three feeding tests showing the value of ground Kansas Orange sorgo seed for dairy cows. In each of the tests the cows were fed a liberal ration of alfalfa hay, corn silage, and a grain mixture made up of: (1) 400 pounds corn chop or 400 pounds ground Kansas Orange sorgo seed; (2) 200 pounds bran; and (3) 100 pounds linseed oilmeal.

These experiments were planned as the result of requests for information on the feeding value of Kansas Orange sorgo seed as compared with corn chop for dairy cows. The results indicate that ground sorgo seed is more valuable for feeding to dairy cows than is generally believed. (By H. W. Cave and J. B. Fitch, Department of Dairy Husbandry. 8 pages; Stables.)

**CIRCULAR 111:** INFORMATION REGARDING RECENT PUBLICATIONS. This circular is the first of a series of informational circulars giving information regarding recent popular publications of the station. It was mailed over the entire station mailing list so that each person on the list might have an opportunity to request copies of any and all publications in which he was interested. Publications presented in Circular 111 are Bulletins 232, 233, and 234, and Circulars 101, 102, 105, 106, 107, 108, 109, and 110.

**CIRCULAR 112:** SWINE-FEEDING INVESTIGATIONS, 1922-'23. This circular reports data relative to: (1) The value of adding tankage to a full feed of

corn for spring pigs on alfalfa pasture; (2) the comparative value of alfalfa and Sudan grass pasture for spring pigs on a full feed of grain; and (3) the value of a concrete feeding floor for summer feeding of pigs on pasture. (By B. M. Anderson and H. W. Marston, Department of Animal Husbandry. 8 pages; 3 tables.)

CIRCULAR 113: CHINCH BUG BARRIERS FOR KANSAS CONDITIONS. This circular describes the best types of barriers for chinch bug control in Kansas. Information is given relative to the construction, operation, and cost of the different types of barriers. (By J. W. McColloch, Department of Entomology. 6 pages; 3 figures.)

CIRCULAR 114: HOW TO GROW AND MARKET HIGH-PROTEIN WHEAT. This circular discusses the meaning of protein and the reasons for the premium paid for high-protein wheat. It also tells how protein is estimated or determined and explains how the farmer may secure the premium for high-protein wheat. The three factors which affect the protein content, of wheat are: Variety, climate, and soil. Kansas has a climate favorable to the production of high-protein wheat. Varieties of the Turkey type are high in protein. The protein content may be increased by early thorough preparation of the seedbed and by rotation with a leguminous crop. (By L. E. Call, Director, Agricultural Experiment Station; R. M. Green, Department of Agricultural Economics; and C. O. Swanson, Department of Milling Industry. 21 pages; 7 tables; 2 figures.)

CIRCULAR 115: THE Loco WEED AND ITS EFFECT ON LIVE STOCK. In this circular are given the recognition characteristics of the plants in Kansas known as "Loco" A brief discussion is given regarding the animals that will eat loco and conditions under which they start to eat it. Treatments for locoed animals and directions for the extermination of loco plants are also included. (By Frank C. Gates, Department of Botany. 4 pages; 1 figure.)

CIRCULAR 116: STRAWBERRY GROWING IN KANSAS. Circular 116 is a brief discussion of those varieties of strawberries which have been proved adapted to Kansas and the most successful methods of growing them. Harvesting and marketing strawberries, as well as the more common pests of the plants, are given some attention. The circular is planned for both the commercial strawberry grower and the owner of a small patch yielding a supply of fruit for home use only. (By R. J. Barnett, Department of Horticulture. 16 pages; 5 figures.)

CIRCULAR 117: CATTLE FEEDING INVESTIGATIONS, 1923-'24. This circular is divided into three parts. Part I reports the results of a study conducted to determine the efficiency of varying amounts of cottonseed meal when fed as a protein supplement to a full feed of corn, alfalfa hay, and silage. These results show the proper amount of cottonseed meal to feed to insure the greatest net return. Part II reports a comparison of full-feeding in a dry lot compared with full-feeding on grass during the entire summer. Part III gives the results of comparing full-feeding on grass all summer with full-feeding on grass during only the last half of the summer. (By C. W. McCampbell, B. M. Anderson, and H. W. Marston, Department of Animal Husbandry. 11 pages; 4 tables; 1 figure.)

CIRCULAR 118: SWINE FEEDING INVESTIGATIONS, 1923-'24. This circular is divided into three parts. Part I reports the results of a study conducted to

determine the amount of concentrated feed required to produce a 100-pound feeder pig from weaning on alfalfa pasture. Part II gives the results of fattening feeder pigs for market, using different methods as follows: (1) Hogging down corn and kafir at different stages of maturity; and (2) hogging down corn compared with feeding the pigs new corn in a dry lot. Part III gives the results of a test showing the value of exercise for brood sows. (By B. M. Anderson and H. W. Marston, Department of Animal Husbandry. 6 pages; 5 tables.)

CIRCULAR 119: GROUND KAFIR AS A FEED FOR DAIRY COWS. Results of three feeding trials comparing ground kafir with corn chop are reported in this circular. In each test the grains compared made up a portion of the grain ration which was fed with alfalfa hay and silage. The results suggest the desirability of a wider use of kafir in the grain ration of the feed for dairy cows. (By H. W. Cave and J. B. Fitch, Department of Dairy Husbandry. 8 pages; 8 tables.)

CIRCULAR 120: CONTROL OF MAMMALS INJURIOUS TO AGRICULTURE IN KANSAS. This circular presents methods of controlling the mammals, or haired animals, injurious to agriculture. The control of the pocket gopher and the prairie dog is discussed in some detail. The use of poisoned wheat is recommended for gophers, and poisoned oats for prairie dogs. Methods of baiting ground squirrels, mice, rats, and rabbits, and the control of woodchucks ("ground hogs") and moles are briefly discussed. (By G. E. Johnson, Department of Zoology. 10 pages; 1 figure.)

CIRCULAR 121: SEASONAL FLUCTUATIONS OF WHEAT PRICES. The seasonal tendency of Kansas City cash wheat prices for a period of 32 years is pictured in this publication. The three frequently weak spots and the three frequently strong spots in the season's range of prices are pointed out. Underlying market conditions which contribute to these seasonal cycles in prices are discussed. (By R. M. Green, Department of Agricultural Economics. 11 pages; 1 table; 4 figures.)

CIRCULAR 122: POULTRY MANAGEMENT ON THE FARM. In this circular the general principles of poultry keeping are discussed. The publication is of general interest to all chicken raisers, especially to all handling small farm flocks. It will assist one in answering many practical questions such as (1) the breed to select for different types of poultry keeping; (2) the type of poultry house to build; (3) the relative value of hens and pullets as breeders; (4) questions relating to incubation, brooding, feeding, and culling; (5) the production and marketing of poultry products; (6) when layers should be confined to their quarters and when given free range; (7) artificial illumination; and (8) the control of poultry parasites. The circular concludes with a farm poultry calendar giving ten timely suggestions for each month in the year. (By L. F. Payne, Department of Poultry Husbandry. 48 pages, 19 figures.)

CIRCULAR 123: LAMB FEEDING INVESTIGATIONS, 1923-24. The results published in this circular give a comparison of the value of alfalfa, sweet clover, cowpeas, and Sudan grass hays as roughages for fattening lambs when fed with shelled corn as the grain portion of the ration. The results also show the comparative value of threshed kafir and kafir heads as a main ration for fattening lambs when alfalfa hay is fed as the roughage portion of the ration (By H. E. Reed and H. W. Marston, Department of Animal Husbandry. 7 pages; 2 tables, )

**CIRCULAR 124: INFORMATION REGARDING RECENT PUBLICATIONS.** This circular is the second of the series of informational circulars of which Circular 111 was the first. Its distribution was similar to that of Circular 111. The publications presented in Circular 124 are Bulletins 235 and 236, and Circulars 112 to 123, inclusive.

**CIRCULAR 125: SPRAYING FRUIT PLANTS.** Brief information about the important insect and fungous enemies of the fruits grown in Kansas is given in this circular and a discussion of spray materials and spray schedules for apples, pears, American plums, peaches, cherries, strawberries, and brambles is presented. (BY W. F. Pickett and L. C. Williams, Department of Horticulture. 15 pages; 3 figures.)

**DIRECTOR'S REPORT**

**DIRECTOR'S REPORT, 1922-24: FOR THE BIENNIUM, JULY 1, 1922, TO JUNE 30, 1924.** This report outlines the scope of the station work for the biennium, makes brief mention of a few outstanding developments affecting the work of the station, and gives brief summaries of the more important results secured in research work. The annual financial statements and a list of the publications of the station are included. (By F. D. Farrell, Director, Agricultural Experiment Station of Kansas State Agricultural College. 145 pages; 30 tables; 2 figures.)

**PUBLICATIONS BY DEPARTMENTS**

The following table contains a list, classified by departments, of the regular publications of the Agricultural Experiment Station and also the technical articles contributed to scientific journals by members of the station staff:

**LIST OF PUBLICATIONS BY DEPARTMENTS**

**Department of Agricultural Economics**

<i>Serial No.</i>	<i>Year of issue.</i>	<i>Title, author, and publication.</i>
9	1924	Assessment and Equalization of Farm and City Real Estate in Kansas Eric Englund. Kan. Agr. Expt. Sta. Bul. 232.
12	1925	A Study of Farm Organization in Central Kansas. W. E. Grimes, J. A. Hodges, R. D. Nichols, and Jesse W. Tapp. U. S. Dept. Agr. Bul. 1296.
13	1924	More Profit for the Wheat Farmers of Central Kansas. W. E. Grimes and Jesse W. Tapp. U. S. Dept. Agr. Farmers' Bul. 1440.
14	1924	Tax Revision in Kansas. Eric Englund. Kan. Agr. Expt. Sta. Bul. 234.
15	1925	Some Phases in the Hard Winter Wheat Growers Problem in Re-adjustment. W. E. Grimes. Jour. Farm. Econ., v. 7, No. 2, pp. 196-219.
16	1925	The Place of Taxation in a Constructive Agricultural Policy. Eric Englund. Jour. Farm Econ., v. 7, No. 3, pp. 305-324.
18 <sup>a</sup>	1925	How to Grow and Market High-protein Wheat L. E. Call, R. M. Green, and C. O. Swanson. Kan. Agr. Expt. Sta. Cir. 114.
19	1925	The Trend of Real Estate Taxation in Kansas from 1910 to 1923. Eric Englund. Kan. Agr. Expt. Sta. Bul. 235.
20	1925	Real Estate Taxation in Kansas. Eric Englund. Jour. Land and Public Utility Econ., vol. 1, No. 4, pp. 444-458.
21	1925	The Present and Future Development of Kansas Agriculture. W. E. Grimes. Kan. Engrg. Expt. Sta. Bul. 16. Reference: Appendix B, pp. 38-47.
22	1925	Seasonal Fluctuations of Wheat Prices. R. M. Green. Kan. Agr. Expt. Sta. Cir. 121.

3. Erroneously marked as No. 19 in the publication.

<i>Serial No.</i>	<i>Year of issue.</i>	<i>Title, author, and publication.</i>
24	1926	Batting Averages in Agricultural Forecasting. R. M. Green. Jour. Farm Econ., v. 8, No. 2, pp. 174-193.
25	1926	Studies of Agricultural Adjustments as They Affect Individual Farms W. E. Gumes. Jour. Farm Econ., v. 8, No. 2, pp. 166-173.

**Department of Agronomy**

150	1924	Relation of the Molecular Proportions in the Nutrient Solution to the Growth of Wheat. M. C. Sewell Jour. Agr. Res., v. 28, No. 4, pp. 387-393.
151	1924	The Effect of Rotation and Tillage on Footrot of Wheat in Kansas, 1920-'24. M. C. Sewell and L. E. Melchers. Jour. Amer. Soc. Agron., v. 16, No. 12, pp. 768-771.
152	1925	The Relation of Sulphur to Alfalfa Production. Oscar C. Bruce. Jour. Agr. Res., v. 30, No. 10, pp. 937-947.
154	1925	A Study of the Variability of Burt Oats. F. A. Coffman, J. H. Parker, and K. S. Quisenberry. Jour. Agr. Res., v. 30, No. 1, pp. 1-64.
155	1924	Some Misapplications and Limitations in Using Student's Method to Interpret Field Experiments. S. C. Salmon. Jour. Amer. Soc. Agron., v. 16, No. 1, pp 717-721.
156 A	1925	Experiments Relating to the Time of Cutting Alfalfa S. C. Salmon, C. O. Swanson, and C. W. McCampbell. Kan. Agr. Expt. Sta. Tech. Bul. 15.
156 B	1925	Tillage Investigations Relating to Wheat Production. M. C. Sewell and L. E. Call. Kan. Agr. Expt. Sta. Tech. Bul. 18.
158	1925	How to Grow and Market High-protein Wheat. L. E. Call, R. M. Green, and C. O. Swanson. Kan. Agr. Expt. Sta. Cir. 114
159	1926	Tillage in Relation to Milling and Baking Quality of Wheat. S. C. Salmon, and M. C. Sewell. Kan. Agr. Expt. Sta. Tech.
160	1926	The Relation of Inheritance Studies to Corn Improvement. A. M. Brunson. Jour. Amer. Soc. Agron., v. 18, No. 4, pp. 308-314.
161	1925	Controlling the Quality of Wheat Through Rotation and Proper Crop Sequence. R. I. Throckmorton. Jour. Amer. Soc. Agron., v. 18, No. 8, pp. 623-629.
—	1925	Adapted Crop Varieties for Kansas. H. H. Laude and H. R. Sumner. Kan. Exten. Bul. 51.
—	1925	Cotton in Kansas. H. H. Laude. Twenty-fourth Blen, Rept. Kan. St. Bd. Agr., pp. 200-262.
—	1926	Comparative Hardiness of Winter Wheat Varieties. J. Allen Clark, John H. Martin, and J. H. Parker. U. S. Dept. Agr. Cir. 378.

**Department of Animal Husbandry**

72	1924	Some Lamb-feeding Results Secured by the Kansas Agricultural Experiment Station A. M. Paterson. Kan. Agr. Expt. Sta. Cir. 108.
73	1924	Lamb-feeding Investigations, 1922-'28. A. M. Paterson and H. W. Marston. Kan. Agr. Expt. Sta. Cir 109.
74	1925	Swine-feeding Investigations, 1922-'23. B. M. Anderson and H. W. Marston. Kan. Agr. Expt. Sta. Cir. 112.
75	1925	Experiments Relating to the Time of Cutting Alfalfa. S. C. Salmon, C. O. Swanson, and C. W. McCampbell. Kan. Agr. Expt. Sta. Tech. Bul. 15.
76	1925	Cattle-feeding Investigations, 1923-'24. C. W. McCampbell, B. M. Anderson, and H. W. Marston. Kan. Agr. Expt. Sta. Cir. 117
77	1925	Swine-feeding Investigations, 1923-'24. B. M. Anderson and H. W. Marston. Kan. Agr. Expt. Sta. Cir. 118.
78	1926	Lamb-feeding Investigations, 1923-'24. H. E. Reed and H. W. Marston. Kan. Agr. Expt. Sta. Cir. 123.
79	1926	Inheritance of Salmon Eye in Guinea Pigs. P. W. Gregory and H. L. Ibsen. Jour. Amer. Nat., 60:166-171.

Serial No.	Year of issue.	Department of Bacteriology	
		Title, author, and publication.	
61	1924	The Bacterial Content of Ice Cream.	N. E. Olson and A. C. Fay. Jour. Dairy Sci., v. 7, No. 4, pp. 330-356.
62	1924	Studies in Poultry Diseases Found in Poultry Feeding Stations.	W. R. Hinshaw. National Poultry, Butter, and Egg Bulletin, 9:3-6.
63	1924	Effect of Gelatine on the Bacterial Content of Ice Cream.	A. C. Fay and N. E. Olson. Abs. Bact., 8:15 (Abstract).
64	1925	The Production of Ice Cream of Low Bacterial Content.	A. C. Fay and N. E. Olson. Abs. Bact., v. 9, No. 1, p. 24 (Abstract).
65	1924	The Probable Error of the Plate Count in the Bacteriological Examination of Milk.	A. C. Fay. Abs. Bact., 8:16 (Abstract).
66	1925	Inoculating Soil with Azotobacter.	P. L. Gamey. Soil Science, v. 20, No. 1, pp. 73-87.
68	1924	Differential Diagnosis of Poultry Diseases and Technique of Post Mortem Examination of the Fowl.	W. R. Hinshaw. Vet Med, 29:373-376.
69	1924	Presentation and Control of Poultry Diseases.	L. D. Bushnell and W. R. Hinshaw. Kan. Agr. Expt. Sta. Cir. 106.
70	1924	Sanitation of the Swimming Pool	L. D. Bushnell and F. S. Davenport. City Manager Magazine (International) 6:12-15.
71	1924	The Use of Vaccines in Poultry Diseases.	I. D. Bushnell and J. W. Patton. Poultry Science, 4:64-73.
73	1925	The Bacterial Content of Ice Cream A Report of Experiments in Bacterial Control in Six Commercial Plants	N. E. Olson and A. C. Fay. Jour. of Dairy Sci., v. 8, No. 5, pp. 415-444.
74	1925	The Significance of Soil Reaction in Controlling Nitrogen Fixation in Soils.	P. L. Gainey. Proc. Fourth Inter. Soil Sci. Conference, Rome, pp. 1-43.
75	1925	Control of Bacillary White Diarrhea	W. R. Hinshaw. No. Amer. Vet., 6:31-34.
76	1925	Management: A Factor in Combatting Avian Tuberculosis.	L. D. Bushnell and W. R. Hinshaw. Poultry Sci., v. 5, No. 1, pp. 35-52; No. 2, pp. 78-97.
78	1926	Studies in Transmission of Bacillary White Diarrhea in Incubators.	W. R. Hinshaw, C. W. Upp, and J. M. Moore. Jour. Amer. Vet. Med. Assoc., v. 68, n. s. 21, No. 5, pp. 631-641.
80	1926	Thermotolerant, Saccharophilic Organisms as a Cause of "pin point" Colonies in the Bacteriological Analysis of Ice Cream.	A. C. Fay. Jour. Bact., v. 11, No. 2, p. 96.
81	1926	Testing for Bacillary White Diarrhea.	L. D. Bushnell. The Jour. of the Kan. Med. Soc., v. 26, No. 2, pp. 68-70.
82	1926	Problems Aiding in the Testing of Bacillary White Diarrhea.	L. D. Bushnell and W. R. Hinshaw. Poultry Science, 5:249-256
<b>Department of Botany</b>			
191	1925	Study of the Life History and Ecologic Relations of the Smut of Maize.	Aldene A. Potter and L. E. Melchers. Jour. Agr. Res., v. 30 No. 2, pp. 161-273.
196	1924	Swamp and Bog Plants: <i>Iris versicolor</i> L.	Frank C. Gates and Elsie Erickson. Torreya, 24:55-57.
205	1924	Three Sets of Megasporangiate Cones Per Year in Pinus.	Frank C. Gates. Bot. Gaz, 77:340-342.
206	1925	Sorghum Smuts and Varietal Resistance in Sorghums.	G. M. Reed and L. E. Melchers. U. S. Dept Agr. Bul. 1284.
207	1924	Daily Variation of the Carbohydrates in the Leaves of Corn and the Sorghums.	E. C. Miller. Jour Agr. Res., v. 27, No. 10, pp. 785-808.
217	1925	Tillage and Weeds.	Frank C. Gates and M. C. Sewell. Ecology, 6:138-142.
219	1924	Elemental Composition of the Corn Plant.	W. L. Latschaw and E. C. Miller. Jour. Agr. Res., v. 27, No. 11, pp. 845-860
220	1924	The Effect of Rotation and Tillage on Footrot of Wheat in Kansas, 1920-'24.	M. C. Sewell and L. E. Melchers. Jour. Amer. Soc. Agron., v. 16, No. 12, pp. 768-771.

Serial No.	Year of issue.	Title, author, and publication.
221	1924	An Annotated List of the Higher Plants of the Douglas Lake, Michigan, Region. Frank C. Gates and J. H., Ehlers. Mich. Acad. Sci., A. and L., 4:183-283.
222	1925	Contributions to the Flora of Hancock County, Illinois. Frank C. Gates. Trans. III. St. Acad. Sci., 18:225-234.
223	1924	The Copper Carbonate Dust Method of Controlling Bunt of Wheat. L. E. Melchers and H. B. Walker. Kan. Agr. Expt. Sta. Cir. 107.
227	1924	A Method of Detecting Mixtures in Kanred Seed Wheat. C. O. Johnston and C. W. Bower. Jour. Amer. Soc. Agron., V. 16, No. 7, pp. 467-470.
230	1925	The Reaction of Certain Grasses to Chinch-Bug Attack. Wm. P. Hayes and C. O. Johnston. Jour. Agr. Res., v. 31, No. 6, pp. 575-583.
235	1926	Pines in the Prairie. Frank C. Gates. Ecology, v. 7, No. 1, pp. 96-98.
236	1925	Hemerarch and Feralarch, Two Additional Terms in Ecology. Frank C. Gates. Science, 61:260.
237	1925	The Loco Weed and Its Effect on Live Stock. Frank C. Gates. Kan. Agr. Expt. Sta. Cir. 115.
241	1926	Evaporation in Vegetation at Different Heights. Frank C. Gates. Amer. Jour. Bot., 13:167-178.
242	1926	Tomato Wilt Investigations. R. P. White. Kan. Agr. Expt. Sta. Tech. Bul. 20.
245	1926	Evaporation in the <i>Scirpus validus</i> and <i>Scirpus americanus</i> Associations. Frank C. Gates. Bot. Gaz., 81:95-102.
246	1926	Botrytis Blossom Blight and Leaf Spot of Geranium, and Its Relation to Gray Mold of Lettuce. L. E. Melchers. Jour. of Agr. Res., v. 32, No. 9, pp. 883-894.
248	1926	Rhizoctonia Crown Rot of Carrots R. P. White. Phytopathology, 16:367-368.
249	1926	The Effect of Inundation Above a Beaver Dam Upon Upland Vegetation. Frank C. Gates and Edith C. Woollett. Torreya, 26:45-50.
253	1926	The Use of Catalase as a Means of Determining the Viability of Seeds W. E. Davis. Proc. Eighteenth Annual Meeting of the Assoc. of Official Seed Analysts of North America.
255	1926	A Study of Smut Resistance in Corn Seedlings Grown in the Greenhouse. W. H. Tisdale and C.O. Johnston. Jour. Agr. Res., v. 32, No. 7, pp. 649-668.
<b>Department of Chemistry</b>		
105	1924	Elemental Composition of the Corn Plant. W. L. Latshaw and E. C. Miller. Jour. Agr. Res., v. 27, No. 11, pp. 845-860.
107	1925	The Influence of Ultra-Violet. Light on Leg Weakness in Growing Chicks and on Egg Production. J. S. Hughes, L. F. Payne, and W. L. Latshaw. Poultry Science, v. 4, pp. 151-156 pp. 151-156.
108	1925	The Relative Value of Ultra-Violet Light and Irradiated Air in Preventing Rickets in Chickens. J. S. Hughes, C. Nitcher, and R. W. Titus. Jour. Biol. Chem., v. 63, No. 2, pp. 205-209.
114	1925	The Relative Values of Green Oat Sprouts, Green Alfalfa, and Cod Liver Oil in the Presentation evention of Rickets in Growing Chicks. J. S. Hughes, R. W. Titus, and L. Witham. Poultry Science, v. 5, No. 2 pp. 59-66.
116	1925	The Relation Between the Amount of Ultra-Violet Light Received by Hens and the Amount of Antirachitic Vitamin in the Eggs Produced. J. S. Hughes, L. F. Payne, R. W. Titus, and J. M. Moore. Jour. Biol. Chem., v. 46, No. 2, pp. 595-600.
117	1925	The Iso-Electric Points of Gliadin and Glutenin. E.L. Tague. Jour. Amer. Chem. Soc., v. 47, No. 2, pp. 418-422.
118	1925	The Solubility of Ghadan in Acids, Bases, and Neutral Salts. E. L. Tague. Cereal Chemistry, v. 2, No. 3, pp. 117-127.
119	1925	Gluten Quality and the Iso-Electric Point. E. L. Tague. Cereal meal Chemistry, v. 2, No. 4, pp. 202-208.
1926		An Adequate Diet for Poultry. J. S. Hughes, The Kan. Agr. Student, v. 5, No. 4, pp. 99-103.

**Department of Dairy Husbandry**

Serial No.	Year of issue.	Title, author, and publication.
48	1924	The Relation of Feeding and Age of Calving to the Development of Dairy Heifers. O. E. Reed, J. B. Fitch, and H. W. Cave. Kan. Agr. Expt. Sta. Bul. 233.
49	1925	Ground Sorgo as a Feed for Dairy Cows. H. W. Cave and J. B. Fitch. Kan. Agr. Expt. Sta. Cir. 110.
51 A	1924	Effect of Gelatine on the Bacterial Content of Ice Cream. A. C. Fay and N. E. Olson. Abs. Bact., 8:15 (Abstract).
51 B	1925	The Bacterial Content of Ice Cream. A Report of Experiments in Bacterial Control in Six Commercial Plants. N. E. Olson and A. C. Fay. Jour. of Dairy Sci., v. 8, No. 5, p. 415.
51 C	1925	The Production of Ice Cream of Low Bacterial Content. A. C. Fay and N. E. Olson. Abs. Bact., v. 9, No. 1 p. 24 (Abstract).
52	1925	Inheritance of Twinning in a Herd of Holstein Cattle. R. H. Lush. Jour. of Heredity, v. 16, No. 8, pp. 273-279.
55	1925	Ground Kafir as a Feed for Dairy Cows. H. W. Cave and J. B. Fitch. Kan. Agr. Expt. Sta. Cir. 119.
56	1925	Dairy Buildings for Kansas. J. B. Fitch and V. R. Hillman. Kan. Agr. Expt. Sta. Bul. 236.

**Department of Entomology**

	1924	Inspection and Care of Bees. J. H. Merrill. Kan. Ent. Com. Cir. 7.
319	1925	<i>Pyrallis farinalis</i> Linn (Lepidoptera), An Alfalfa Hay Worm in Kansas. Nellie M. Payne. Jour. Econ. Ent., v. 18, No. 1, pp. 224-227.
321	1924	Relation of Stores to Broodrearing. J. H. Merrill. Amer. Bee Jour., v. 44, No. 11, pp. 506-507.
322	1924	The Resistance of Plants to Insect Injury. J. W. McColloch. Bien. Rept. Kan. St. Hort. Soc., 37:196-208.
324	1925	A Comparative Study of the History of Certain Phytophagous Scarabæid Beetles. Wm. P. Hayes. Kan. Agr. Expt. Sta. Tech. Bul. 16.
328	1924	The Biology of <i>Anomala kansana</i> (Scarabæidæ, Coleop). Wm. P. Hayes and J. W. McColloch. Jour. Econ. Ent., v. 17, No. 5, pp. 589-594.
330	1924	Winter Consumption of Stores. J. H. Merrill. Gleanings in Bee Culture, v. 52, No. 11, pp. 700-703.
334	1925	A Preliminary List of the Ants of Kansas (Hymenoptera, Formicidæ). Wm. P. Hayes. Ent. News, v. 36, No. 10, pp. 39-43; No. 12, pp. 69-73.
337	1924	Sealed and Unsealed Brood. J. H. Merrill. Amer. Bee Jour., v. 44, No. 9, pp. 424-425.
339	1925	The Reaction of Certain Grasses to Chinch-Bug Attack. Wm. P. Hayes and C. O. Johnston. Jour. Agr. Res., v. 31, No. 6, pp. 575-583.
340	1925	Chinch Bug Barriers for Kansas. J. W. McColloch. Twenty-fourth Bien Rept. Kan. St. Bd. Agr., pp. 36-45.
341	1924	Broodrearing. J. H. Merrill. Bee World (England), v. 6, No. 7, pp. 102-103.
342	1925	Expereince with Package Bees. J. H. Merrill. Beekeeper Item, January, pp. 5-6.
343	1925	Colony Influence on Brood Rearing. J. H. Merrill. Amer. Bee Jour., v. 45, No. 4, pp. 172-174.
344	1925	Relation of Broodrearing to Honey Production. J. H. Merrill. Amer. Bee Jour., v. 45, No. 3, pp. 118-119.
345	1925	The Hessian Fly Problem in Kansas. J. W. McColloch. Jour. Econ. Ent., v. 18, No. 1, pp. 65-68 (Abstract).
346	1925	The Neuroptera and Mecoptera of Kansas. Roger C. Smith. Bul. Brooklyn Ent. Soc., v. 20, No. 4, pp. 165-171.
347	1926	The Pea Aphid as an Alfalfa Pest in Kansas. Roger C. Smith and Edgar W. Davis. Jour. Agr. Res., v. 33, No. 1, pp. 47-57.
348	1925	Chinch Bug Barriers for Kansas Conditions. J. W. McColloch. Kan. Agr. Expt. Sta. Cir. 113.
349	1925	The Hessian Fly and Its Control in Kansas. J. W. McColloch. Kan. Exten. X-Form 225.
350	1926	The Role of Insects in Soil Determination. J. W. McColloch. Jour. Amer. Soc. Agron., v. 18, No. 2, pp. 143-150.

Serial No.	Year of Issue.	Title, author, and publication.
361	1926	Life History and Habits of <i>Eremochrysa punctinervis</i> McLach. Roger C. Smith. Bul. Brooklyn Ent. Soc. v. 21, No. 2, pp. 48-52.
352	1926	House Fumigation with Calcium Cyanide. Roger C. Smith. Jour. Econ. Ent., v. 19, No. 1, pp. 65-77.
<b>Department of Home Economics</b>		
1	1926	Fabrics of Vegetable Origin Penetrable by Ultra-Violet light. Lilian C. W. Baker. Women's Wear, March 16, p. 57.
<b>Department of Horticulture</b>		
57	1925	Strawberry Growing in Kansas. R. J. Barnett. Kan. Agr. Expt. Sta. Cir. 116.
58	1924	Where to Grow Fruit. R. J. Barnett. Iowa Hort. Rept., 59:16-22.
59	1924	Two Years' Work with Fire Blight on Apples, R. J. Barnett. Amer. Soc. Hort. Sci., 21:292-296.
64	1925	The Place of Cover Crops in Orchard Soil Management. R. J. Barnett. Bulletin of the Chicago, Rock Island, and Pacific Railroad Mid-Continent Horticultural Campaign.
65	1926	Recent Spraying Practices and Investigations W. F. Pickett, Fruits and Gardens, v. 24, No. 8, pp. 16 and 21.
66	1925	Notes on Hardy Cover Crops R. J. Barnett, Proc. Amer. Soc. Hort. Sci., 22:283-280.
67	1926	Spraying Fruit Plants. W. F. Pickett and L. C. Williams. Kan. Agr. Expt. Sta Cir 125.
<b>Department of Milling Industry</b>		
24	1924	Lipoids as a Factor in Gluten Quality. Earl B. Working. Cereal Chemistry, v. 1, No. 4, pp. 153-158.
25	1924	Factors Which Influence the Quantity of Protein in Wheat. C. O. Swanson. Cereal Chemistry, v. 1, No. 6, pp. 279-287.
26	1925	How to Grow and Market High-Protein Wheat. L. E. Call, R. M. Green, and C. O. Swanson Kan Agr. Expt. Sta. Cir. 114.
27	1925	A Theory of Colloid Behavior in Dough. C. O. Swanson. Cereal Chemistry, v. 2, No. 5, pp. 265-275.
28	1926	Tillage in Relation to Milling and Baking Qualities of Wheat. M. C. Sewell and C. O. Swanson. Kan. Agr. Expt. Sta. Tech. Bul. 19
29	1026	Mechanical Modification of Dough to Make it Possible to Bake Bread with Only the Fermentation in the Pan. C. O. Swanson and Earl B. Working. Cereal Chemistry, v. 3, No. 2, pp. 65-83.
30	1926	Milling and Baking Qualities of Wheat Twenty-five Years Old. C. O. Swanson. Jour. Amer. Soc. Agron., v. 18, No. 4, pp. 367-368 (Note).
<b>Department of Poultry Husbandry</b>		
26	1925	The Cause of Olive-colored Yolks Commonly Called "Grass Eggs" by the Trade. L. F. Payne. Poultry Science, v. 4, No. 3, pp. 102-108.
27 A	1925	Influence of Ultra-Violet Light on Leg Weakness in Growing Chicks and on Egg Production. J. S. Hughes, L. F. Payne, and W. L. Latshaw. Poultry Science, v. 4, No. 4, pp. 151-156.
27 B	1925	The Relation Between the Amount of Ultra-Violet Light Received by Hens and the Amount of Antirachitic Vitamins in the Eggs Produced. J. S. Hughes, L. F. Payne, R. W. Titus, and J. M. Moore. Jour. Biol. Chem., v. 46, No. 2, pp. 595-600.
28	1925	The Correlation Between Age at the Laying of the First Egg and the Weight of Eggs During the First Laying Year of White Leghorns W. A. Lippincott, Sylvia L. Parker, and Luella M. Schaumburg. Poultry Science, v. 4, No. 4, pp. 127-140.
29	1925	Inheritance of Rate of Feathering in Poultry. D. C. Warren. Jour. of Heredity, v. 16, No. 1, pp. 13-18.
31	1926	Studies in Transmission of Bacillary White Diarrhea in Incubators. W. R. Hinshaw, C. W. Upp, and J. M. Moore. Jour. Amer. Vet. Med. Assoc., v. 21, No. 5, pp. 631-641.
32	1926	Poultry Management on the Farm. L. F. Pavne. Kan. Agr. Expt. Sta. Cir. 122.
34	1926	Genetics of Breed Characteristics. D. C. Warren. Poultry Science, v. 5, No. 5, pp. 209-212.

DIRECTOR'S REPORT, 1924-1926

Department of Veterinary Medicine

Serial No.	Year of issue.	Tit/e, author, and publication.
30	1925	Studies of Certain Characteristics of <i>Clostridium chauvei</i> and <i>C. edematis</i> . J. P. Scott. Jour. Bact., v. 10, No. 3, pp. 265-313.
31	1924	Infectious Abortion of Cattle. H. F. Lienhardt, C. H. Kitselman, and C. E. Sawyer. Kan. Agr. Expt. Sta. Tech. Bul. 14.
32	1925	Recent Investigations on Blackleg Immunization. J. P. Scott. Jour. Amer. Vet. Med. Assoc., v. 20, No 5, pp. 623-631.
33	1926	A Method for the Preliminary Identification of Common Tissue In-vading Anaerobes J. P. Scott Cornell Veterinarian, v. 16, No. 1, pp 55-58.
34	1926	Comparative Study of Strains of <i>Clostridium chauvei</i> Obtained in the United States and Abroad. J. P. Scott. Jour. Infectious Diseases, v. 38, No. 3, pp. 262-272.

Department of Zoölogy

—	1924	Inheritance of Color patterns in the Grouse Locust, <i>Telmatettix aztecus</i> Sanssure Robert K. Nabours and Bertha Snyder. The Anatomical Record, v. 29, No. 2, p. 152 (Abstract).
—	1924	Effect of Parasitism on Fowl Thymi. J. E. Ackert. Anatomical Record, v. 29, No. 2, p. 120 (Abstract).
—	1924	The Effect of the Nematode <i>Ascaridia perspicillum</i> on the Blood Sugar Content of Chickens. J. E. Ackert. Anatomical Record, v. 29, No. 2, p. 120 (Abstract).
72	1925	The Question of the Human and Pig Ascaris F. K. Payne, J. E. Ackert, and Ernest Hartman. Amer. Jour. Hyg., v. 5, No. 1, pp. 90-101.
73	1924	Ecological Studies of Aquatic Insects: 11. Size of Respiratory Organs in Relation to Environmental Conditions. G. S. Dodds and F. L. Hisaw. Ecology, v. 5, No. 3, pp. 262-271.
74	1925	Studies on the Migratory Habits of Certain Nematode Larvæ. Bertha L. Danheim. Trans Amer. Micro Soc., v. 44, No. 1, pp. 14-23.
75 A	1925	Studies of Inheritance and Evolution in Orthoptera V. The Grouse Locust <i>Apotettix eurycephalus</i> Hancock. Robert K. Nabours. Kan Agr. Expt. Sta. Tech. Bul. 17.
75 B	1925	Influence of the Ovary on the Resorption of the Public Bones of the Pocket Gopher. F. L. Hisaw. Jour. of Experimental Zoology, v. 42, No. 4, pp. 10-25.
76 A	1924	Field Studies of the Diurnal Raptores of Eastern and Central Kansas. Howard K Gloyd. Wilson Bulletin, v. 37:133-149.
76 B	1925	Control of Mammals Injurious to Agriculture in Kansas. George E. Johnson. Kan. Agr. Expt. Sta. Cir. 120.
—	1925	Ecological Studies of Aquatic Insects: III. Adapations of Caddisfly Larvæ to Swift Streams. G. S. Dodds and F. L. Hisaw. Ecology, v. 6, No. 2, pp. 123-137.
—	1925	Studies of Inheritance in <i>Stagmonantis carolina</i> . Everett H. Ingersoll. The Anatomical Record, v. 31, No. 4, p. 295 (Abstract).
—	1925	Parthenogenesis in the Grouse Locust, <i>Paratettix texanus</i> Hancock. Robert K. Nabours and Martha E. Foster. The Anatomical Record, v. 31, No. 4, p. 295 (Abstract).
78	1925	The Reproductive System of <i>Apotettix eurycephalus</i> . Mary T. Harman. Jour. of Morph and Physiol, v. 41, No. 1, pp. 217-237.
81	1925	Studies on the Resistance of the Chicken to the Nematode <i>Ascaridia perspicillum</i> . C. A. Herrick. Amer. Jour. Hyg., v. 6, No. 1, pp. 153-172.
—	1926	Effect of Repeated Bleeding Upon Resistance of Chickens to Parasitism. J. E. Ackert. Jour. Parasit., v. 12, No. 3, p. 163 (Abstract).
—	1926	Vitamin B, a Factor in the Resistance of Chickens to <i>Ascaridia perspicillum</i> . Naömi B. Zimmerman, Lola B. Vincent, and J. E. Ackert. Jour. Parasit., v. 12, No. 3, p. 164 (Abstract).

Director's Office

30	1924	Director's Report, 1922-'24.
31	1925	Information Regarding Recent Publications Kan. Agr. Expt. Sta Cir. 111.
32	1926	Information Regarding Recent Publications. Kan. Agr. Expt. Sta. Cir. 124

AGRICULTURAL EXPERIMENT STATION

FINANCIAL STATEMENT, 1924-'25

(The Kansas Agricultural Experiment Station in account with federal and state appropriations.)

	<i>Federal appropriations.</i>	<i>State appropriations and receipts.</i>	<i>Totals.</i>
Main station .....	\$30,000.00	(a) \$57,241.29	\$87,241.29
Branch stations, appropriations .....		(b) 51,358.18	51,358.18
Branch stations, sales .....		88,611.39	88,611.39
<b>Totals .....</b>	<b>\$30,000.00</b>	<b>\$197,210.86</b>	<b>\$227,210.86</b>
Salaries .....	\$20,000.00	\$27,141.65	\$47,141.65
Labor .....	7,584.98	61,981.74	69,566.72
Scientific supplies, consumable .....	419.86	2,968.91	3,388.77
Stationery and office supplies .....	7.86	1,392.13	1,399.99
Feeding stuffs .....	417.42	11,319.05	11,736.47
Sundry supplies .....	88.44	8,955.16	9,043.60
Fertilizers .....		165.61	165.61
Communication service .....		1,711.93	1,711.93
Travel expenses .....	392.62	4,018.51	4,411.13
Transportation of things .....	12.09	3,346.35	3,358.44
Publications .....	100.00	1,472.01	1,572.01
Heat, light, water, and power .....		4,328.50	4,328.50
Furniture, furnishings, and fixtures .....	41.04	1,392.26	1,433.30
Library .....	8.38	94.08	102.46
Scientific equipment .....	280.15	345.08	625.23
Live stock .....	22.50	6,388.20	6,410.70
Tools, machinery, and appliances .....	462.68	9,715.13	10,177.81
Buildings and land .....	161.98	18,791.53	18,953.51
Contingent expenses .....		371.53	371.53
Balance, June 30, 1925 .....		31,316.50	31,316.50
<b>Totals .....</b>	<b>\$30,000.00</b>	<b>\$197,210.86</b>	<b>\$227,210.86</b>

(a) Includes a balance on hand June 30, 1924, of \$2,041.29  
(b) Includes a balance on hand June 30, 1924, of \$6,158.18.

FINANCIAL STATEMENT, 1925-'26

(The Kansas Agricultural Experiment Station in account with federal and state appropriations.)

	<i>Federal appropriations.</i>	<i>State appropriations and receipts.</i>	<i>Totals.</i>
Main station .....	\$50,000.00	(a) \$56,543.51	\$106,543.51
Branch stations, appropriations .....		(b) 48,155.63	48,155.63
Branch stations, sales .....		84,763.51	84,763.51
<b>Totals .....</b>	<b>\$50,000.00</b>	<b>\$189,462.65</b>	<b>\$239,462.65</b>
Salaries .....	\$29,933.31	\$28,446.02	\$58,379.33
Labor .....	15,860.09	55,509.24	71,369.33
Scientific supplies, consumable .....	818.15	3,027.74	3,845.89
Stationery and office supplies .....	63.03	1,713.52	1,776.55
Feeding stuffs .....	563.01	11,544.56	12,108.47
Sundry supplies .....	321.24	9,453.22	9,774.46
Fertilizers .....	1.55		1.55
Communication service .....	14.58	1,763.17	1,777.75
Travel expenses .....	856.98	4,222.16	5,079.14
Transportation of things .....	79.77	2,539.52	2,619.29
Publications .....	41.31	1,675.40	1,716.71
Heat, light, water, and power .....		4,266.00	4,266.00
Furniture, furnishings, and fixtures .....	124.70	998.34	1,123.04
Library .....	8.43	88.45	96.88
Scientific equipment .....	281.18	915.04	1,196.22
Live stock .....	454.54	12,581.49	13,036.03
Tools, machinery, and appliances .....	427.14	11,997.23	12,424.37
Buildings and land .....	148.29	15,023.87	15,174.16
Contingent expenses .....		1,848.54	1,848.54
Balance, June 30, 1926 .....		21,847.14	21,847.14
<b>Totals .....</b>	<b>\$50,000.00</b>	<b>\$189,462.65</b>	<b>\$239,462.65</b>

(a) Includes a balance on hand June 30, 1925, of \$1,343.51  
(b) Includes a balance on hand June 30, 1925, of \$955.63.

