

AGRICULTURAL EXPERIMENT STATION

KANSAS STATE COLLEGE OF AGRICULTURE
AND APPLIED SCIENCE

MANHATTAN, KANSAS

**SIXTH BIENNIAL REPORT
OF THE DIRECTOR**

1930-1932



KANSAS AGRICULTURAL EXPERIMENT STATION

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J. F. MERRILL, *Fertilizer Analysis*
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W. H. RIDDELL, *Dairy Production*
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E. L. PARKER, *Apiculture, Fruit Insects*
F. C. SMITH, *Staple Crop Insects*
HUBBY R. BRYSON, *Staple Crop Insects*
E. H. PALMER, *Staple Crop Insects*
DONALD A. WILBUR, *Staple Crop Insects*

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MURTA KRAMER, *Human Nutrition*
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FLORENCE STEBBINS, *Genetics*
G. E. JOHNSON, *Injuries to Mammals*

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E. H. COLES, *Superintendent*

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* On leave.

LETTER OF TRANSMITTAL

OFFICE OF THE DIRECTOR,

June 30, 1932.

To His Excellency, Harry H. Woodring, Governor of Kansas:

I have the honor to submit herewith the report of the Agricultural Experiment Station of the Kansas State College of Agriculture and Applied Science for the biennium ending June 30, 1932. 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 REPORT¹

INTRODUCTION

This report contains a brief statement of the work of the Kansas Agricultural Experiment Station, including the four branch stations, for the biennium ending June 30, 1932. The work as in the past has been conducted upon the project basis. These projects include studies in five distinct fields as follows: Studies in rural economics, studies in soil conservation, investigations in the plant industries, investigations in the animal industries, and studies in home economics. The progress made by the station during the biennium and the results secured from each of the more important projects conducted during the biennium are briefly summarized.

COOPERATION WITH OTHER AGENCIES

The station has been fortunate in having helpful coöperative relationships during the past biennium with a number of related agencies. Such work has been conducted with other state agricultural experiment stations, with the United States Department of Agriculture, with other departments of this state, and with farmers. Each year has brought an increase in this type of work until during the past biennium more work of a coöperative character has been in progress than at any other time in the history of the station.

The coöperative work with the United States Department of Agriculture as outlined in the last report has been continued with some modification. These coöperative relations have been most satisfactory to this station and have resulted in an increase in the volume and effectiveness of the work done. The work during this period has included investigations relating to: Small grain production and breeding, corn breeding, and the control of cereal diseases with the Division of Cereal Crops and Diseases; dry-land agricultural investigations with the Division of Dry-Land Agriculture; alfalfa improvement, the control of alfalfa diseases, and forage crop production with the Division of Forage Crops and Diseases, Bureau of Plant Industry; a soil survey of five counties with the Division of Survey of the Bureau of Chemistry and Soils; soil and water conservation with the Division of Soil Erosion Investigations of the Bureau of Chemistry and Soils and the Bureau of Agricultural Engineering; factors influencing the palatability and quality of meat with the Division of Animal Husbandry; and anaplasmosis of cattle with the Pathological Division of the Bureau of Animal Industry; methods of controlling the codling moth in the Arkansas river valley with the Bureau of Entomology; the propagation and distribution of forest

1. Contribution No. 48 from the director's office.

trees with the Forest Service; and farm organization, cost of production, land utilization, wheat marketing, and hay storage and grading in cooperation with the Bureau of Agricultural Economics.

As outlined in the last report, the station has continued to cooperate with the Kansas State Board of Agriculture by providing facilities for analytical determinations of feeding stuffs, live-stock remedies, fertilizers, and dairy products and has maintained in cooperation with the Board a state seed-testing laboratory. Coöperation has also been continued with the state live-stock sanitary commissioner in a study of live-stock diseases. The station has also coöperated with thousands of farmers located in practically every section of the state upon problems of special interest to the citizens in the communities in which these studies were conducted. Co-operative research on industrial projects has also been undertaken in a limited way with a few commercial agencies that have financed such work.

ESTABLISHMENT OF ADDITIONAL OUTLYING EXPERIMENT FIELDS

At the request of the Agricultural Experiment Station, the legislature of 1923 made an appropriation of \$6,000 per annum to support outlying experiment fields in southeastern Kansas. Five fields were established. These fields have proved valuable in the solution of the soil and crop problems of a section of the state where soil, crop, and climatic conditions vary widely in character from conditions at the main station and at the four western Kansas branch stations. Their success led to requests for additional work of this character in sections differing in soil, crop, and climatic conditions

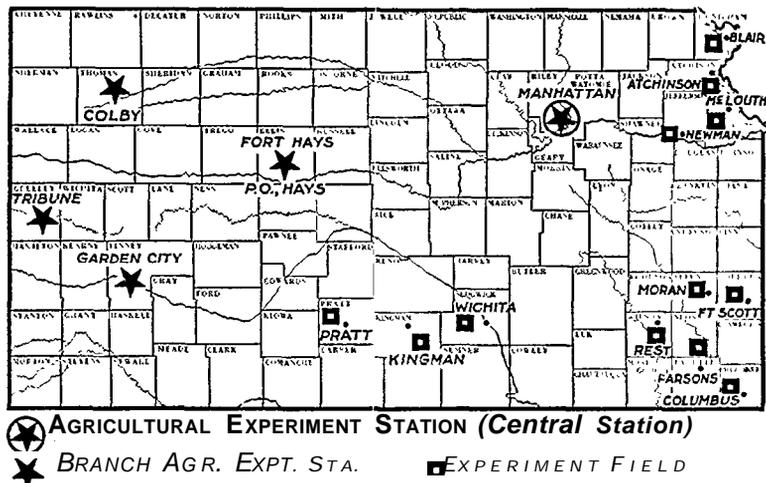


FIG. 1.--Map showing the location of the Agricultural Experiment Station of Kansas, the branch stations, and the experiment fields.

from those already served by existing stations and fields. Consequently the legislature of 1931 made appropriations for two additional groups of outlying experiment fields: First, an appropriation of \$6,000 per annum for a group of crop and soil experiment fields in south central Kansas; and second, an appropriation of \$10,000 for fields to serve the potato industry of the Kansas river valley and the fruit industry and the general farming industry of northeastern Kansas. Later by action of the Board of Regents the portion of these appropriations made available for the support of this work was reduced to \$4,500 and \$7,500, respectively. Accordingly, since the appropriations became available on July 1, 1931, three outlying fields have been established in south central Kansas, a potato experiment field in the Kansas river valley, a young apple orchard field, a mature apple orchard field, and a crop and soil field in northeastern Kansas. The locations of these fields are shown in figure 1.

The south central Kansas fields have been located on three of the principal soil types of south central Kansas, the potato field on a leading potato soil of the Kansas river valley, the crop and soil field in northeastern Kansas on the most important glaciated soil in that section of the state, while the apple fields have been located on the loessial soil near the Missouri river valley. Disease and insect problems, as well as soil management problems of the potato and fruit industries, are being investigated at these fields.

THE SOIL SURVEY

The state soil survey, resumed in 1925 after a period of several years of inactivity, was continued in coöperation with the Bureau of Chemistry and Soils of the United States Department of Agricul-

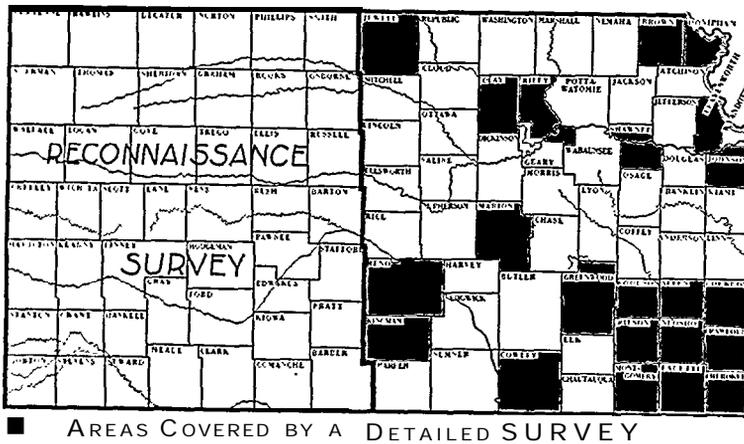


FIG. 2--Map showing areas in Kansas included in detailed and reconnaissance soil surveys up to June 30, 1932.

ture. The sum of \$5,000 per annum of state funds was available for the work. During the biennium the field work for detailed surveys was completed for Marion, Neosho, Bourbon, Woodson, and Kingman counties. Reports have been completed for all counties surveyed except the last three, and these will be completed by 1933. Reports and maps covering the surveys of Clay, Labette, Crawford, Doniphan, Johnson, and Wilson counties have been published during the biennium. The extent of the soil survey in Kansas at the end of this biennium is shown in figure 2. Because of the impounding of the appropriation made by the legislature for the soil survey for the year 1932-'33, the work was temporarily discontinued at the close of this biennium. It is hoped that these fundamental investigations of the soil resources of Kansas, so necessary as a basis for soil, crop, and economic studies, may be resumed at an early date.

LAND, BUILDINGS, AND EQUIPMENT

A tract of land embracing approximately 15½ acres formerly used for military purposes has been assigned to the station for use. Only slightly more than one-half of this area is suitable for cultivation, the remainder being rough native-grass pasture land. Approximately 1½ acres of the cultivated land on this area has been assigned to the Department of Horticulture for experimental work with trees, shrubs, and small fruit. The rest of the major portion of the area suitable for cultivation, approximately 4 acres, has been assigned to the Department of Botany for experimental work with plant diseases to replace land formerly assigned to the Department of Botany, but transferred during the biennium to the Department of Physical Education. The remainder of the tract, about 10 acres consisting chiefly of rough native-grass pasture, has been assigned to the Department of Agronomy for investigational work in pasture management.

A new fire-proof office building 50 feet by 43 feet, erected at a cost of \$17,600, was completed at the Fort Hays Branch Experiment Station in March, 1931. (Fig. 3.) The building is made of concrete and hollow tile faced with mangle shade rug brick. The roof is covered with French pattern red tile. The floors and deck are made of reinforced concrete. The building has two stories and basement. The first floor provides offices for the superintendent, three rooms for the clerical staff, a large reading room, and lobby and rest rooms. The second floor contains seven office rooms for the technical staff. The basement provides two laboratories, a photographic room, five store rooms, and a room for a heating unit. Large vaults on each floor supply additional safe storage for records. The building provides a much-needed improvement at the Hays station.

A poultry nutrition laboratory building 30 feet by 40 feet was built on the poultry farm at the main station at a cost of \$6,255. The building consists of a basement with concrete deck and two stories of frame construction. The basement is adequately equipped

for experimental brooder feeding under controlled temperature and humidity conditions. The top floor is used for feed storage and the main floor for the grinding, mixing, and the preparation of feed. The building is equipped with grain elevators and with modern grain grinding and mixing machinery.

Another minor building constructed during the biennium was a plant-breeding laboratory for the Department of Agronomy, constructed at a cost of \$2,500. The building is of frame construction 52 feet long and 26 feet wide. Besides a threshing room the building provides room for field offices and storage space for plant material. The building will provide the housing facilities needed on



FIG. 3.—New fire-proof office building at the Fort Hays Agricultural Experiment Station, Hays, Kan.

the new cereal crop nursery area of 8 acres recently assigned to the Department of Agronomy on the northeast corner of the dairy farm, the Department of Dairy Husbandry having been assigned the area formerly used as a cereal nursery, for the location of a new dairy barn for which an appropriation of \$60,000 was made by the legislature of 1931.

Other minor buildings constructed during the biennium include a new hog house at the Garden City station, constructed at a cost of \$2,000, a forest nursery packing house built as an addition to the forest greenhouse and office building at the Fort Hays station, at a cost of \$2,500, and a modern poultry house at the Tribune station.

New equipment constructed during the biennium includes combine harvester-threshers suitable for use in harvesting experimental plots for the Garden City and Colby stations. During the period there have been secured additional automatically controlled refrigeration

equipment for the meats laboratory of the main station, electrically driven grain and forage grinding equipment for the sheep nutrition laboratory, equipment for laboratories for plant physiology and plant pathology, including seven electrically controlled incubators, and special soil equipment for the study of insects injurious to the roots of staple crops.

PERSONNEL

Prof. Albert Dickens, horticulturist, died on November 28, 1930. His death removed from the station staff one of the oldest members from the standpoint of length of service. He was appointed to the staff in 1899 and served as head of the Department of Horticulture from 1902 until a short time before his death. He was succeeded by R. J. Barnett of the same department.

Appointments.--The average number of persons regularly employed on the scientific staff during the biennium was 115. A total of 16 new appointments were made, the number of appointments equalling 13+ per cent of the average personnel. The appointments made during the biennium are listed below:

- George Montgomery, marketing fruits and vegetables.
- C. E. Crews, superintendent, south central Kansas experiment fields.
- F. G. Ackerman, foreman, agronomy farm.
- A. L. Clapp, coöperative experiments.
- W. H. Metzger, soil investigations.
- A. D. Weber, cattle investigations.
- R. F. Cox, sheep investigations.
- W. E. Connell, live-stock investigations.
- F. B. Wolberg, official dairy tests.
- G. A. Filinger, pomology investigations.
- T. R. Reitz, superintendent, northeastern Kansas experiment fields.
- F. J. Feight, superintendent, poultry farm.
- F. J. Zink, farm machinery.
- H. W. Loy, assistant chemist.
- Ruth McCammon, technician.
- Florence Stebbins, assistant in genetics.

Resignations.--A total of 17 members of the staff resigned during the biennium, the number of resignations being 14+ per cent of the average personnel. The persons who resigned from the staff during the biennium are listed below:

- W. P. Mortenson, marketing fruits and vegetables.
- S. C. Salmon, wheat investigations.
- M. C. Sewell, soil investigations.
- R. O. Lewis, soil survey.
- C. E. Crews, foreman, agronomy farm.
- H. E. Reed, sheep investigations.
- B. M. Anderson, cattle investigations.
- M. A. Alexander, live-stock investigations.
- H. J. Brooks, official dairy tests.
- A. P. Loomis, superintendent, poultry farm.
- R. H. Driftmier, farm machinery.
- E. J. Coulson, assistant chemist.
- Margaret Chaney, food economics and nutrition.
- Myra T. Potter, technician.
- C. W. Hobbs, superintendent, vaccine laboratories.
- Iva Larson, assistant in genetics.

SCOPE OF THE STATION WORK, JULY 1, 1930, TO JUNE 30, 1932.

A list of the principal active projects carried during the biennium ending June 30, 1932, is given below, together with statements of the sources of financial support and references to the discussions included in this report:

NAME.	Project No.	Department.	Leader.	Funds.	Discussed on page—
Studies of Factors Affecting the Organization and Operation of Kansas Farms.	95	Agr. Econ.....	W. E. Grimes..... J. A. Hodges. Morris Evans.	Purnell and State....	19
Investigations in Land Tenure and Other Related Problems.....	132	Agr. Econ.....	Harold Howe.....	Purnell.....	21
The Marketing of Kansas Wheat.....	143	Agr. Econ.....	R. M. Green.....	Purnell.....	19
The Economics of the Poultry Industry in Kansas.....	144	Agr. Econ.....	Morris Evans.....	Purnell.....	22
The Marketing of Kansas Live Stock and Live-stock Products....	149	Agr. Econ.....	H. J. Henney.....	Purnell.....	22
The Marketing of Kansas Fruits and Vegetables.....	177	Agr. Econ.....	George Montgomery.....	Purnell.....	24
A Study of Factors Governing the Marketing of Kansas Dairy Products.	185	Agr. Econ.....	George Montgomery.....	State.....	25
Soil Fertility Investigations.....	17	Agron.....	F. L. Duley.....	Hatch and State....	25
Plant Nutrition Investigations.....	152	Chem. Agron.....	W. L. Latshaw..... M. C. Sewell.	State.....	26
The Influence of Legumes and Free-living Nitrogen-fixing Organisms on the Growth of Plants and on the Nitrogen Balance,	172	Agron..... Bact.....	H. E. Myers..... M. C. Sewell. P. L. Gainey.	Purnell.....	27
The Influence of the Absolute Reaction of the Soil Solution upon the Growth and Activity of Azotobacter.	128	Bact.....	P. L. Gainey.....	Adams and State....	28
A Study of the Soil Solution as Governed by Ion Concentration...	155	Chem.....	A. T. Perkins.....	State.....	29
A Study of Replaceable Cations and Anions in Some Kansas Soils.	179	Chem.....	H. H. King.....	Purnell.....	29

SCOPE OF STATION WORK—CONTINUED.

NAME.	Project No.	Department.	Leader.	Funds.	Discussed on page—
Soil and Crop Experiment Fields.....		Agron.... Hort..... Bot..... Ent.....	R. I. Throckmorton.... R. J. Barnett. L. E. Melchers. G. A. Dean.	State.....	30
Field Survey and Herbarium Investigations.....	137	Bot.....	F. C. Gates.....	State.....	33
Drought Resistance of Plants.....	74	Bot.....	E. C. Miller.....	State.....	33
Temperature Relations of Crop Plants.....	157	Agron.....	H. H. Laude S. C. Salmon.	Purnell.....	33
Small Grain and Sorghum Improvement.....	67	Agron.....	J. H. Parker W. H. von Trebra.	Hatch.....	34
Inheritance of Factors Affecting Quality of Wheat ..	178	Agron .. Mill Ind.....	J. H. Parker .. C. O. Swanson.	Purnell	35
Sorghum Varietal Tests.....	129-1	Agron.....	H. H. Laude...	Hatch.....	35
Small Grain Varietal Tests.....	129-2	Agron.....	H. H. Laude.....	Hatch.....	36
Soybean Production Tests	129-3	Agron.....	J. W. Zahnley.....	Hatch.....	36
Miscellaneous Legumes for Forage.....	129-4	Agron.....	J. W. Zahnley.....	Hatch.....	37
Corn Production and Improvement.....	156	Agron.....	A. M. Brunson..	Purnell.....	37
Pasture Improvement Investigations.....	96	Agron..... Chem.....	A. E. Aldous..... W. L. Latshaw.	Purnell	39
Alfalfa Investigations in Relation to Winter Hardiness and Bacterial Wilt.	183	Agron ..	C. O. Grandfield.....	Purnell ..	38
Turf and Lawn Grass Experiments.....	167	Agron.....	J. W. Zahnley.....	State....	41
Weed Eradication with Chemical Sprays.....	166	Chem .. Agron..... Hort.....	W. L. Latshaw... J. W. Zahnley. W. F. Pickett.	State..	42

SCOPE OF STATION WORK—CONTINUED.

NAME.	Project No.	Department.	Leader.	Funds.	Discussed on page—
Coöperative Experiments with Farmers.....	.....	Agron.....	A. L. Clapp..... H. H. Laude.	State.....	43
The Influence of the Method of Harvesting and Baling Alfalfa Hay upon Quality.	182	Agr. Engr.....	F. J. Zink.....	Purnell.....	45
A Study of the Efficiency of the Combined Harvester-Thresher for Harvesting Grain Sorghums.	181	Agr. Engr.....	F. J. Zink.....	Purnell.....	45
A Study of the Effect of the Method of Storing Combined Wheat Upon Quality.	143	Agr. Engr..... Mill. Ind.....	F. C. Fenton..... C. O. Swanson.	Purnell.....	46
Chemical Factors Influencing the Quality of Wheat and Flour....	60-A	Mill. Ind.....	E. B. Working.....	State.....	47
The Quality of Wheat as Influenced by Cropping System and Fertilizer Treatment.	60-B	Mill. Ind.....	C. O. Swanson.....	State.....	47
The Quality of Wheat as Influenced by Seed-bed Preparation and Tillage Methods.	60-C	Mill. Ind.....	C. O. Swanson.....	State.....	48
The Relation of Variety to the Quality of Wheat.....	60-D	Mill. Ind.....	C. O. Swanson.....	State.....	48
A Comparison of the Quality of Wheat Varieties Grown in Different Parts of Kansas.	60-E	Mill. Ind.....	C. O. Swanson.....	State.....	48
A Study of the Protein Content of Some Common Kansas Wheat Varieties.	60-F	Mill. Ind.....	C. O. Swanson.....	State.....	49
Tempering Factors Affecting the Quantity and Quality of Wheat Flour.	170	Mill. Ind.....	C. O. Swanson..... R. O. Pence.	Purnell.....	49
Flour Chemistry Investigations.....	60	Chem.....	E. L. Tague.....	State.....	50
Orchard Investigations.....	25	Hort.....	R. J. Barnett..... G. A. Filingner. W. F. Pickett.	State.....	50
Small Fruit Investigations.....	26	Hort.....	R. J. Barnett.....	State.....	53

SCOPE OF STATION WORK—CONTINUED.

NAME.	Project No.	Department.	Leader.	Funds.	Discussed on page—
Flower and Vegetable Investigations.....	27	Hort.....	W. B. Balch.....	State.....	53
Forest Tree Investigations.....	82	Hort.....	E. W. Johnson.....	State.....	54
Nutritive Requirements of Swine.....	38	An. Husb..... Chem..... Vet. Med.....	C. E. Aubel..... J. S. Hughes. H. F. Lienhardt.	Adams.....	55
Swine Feeding Investigations.....	110	An. Husb.....	C. E. Aubel..... W. E. Connell.	State.....	55
Investigations in the Use of Silage for Fattening Beef Cattle.....	78	An. Husb.....	A. D. Weber..... W. E. Connell.	State.....	56
Methods of Utilizing Native Pasture in Beef Cattle Feeding.....	151	An. Husb.....	C. W. McCampbell.....	State.....	57
Lamb Feeding Investigations.....	111	An. Husb.....	Rufus F. Cox	State.....	58
A Study of Pasture Values and Pasture Methods for Live Stock..	142	An. Husb.....	C. W. McCampbell.....	State.....	59
The Influence of Feed on the Color, Chemical Composition, and Cooking Quality of the Meat of Grass-fat Cattle.	163	An. Husb..... Chem..... Home Econ.....	C. W. McCampbell..... D. L. Mackintosh. W. L. Latshaw, J. L. Hall. Martha Pittman, Martha Kramer.	Purnell.....	60
Antagonism of Monovalent and Polyvalent Metals in Biological Processes.	184	Chem.....	H. H. King..... J. L. Hall.	Adams.....	62
Factors Influencing the Mineral Metabolism of Dairy Animals	147	Dy. Husb..... Chem..... Vet. Med.....	W. H. Ruddell..... J. S. Hughes, C. H. Whitnah, H. F. Lienhardt.	Purnell and State..	63

SCOPE OF STATION WORK—CONTINUED.

NAME.	Project No.	Department.	Leader.	Funds.	Discussed on page—
Dairy Cattle Feeding Investigations	34	Dy. Husb.	H. W. Cave J. B. Fitch.	State	65
Silago Investigations	34	Chem. Dy. Husb.	W. L. Latshaw J. B. Fitch.	State	67
Normal Growth of Dairy Cattle		Dy. Husb.	W. H. Riddell	State	67
Ice Cream Investigations	124	Dy. Husb.	W. H. Martin W. J. Caulfield.	State	68
A Bacteriological Study of Ice Cream	124	Bact.	A. C. Fay	State	70
A Study of the Effectiveness of Lye as Compared with Chlorine for Sterilizing Milking-machine Parts.		Dy. Husb.	W. J. Caulfield	State	71
Butter Investigations	175	Dy. Husb.	W. H. Martin	State	72
The Inheritance of Standard Characteristics of Poultry	77-3	Poult. Husb.	D. C. Warren	State	72
The Inheritance of Breed Characteristics in Poultry	77-4	Poult. Husb.	D. C. Warren	State	73
The Inheritance of Egg Production in Single-comb Rhode Island Red Chickens.	77-5	Poult. Husb.	D. C. Warren	State	74
Poultry Flock Management	77-6	Poult. Husb.	L. F. Payne	State	74
Turkey Production	77-15	Poult. Husb.	H. M. Scott	State	75
Turkey Nutrition Investigations	77-17	Poult. Husb. Chem.	H. M. Scott J. S. Hughes.	State	78
The Comparative Nutritive Value of Certain Grain Sorghums, Corn, and Wheat in Poultry Production.	77-18	Poult. Husb.	L. F. Payne	State	80
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STUDIES IN THE ECONOMICS OF AGRICULTURE

Studies in the economics of agriculture, conducted under the leadership of the Department of Agricultural Economics, have been pursued during the past biennium along seven major lines, each of which is discussed. briefly on the following pages.

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

1. Maintaining up to date a type-of-farming file in which data on the major crop and live-stock enterprises are tabulated. The completed files will have data showing the trends and status of practically all lines of agricultural production by counties and by type-of-farming areas.

2. In coöperation with the federal Bureau of Agricultural Economics, continuing the study with from 150 to 200 coöperators in southwestern Kansas, which has included obtaining data concerning size of farm, acreage of crops, crop yields, cash requirements for wheat production, distribution of investment, amounts of assets and liabilities, material requirements and costs of operating machinery, changes in live stock on farms, farm products used in the home, etc. Records on these southwestern Kansas farms have been obtained for two years. The work of tabulating and summarizing these records is now well along and preparation of a bulletin presenting results is started. Estimated costs of producing wheat per bushel as obtained from this study for the years 1930 and 1931, when all costs are taken into account, are as follows:

Bus. per acre.	<i>Estimated cost per bu.</i>	
	<i>1931</i>	<i>1930.</i>
9.....	\$ 0 .32.	\$0.73
12.....	.65	.54
15.....	.52	.44
18.....	.42	.36
21.....	.37	.31
24.....	-32	.27

3. Securing income, expense, and inventory data on approximately 300 Kansas farms coöperating in the keeping of accounts.

4. Studying the relation of rainfall and temperature to crop yields for the state by selected type-of-farming areas. This work was concerned primarily with corn, but data have been secured on wheat. The effects of rainfall and temperature on corn yields in Kansas have been summarized and published in the April, 1931, issue of the *Journal of Farm Economics*.

[Project 95; Department of Agricultural Economics. Leaders, W. E. Grimes, J. A. Hodges, Morris Evans; Purnell and state funds.]

The Marketing of Kansas Wheat.--The work on this project is divided into a number of phases. Those that have been active during the past biennium are briefly discussed below.

Farm Storage Facilities in Kansas.--Work was resumed on this phase of the project at the request of representatives of the Federal Farm Board. Data on the supply and distribution of farm and local storage space in Kansas were collected through the office of the State Board of Agriculture, the railroads, and the grain trade sources. Important findings are as follows:

1. More than half of the time in the last ten years, the greatest shortage of farm storage in Kansas has been in the territory around Dodge City and west. The largest shortages have been in Clark, Ford, Gray, Meade, Grant, and Haskell counties.

2. West of the Smith-Barber tier of counties there are 19 to 29 counties in which local elevator space can still be increased without cutting down capacity turnover to below five or six times, when the crop is average or better in size.

East of this section, local elevator space is already built up to about the economical limit.

3. In western Kansas 48 towns on one railroad line were found where local elevator space could be increased without reaching an overbuilt condition.

4. The total increase in local elevator capacity in the western half of the state between 1928 and 1930 was 2,875,500 bushels.

5. By 1931, Gray, Ford, Meade, and Haskell counties were built up close to an economical limit, except when the crop exceeds 1929 proportions.

6. Rail facilities are not sufficient in southwestern Kansas to handle the large wheat crops without resorting to some local elevator storage. In turn, if the local elevator is to have sufficient capacity turnover to operate profitably, the relation of its capacity to the wheat crop will be such that some wheat will have to be stored on the farm. The problem is not of kind of storage, but of balance, so that one type is not overbuilt to its own detriment or to that of a competing type of storage.

Local Elevator Costs in Handling Wheat.—Work during the past two years has consisted of an analysis of the financial records of 40 coöperative elevators. It has been found that--

1. An ordinary-sized country elevator of 10,000 to 15,000 bushels capacity needs a grain turnover of six to ten times its capacity to give a reasonable chance to break even in the long run, and needs more volume than this if substantial profits are to be shown.

2. Membership patronage in the coöperative elevators studied went along with successful operation from the standpoint of net profits.

3. In well-managed elevators, salaries and wages constitute not more than around 60 per cent of total expenses and should not exceed 2 to 2½ per cent of sales.

4. A country elevator with an average capacity turnover of around 10 times, can hardly buy wheat on less than a 5-cent margin and show consistent profits.

5. Beginning business with too little working capital, buying wheat on too narrow a margin, and making overadvances to farmers on large unhedged quantities of grain account for most of the cases where current assets fail to compare with current liabilities in a favorable ratio.

Coöperative Membership Studies.--During the past two years a study has been made of the extent to which large-scale wheat producers are associated with present types of coöperative marketing agencies, of the reasons for large-scale operators not being members of coöperatives, and of the extent to which coöperative control of local elevator capacity is associated with membership of large-scale producers. It was found that:

1. In 13 counties in southwestern Kansas in the Dodge City territory, 10.8 per cent of the farmers, or a total of 802 farmers, have 34.7 per cent of the wheat acreage. In the Salina territory, 12 per cent of the farmers in 13 counties, or a total of 1,682 farmers, control 33.8 per cent of the wheat acreage.

2. In the Dodge City territory, 72 per cent of the large-scale operators replying to the inquiry made, were members of one or more coöperatives, leaving 28 per cent nonmembers. In the Salina territory, 52 per cent were members and 48 per cent nonmembers.

3. Of the total number of nonmember large-scale producers replying, about 33 per cent had more or less definite convictions against coöperative marketing of grain. Either they had had an unfortunate experience with a coöperative or they wanted to do their own marketing as they saw fit. There were 22.3 per cent of the nonmembers large producers who thought coöperatives were of no benefit, were poorly managed, were not on a sound footing, or who for some similar reason were not committed to the idea. There were 29.3 per cent of the nonmember large producers who had no special reason for not belonging to a coöperative and were not averse to the idea.

4. Indications to date are that 50 to 60 per cent of the present nonmember large-scale producers constitute a potential market for the extension of the coöperative plan of marketing, provided good business principles are demonstrated.

Factors Affecting Seasonal Price Fluctuations.--Much time was given to this phase of the project during the last two years, because of the increased number of calls from farmers for market information that will aid them in selling to the best advantage within a 12- to 14-month period. Price fluctuation studies have been predicated largely on the thesis that wheat prices within a crop year exhibit enough characteristic changes in relationships from one month to the next, from one end of the crop year to the other, from season to season within the year, and even from one period within the month to another period within the month to signify whether wheat prices are working toward higher or lower levels. A summary of some of the findings made to date are as follows:

1. Seventy to 75 per cent of the August, September, January, and February advances over the previous months, since 1894, have come in periods when wheat prices were working from a low point to a peak point. This is for top No. 2 hard winter wheat at Kansas City, Mo. These four months, more than any other months, move upward with the general trend upward in wheat prices.
2. Seventy-five to 78 per cent of the July, August, September, January, April, and June declines from the previous months have come in periods when wheat prices were working from a peak price to a low point. These six months, more than others, move downward with the general trend downward in wheat prices.
3. A seasonal advance in price from July to September or a decline not to exceed ½ cent has accompanied advancing price levels 77 per cent of the time.
4. A seasonal decline in price from July to September of more than ½ cent has accompanied declining price levels 87 per cent of the time.
5. A seasonal advance in price from February to April or a decline of not more than ½ cent has accompanied advancing price levels 77½ per cent of the time.
6. A seasonal decline in price from February to April of more than ½ cent has accompanied declining price levels 91 per cent of the time.
7. As a general rule, in price recovery periods or periods of advancing price levels, the future price is below the cash price a higher percentage of the time than it is in price-declining periods.
8. Especially after a considerable period of narrow spreads between the top and bottom of No. 2 hard cash wheat, a protracted period of widening spreads is some indication that an upward phase of the wheat price cycle is in process of formation.
9. Inter-market price spreads between Kansas City and Chicago do not vary regularly with up and down phases of the wheat price cycle. However, when the uptrend is due largely to local scarcity, as in 1911, the spread narrows, the price at Kansas City tending to move up faster than that at Chicago. At other times, variations are largely seasonal. As a rule, during downtrend price periods the normal Kansas City-Chicago spread is more consistently maintained than at any other time.

[Project 143; Department of Agricultural Economics. Leader, R. M. Green; Purnell fund.]

Investigations in Land Tenure and Other Land Problems.—

The work on this project during the last two years has consisted of studies on taxation and credit.

A study of the taxation systems of this and other states to obtain information on income taxation and the limitation of tax levies has been made. On the basis of this study and upon research of a more general nature, an article on income taxes and a set of 13 lessons, constituting a course of study on the fundamentals of taxation, were prepared. The latter manuscript was prepared jointly with Prof. Jens P. Jensen of the University of Kansas. A supplement to bulletin No. 235, "The Trend of Real Estate Taxation in Kansas from 1910 to 1923," has been issued, containing data for the years 1924-1929, inclusive. This publication is circular No. 159.

The work on credit has consisted of a comparison of the loans and discounts,

cash, and deposits of all commercial banks in Kansas in 1924 and 1930 for the purpose of indicating what changes have occurred in the resources of Kansas banks and what possible effects these changes may have on the farmers' supply of credit. A significant change in Kansas commercial banks during the last few years is revealed by comparing the condition statements of these institutions in 1924 and in 1930. The most outstanding change has been the movement of banking business away from the strictly rural sections to the larger cities and from the small to the large banks.

A study has also been made of the methods used by insurance companies, mortgage and loan companies, and trust companies in extending long-time credit to agriculture. The farm mortgage debt of Kansas is estimated at \$447,586,000 by the United States Department of Agriculture (1928). A study of insurance loans in this state revealed that on December 31, 1930, these companies held farm mortgages amounting to \$170,564,000, or 38.3 per cent of the total. Insurance companies with Kansas mortgages amounting to \$148,000,000 responded to a questionnaire regarding how mortgages were secured. These replies indicate that the most common practice is for insurance companies to purchase their farm mortgages indirectly from the mortgage companies and trust companies. Mortgages amounting to 81.29 per cent of the total were secured by this indirect method; 16.4 per cent were acquired by insurance companies or their agents direct from borrowers; and 2.31 per cent were acquired both by direct and indirect methods.

[Project 132; Department of Agricultural Economics. Leader, Harold Howe; Purnell fund.]

The Economics of the Poultry Industry in Kansas.--During the past biennium the work has consisted of studies of poultry population and production of poultry products, including the completion of the analysis of detailed studies previously reported; the beginning of a new phase of work for the purpose of determining the reasons for the relatively low price of Kansas eggs and poultry; the beginning of further studies on the effect of the poultry enterprise on the farm income; and a continuation of price studies of poultry and eggs. As a result of these studies the following conclusions were drawn:

1. Poultry population on farms is highest in eastern Kansas and in a group of 15 counties centering in Riley county. The areas of lowest population are the two western tiers of counties and the southeastern counties.
2. The central portion of the state is the region of heaviest production of poultry. The southeastern counties and extreme western counties are the areas of lowest production.
3. Production of eggs per flock does not follow closely the size of flock.
4. The usual investment in the poultry enterprise is small, the amount being less than for other major live-stock enterprises.
5. Transportation costs are apparently not the reason for the relatively low price of Kansas eggs. Practically all the eggs shipped out of Kansas go by freight.
6. There is a direct relation between the size of flock and the proportion of total farm receipts coming from poultry. The poultry enterprise is an important source of farm income.
7. The poultry enterprise is maintained with small cash outlay for new stock.
8. A study of prices paid to producers over the state shows that nearness to a good market tends to keep prices up.

[Project 144; Department of Agricultural Economics. Leader, Morris Evans; Purnell fund.]

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

Associations Marketing Kansas Live Stock.--It has been found that the associations marketing live stock in Kansas have declined from a total of 230 to 250 in 1925, to 175 in 1931. The active associations in 1931 were divided about as follows:

Live-stock shipping associations.....	100
Local unions of some type.....	50
Grain and Grange exchanges.....	25
	<hr/>
Total	175

The main factor responsible for the big decrease in associations has been trucking competition. The only increase in the number of associations by districts has been in western Kansas where trucking competition is less severe. It is intended to issue a summary of this study and drop this phase of the project.

When and Where Kansas Live Stock and Live-stock Products Move to Market.--The work on this phase of the project has consisted of a compilation of data on the movement to markets for the different classes of stock. The results of this study show--

1. That there is a tendency for the smaller markets and within-state markets to continue to show an increase in the proportion of all live stock sold.
2. That there seems to be a tendency for trucking facilities to even out the proportion marketed monthly.
3. That trucking has influenced the when and where movement in 1931 more than in any previous year.
4. That method of movement has changed almost entirely to trucking for hogs with big increases for cattle and sheep.
5. That in 1931 truck shipments moved greater distances than in any other year.
6. That shipments by truck from the 25-50-mile zone are still greater than from any other 25-mile zone but show a lesser proportion each year since 1927.

Economic Factors Influencing the Time and Place of Marketing Live Stock and Live-stock products.--This work has consisted chiefly of securing opinions and ideas from county agents, farmers, and writers on agricultural subjects concerning factors that cause farmers to change from the normal time of marketing. Each of these opinions is checked with data on the movement of Kansas live stock to verify the accuracy of such reports. It has been found that some factors responsible for change are the following:

1. That the use of trucks has often resulted in a shift in the place of marketing.
2. That direct buying of hogs is causing fewer receipts at markets and quicker return to the farmer.
3. That fear of still lower prices frequently causes premature marketing.
4. That farmers in the Wichita territory are selling a lesser proportion of their hogs in March and April.
5. That Oklahoma City prices and Wichita prices indicate a stronger demand outlet to the south and west in recent years.

It is planned during the coming year to study the economic factors causing a shift from one class of live stock to another in each of the various crop-reporting districts of the state.

Price Trends and Price-making Factors in the Live-stock Industry.--The work has consisted of preparing sets of average price trends for all years and for special groups of years, also of finding economic factors causing diversion from the normal trend. This was done by finding the relation of the price change of one period to the price change of the subsequent periods. This was done for each month of the year for cattle, sheep, and hogs.

A new set of definite cyclical trends for sheep, hogs, and cattle was completed with data for recent years and also since 1860. Most of the studies of individual factors affecting trends show the influence of corn production as a major factor.

The results of this study have been published in part in circular No. 158

entitled "Judging Price Risks in Marketing Cattle." Another manuscript on "Factors Influencing the Time of Buying Feeder Steers and of Selling Them as Choice Summer-fed Steers," is in preparation.

[Project 149; Department of Agricultural Economics. Leader, H. J. Henney ; Purnell fund.]

The Marketing of Kansas Fruits and Vegetables.--The work on this project consists of five phases, each of which is briefly discussed below.

The Present Status of the Fruit and Vegetable Industry in Kansas.--Vegetable production in Kansas is centered in three areas with scattered production in other sections. These areas are (1) the territory around Topeka and Kansas City, including the counties of Shawnee, Leavenworth, Wyandotte, and Johnson; (2) an area in the southeastern corner of the state consisting of the nine southeastern Kansas counties; and (3) the valley of the Arkansas river, including parts of Reno, Sedgwick, Sumner, and Cowley counties.

Car-lot shipments represent a relatively small amount of the vegetable production because of local sales and truck shipments to near-by markets.

Marketing Methods and Practices.--A study has been made of the distribution of Kaw valley potatoes and daily fluctuations in prices during 1931 and 1932 as compared with previous marketing seasons to determine the results of cooperative marketing. The study has shown that as a result of cooperative marketing there have been (1) a wider distribution of Kaw valley potatoes and a development of new markets; (2) fewer shipments to Chicago and other central markets and an increased number of shipments to the smaller cities and towns of the middle western states; (3) smaller daily fluctuations in prices and a narrower margin between Chicago prices and local prices; and (4) less dependence on the Chicago market in determining prices.

Price-making Factors.--It has been found that three major factors determine the price of Kansas potatoes: (1) The total United States production, (2) the production in the early and second early producing states, and (3) the production of potatoes in the Kaw valley. To Kansas producers the production in the early and second early states is the most important price-determining factor, since potatoes from these states come in direct competition with Kansas potatoes. The seasonal level of prices at which the Kansas crop is marketed is established chiefly by the production in these states.

Sources and Character of Competition.—Daily arrivals and unloads of apples at Kansas City and Omaha during the period in which Kansas apples are marketed have been compiled for 3 period of six years. Daily prices of various grades and varieties of Kansas apples, as well as daily prices of apples from competing regions which are sold on the Kansas City and Omaha markets, have also been secured. These data have not been analyzed as yet. A preliminary examination of the figures indicates that the states of the Pacific northwest and Colorado are the principal competitors of Kansas apples.

Seasonal Variations in Production.—During the past year the effect of weather on yield and acreage of potatoes has been studied. This study has shown that—

1. Changes in acreage are responsible for 25 to 30 per cent, of the fluctuation in production, while variations in yield are responsible for 70 to 75 per cent of the fluctuations.
2. Temperature and amount of precipitation at planting time are major factors in determining changes in acreage. The temperature from March 20 to April 10 is more important in determining changes in acreage than is the price or the yield the year before. With the exception of 1929, the years of the highest temperatures during this period have been the years of the largest increase in acreage. Years of low average temperatures during this period have consistently been years of decreased acreage. There is also a marked relation between the amount of snowfall in March and changes in potato acreage.
3. Other factors causing changes in potato acreage in the Kaw valley are:

(1) The price in previous marketing seasons, (2) the yield of the previous year, (3) the value of potatoes during January and February, and (4) the cost of seed potatoes.

4. Yield per acre is determined largely by temperature and rainfall. April and June seem to be more critical months as far as temperature is concerned than is May. Cool weather in June, especially June 1 to 10, is favorable to high yields. The three years of largest yields since 1922 have been years of the lowest maximum temperatures during the period June 1 to 10. The two years of lowest yields were the years of the highest temperatures during the period June 1 to 10.

5. High yields are associated with low precipitation in March and April and high precipitation in May and June.

Data have been collected preparatory to making a study of factors influencing the fluctuations in apple production. These data will be analyzed and studies continued of weather influences upon the production of both apples and potatoes in Kansas.

[Project 177; Department of Agricultural Economics. Leader, George Montgomery; Purnell fund.]

A Study of the Factors Governing the Marketing of Kansas Dairy Products.--This project was started in the spring of 1931. A study was undertaken of organizations marketing dairy products in Kansas, of price-making factors, and of marketing methods and practices of marketing agencies. It was found that there were 2,257 licensed cream-buying stations in Kansas in 1931. There is one cream station in Kansas for each 320 milk cows, and an average of slightly less than three cream stations in each town in Kansas. In 11 counties the average number of cows per station is less than 170, and in nine counties the average amount of butter fat sold (including direct shipment) is less than 10,000 pounds per station.

Seven centralizer creameries own or operate 1,411 stations or approximately two-thirds of the total number. There are 20 centralizer companies which operate more than 25 cream stations each. Approximately one-half the butter-making plants of these 20 stations are located outside of Kansas.

The study also showed that all but two of the local coöperative creameries of Kansas have been promoted by agencies outside the community. The promoted local creameries have sustained heavy operating losses and have failed to render their members efficient economical service. These creameries have been handicapped by (1) limited volume of business, (2) operating policies which encourage unnecessary competition, (3) lack of leadership and coöperative spirit among the members, and (4) inexperienced and inefficient management. On the other hand the two coöperative creameries established by local initiative are soundly organized and well managed. A manuscript, entitled the "Organization and Operation of Coöperative Creameries in Kansas" has been prepared for publication.

[Project 185; Department of Agricultural Economics. Leader, George Montgomery; state fund.]

SOIL CONSERVATION

The problem of soil conservation has continued to receive careful consideration by the Agricultural Experiment Station during the past biennium. No problem is of greater fundamental importance. A brief report of these investigations is given in the following pages.

Soil Fertility Investigations.--The work on this project during

the past biennium has consisted in part of a continuation of the field investigations that have been in progress on the agronomy farm since 1910. A few new phases have been introduced. These are designed to answer certain questions that were not included in the original plan. Some of these new subprojects are essentially field projects, while others require considerable laboratory study.

In 1930 the yields of wheat and oats were good, but corn yields were the lowest since 1926, due to very severe drought during July and the first half of August. In 1931 conditions were exceptionally favorable for wheat and the yields of several of the plots receiving fertilizer produced more than 40 bushels per acre. The plot receiving manure and superphosphate made a yield of 47.15 bushels, testing 61.7 pounds.

Alfalfa has had a pronounced effect on the protein content of wheat. In 1931, wheat on land broken out of alfalfa in the fall in 1929, gave a protein content of 13.35 per cent. Wheat under the same conditions but following brome grass instead of alfalfa gave only 9.15 per cent protein.

In the three-year rotations wheat after soybeans or after corn has given lower average yields during the past two years than wheat continuously. A summer-grown crop reduces the available plant food to such an extent that the wheat following it is at a decided disadvantage.

Soil moisture determinations on alfalfa ground made to a depth of 25 feet have been continued and show that alfalfa dries out the deep subsoil so thoroughly that little or no moisture is available for a following crop. Furthermore, when the alfalfa is broken and the land is used for wheat or corn the subsoil below 10 feet does not readily regain its original moisture content. Thus the deep subsoil in a rotation that has been out of alfalfa for 12 years is practically as dry as that just recently broken out of alfalfa. Two full years of fallow were not sufficient to replenish the original moisture to a depth of 20 feet on old alfalfa land. One season of fallow accumulated some moisture to about 9 feet, but this was removed the next season when the land was seeded to alfalfa.

A continuation of the work started in 1926 on methods of applying fertilizers to wheat, has borne out the previous conclusions, that phosphates applied in the row with the grain are much more elective than when the same amount of fertilizer is applied broadcast. Increases in wheat yields were obtained with superphosphate (16 per cent) up to 250 pounds per acre. Treble superphosphate (43 per cent P₂O₅) gave approximately the same results as superphosphate when the rate of application was such that equal amounts of phosphorus were supplied.

Attempts are being made to use small terraces placed at 18-inch and 24-inch vertical intervals to control erosion on some of the experimental plots. So far the results are fairly satisfactory.

Studies have also been made to determine the effect of the degree of slope on the amount of runoff and erosion. Rapid increases in the amount of runoff have been observed as the slope increases from level land up to about 3 or 4 per cent. The increase in runoff is then very slow and gradual as the slope becomes steeper. The amount of soil eroded increases slowly up to about 4 per cent then more rapidly up to 8 or 10 per cent and then very rapidly as the slope becomes steeper.

A manuscript containing the results of 20 years of soil fertility investigations is ready for publication.

[Project 17; Department of Agronomy. Leader, F. L. Duley; Hatch and state funds.]

Plant Nutrition Investigations.—Two phases of this study have been in progress during the past two years. Each is briefly discussed below.

A study of the Relation of Calcium, Phosphorus, and Nitrogen as Found in

Kansas Soils with These Elements as Found in Second Cutting Alfalfa Hay.--Thirty-two samples of alfalfa were collected from various points in north central and northeastern Kansas. Surface (0-7") and sub-surface (7"-20") soils were taken from the locations where the alfalfa was grown. These samples have been, or will be, analyzed for total and exchangeable calcium, total and available phosphorus and nitrogen. The alfalfa grown on these soils was analyzed for calcium, phosphorus, and nitrogen, together with regular feeding stuffs analysis. While much of the data for this year's work is available, some of the analyses are yet to be completed. From the data available, the following significant facts are disclosed:

1. The total phosphorus content of soils analyzed varied between the following limits: 0.0263 per cent and 0.0716 per cent.
2. The available phosphorus showed an extreme variation between the following limits: 0.0315 per cent and 0.0000592 per cent.
3. There is no apparent correlation between the quantity of available and total phosphorus in these soils.
4. The calcium content of the alfalfa ranged between 1.41 per cent and 2.48 per cent.
5. The phosphorus content of plants varied between 0.149 per cent and 0.314 per cent.
6. It is significant that high phosphorus and low calcium appeared in plants grown on soil high in available phosphorus.
7. The sample of alfalfa with highest percentage calcium, 2.48 per cent, grew on soil with the highest calcium carbonate content.

The Effect of Lime, Superphosphate, and Potash on Reaction of Soil and Growth and Composition of Alfalfa.--A complete report of this study has been published in the Journal of the American Society of Agronomy, Vol. 23, No. 10, October, 1931.

[Project 152; Departments of Chemistry and Agronomy. Leaders, W. L. Latshaw and M. C. Sewell; state fund.]

The Influence of Legumes and Free-living Nitrogen-fixing Organisms on the Growth of Plants and on the Nitrogen Balance.--A portion of the work the past biennium has consisted of a continuation of the 52 tenth-acre plots at the agronomy farm as previously reported.

The yield data for oats and wheat thus far obtained indicate the superior value of one year sweet clover; as compared to one year soybeans as a soil improvement crop as shown in Table I.

TABLE I.-YIELD OF OATS AND WHEAT FOLLOWING ONE YEAR SOYBEANS AND ONE YEAR SWEET CLOVER.

TREATMENT.	Oats.		Wheat.	
	1931.	Average, 1927-1931.	1931.	Average, 1927-1931.
One year soybeans	44.50	35.24	24.75	26.54
One year sweet clover	52.10	43.78	27.20	28.93
No legume or soil treatment	32.08	26.84	14.7	16.48

The yields of corn, oats, and wheat have been approximately the same where these crops follow two years of alfalfa or two years of sweet clover. This indicates that when these two legumes are kept on the soil for the same length of time, they are about equal in soil improving value. Inoculation with

Azotobacter has not increased the yield of crops even though the soil conditions have been made favorable for their development, by the addition of lime.

A second phase of the work has consisted of greenhouse investigations. By using very acid soils the effect of various soil treatments on the growth and inoculation of alfalfa has been studied. The treatments consisted of the addition of varying amounts of CaCO_3 and fertilizer elements in different combinations. As a result of this work the following observations have been made:

1. In strongly acid soils phosphorus encouraged the formation of a few large clusters of nodules while a medium amount of calcium caused the formation of a relatively large number of small nodules.
2. Large amounts of calcium alone depressed the development of alfalfa. The plants growing under these conditions, showed a characteristic small and discolored leaf development.
3. Calcium alone did not cause nodule development.

[Project 172; Departments of Agronomy and Bacteriology. Leaders, H. E. Myers, M. C. Swell, and P. L. Gainey; Purnell fund.]

The Influence of the Absolute Reaction of the Soil Solution Upon the Growth and Activity of Azotobacter.--The cylinder experiments started in 1923 and previously reported have been continued. In 1930 and 1931 the cylinders were grown to oats and they are in oats at the present time (1932). No significant differences in the growth of oats have been observed between the inoculated and uninoculated cylinders.

The major activity pursued during the biennium has been a study of the spotted condition so commonly observed in wheat fields of central and eastern Kansas. Thus far extensive comparisons have been made with special reference to nitrogen, and biological differences existing in soil taken from such spots and from the immediately adjacent areas and the quantitative and qualitative differences in the plant growth on such areas compared with the immediately adjacent areas.

From these comparisons it is evident that the soil of the spots is supplying much more available nitrogen than the surrounding soil, for even though the growing plants remove 4.7 times as much nitrogen from the soil of the spot, this soil still contains 3.6 times as much NO_3 . Furthermore, it was found to be capable of continuing to accumulate NO_3 3.6 times as rapidly. This increased ability to supply available nitrogen is not due to differences in the nitrifying organisms, for when organic nitrogen was supplied the accumulation was just as rapid in the area surrounding these spots as in the spots themselves. The soil taken from the spots contained an average of 230 pounds per acre (2,000,000 lbs.) more nitrogen than did the soil from surrounding areas, and when a correlation between this excess nitrogen and the soil's ability to accumulate NO_3 was calculated, the coefficient was found to be 0.5+ and 0.8+ for the two years for which data were available, indicating that the ability of the soil from the spots to supply more available nitrogen was tied up closely with this 230 pounds of additional nitrogen.

Spots identical in every respect have been produced by the application of various forms of nitrogen, including sodium nitrate, urea, ammonium phosphate, ammonium sulphate, calcium cyanamide, and urine. It is believed that the spots are produced by a limited quantity of nitrogen, either in an available form or capable of being readily transformed into such a condition, finding its way into the soil, and that in most instances the origin of such nitrogen is the urine of grazing animals.

Studies of the influence of increased quantities of available nitrogen upon the nitrogen fixing (Azotobacter) flora have been pursued the past two years in connection with the studies of spotted wheat fields, but the data available warrant no conclusions being drawn.

[Project 128; Department of Bacteriology. Leader, P. L. Gainey; Adams and state funds.]

A Study of the Soil Solution as Governed by Ion Concentration.--Work done during the two years has consisted of: (1) a detailed study of the effect of various ions adsorbed by the soil on soil acidity, especially the acidity determined by the quinhydrone electrode; (2) a study of the quinhydrone electrode as used to determine soil acidity with especial reference to the drifting potential; and (3) a study of methods used in extracting exchangeable bases from the soil.

The effect of adsorbed base on soil acidity as determined by the quinhydrone electrode was determined by working with six soils obtained from southeastern and central Kansas. The more active portions of the soil were separated and individual portions were saturated with H, Na, K, NH₄, Ca, Mg, Fe, and Al by double exchange with the chloride of the base. The effect of dilution as the pH was recorded and other results are summarized in Table II.

TABLE II.--THE PH VALUES OF SOILS TREATED WITH VARIOUS BASES (a).

SOIL WATER RATIO.	Base soil water treated with--							
	H ⁺	Fe ⁺⁺⁺	Al ⁺⁺⁺	NH ₄ ⁺	Mg ⁺⁺	Ca ⁺⁺	K ⁺	Na ⁺
1:1.....	3.06	3.10	4.19	5.50	6.20	6.42	6.74	6.82
1:2.5.....	3.32	3.36	4.36	5.81	6.47	6.69	6.97	7.04
1:10.....	3.39	3.38	4.34	6.36	6.75	7.00	7.54	7.80
1:100.....	3.75	3.59	4.72	6.66	6.69	7.01	7.71	7.92

(a) Each figure in this table is an average obtained from six soils.

It is seen that regardless of the base adsorbed by the soil the effect of dilution is similar in that it tends to increase alkalinity. It is considered that a dilution of 1:2.5 is satisfactory for making pH determinations. A smaller amount of water with many soils gives a viscous paste that is hard to bring into intimate contact with the electrode and a larger amount of water departs further from natural soil conditions.

Work was also done to help determine the reliability of the pH value of the soil as determined by the quinhydrone electrode. The drift of potential was studied on moist and dried soils saturated with various bases at four soil water ratios. The results indicated that adsorbed base has little or no effect on potential drift. The amount of water contained by a soil apparently influences the drift, the moist soils having a greater drift than the dry soils. The drift varies with dilution, the greater the dilution, the greater the drift.

A study was made of the methods used in extracting exchangeable bases from soils. A simplified method was devised which depends upon the use of acetic acid and a soxhlet detractor. It is recommended in using this method that 25 grams of soil be extracted by 250 c.c. of 5 normal acetic acid for 24 hours. The extraction to proceed at such a rate that 50 c.c. of condensate would be collected every 15 minutes.

[Project 155; Department of Chemistry. Leader, A. T. Perkins; state funds.]

A Study of Replaceable Cations and Anions in Some Kansas Soils.--The work done during the biennium has consisted of a de-

tailed study of the effect of various fertilizers on the solubility of phosphorus in Cherokee silt loam soil. Samples of Cherokee silt loam which had been saturated with H, Na, K, NH_4 , Ca, Mg, Fe, Al, and an untreated portion were tested in this way. The untreated Cherokee silt loam and that whose base exchange capacity was saturated with H, Na, K, NH_4 , Ca, Mg, Fe, Al were treated with calcium carbonate, monobasic calcium phosphate, and potassium chloride on a triangulation basis. The water soluble phosphate was determined and the results indicated that the adsorbed base had a very great effect on the solubility of the phosphate.

The Cherokee silt loam saturated with the various bases was treated with varying amounts of CaCO_3 , $\text{CaH}_4(\text{PO}_4)_2$, CaCl_2 , and KCl. The effect of these salts upon phosphorus solubility may be summarized as follows:

1. The soluble phosphorus of the soil is increased by replacing the adsorbed bases by K or NH_4 .
2. When phosphorus is applied as $\text{CaH}_4(\text{PO}_4)_2$ the Fe and Al soils precipitate large amounts of phosphorus; the H, Mg, Ca soils intermediate amounts; and the K and NH_4 soils small amounts.
3. In acid soils, with similar pH values, less phosphorus will be precipitated on the application of phosphatic fertilizers when the acidity is caused by absorbed hydrogen rather than by the hydrolysis.
4. CaCO_3 applications increase the soluble phosphorus in the Fe, Al, and Mg soils, but decrease it in the H, Ca, NH_4 , and K soils.
5. Phosphorus solubility is increased by lime on soils made acid by absorbed Fe or Al, but, is decreased on soils made acid by absorbed H.
6. The increased phosphorus solubility resulting from lime is attributed to the reaction rather than to the calcium, since applications of CaCl_2 failed to increase the solubility.
7. The solubility of the phosphorus in a soil is not affected by the application of KCl, regardless of the base held by the soil.

[Project 179; Department of Chemistry. Leader, H. H. King; Purnell fund.]

Soil and Crop Experiment Fields.--Three groups of crop and soil experiment fields were in operation at the close of the biennium. The work of each group is briefly described below.

Southeastern Kansas Experiment Fields.--The work on these fields, established in 1923, has consisted of a continuation of crop rotation and soil fertility studies; variety tests of alfalfa, soybeans, corn, sorghums, wheat, oats, flax, and grasses; and studies of different methods of seed bed preparation for flax. Because of a reduction in the funds available for this work it was necessary to discontinue the Rest field on January 1, 1932.

Experiments conducted on these fields have demonstrated that alfalfa can be grown successfully on the more extensive soil types of southeastern Kansas when proper soil and cultural methods are used. The results of various soil treatments for alfalfa at each of the five fields are given in Table III.

Since most of the soils of southeastern Kansas are too acid to grow sweet clover without the use of lime, and because of the relatively high cost of liming at the usual rate of 2 tons per acre, experiments were started to determine whether smaller quantities of lime might be effective. Varying amounts of finely crushed limestone were drilled in the row with the sweet clover seed. Stand counts and observations indicated that sweet clover will make a satisfactory growth when approximately 300 pounds of finely ground limestone is applied in this manner. Similar studies are being conducted on several other fields.

TABLE III.-EFFECT OF SOIL TREATMENTS ON YIELDS OF ALFALFA.
Southeastern Kansas experiment fields.

TREATMENTS.	Average yields in tons per acre.				
	Moran.	Rest.	Parsons.	Columbus.	Fort Scott.
	Average of 7 years.	Average of 7 years.	Average of 6 years.	Average of 5 years.	Average of 4 years.
No treatment.....	1.23	1.47	0.89	0.72	1.33
Lime.....	2.00	1.67	1.52	1.92	1.58
Lime and superphosphate.....	2.50	2.26	1.92	2.20	2.06
Lime and manure.....	2.55	2.23	2.24	2.38	2.03
Lime, manure, and superphosphate..	3.22	2.72	2.68	2.36	2.76
Lime, manure, and rock phosphate...	3.15	2.66	2.44	2.52	3.45

Much interest has been manifested in the production of flax in southeastern Kansas during the last few years. Studies have been made to determine the best varieties of flax to grow and the best methods of seed-bed preparation for the crop. It has been found that the most practical method of increasing the yield of flax was by the preparation of a proper seed bed. Studies started in 1930 with the first yields secured in 1931 have been most productive. The results of these studies at the Columbus field are given in Table IV.

TABLE IV.- SEED-BED PREPARATION AND YIELDS OF FLAX SEED.
Columbus field.

CROPPING FOR 1930.	Seed-bed preparation for flax.	Yields of flax seed in bushels per acre, 1931.
Soybeans drilled.....	Disked in spring.....	13.17
Soybeans in rows.....	Disked in spring.....	12.09
Corn.....	Disked in spring.....	6.91
Corn.....	Fall plowed.....	9.29
Soybeans in rows.....	Fall plowed.....	12.53
Soybeans drilled.....	Fall plowed.....	11.23
Oats.....	Fall plowed.....	2.80
Oats followed by soybeans for green manure.....	Fall plowed.....	16.85
Oats.....	Plowed in August.....	8.85

Due to a further reduction in funds for the support of these fields work on the Fort Scott field will be discontinued at the end of the crop season of 1932. The experimental work on the three remaining fields, Moran, Parsons, and Columbus, will be continued as in the past, but more emphasis will be placed on the studies related to the growth of sweet clover with light applications of finely ground limestone. [Department of Agronomy; Leaders, R. I. Throckmorton and I. K. Landon; state funds.]

South Central Kansas Experiment Fields.--Three crop and soil experiment fields were located in 1932 in south central Kansas at the following points: Sedgwick field, 35 acres, in coöperation with M. W. Reese, 11 miles east of Wichita (Sedgwick county); Kingman field, 30 acres, in coöperation with Claude Brand, 11 miles south of Kingman (Kingman county); and Pratt field, 25 acres, in coöperation with Frank Schaffer, 2½ miles northwest of Pratt (Pratt county).

The work on these fields will include crop rotations in which different legumes are compared; the use of commercial fertilizer, lime, manure, and green manure; various cultural methods; and variety tests of alfalfa, sweet clover, cowpeas, soybeans, grain sorghums, sweet sorghums, corn, oats, wheat, barley, flax, and pasture crops. On the Pratt field extensive studies will also be made of combine types of grain sorghums. [Department of Agronomy. Leaders, R. I. Throckmorton and C. E. Crews; state fund.]

Northeastern Kansas Experiment Fields.--Four experiment fields were established in northeastern Kansas in 1932 for the purpose of studying problems in fruit production, potato production, the production of general farm crops, and the management of soils. These fields were established as follows: Blair experiment orchard, 10 acres, in coöperation with John Muench, Jr., one-fourth mile west of Blair (Doniphan county); Atchison experiment orchard, 12 acres, in coöperation with Matt Ernsen, 10 miles south of Atchison (Atchison county); Newman potato field, 12 acres, in coöperation with R. Shirley, two and one-half miles southwest of Newman (Jefferson county); McLouth field, 25 acres, in coöperation with J. R. Tullis, 15 miles west of Leavenworth (Leavenworth county).

Experimental work with trees in bearing is being conducted on the Blair orchard. The studies are in soil management, including sod culture with and without commercial fertilizers; clean cultivation with cover crops, with and without commercial fertilizers; and manure and straw mulch treatments. Other experiments will consist of studies of different pruning methods, of fruit thinning, and of the apple curculio, black rot, and the possible cause of the dropping of Jonathan apples the latter part of the season. The effect of various treatments and management methods will be measured of fruit and in the growth of the trees.

The Atchison experiment orchard consists of approximately 10 acres and was planted in the spring of 1932 to Jonathan, Winesap, Richard Delicious, and Grimes Golden apples, and Montmorency and Early Richmond cherries. Soil management investigation to be conducted on the orchard will consist of studies of clean cultivation plus various cover crops, straw mulch, red clover, and different fertilizer treatments. Other studies will deal with the use of different sprays, different pruning methods for both apple and cherry trees, and methods of insect and disease control.

The field on which the potato experiments have been established is typical of the better potato lands of the Kaw valley. The studies on this field consist of the growing of potatoes in various rotations and preceded by various crops. Many different green-manuring crops and commercial fertilizers are being used in comparative studies. Comparisons are made on the effect of size of the seed piece of potatoes, rate of planting, date of planting, and method of cultivation. Intensive studies are being made on problems of preventing and controlling various potato diseases.

The McLouth field, used for the farm crops and soil experimental work, is located on the Shelby series which is one of the more extensive soils of northeastern Kansas. It is also one of the soils requiring careful management for economic crop production. The experiments established on this field consist of different rotations in which corn, oats, alfalfa, sweet clover, and grasses are used. Lime and commercial fertilizers will be used on a part of the land. Considerable work will be done in comparing the different varieties of general farm crops commonly grown in that part of the state. Relatively extensive pasture grass experiments have been established and some work will be done on methods of controlling soil erosion through the use of grasses and crop rotations. [Departments of Agronomy, Horticulture, Botany, and Entomology. Leaders, R. I. Throckmorton, R. J. Barnett, L. E. Melchers. G. A. Dean and T. R. Reitz; state funds.]

INVESTIGATIONS IN THE PLANT INDUSTRIES

The following pages contain a brief summary of some of the work done during the past two years relating to the problems of plant improvement and production.

Field Survey and Herbarium Investigations.--The special features of the biennium included the receipt by donation of three important county collections. A collection of about 650 Saline county plants from John Hancin, of Salina, more than doubles the previously recorded flora of that county. It includes one species not previously known away from the coastal plain. A collection of about 680 Cloud county plants from S. V. Fraser, of Aurora, Kan., almost triples the previously known list of plants in Cloud county. A collection of about 425 Sheridan county plants from Clement Weber much more than doubles the previously recorded flora of that county. The thoroughness of these collections in the counties in question makes them extremely valuable additions to the herbarium. A private collection of about 300 Washington county plants was gone over and the identifications checked. This collection about doubles the previously recorded plants for Washington county. Smaller collections were received from a number of other individuals. In all about 1,400 sheets were mounted and added to the herbarium.

[Project 137; Department of Botany. Leader, F. C. Gates; state fund.]

Drought Resistance of Plants.--During the past 20 years the major work of this project has been a study of the physiological relationships of drought resistance, although some time has been devoted to investigations of general plant physiological problems. Due mainly to the fact that suitable land is no longer available near at hand for this type of work it has been considered advisable to close this study and to undertake work in which plants could be grown in a more limited space.

Hence the main work during the past biennium has been directed toward (1) the closing of the general experiments and (2) the compiling for publication of data which have accumulated.

These data are now being compiled for publication in several technical bulletins or papers and include the following:

1. The number of stomata on crop plants.
2. The relative loss of water from weeds and crop plants.
3. Three years' observations on the rate of growth of the corn plant.
4. The effects of Bordeaux spray on the rate of transpiration.
5. The diurnal variation in the nitrogen content of leaves.

[Project 74; Department of Botany. Leader, E. C. Miller; state fund.]

Temperature Relations of Crop Plants.--The work on temperature relations of crop plants consisted chiefly of studies in resistance of wheat and alfalfa to low temperatures.

The results with artificial refrigeration of wheat were found to correlate well with winter survival under natural conditions, except that very hardy

wheats such as Minhardi are relatively easily killed if exposed to low temperatures in an unhardened condition. Such varieties as Kanred, Turkey, Blackhull, Harvest Queen, Fulcaster, Currell, and others appear to exhibit their true relative resistance to low temperature regardless of whether they are frozen in a hardened or an unhardened condition.

The influence of time of planting and age of plant on resistance was studied for five varieties planted on four dates and one variety planted on 10 dates. The results indicate that wheat planted the last of September or first of October is more resistant to low temperature than is wheat planted either earlier or later. This may afford some explanation as to why that period is ordinarily the most satisfactory time for seeding wheat in this section. The varieties arranged from most hardy to least hardy were in the following order for each date of planting: Minhardi; Minturki; Kanred; Prelude X Kanred. Kansas 2628; and Blackhull. Greatest resistance was attained for the October 3 date of planting by all of the varieties except Blackhull, which was slightly more resistant when planted October 14. In general the plants exhibited more resistance when 7 to 12 weeks of age than when either younger or older.

The differences in hardiness among varieties as well as among plants of different ages were similar but less pronounced for plants grown continuously in the greenhouse as compared to those hardened to outdoor conditions during the fall and winter.

Artificial freezing of alfalfa indicated a high degree of cold resistance for Province (F. C. I. 34886), which has been named Kaw. It was equally as hardy as Hardistan, slightly more so than Grimm and Ladak, and considerably more resistant than Common alfalfa from Dakota, Nebraska, Colorado, Kansas, Utah, and Idaho.

Studies were continued, having as their objective the determination of the role of winter hardiness in the distribution of crop plants. Evidence was secured supporting the belief that it plays an important part in limiting the distribution of many varieties of winter wheat and alfalfa.

Preliminary studies of seed production in alfalfa under controlled high temperatures were begun but results are not yet available.

[Project 157; Department of Agronomy. Leaders, H. H. Laude and S. C. Salmon; Purnell fund.]

Small Grain and Sorghum Improvement.--Improvement work with wheat for the past biennium has consisted principally in the selection and testing of hybrid material for winter hardiness, quality, and yield.

A large number of lines of three backcrosses, Tenmarq X Kanred, Kanmarq X Kanred, and Kanred X (Kanred X Marquis, Kansas No. 443), have been grown at Colby, Moccasin, Mont., Redfield, S. Dak., St. Paul, Minn., and Manhattan, for winter-hardiness studies in coöperation with the United States Department of Agriculture. Several lines of the Kanred X (Kanred X Marquis, Kansas No. 443) are more winter hardy than Kanred. Lines of all three of these backcrosses show promise of producing wheats of high quality that are sufficiently winter hardy for this area and mature early.

Tenmarq, a cross of a Crimean hard red winter wheat and Marquis, has been approved for distribution in the hard winter wheat belt of central and southern Kansas, and is being increased for distribution this fall.

Kawvale, a semi-hard pedigree selection, relatively resistant to leaf rust and Hessian fly, was approved and increased for distribution in southeastern Kansas in 1931.

Hybrid material in the F_2 to F_3 generations is being carefully studied. In this hybrid material are crosses for stiff straw, Hessian fly resistance, rust resistance, winter hardiness, improved milling and baking quality, shattering in Kawvale, and earliness.

As in wheat, oat improvement is shifting from testing of varietal selections to hybrid selections. Kanota continues to do well on Kansas farms, but needs

improvement regarding (1) stiffness of straw, (2) resistance to smut, (3) ability to yield well from medium-late planting, and (4) appearance of off-types. Pedigree selections have failed to correct the faults of Kanota. Accordingly, hybrids with Richland, Markton, Green Russian, Burt, Kansas No. 5211-22, and Early Red Texas, Kansas No. 5213-7, which have been made in the hope of correcting these faults are being carefully studied. Several selections involving Richland and Markton are promising.

The barley nursery at Manhattan has been discontinued, but uniform nurseries are being grown at the Hays and Colby branch stations. Flynn, a promising smooth-awned type, and Vaughn, an early, high-yielding, short stiff-strawed type, are being increased for distribution to farmers in the barley-growing sections of western Kansas.

The sorghum nursery at Manhattan includes (1) selections of crosses of kafir X milo and other varieties to produce new types of grain sorghums suitable for combine harvesting, (2) selections of strains from a cross, Kansas Orange X Dwarf Yellow milo (relatively resistant to chinch bugs), and (3) standard varieties.

Atlas continues to be a popular dual-purpose (forage and grain) variety for eastern Kansas.

Selections of Atlas X Early Sumac and Atlas X White African are being made with the expectation of getting earlier types adapted to central and western Kansas.

[Project 67; Department of Agronomy. Leaders, J. H. Parker and W.H. Van Trebra; Hatch fund.]

Inheritance of Factors Affecting Quality of Wheat.--Protein determinations were made of 446 selections of wheat in 1930 and 410 in 1931. These studies were of distinct value in discarding the low protein selections from any group of reselections in the plant-breeding nursery. High protein selections are then retained for more critical agronomic and quality studies.

Milling and baking tests were made of 25 selections of wheat in 1930 and 53 in 1931. In addition to the protein determinations and milling and baking tests, some preliminary studies were made on gluten quality of a few well-known varieties such as Kanred, Tamarq, and Blackhull.

These studies indicate that the Pelshenke or some other simple method may be used to determine a reliable index of quality on small samples such as are available from F₂ to F₃ generations. Since the tests are still in experimental stages, it is too soon to state the reliability of the test.

[Project 178; Departments of Agronomy and Milling Industry. Leaders, J. H. Parker and C. O. Swanson; Purnell fund.]

Sorghum Varietal Tests.--Sorghum variety tests were continued in about the same way as in former years. Club kafir and Yellow kafir, two new varieties developed at the Fort Hays Experiment Station, are of special interest. They seemed well adapted and made intermediate yields in 1930.

In 1931 they made unusually high yields, outyielding Blackhull, the standard variety in this locality, and Darso, which has made the highest average yield for a 13-year period. Club kafir yielded more than any other variety in 1931, averaging 90.6 bushels, as compared to 79.7 for Darso and 77.0 for Blackhull. Yellow kafir yielded 82.0 bushels. Attention was given to the significance of tillering in relation to yield. Darso and Blackhull tillered very little and produced more than 90 per cent of their yield on the main heads, while 68.9 per cent of the total yield of Club kafir and 68.0 per cent of the yield of yellow kafir were produced by the main heads. Although tillering was an important factor in determining the yields of the highest yielding varieties tested, it did

not hold that low yield and tillering were not also associated in some varieties. It is possible, however, that in those cases other factors were responsible for the low yields.

Atlas maintained its good record for resistance to lodging and has averaged 9 tons of dry forage over a period of six years as compared to 9.2 for Kansas Orange.

[Project 129-1; Department of Agronomy. Leader, H. H. Laude; Hatch fund.]

Small Grain Varietal Tests.—As in past years attention was given in the varietal tests of wheat to the development of an early-maturing variety of winter wheat that will be equal in other respects to later varieties. The results last year as well as in several previous seasons indicate that yields equal or superior to those produced by Kanred or Turkey may be obtained from varieties that ripen from one to several days earlier than those varieties. The extent to which the date of ripening may be advanced to advantage is being studied. It apparently may be limited by injury due to late spring freezes and by reduction in yield due to shortening the growth period. As an illustration of the former, early varieties of wheat which had reached the heading stage were severely injured by temperatures of 29 degrees Fahrenheit in May, 1931, on the Colby station and at other places in western Kansas.

Tenmarq for the last 8 years during which it has been tested has outyielded Kanred an average of 4.8 bushels and Blackhull 3.7 bushels. In 1930 it outyielded Kanred 5.3 bushels and Blackhull 6.1 bushels. In 1931 it yielded 0.3 of a bushel more and 0.1 of a bushel less respectively than those varieties. Tenmarq is characterized by moderately stiff straw and resistance to lodging, moderate resistance to leaf rust and extreme susceptibility to Hessian fly. It is slightly more winter hardy than Blackhull but is less hardy than Turkey and Kanred. Two small fields of Tenmarq were grown in 1932 with the expectation of placing pure seed with a few farmers whose fields will serve as the initial sources of certified seed for distribution in south central Kansas. Kawvale, a new variety resistant to Hessian fly and leaf rust, continued its good record and was distributed to farmers in southeastern Kansas in the fall of 1931.

The work with spring small grains included variety tests of oats, barley, and flax. One variety of spring wheat was grown for comparison with other crops. Kanota outyielded other varieties of oats as it has done consistently over 3 period of 15 years. During that time it has averaged 5.9 bushels more than Red Texas, 6.8 more than Burt, and 10 bushels more than Kherson. Varieties of barley were injured by chinch bugs and diseases which seem to be the limiting factors for the success of this crop. However, Flynn, the best variety in 1930, yielded 51.1 bushels. The average yield for the biennium was 43.4 bushels as compared to 42.6 bushels for Vaughn. Over a 13-year period barley has made 21.1 bushels as compared to 46.7 bushels for Kanota oats. In the flax variety tests Linota made the highest yield, averaging 13.7 bushels, followed closely by Winona.

[Project 129-2; Department of Agronomy. Leader, H. H. Laude; Hatch fund.]

Soybean Production Tests.—Relatively more attention was given during the biennium to selection and cultural work and fewer varieties were grown. Twenty-five selections were grown in 1931 and sixty additional selections were made from the A.K. and Hong-kong varieties and planted in 1932. Cultural tests included method and rate of planting. Four rates of planting in 38-inch rows and

six rates with the grain drill were used and yields of hay and seed obtained. Planting in rows spaced 19 inches apart with the corn planter was discontinued on account of difficulty of cultivation and inability of the crop to compete with weeds.

The varieties which have produced the highest yields of seed in bushels per acre in 1930 and 1931 were Austin 29.1, Illini 28.7, Hongkong 28.4, Pinpu 28.4, A.K. 27.8, I.P. No. 6 27.7. In hay production, Laredo, Chiquita, Hongkong, A.K., and I.P. No. 6 ranked in the order named with yields ranging from 2.78 tons to 2.27 tons per acre. Lodging in I.P. selection No. 6 has averaged 16 per cent over a three-year period as compared with 70 per cent in A.K. There has been no significant difference in yield of the selection and of the parent variety. Laredo consistently yields more hay than any other variety grown but its habit of lodging is a serious disadvantage.

In the rate of planting tests no consistent difference in yield was obtained with rates of 58, 70, 86, 102, and 116 pounds per acre. The quality of hay was much better in the higher rates of planting due to fewer weeds and finer stems of the soybean plants.

Determinations of the relation of stage of harvesting and protein content were made. Analysis showed a higher protein content when the pods are forming than at later stages, the range being from 21.2 in the earlier stage to 18.6 when the pods were half filled with seed.

Three new varieties and sixty new selections have been added to the plantings in 1932 and the number of older varieties reduced to eleven. Tests have been started to determine the effect of date of planting on lodging and yield of Laredo. Sudan planted with soybeans for hay is also being tried.

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

Miscellaneous Legumes for Forage.--Different species and varieties of clovers, vetches, sainfoin, crotalaria, sweet clover, lespedeza, and the nonlegumes Pyrethrum and Ephedra, were grown during the last biennium. The work with lespedeza was transferred to the pasture improvement project at the close of the 1930 season.

Tests of sweet clover varieties have comprised a large part of the work since the spring of 1931. Twenty-five varieties from the United States Department of Agriculture and three from Canada were planted in 1931. Duplicate plantings were made in 1932 and several varieties added. A half dozen of these appear to be promising and are superior to the biennial white variety commonly grown in Kansas, especially in quality of forage and resistance to frost, in the fall. Several of these varieties produced a heavier yield than the common biennial white, the forage was more leafy and the stems were finer. On December 16, after 21 days of minimum temperature ranging from 32 degrees to as low as 18 degrees F., two varieties had only 15 per cent dead foliage compared with 96 per cent on the common white variety.

Preliminary tests of two species of Crotalaria made in 1931 indicated that this plant may have some value as an annual green-manure crop. Five species of this crop were planted in 1932 along with Florida beggarweed and soybeans for comparison.

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

Corn Production and Improvement.--This project, coöperating with the Division of Cereal Crops and Diseases, Bureau of Plant Industry, United States Department of Agriculture, has been continued during the past two years along lines similar to those reported in the past. During the two unfavorable corn years of this bienn-

nium, the very late dates of planting produced the highest yields. This relation is contrary to past experience and was due to unusual weather conditions so that the late plantings silked in August after rains had relieved the severe drought of July when the earlier plantings were in flower. As is frequently the case, however, the corn in the late plantings was badly down at harvest time.

A new series of single crosses between 60 inbred lines from Pride of Saline was grown in 1930 and again in 1931. A number of the parental lines show considerable promise for the production of outstanding hybrids. In a number of instances the hybrids yielded over twice as much as the adjacent checks under the unfavorable seasonal conditions of the two years. Double crosses and three-way crosses from the most promising selfed lines are being made and tested as rapidly as possible.

Another series of single crosses between inbred lines from early western Kansas varieties was grown for the first time in 1931. At Manhattan the yields of the hybrids ranged from 66 to 160 per cent of the average yields of the adjacent checks (Freed White Dent). At the Colby substation the yields of the hybrids ranged from 62 to 230 per cent of the average yields of the adjacent checks (Colby Bloody Butcher). In addition, some of the hybrids had pronounced characteristics of smut resistance, erect stalks, and high quality ears. Yield tests are being repeated and double crosses involving the more promising combinations are being made.

The new selection of pop corn, previously reported, continues to rank first in popping expansion among all varieties tested. It appears doubtful whether mass selection or ear-to-row selection will be effective much further to improve the popping expansion of this strain. A number of hybrids between inbred lines from this selection have been made and will be tested in 1932.

Repeated tests have shown that under Kansas conditions little increase in the per cent of field germination of corn is obtained by the various advertised dust seed treatments. On the average, no measurable difference was found in the vigor or rate of growth of seedlings from treated and untreated seed.

A chemical study has shown that the stalks and leaves of corn prevented from setting ears contain more protein and carbohydrates than ordinary stover. This indicates that in years when hot winds at silking time greatly reduce the grain yield, the stover contains more nutrients than usual, and consequently is particularly desirable as roughage.

[Project 156; Department of Agronomy. Leader, A. M. Brunson; Purnell funds.]

Alfalfa Investigations in Relation to Winter Hardiness and Bacterial Wilt.--This work, conducted in coöperation with the Division of Forage Crops and Diseases, Bureau of Plant Industry, United States Department of Agriculture, has been continued along the lines previously reported. A total of 431 square rod plots of alfalfa seeded over a period of five years are being grown. The best stands have been maintained by Turkestan 2674 with 86 per cent stand, Ladak with 76 per cent stand, Dakota No. 12 with 59 per cent stand, and Kansas Common with 55 per cent stand. Turkestan 2674 has shown less wilt than any other variety, with Ladak second. Although Dakato No. 12 and Kansas Common show only slightly better than half a stand, they are outstanding in that all other varieties except the two mentioned above are much poorer.

In the fall of 1930 larger duplicate plots were seeded on upland and bottom-land fields, both of which previously had grown alfalfa that had been killed

out by wilt. Perfect stands were secured on all plots. The yields the first year were exceptionally good. The outstanding variety was Ladak, which made especially good yields the first cutting. The yield of this cutting was sufficiently high to bring the total yield for the variety higher than any other on the upland field and into second place on the bottom-land field. A strain of Kansas Common, seed of which was secured from a farm near Lawrence, ranked first on the bottom-land field.

The high yield made by Ladak suggests a possibility that some varieties may be better adapted than others for reseeding on old alfalfa fields where the subsoil moisture has been depleted, making it necessary for the crop to depend on current rainfall. Ladak produced 68 per cent of its total yield the first cutting, while Kansas Common produced but 52 per cent. Theoretically, the average rainfall in the spring is enough to produce more than 2-ton yields of alfalfa the first cutting. Ladak was the only variety capable of utilizing that amount of moisture. From this standpoint Ladak has possibilities for planting on old alfalfa ground where the subsoil moisture is exhausted and the crop must depend largely on current rainfall.

Selfed seed from approximately 450 plants of two strains of wilt-resistant alfalfa has been gathered. The seedlings from this seed will be subjected to wilt and cold tests for the elimination of the more susceptible plants. The resistant ones will be increased and developed by crossing and selecting.

Outstanding new strains being developed are Turkestan 2674, Kansas 231, Kansas 308, and Kaw. Plantings of these strains are being made at the Garden City branch station for seed production purposes under conditions where the crop can be irrigated.

Studies have been continued of the effect of the winter protection afforded by leaving uncut the late fall growth of alfalfa. The protection thus afforded has resulted in less winter killing, less wilt, and increased yields the following spring. It is evident from the treatments given these plots that the last cutting of alfalfa should be taken off sometime in September, depending on the season. At this station, September 15 probably should be the latest date. By cutting not later than this date there will be approximately 8 inches of good green succulent growth on the field during the fall dormant period. This will allow the plants to build up their root reserves and will afford a good covering for winter protection.

[Project 183; Department of Agronomy. Leader, C. O. Grandfield; Purnell fund.]

Pasture Improvement Investigations.--Eight phases of this project have been active during the past two years, each of which is briefly discussed below.

Management of Live Stock on Native Bluestem Pastures.--This investigation has been continued as previously reported. As an average of 13 years the grazing capacity of the deferred pastures has been 3.43 acres per head while in the season-long pasture it has been 4.93 acres per head.

During the past two seasons the deferred pasture produced a gain of 109.3 pounds per acre while the pastures grazed season long produced but 44.18 pounds of gain per acre. The average gain per animal unit per day in the deferred pasture was 1.95 pounds and 1.70 pounds for the season-long pasture. A study of the vegetation shows the deferred pastures to have a little less brush and weeds and equally as much grass.

Effect of Burning on Bluestem Pastures.--Burning was done at four periods on two types of pasture to determine its effect on the yield and succession of vegetation, on the time growth starts in the spring, on weed and brush growth, and on the fertility of the soil. Late-spring burning was found to reduce the density of the vegetation. It was also detrimental to the bunch grasses, such as little bluestem, resulting in a succession to big bluestem and Indian grass. Burning had no effect in controlling weeds or brush unless it was done in the late spring, after approximately April 20. Counts made of the vegetation on each of the experimental areas at monthly periods showed that burning promoted earlier growth in the spring.

Eradication of Undesirable Plants from Pasture Lands.--Experiments have been conducted to determine the effect of various methods and time of cutting in the eradication of buckbrush (*Symphoricarpos racemosus*); sumac (*Rhus glabra*); ironweed (*Vernonia baldwini*); vervain (*Verbena stricta*); stiff leafed golden rod (*Solidago rigida*); rockweed (*Helianthus orgyalis*); wild alfalfa (*Psorolia tenuifolia*); and ragweed (*Ambrosia psilostachy*).

The cutting experiments have been supplemented with analyses of the food reserves in the roots. The experiments have shown that the most effective time to cut weeds is the time that they have the least amount of reserve food stored in their roots. In nearly all plants studied this has been in the bud stage. The only exceptions have been buckbrush and rockweed, which in both plants has been a month ahead of flowering.

Effect of Different Frequencies and Heights of Clipping on the Yield, Vigor, and Quality of Pasture Vegetation.--In this investigation various clipping frequencies and heights are used to imitate different systems and intensities of grazing. It has been found that the vigor and yield of the vegetation varied inversely with the frequency and height of the clipping. The quality of the vegetation was highest on the plots cut most frequently. The vegetation on the plots cut most frequently is changing from bluestems to short grasses (grama-buffalo) on the ridge tops, while on the slopes it is changing mainly to prostrate weeds and annual grasses.

Effect of Fertilizers on the Yield, Vigor, and Succession of the Vegetation on Tame and Native Pastures.--Fertilizers were applied during the past year to two native bluestem pastures and one tame pasture located near Manhattan. In each of these pastures the protein content of the vegetation where NaNO_3 was applied was increased about 13 per cent. The yield of grass has also increased but not sufficiently to make commercial fertilization profitable.

Different fertilizer treatments were applied to brome grass in Washington county in an effort to correct the sod bound condition of the meadow. Nitrate fertilizer was most effective in remedying this condition. Sodium nitrate applied at the rate of 150 pounds per acre increased the seed production from 101 to 270 pounds per acre.

Grass Nursery.--The value of different tame and introduced grasses for pasture when seeded alone and in various mixtures with other grasses, and with one or more legumes, was tested in the grass nursery as in the past. Much work has been done with Korean lespedeza to determine more definitely the portion of the state where it can be profitably produced.

Chemical Determinations of the Nutritive Content of Pasture Plants and the Organic Food Reserves of Desirable and Objectionable Pasture Plants.--During the past two years chemical analyses were made of 93 plants. The samples of roots analyzed showed for most plants a decrease in stored starch and sugar from the time the growth of the plant started until about the bud stage. The only exceptions were rockweed and buckbrush. With these plants the low point in food reserve was reached a month ahead of flowering.

When samples of grass collected at different times in the season were analyzed for nutritive content, the grass which was collected from a grazed bluestem pasture showed a decrease in protein and an increase in crude fiber until about the latter part of August. After this date renewed growth increased the protein, while the crude fiber decreased slightly. On a protected bluestem-grass pasture there was little change in the composition of the grass.

Cooperative Pasture Experiments.--Experiments have been conducted during the past two years on two very much overgrazed pastures in southeastern Kansas to determine methods for their improvement. Four different soil treatments were made with 11 different seedings of grasses and legumes and mixtures of grasses and legumes. Four different fertilizer treatments were tried also.

[Project 96; Departments of Agronomy and Chemistry. Leaders, A. E. Aldous and W. L. Latshaw; Purnell fund.]

Turf and Lawn Grass Experiments.--Nineteen varieties and strains of bent grass have been grown to determine their suitability for use on putting greens for golf courses and for lawns. The Washington, Metropolitan, and Cocoos strain of seaside have all produced good turf for golf greens and can be maintained throughout the eastern one-third or one-half of Kansas. The Cocoos is propagated readily from seed which can now be obtained at fairly reasonable prices. Both Washington and Metropolitan are propagated only by stolons. No variety of bent has been found that is suitable for lawns in this state unless an unusual amount of time and effort can be spent on the lawn.

The best bent grass turf is produced by the use of fertilizers and compost, together with frequent close clipping. Close attention must be given to combating brown patch, a fungus disease, especially during summer and early fall. Chlor-phenol mercury compounds have been found effective in controlling this disease. A minimum of four applications of nitrogenous fertilizers each season is necessary to maintain a good turf of bent grass. Good results have been obtained with ammonium sulphate at the rate of 5 pounds per 1,000 square feet of turf applied in April, May, June, and September. Fertilizers applied during hot weather in July and August are usually undesirable. Compost made by mixing 1 part each of sand and rotted manure to 2 parts silt loam soil should be applied with the fertilizer.

Twenty-seven plots of bluegrass each 10 feet by 10 feet, have been used for tests of different heights of clipping, methods of watering, and fertilizers, in triplicate plots of each. Areas have been cut 7/8 inch, 1 5/8 inches, and 2 3/16 inches high and measured amounts of water applied by three methods: In heavy infrequent applications, frequent light applications, and in applications mainly after showers. In combination with these treatments nitrogen, nitrogen and phosphorus, and complete fertilizers have been used.

Results show that the most economical use of water to maintain a vigorous growth of grass is by medium heavy applications whenever the grass shows signs of needing water. Measured either by density of turf or yield of clippings, nitrogenous fertilizers alone have been equally as good as where phosphorus was added or complete fertilizers used. High clipping is essential to vigor of growth, density of turf, and weed control. Fertilizing and careful watering failed to maintain a good turf or to control weeds on closely clipped plots.

On nine plots cut at each of three heights, counts for crab grass in September, 1931, and dandelions in April, 1932, are shown in Table V.

TABLE V.-EFFECT OF HEIGHT OF CLIPPING BLUEGRASS ON CRABGRASS AND DANDELIONS.

HEIGHT OF CLIPPING.	Average number of weeds per plot.	
	Crabgrass September, 1931.	Dandelion April, 1932.
<i>Inches.</i>		
2 3/16.....	23	Trace
1 5/8.....	45	2.6
7/8	204	31.0

Studies of lawns in and around Manhattan, as well as results of these experiments, show that by high clipping and proper fertilizing and with very little hand weeding it is possible to maintain practically weedless bluegrass lawns.

This project will be discontinued at the end of the summer of 1932, at which time results of the work will be submitted for publication as a station bulletin.

[Project 167; Department of Agronomy. Leader, J. W. Zahnley; state fund.]

Weed Eradication with Chemical Sprays.--During the biennium the use of chemical sprays has been studied for the eradication of bindweed (*Convolvulus arvensis*), Johnson grass (*Sorghum halepense*), and narrow-leaf plantain (*Plantago lanceolata*).

Eradication of Bindweed.--In 1930 applications of sodium chlorate were made beginning July 1, August 1, and September 1, using different rates and number of applications. Several commercial preparations were tried in comparison with sodium chlorate. Roots were collected from plots at intervals of two weeks throughout the years 1929 and 1930. In 1931 plans were made to continue the work of 1930, but beginning July 15 and giving particular attention to the growth at time of application. Extreme drought in July and early August forced the bindweed into a dormant condition and it was considered advisable to delay treatment until a satisfactory return growth had been made.

The work during this year consisted of two applications of 200 pounds per acre compared with the three applications as usually recommended. The applications of 200 pounds per acre were made on duplicate plots for one of which the acidity of the spray solution was adjusted to a pH value slightly on the acid side. One plot was treated with three applications of perchlorate. One plot received a single application of 300 pounds sodium chlorate, October 16.

Results of root analysis show that there was a definite increase in the stored plant food until about June 15, which is a short time after full bloom. This increase for 1929-'30 amounted to 75 to 100 per cent over the amount of stored food in the roots May 1. This is followed by a gradual decrease in reserve which reached a low point in 1929 on August 3. From this date there was an increase until the end of the growing season. During 1930 the quantity of stored food decreased rapidly after June 15. This was followed by an increase during the protracted dry spell of July and August, during which time the plants were in a dormant condition. When new growth started, following rains which came August 13, there was a rapid decrease in stored food which reached a minimum about September 1, at which time there was a luxuriant growth of vines. From this point the reserves increased slowly at first and then rapidly until the end of the growing season. These results indicate that the best time to begin the spray treatment is between August 1 and September 1, depending upon the season and its influence upon growth.

The examination of roots from areas treated with sodium chlorate shows a decided decrease of stored food following the second application of this material. On November 1 the quantity of stored food in the roots of treated plants as compared with the untreated plants is less than 50 per cent of that found in the latter. By March 15 it has dropped to 33 per cent. Indications are that plants with a small amount of stored food in their roots do not have sufficient energy to promote new growth and die as a result.

The results with the several commercial preparations compared with sodium chlorate during 1930 and 1931 show that they are all inferior to sodium chlorate as herbicides even when used in stronger solutions. Sodium perchlorate was tried on one plot for the first time; the reaction from this material is very interesting. While not as vigorous as that from sodium chlorate, the influence is continued over a greater period of time. This material deserves further consideration and study.

Four hundred pounds of sodium chlorate used in two applications of 200 pounds each was as effective as 350 pounds used in three applications. Each

method resulted in killing 100 per cent of the weeds. No advantage was obtained by adjusting the acidity of the spray solution. A single treatment with 300 pounds per acre on October 16 resulted in a fairly satisfactory kill, but a few weeds were left along the edges of the plot, probably because of the difficulty of obtaining as good distribution with a single application as with two or more.

It is of interest to note that plots nearly green with seedlings in April were later found to be entirely free from weeds, because of the latent influence of the sodium chlorate in the surface soil. This fact indicates the undesirability of disturbing the soil on treated areas until the middle of May or later.

Eradication of Johnson Grass.--Plots of Johnson grass treated in 1929 were examined in June, 1932, and the following observations made:

1. An area treated with 150 pounds of sodium chlorate per acre on July 15, when the plants were in head and near the bloom stage, was entirely free from the grass.

2. Plots mowed on June 27 as the plants were beginning to head and the second growth sprayed on July 15 and on July 27, when the growth was 6 to 10 inches and 12 to 16 inches high, respectively, resulted in killing approximately 98 per cent of the plants.

Eradication of Narrow-leaf Plantain.--An effort was made to eradicate narrow-leaf plantain from the blue-grass lawn on the college campus with sodium chlorate during the summer of 1931. An area was selected that had a uniform distribution of plantain over the entire area. Five plots were staked out, one for a check and four to be sprayed with sodium chlorate of different concentrations. The concentrations varied from 1/4 pound to 1 pound of sodium chlorate to the gallon of water, with 1 gallon of the solution applied to an area 10 feet by 10 feet. The first application of the spray mixture was made August 11. A second application of the same strength was applied November 7. The object was to kill the new seedlings which were from 1 inch to 2 1/2 inches tall.

Observations made in the spring of 1932 showed a complete eradication of the plantain where a solution of 1/2 pound or more of sodium chlorate per gallon was used. From these results it appears that 1/2 pound of sodium chlorate plus 1 gallon of water per 100 square feet of blue-grass lawn will eradicate the narrow-leaf plantain without injuring the grass, if two applications of the above mixture are made during the growing season.

[Project 166; Departments of Chemistry, Agronomy, and Horticulture. Leaders, W.L. Latshaw, J.W. Zahnley, and W.F. Pickett; state funds.]

Cooperative Experiments with Farmers.--This work during the biennium included 1,310 tests with the principal crop plants of the state. These tests were conducted in cooperation with farmers in 90 counties of the state. The kind of tests, the number placed, and the number of counties in which they were located, are shown for each year of the biennium in Table VI.

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

1. Pride of Saline outyielded all other varieties of corn in eastern Kansas in 1930, but in 1931 Harmon White gave a yield of 3.5 bushels per acre higher yield than Pride of Saline. Pride of Saline averaged 2.5 bushels more per acre than Reid Yellow Dent in the northeastern section of the state and about the same as Midland in the southeastern section for the two-year period. Freed White and Hays Golden, two very similar varieties with the exception of color, gave the best yields in south central Kansas both years, but Pride of Saline and Harmon White outyielded them in the north central section of the state. In western Kansas, Hays Golden, Freed White, Cassel White, and Colby Bloody Butcher continued to give higher yields than Pride of Saline.

TABLE VI.—COÖPERATIVE TESTS CONDUCTED DURING THE BIENNIUM, 1930-'32.

KIND OF TEST.	Number of tests.		Number of counties.		Total number of tests.
	1930.	1931.	1930.	1931.	
Wheat variety.....	76	76	45	48	152
Wheat soil moisture.....	75	3	10	3	78
Wheat fertility.....	19	42	11	28	61
Wheat date of seeding.....	12	11	8	9	23
Barley variety.....	19	21	16	16	40
Oat variety.....	15	11	15	11	26
Oat fertility.....	7	14	6	9	21
Oat seed treatment.....	8	4	8	3	12
Corn variety.....	84	60	59	49	144
Sorghum variety.....	71	76	49	48	147
Soybean variety.....	31	34	21	26	65
Alfalfa variety.....	86	83	43	47	169
Alfalfa fertility.....	78	65	38	31	143
Sweet clover variety.....	4	6	4	5	10
Sweet clover fertility.....	16	24	9	10	40
Flax variety.....	7	7	7	7	14
Popcorn variety.....	4	7	4	4	11
Pasture crops.....	23	26	18	20	49
Pasture weed control.....	7	7	5	5	14
Miscellaneous.....	44	47	25	23	91

2. Tenmarq gave the highest average yield in the 109 wheat variety tests conducted in the state in 1930 and 1931. In 1930 it averaged 24.7 bushels per acre compared to 23.3 bushels for Turkey, the second highest in yield. In 1931 Tenmarq averaged 1 bushel per acre more than Turkey. A comparison of early, mid-early, and late varieties of wheat in eastern and western Kansas indicates that the early varieties are better adapted to the western part of the state than the eastern.

3. Yellow kafir, a new variety of grain sorghum developed at the Fort Hays branch station, made a higher yield than any of the standard varieties in both 1930 and 1931. Club kafir, a new selection from Dawn now being developed at Hays, gave a better yield than Yellow kafir in eastern Kansas in 1930, and Wheatland, a new combine type sorghum, gave a slightly better yield in northwestern Kansas in 1931. Kansas Orange gave an average yield of 10.8 tons of silage and 19.4 bushels of grain per acre compared to 10.2 tons of silage and 21.4 bushels of grain for Atlas.

4. A. K. soybeans made a higher average grain yield than any other variety in 1930 as well as over a nine-year period.

5. Kanota oats outyielded Red Texas an average of 7.9 bushels in 1930 and 17.2 bushels in 1931. In 241 farm tests over a period of 13 years Kanota has averaged 9.9 bushels more than Red Texas.

6. Flynn barley gave the highest, average yield of all barley varieties in 1930 and 1931. In 30 tests Flynn yielded 29 bushels and Colby 6-row 28.2 bushels.

7. Linota, the highest-yielding variety of flax, gave an average yield of 8.6 bushels per acre as compared with 8 bushels per acre for Southwestern, the lowest-yielding variety in 1930 and 1931.

8. Grimm and Kansas Common have continued to be the most satisfactory varieties of alfalfa for Kansas.

9. Phosphate and nitrate fertilizers sown with wheat on the average did not give a profitable increase.

[Department of Agronomy. Leaders, H. H. Laude and A. L. Clapp; state fund.]

The Influence of the Method of Harvesting and Baling Alfalfa Hay Upon Quality.--During the 1930 season four plots of alfalfa of approximately 4.8 acres each were harvested and cured by different methods. One plot was mowed and raked in the same operation, cured in the windrow, and stored in bulk. Another plot was cured in the swath and stored in bulk. Two other plots were handled similarly to the above but baled. A sweep rake was used to push the hay to a standing field baler.

During the season of 1931 four plots of approximately 4.5 acres each were harvested and cured by two different methods. Two were mowed, raked, loaded, and stored in a hay mow. Two were mowed, raked, and baled, using a sweep rake to push the hay to a standing field baler. A combined windrow pick-up traveling baler was used for a part of one crop. Moisture and quality studies were made. Labor and individual machine costs were recorded.

A study was made of the rate of drying of hay in the field under different weather conditions, and a preliminary study was made of the effect upon the rate of drying of crushing the leaves and stems.

The combined windrow pick-up baler gives promise of developing into a worth-while machine. The machine used during the past year was mechanically defective, however. Crushing the hay during the cutting process hastened the drying and this shortened the time required for curing.

[Project 182; Department of Agricultural Engineering. Leader, F. J. Zink; Purnell fund.]

A Study of the Efficiency of the Combined Harvester-Thresher for Harvesting Grain Sorghums.--During the 1930 harvesting season 11 plots of 5 acres each of grain sorghum of the combine type were harvested with a 12-foot Holt combine at the Fort Hays branch station. The crop was harvested following killing frosts on the dates of December 10, 11, and 12. From these plots approximately 475 bushels of grain averaging 15.9 per cent moisture were stored in a 500-bushel steel tight bin in which were placed electrical resistance-type thermometers. Bin temperatures were recorded at intervals. Mechanical ventilating apparatus was installed in the bin for blowing air through the grain to check heating.

During the 1931 season 13 plots were harvested in the same manner. The harvesting was done November 2 and 3 following a killing frost of October 30. The grain was placed in a ventilated steel bin. The average moisture content was 11.25 per cent.

During 1930 the combine operated efficiently and the tailings losses were low, the maximum being 0.5 per cent. Losses occurring from cut and dropped heads from the cutter bar were recorded as ranging from 8.2 to 23.3 per cent for the different varieties. The grain, having 15.9 per cent moisture when placed in the bins, kept well from December 22, 1930, to April 7, 1931, with temperatures ranging from 33 to 40 degrees F. The grain was thought to be safe for keeping further in storage, but on July 15 the temperature was found to be 132 degrees F. It was thought impractical to force air through the grain after this temperature had been reached. The temperature gradually declined to 97 degrees F. on November 1. About 400 of the 475 bushels were suitable for feed and were used as such.

During the fall of 1931 the tailings losses were again low. The crop was extremely short, necessitating leaving a stubble as low as 10 inches. When cutting in this low position a small loss occurred from heads sliding off the platform. Grain breakage was more severe during 1931 and ranged from a minimum of 6.7 to a maximum of 15.2 per cent for the different varieties. During the next biennium a special header is to be used that will drop the cut heads on a stubble base. The combine pick-up will be used for harvesting and by this means avoid delays in waiting for killing frosts to dry out the grain.

[Project 181; Department of Agricultural Engineering. Leader, F. J. Zink Purnell fund.]

A Study of the Effect of the Method of Storing Combined Wheat Upon Quality.--Three years of work upon this project have been completed. In 1929 the emphasis was on the type of bin, and 11 bins were used. The materials used in building were concrete, wood, steel, and the individual bins differed in construction. Ventilators were used in some of the steel bins. In 1930 the emphasis was on natural methods of ventilation and five steel bins were used. The types of ventilation used were: (1) Perforated floor with roof ventilator; (2) special inside ventilating flues; (3) small wall perforations with small suction cupola; (4) large side-wall perforations with large cupola on top, and (5) no ventilation.

In 1931 forced-draft ventilation was tried in comparison with floor and roof ventilation (1), as well as large side-wall perforations with large suction cupola (4). From one bin (3) the air was drawn from the center of the bin with a large suction pump. In the other bin (5) the air was forced in with a force pump.

During 1931-'32 laboratory storage experiments have been conducted. Wheat was placed in gallon bottles under various conditions of temperature, moisture content, and air supply. The time factor was also studied. This phase of the work is still in progress, but valuable information as to the causes of wheat damage in bins has been obtained.

As a result of this work the following conclusions are drawn:

1. Damage to the quality of combined wheat results from storing with too much moisture which causes heating and usually molding. Excessive heating is more likely to take place when the wheat is hot at the time of binning than when it is cool. Continued hot weather soon after storing will promote heating of the wheat. Heat diffuses slowly in wheat, hence hot pockets may develop from loads of high-moisture or high-temperature wheat. A small amount of damp wheat, which if placed by itself might start heating, is less likely to be damaged if mixed and stored with very dry wheat.

2. The heating of wheat which is high in moisture content results from the accelerated natural respiration in the wheat and from the respiration of mold. The rate of respiration depends on the moisture content and the temperature. In normally dry wheat it is very slow but increases many fold as the moisture is increased. It seems to make little difference whether the high moisture is due to immaturity or to water added by rain.

3. Heating alone may damage the wheat, but the greatest injury results when heating is accompanied by mold growth. Whether or not enough heat may result from wheat respiration alone to do damage has not been determined. Natural respiration in normally dry new wheat brings about an improvement in the baking value of the flour. This process may be hastened by heat and moisture under carefully controlled conditions.

4. The damage from too high moisture with resultant heating and molding causes a lowering of the milling and baking value. The odors and appearance of the wheat lower the market grades and hence the selling value.

5. The type of bin is of less importance than the type of ventilation used in the bin. If ventilation is to be effective it must cause enough air movement to cool the wheat and remove excess moisture. The type of ventilators which do not do this promote damage rather than prevent it, because they create condensation and bring enough oxygen to favor mold growth. Natural ventilation passing upward through a perforated floor has given the best results. Another good method is by means of perforated side walls and a large, central perforated flue with suction cupola on top.

6. Heating wheat may be cooled and lowered in moisture by transferring from one bin to another. In very hot weather the amount of cooling may be very little. The amount of moisture removed is dependent upon the relative humidity of the air. A manuscript reporting the results of this work has been prepared for publication as a station bulletin.

[Project 143; Departments of Agricultural Engineering and Milling Industry. Leaders, F. C. Fenton and C. O. Swanson; Purnell fund.]

Chemical Factors Influencing the Quality of Wheat and Flour.--During the biennium three separate problems have been studied: (1) Factors of fermentation tolerance; (2) effect of different bleaching agents and rates of bleaching on flour from the wheat crop of the current year and from that of the year preceding; and (3) the influence of bleaching, oxidizing agents added to the dough, and fermentation on the variation in water-soluble phosphatides. In addition to these studies much time has been spent on methods. An important advance has been made in the development of an accurate mechanical means for the determination of the correct water absorption of flour through use of a high-speed super-centrifugal.

In the fermentation studies it was shown that with the straight-dough method of baking, the lack of sugar for yeast activity is usually the first factor operating to injure bread quality as the fermentation period is increased. By adding more sugar at this time good bread may again be obtained if the dough break is used to overcome the injurious effects of the remixing. Those factors which affect the gas retention of the dough are shown to be reversible, at least within reasonable limits, by the use of the dough break. Thus it was shown that bread of excellent volume and texture may be produced after such prolonged fermentation that a highly acid and unpleasant flavor had been developed. Study of the actual physical changes of the dough during fermentation is, however, hampered by the fact that such changes are modified or entirely overcome by the mechanical processes necessary for the addition of more sugar for continued yeast action.

In the flour-bleaching studies it was shown that injury resulted with the chlorine bleach only when it was applied at heavy rates. It should be noted that neither of the wheat flours used was especially sensitive to oxidizing agents.

The increase in water-soluble phosphatides, due to the addition of oxidizing agents, is the only change in flour which has been yet demonstrated chemically as resulting from the addition of such agents. It is also the only known chemical change that results from bleaching agents which could in any way affect the baking characteristics.

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

The Quality of Wheat as Influenced by Cropping System and Fertilizer Treatment.--From the rotation and fertilizer plots 761 samples of wheat were analyzed for protein during the biennium.

These data are being tabulated and will be interpreted and published later in connection with the fertilizer and rotation studies of which they are a part. [Project 60-B; Department of Milling Industry. Leader, C. O. Swanson; state fund.]

The Quality of Wheat as Influenced by Seed-bed Preparation and Tillage Methods.--The influence of soil management on the milling and baking characteristics of wheat is so slight in comparison with the influences of weather conditions and variety that, so far, it has not been possible to measure this factor with any degree of satisfaction. The influence of soil management on protein is no doubt influenced by the same factors, but methods of measuring quality are not sufficiently refined to differentiate the influence of soil management from that of variety and weather. [Project, 60-C; Department of Milling Industry. Leader, C. O. Swanson, state fund.]

The Relation of Variety to the Quality of Wheat.--Resistance of gluten to disintegration under mechanical action has been found to be the best measure of quality as far as that depends on genetic factors. In testing varieties it is necessary to differentiate between the factors which are genetic and those which are due to soil and climate. The factors which determine the quality of wheat or flour and resulting dough or bread may be considered in three groups: (1) Those which are due to protein or gluten structure; (2) those which are influenced by the substances from wheat other than protein; and (3) the substances other than flour used in the dough formula.

In testing wheat varieties the influence of the third group must be wholly eliminated, and the influence of the second group must be very minor. The second group includes the starch, fats or lipid material, inorganic matter, some sugar, and enzymes. With the possible exception of the lipid material it is not known that any of these materials vary genetically. If the lipid material is the substance mostly affected by oxidation then this varies genetically. Thus it has been found that Blackhull and related varieties respond favorably to bromate in the dough formula, while the Turkey and related varieties, particularly Tenmarq, do not so respond.

The resistance of dough to mechanical action has been used for several years in measuring quality of flour as influenced by genetic factors. A new self-recording dough mixer has made it possible to make this measure with much greater precision. The new mixer has been described fully in a paper entitled "Testing the Quality of Flour by the Recording Dough Mixer" to be published in *Cereal Chemistry*.

[Project 60-D; Department of Milling Industry. Leader, C. O. Swanson; state fund.]

A Comparison of the Quality of Wheat Varieties Grown in Different Parts of Kansas.--Milling, baking, and chemical tests have been made of a number of comparatively new varieties of wheat during the biennium. These varieties were Tenmarq, Superhard Blackhull, Early Blackhull, Clark's 40, Cheyenne, and Kawvale. The samples from each variety were blended so as to make them composite samples, one from each of those samples grown in the north half of the wheat belt, one from each of those grown in

the south half of the wheat belt, and a third from each of those grown in the eastern part of the state. The composite samples of each variety from each section were then studied.

Kawvale, a new soft wheat developed for the eastern part of the state, has some of the baking characteristics of a soft wheat, but is more like Fulcaster than Harvest Queen or Michigan Wonder, which are typically soft wheats. Superhard Blackhull, Early Blackhull, and Clark's 40 have characteristics very similar to Blackhull, but are somewhat less desirable from the milling and baking standpoint.

Tenmarq has characteristics very similar to northern hard spring wheat. It has a very good quality of gluten and the flour may be designated as an all-purpose flour. That is, the gluten has the strength required for factory bread making, and at the same time it has the pliability desired for home baking as well as for use in making small bakes. Cheyenne is similar to Tenmarq in several of its characteristics. The gluten shows the same resistance toward disintegration by mechanical action, but it seems to have more of the pliability found in soft wheat. Not enough work has been done with Cheyenne to give it proper evaluation.

Next year greater emphasis will be placed on determining the particular characteristics inherent in the different varieties. Genetic factors give varieties certain inherent characteristics which make them suitable for certain purposes. The main purpose of wheat and flour testing is to determine the characteristics inherent in the wheat. After these are determined it will be possible to evaluate the wheat for the general demands of the trade. Much yet remains to be done before it will be possible to determine these essential characteristics as accurately as is desired.

[Project 60-E; Department of Milling Industry. Leader, C. O. Swanson; state fund.]

A Study of the Protein Content of Some Common Kansas Wheat Varieties.--During the biennium 780 samples representing varieties from all parts of the state were analyzed for protein, 514 samples being analyzed from the crop of 1930 and 266 from the crop of 1931. This work, together with that previously reported, has shown that the protein content is influenced so much by soil and climate that varietal differences are overshadowed. For this reason the protein determinations on wheat grown in different parts of the state will be limited to 60 samples of Kanred. These samples will be studied to determine the influence of climate on the yearly variation in protein content. [Project 60-F; Department of Milling Industry. Leader, C. O. Swanson; state funds.]

Tempering Factors Affecting the Quantity and Quality of Wheat Flour.--This project has been continued as previously reported. The results secured have been as a rule negative rather than positive in character. That is, variations in tempering conditions do not have so great an influence on the results as is commonly believed.

The following may be stated as tangible results of the experiments:

1. The rate of evaporation from wheat and mill stocks does not primarily depend on the length of the tempering period nor upon the temperature of the tempering water, provided that the conditions are such that the tempering water is completely absorbed. The rate of evaporation is influenced by the character, moisture content, and temperature of the stocks. Relative humidity

is the most important condition influencing evaporation, but in these experiments this factor was kept constant. A relative humidity of a little over 50 has been found to give best results.

2. The length of the tempering time had no effect on the percentage of extraction or its distribution. That is, wheat tempered a short time ground as easily as that tempered a long time. The moisture content of the flour streams was not influenced and the power consumption was not consistently higher nor lower. The longer temper increased the percentage of break flour due to a greater mellowing of the endosperm. It also increased slightly the ash content of the break flour. Hence, from this standpoint, the longer temper is less desirable. The longer temper also increased the temperature rise on the rolls. This means that the energy required to grind long-tempered wheat is no less than that required to grind short-tempered wheat.

3. The above results were obtained on plump wheat in first-class condition. A few results on shrivelled and also on extremely dry wheat indicated that such wheat required a considerable longer tempering time than plump wheat.

4. The amount of water absorbed by wheat during washing depends upon the original moisture content of the grain, its physical condition, and the speed of the revolving agitators. The amount of scourings removed in washing depends on the original brittleness of the grain and the speed at which the machine is operated. Wheat washing improves the color of the flour, but does not consistently lower the ash content.

[Project 170; Department of Milling Industry. Leaders, R. O. Pence and C. O. Swanson; Purnell fund.]

Flour Chemistry Investigations.--The investigations on flour for the past biennium have been confined largely to a study of the gluten proteins, the crude fiber, and other factors thought to influence the gluten quality. The work with the gluten proteins was confined to an investigation of the absorption bands of the proteins in the ultra-violet region of the spectrum. It has been found that the gluten proteins give two distinct absorption zones, one characteristic of the gliadin and the other of the glutenin.

A method for determining accurately the true crude-fiber content of wheat and flour is urgently needed. Considerable work was done this biennium in an endeavor to work out such a method. The separation of starch and crude fiber has been found very difficult, owing to their similarity in composition.

Other factors which are thought to have an influence on gluten quality have been investigated, but the difficulties are great and exact methods are lacking in many instances. Among the more important factors investigated are charge on the flour particle, influence of adsorbed ions, ultimate pH and ash content of flour after dialysis.

[Project 60; Department of Chemistry. Leader, E. L. Tague; state fund.]

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

Spraying.--The results obtained from apple spraying the last two years are discouraging because of unfortunate circumstances. The set of apples for the 1930 season was very light, approximately 500 bushels from 30 acres, so no experimental work was done in spraying apple trees. The entire orchard was sprayed April 19 to 22 using lime sulfur, 1½ gallons, and lead arsenate, ½ pounds, to 50 gallons of water. Subsequent sprays consisting of 1½ pounds of lead arsenate to 50 gallons of water were applied only to trees having apples.

The set of fruit during the 1931 season was good and six sprays were applied, but a severe hailstorm occurred on August 31, 1931, which practically destroyed the apple crop. About 30 per cent of the apples were knocked to the

ground. Over 95 per cent were bruised by the hail, and careful counts of important varieties showed the following percentages with broken skins:

	<i>Per cent.</i>		<i>Per cent.</i>
Jonathan	75	Rome	80
Winesap	85	York	75
Delicious	85	Grimes	75
Ralls	85	Stayman	85
King David	83	Golden Delicious	92
Gano	90		

Since the injury to the fruit was so severe it was evident that no reliable figures could be obtained in making counts for insect and disease control. The various spray plots were abandoned. Only gross-yield records were kept.

The spraying experiments on cherry trees during the biennium were primarily attempts to determine control measures for the cherry leaf spot. As there was practically no leaf spot present in the orchard during both seasons because of dry, unfavorable weather, no important data were secured.

Black rot and leafhoppers, the two common pests of grapes, were not so difficult to control the past two years. Bordeaux 3-6-50 was very efficient in controlling the black rot. In 1930, because of a lack of rain during the latter part of the season, the Bordeaux residue was abundant. Acetic acid at the rate of 1 quart to 100 gallons was sprayed on the vines. This treatment was very effective in removing the spray residue and did not injure either fruit or foliage.

Methods of Pruning Fruit Trees.--This subproject has been carried on during the past two years along the same lines as previously reported. Maintenance pruning tests of both apple and cherry trees of bearing age have been continued. The losses which follow wrong methods of pruning applied to young trees become more and more evident each year as the trees approach maturity. In the station orchard many open-center cherry trees have been split down the trunk by high winds. Similar apple trees have suffered in the same way, but more severely because of both high winds and heavy loads of fruit. The apple varieties showing the greatest percentage of loss from this cause are Delicious and Stayman Winesap. Bracing with iron rods seems to be effective in avoiding such injury, but it is expensive. The removal of surplus framework branches from these open-center trees was continued, but the wounds made in such pruning are in a very hazardous location and are very slow to heal over. This type of pruning will receive further tests.

The young apple trees have been pruned according to the modified-leader system and many of the varieties are producing trees of excellent shape under such treatment. Others, as the Golden Delicious, do not respond well, but persist in a dense, upright habit of growth.

In March, 1930, 234 cherry trees were planted to study formative pruning of young cherry trees. Two varieties were planted, 188 Montmorency and 46 Early Richmond. The methods of pruning consisted of center-leader and open-center pruning. A comparison was made of severe and moderate heading when the center-leader type of pruning was used. During the summer of 1931 these trees did not make a great amount of growth because of lack of moisture. One Early Richmond and six Montmorency trees died during this season. These trees were replaced in April, 1932.

Orchard Soil-Management Experiments.--The orchard soil-management work for the past biennium has consisted of studies of the use of chemical fertilizers, the efficiency of a straw mulch, the management of cover crops, and terracing the planted orchard.

Nitrate of soda was applied to Winesap and York apple trees of bearing age at different times in the season as follows:

1. Each tree receives 5 pounds of nitrate of soda two weeks before the bloom period.
2. Each tree receives 5 pounds of nitrate of soda each fall, about September 15.
3. Each tree receives 2½ pounds of nitrate of soda two weeks before the bloom period and 2½ pounds of nitrate of soda each fall, about September 15.
4. Check plot on which no nitrate of soda is to be applied.

The principal value of such applications will be in information regarding their effect on the fruit production of the tree, although the record of vegetative development of these trees, which dates back to 1921, will also be continued. The trees of both Winesap and York set an average crop of fruit in 1931, but none was harvested because of the hail of August 31.

The straw-mulch plots were continued as previously reported and growth comparisons made. Inspection and study of the records show that the straw-mulch system of soil management is not adapted to the type of soil on which this experiment is located, even though the trees have responded favorably in growth and fruit production. Too many trees have been lost, principally because of a high water table during rainy periods.

Cover-crop experiments were continued through the biennium. Conditions were favorable for fair yields of hardy cover crops, though both rye and winter vetch far exceeded Austrian Winter pea in yield. For this reason, and because the seed was difficult to obtain and high in price, the Austrian Winter pea was not planted in the fall of 1931.

Cover crops planted among large apple trees the fall of 1931 were almost a failure. Fall growth of the trees following the hailstorm was heavy, and the top soil over much of the orchard became so dry that both winter vetch and rye plants perished soon after germination. On the contrary, both crops made a good stand among young apple trees, in the young peach orchard, and in the vineyard.

Another division of the cover-crop study relates to the influence of the kind of cover crop on the moisture supply and the nitrate content of the orchard soil. The data so far collected do not show significant differences between rye and winter vetch in building up the nitrate fraction of this orchard soil.

Terrace construction was carried out on approximately 20 acres of the apple orchard during the spring and summer of 1931. Although it was necessary to prune off many low branches, which pruning would ordinarily be undesirable, the trees were not seriously injured in the course of this work. Several of the terraces broke through during the heavy rains in the late fall of 1931, but in the main they have proved valuable in lessening erosion in the southeastern part of the apple orchard. They interfere seriously with the care of the orchard.

Testing New and Promising Varieties of Tree Fruits.--The past two years have been trying ones for fruit varieties under test. During 1930 the drought was so severe that fruit which did start development fell from the trees before maturity, and in 1931 the hailstorm of August destroyed nearly all fruit then on the trees. Fortunately, certain of the peach, nectarine, apple, and pear varieties had ripened fruit prior to the storm and specimens of these were secured for description and, with a few of them, culinary tests. Several peach and nectarine varieties set fruit in 1930, but none adhered through the drought to maturity. Records of their behavior show that the fruits of all varieties of nectarines wilted and dropped before those of the peach varieties, indicating a higher rate of transpiration for the nectarines.

Half of the jujube trees died during the drought of 1930. The trees which survived made a moderate growth in 1931, bloomed in June, and set a few fruits which were beaten off by the hail before maturity. None of the plums under test produced any fruit.

The Orange quince had a light set of fruit in 1931, but these were immature when destroyed by the hail. Several varieties of apples set fruit for the first time in 1931. Henry Clay, planted in 1921, bore a light crop of fruit. It ripened in July and was of fair culinary quality. These trees have been infected by the black-rot fungus ever since they were planted in the test orchard.

Vegetative development and other particulars regarding the various varieties of pome fruits now under test show the following significant points: (1) Tenderness of the quince varieties to the combination of heat and cold experienced in February and March, 1932; (2) lack of resistance to fire blight of varieties of pears bred for that characteristic; (3) good vegetative development of the early varieties originated by Prof. C. P. Close of the United States Department of Agriculture. A long time is necessary to give an adequate test

to fruit trees of the pome group. Although some of these are now in their twelfth year of growth none has yet proved itself.

New plantings were not numerous during the past biennium. They were eight varieties of apples received from Prof. F. W. Faurot, Mountain Grove, Mo., and three new varieties of jujube from the Office of Plant Introduction, United States Department of Agriculture. New fruits for such tests do not follow any rule in regularity of appearance, consequently new plantings are irregular.

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

Small-Fruit Investigations.--Lack of fruit yields, because of drought and hail injury, have badly handicapped experimental work with all small fruits during the crop seasons of 1930 and 1931. In 1930 the brambles all dried upon the canes. The grapes withstood the drought much better, but they failed to mature properly. The 1931 crop of berries was extremely light, but the grapes, although deficient in cane growth from the preceding summer, set a fair crop and those remaining after the cutworm attack were making good development until the storm of August 31 which destroyed all the fruit and practically defoliated the plants. The cutworms cut off the berries and devoured the leaves. Before they could be brought under control they had damaged the crop and had defoliated the newly set vines. The newly set vines died from those injuries. It is proposed to abandon further work with brambles, except further test of varieties, for a few years. The experimental work with grapes will be somewhat expanded.

[Project 26; Department of Horticulture. Leader, R. J. Barnett; state fund.]

Flower and Vegetable Investigations.--The work in this project has been conducted along four different lines as follows:

1. Outdoor flower-garden work dealing with the formal, or perennial garden, the dahlia test gardens, the gladioli gardens, the peony test gardens, and the iris test gardens, just added in 1931.

2. The greenhouse work which during the past two years has been principally vegetable production under glass with studies of the effect of soil sterilization on the growth of lettuce, cucumbers, and tomatoes.

3. The outdoor vegetable garden variety tests.

4. A study of the enzymatic activities of asparagus roots treated to break the rest period and the chemical changes occurring in these roots.

Records taken in the test gardens indicate that there is no change with regard to the time of flowering or desirability of various peonies, dahlias, and gladioli grown. For the iris test gardens only this spring's records are available and, as all the varieties are not through flowering, a complete record is not available.

The greenhouse soil-sterilization study started in the fall of 1930 should be carried on for at least five years in order to draw definite conclusions from the work, although at present it would seem that creosote or acetic acid for sterilizing greenhouse soil is satisfactory in many respects and costs one-fourth to one-half less than steam sterilization. These two materials, however, do not seem to control nematodes and cannot be recommended when this pest is present in the soil.

Catalyse studies of asparagus roots have been made according to the Benzell method and the Benzell catalyse tube was used. Constant temperatures during

the formation of the catalyse were maintained by submerging the tube in the constant-temperature water bath. A study of the growth of the plants from the cut shoots indicates that the hot-water treatment, that is, submerging the roots in water at a temperature of 123 degrees F. for three minutes, is more effective in breaking the rest period of the asparagus plants than is freezing at 10 degrees F. for 24 hours or treating with ethylene gas.

[Project 27; Department of Horticulture. Leader, W. B. Balch; state fund.]

Forest Tree Investigations.--The forestry work for the past year has consisted mainly of thinning, pruning, and planting operations and growth studies. A study of the rate of growth in the pine grove (planting of 1898) showed a rate of growth of only 4.3 per cent., using Schneider's formula. A count of the stand showed that there were 508 trees on approximately 0.7 of an acre. With trees averaging a 6-inch diameter only 357 trees per acre are necessary for a full stand, and in view of this and the low rate of growth the trees in the planting were thinned to a stand of 347 per acre. Ninety per cent of the material removed was Jack Pine, suppressed or injured trees. This thinning left a stand of approximately 70 per cent Scotch Pine and 30 per cent Jack Pine. Direct examination of the increment boring samples, aside from giving the count from which the rate of growth was computed, showed that the entire stand has been suppressed since 1915. During the first 12 years of growth a 20 per cent increment was being realized, as compared to the above-shown 4.3 per cent increment for the last period. In 1936 another growth study should be made and proper thinning done.

A study of the rate of growth of the 1872 Austrian Pine grove was made. In this stand an increment of only 2.5 per cent was found. The ultimate height growth has probably been reached, but a thinning should result in an increased rate of diameter growth.

A planting of Western Yellow pine on the hillside at the west end of the horticultural farm was started in December, 1931. A total of 122 trees, spaced alternately 6 by 6 feet, were planted. The entire area is underlaid with rock with numerous outcroppings. In some instances it was necessary to haul earth to fill in around the balled and burlapped roots of the trees. It is planned to continue pine plantings until the entire area is covered. If this planting proves successful it will be an excellent demonstration of utilization of similar tracts in this and adjacent counties in eastern Kansas.

A permanent record of the pecan planting has been started. Measurements of diameters and heights of each individual tree, as well as the date of planting, were recorded. These trees consist of named varieties secured from Indiana and Texas, and college-grown stock produced from seed secured near Chetopa, Kan.

[Project 82; Department of Horticulture. Leader, E. W. Johnson; state fund.]

INVESTIGATIONS IN THE ANIMAL INDUSTRIES

A brief report of the work that the Agricultural Experiment Station has done during the past biennium on problems relating to the live-stock industry is contained in the pages that follow.

Nutritive Requirements of Swine.--During the past two years studies on the vitamin B and E requirements for reproduction in swine have been completed. The addition of wheat germ as a source of vitamins B and E did not improve reproduction in swine, there being practically no difference in the production of the group of sows receiving wheat germ and the group that did not receive wheat germ. The results of this study were published in Technical Bulletin 31 of this station.

During 1931-'32 a study was made of the effect of exercise upon reproduction in swine. Ten sows, all litter mates, were fed an adequate ration. One-half were walked 0.4 of a mile each day from the day they were bred. The other half received no exercise except that which they took voluntarily in a space 7 by 14 feet allotted each sow. The farrowing records of these sows are given in Table VII.

TABLE VII.-THE EFFECT OF EXERCISE UPON THE FARROWING RECORDS OF SOWS.

GROUP.	I I-5 sows (exercise).	II II-5 sows (no exercise).
Farrowed alive..	47	47
Farrowed dead.	1	0
Total farrowed..	48	47

The pigs in Group I (exercise) had an average birth weight of 1,296 grams and those in Group II (no exercise), 1,238 grams, a difference of 58 grams or 4.5 per cent. At the end of 10 days the pigs in Group I (exercise) averaged 2,280 grams each, and those in Group II (no exercise), 2,243 grams, a difference of 37 grams or 1.6 per cent.

During the first five days milk production checks were made twice daily. The average per check during this period for Group I (exercise) was 192 grams; for Group II (no exercise) 209 grams. There was, however, a wide variation in the milk flow within each group. The highest and lowest productions were found in Group I (exercise).

Pig losses were as follows:

Group I-Exercise : Born dead 1 Abscess 1 Enteritis 3 Killed by sows 4 Total 9	Group II-No exercise: Ruptured liver 1 Killed by sows 2 Total 3
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No significant difference could be noted in the size, vigor, or thrift of the pigs in the two groups at a given age. The pigs in this test will be fattened to a 200-pound weight and observations will be made as to the thrift and feed required to produce 100 pounds of gain after weaning. Much other data are being and will be collected as the experiment progresses.

[Project 38; Departments of Animal Husbandry, Chemistry, and Veterinary Medicine. Leaders, C. E. Aubel, J. S. Hughes, and H. F. Lienhardt; Adams fund.]

Swine-Feeding Investigations.--The work on this project during the biennium consisted of eight different phases comparing: (1) The fattening of spring pigs in a dry lot and on alfalfa pasture; (2) single with mixed protein supplements in swine-feeding rations; (3)

self-feeding with hand-feeding sows and litters; (4) the effect of vitamin D on reproduction in swine; (5) the effect of adding different amounts of finely ground limestone to swine rations; (6) the response of different groups of swine of similar breeding, age, quality, and thrift to the same ration; (7) further protein supplements in swine-fattening rations; and (8) the value of alfalfa hay, alfalfa meal, and alfalfa leaf meal in swine-fattening rations.

The results secured may be summarized as follows:

1. Hogs self-fed corn and tankage on alfalfa pasture during the summer of 1930 made larger and more economical gains than hogs fed corn, tankage, and alfalfa hay in a dry lot.
2. Hogs fed a protein mixture consisting of tankage 2 parts, linseed oil meal 1 part, and alfalfa meal 1 part during the winter of 1930-'31, made larger and more economical gains than hogs fed corn, tankage, and alfalfa hay. No significant differences were noted in the values of the following protein supplements: (1) Tankage and alfalfa hay; (2) tankage 2 parts, linseed oil meal 1 part plus alfalfa hay, ad lib.; and (3) tankage 2 parts, cottonseed meal 1 part plus alfalfa hay, ad lib.
3. Self-feeding sows and litters proved to be more satisfactory than hand-feeding.
4. The addition of cod-liver oil to a ration of corn, barley, and tankage fed to brood sows did not increase the size, vigor, or number of pigs farrowed and raised.
5. The addition of 0.125 pound of ground limestone to the ration fed fattening pigs did not have an injurious effect. The addition of 0.25 to 0.5 pound did have a deleterious effect.
6. Four lots of feeder pigs self-fed identical rations, showed differences in daily gains varying from 1.90 to 1.99 pounds per head per day--not a significant difference. This is the fourth test of this nature conducted with hogs produced and owned by the Federal Station at Ardmore, S. Dak.
7. There was no significant difference in the value of the following protein supplements fed to hogs on alfalfa pasture during the summer of 1931: (1) Tankage; (2) tankage 50 per cent, cottonseed meal 50 per cent; (3) tankage $33\frac{1}{3}$ per cent, cottonseed meal $33\frac{1}{3}$ per cent, linseed oil meal $33\frac{1}{3}$ per cent; (4) tankage 67 per cent, linseed oil meal 33 per cent.
8. Cottonseed meal 50 per cent and linseed oil meal 50 per cent were decidedly inferior in every way to any of the protein supplements listed above under No. 7.
9. When fed in a dry lot during the winter 1931-'32, a combination of tankage 75 per cent and alfalfa meal 25 per cent proved to be worth more than tankage 50 per cent and alfalfa meal 50 per cent. A combination of tankage 75 per cent and alfalfa leaf meal 25 per cent proved to be worth more than tankage 50 per cent and alfalfa leaf meal 50 per cent. Alfalfa leaf meal was more profitable than alfalfa meal despite the fact that it cost twice as much as alfalfa meal.

[Project 110; Department of Animal Husbandry. Leaders, C. E. Aubel and W. E. Connell; state fund.]

Investigations in the Use of Silage for Fattening Beef Cattle.--During the past biennium a third and final year's study of the possibility of depending upon silage alone as the roughage portion of calf-fattening rations was made during the winter of 1930-'31. Also a study was made during the winter of 1931-'32 of the value of wheat as a cattle-fattening feed and the advantage, if any, of feeding wheat with silage.

The results of the third year's study mentioned above gave results relatively

the same as those of the two previous years, and these studies justify the conclusion that silage alone, fortified with a small amount of calcium in some form, in this instance 0.1 pound of powdered limestone, is a satisfactory roughage in calf-fattening rations.

The results of the study made of the value of wheat and of feeding wheat with and without silage were as follows:

1. Adding silage to the ration did not improve wheat as a Cattle-fattening feed.
2. No difficulty was experienced in keeping steers on a full feed of wheat.
3. No digestive disturbances developed in the lots fed wheat alone as the grain portion of the ration fed.
4. The rate and economy of gain made by the lots fed wheat alone as the grain portion of the ration indicate that, from a nutritive standpoint, wheat is an excellent feed for fattening cattle.
5. Slightly less wheat than corn was required to produce a unit of gain.

[Project 78; Department of Animal Husbandry. Leaders, A. D. Weber and W. E. Connell; state fund.]

The Comparative Nutritive Value of Dry Matter in Silage and Fodder.--During the past biennium one year's work on this subproject of the general project, "Silage Investigations," was completed. Twelve yearling steers were allotted by pairs on the basis of weight, condition, feeder grade, temperament, and probable outcome. Both members of each pair received the same amount of dry matter by weight, one steer of each pair receiving his dry matter from Atlas sorgo silage and cottonseed meal, the other receiving his dry matter from ground Atlas sorgo fodder and cottonseed meal. Moisture determinations of the silage and ground fodder were made every four days. Chemical analyses of composite samples of the feeds were made at irregular intervals. The coefficients of digestibility of the dry matter in the silage and in the ground fodder were determined indirectly by calculations which were made possible by chemically determining the ratio of silica to dry matter in the feed and feces. The steers were fed 140 days.

The principal results of this one year's work were as follows:

1. The steers fed ground fodder gained 34.6 pounds more per head than the steers fed silage. The results for the two lots were treated statistically and this difference found not to be significant.
2. The average coefficient of apparent digestibility of the dry matter in silage fed with cottonseed meal was 73.32 and of the ground fodder fed with cottonseed meal, 72.69. Coefficients of apparent digestibility of the dry matter of the silage and ground fodder, each fed alone, were 62.94 and 62.35, respectively.
3. On a dry-matter basis, the silage contained 2.82 per cent less reducing sugar, 1.54 per cent less crude protein, 3.04 per cent less true protein, 0.038 per cent more free amino nitrogen, and 2.52 per cent more nitrogen-free extract than the ground fodder.

[Project 78, subproject 14; Department of Animal Husbandry. Leader, A. D. Weber; state fund.]

Methods of Utilizing Native Pasture in Beef-cattle Feeding. During the past biennium two years' work of a three-year program has been completed. Each year's major objectives may be summarized as follows:

1. A comparison of wintering calves well, grazing to August 1, and then full-feeding in a dry lot, with wintering well, grazing to August 1, and then full-feeding on grass.

2. A comparison of wintering calves well and then full-feeding on grass after May 1 with the two methods outlined in No. 1.

3. A comparison of wintering calves well and then full-feeding in a dry lot after May 1 with the three methods outlined in No. 1 and No. 2. This lot was used as a check with which to measure the results secured when grass made up a part of the fattening ration.

The outstanding results secured from these tests are indicated in the following statements:

1. The returns above cattle, feed, and labor costs were:

(a) Wintered well, grazed to August 1, and then full-fed for 100 days in a dry lot: 1930, +\$14.51 per head; 1931, +\$8.07 per head.

(b) Wintered well, grazed to August 1, and then full-fed 100 days on pasture: 1930, +\$4.62 per head; 1931, +\$1.13 per head.

(c) Wintered well and then full-fed on grass 150 days after May 1: 1930, —\$11.88 per head; 1931, —\$3.29 per head.

(d) Wintered well and then full-fed in a dry lot after May 1: 1930, +\$14 per head; 1931, +\$2.19 per head.

2. Grazing May 1 to August 1 and then full-feeding 100 days produced each year approximately as highly finished cattle as full-feeding 150 days beginning May 1.

3. Cattle full-fed on grass were each year appraised at a lower price than cattle fed in a dry lot.

4. Cattle wintered well, grazed May 1 to August 1, then full-fed each year, required less grain to produce a unit of gain than cattle wintered well and then full-fed after May 1.

[Project 151; Department of Animal Husbandry. Leader, C. W. McCampbell; state fund.]

Lamb-Feeding Investigations.--The work done under this project during the past biennium has consisted of (1) the third of a series of three tests in which studies were made of the rate of growth or development of the animals and of the grades, yield, and value of fleece wool of purebred Hampshire, Shropshire, Southdown, and Dorset lambs, and (2) an experiment involving the use of ground Atlas fodder supplemented with various other feeds for fattening range lambs. A small amount of ground limestone was fed in some cases, to determine whether it would improve the various rations. Comparisons were also made of wheat and Atlas grain, Atlas fodder, and Atlas silage, and various proportions of concentrates to roughage in lamb fattening rations.

The results of the first study may be summarized as follows:

1. The total gain and average daily gain per lamb ranked the four breeds in the following order: Hampshires, Shropshires, Dorsets, and Southdowns.

2. The average fleece yield of the four breeds and the value of fleeces ranked the four breeds as follows: Shropshires, Hampshires, Dorsets, and Southdowns.

3. In grades of wool, based on fineness, the breeds ranked: Southdowns, Shropshires, Dorsets, and Hampshires.

4. In classes of wool, based on length of staple, the breeds ranked in the following order: Dorsets, Shropshires, Hampshires, and Southdowns.

5. In the matter of gains made per unit of feed consumed, the breeds ranked as follows: Shropshires, Hampshires, Southdowns, and Dorsets.

The results of the second study were as follows:

1. A ration of ground Atlas fodder, cottonseed meal, and ground Atlas grain

composed of approximately 50 per cent concentrates and 50 per cent roughage, produced larger and cheaper gains on lambs than similar rations containing less concentrates.

2. Ground Atlas fodder supplemented with cottonseed meal but no extra grain failed to finish lambs satisfactorily.

3. The addition of calcium carbonate in the form of ground limestone to various lamb-fattening rations, the roughage portion of which was either ground Atlas fodder or Atlas silage, proved very beneficial from the standpoint of rate of gains and cost of gains.

4. The addition of ground limestone to a ration in which a small amount of alfalfa hay was fed, proved to be of no value.

5. Ground wheat produced a little larger gain than ground Atlas grain when fed, with ground Atlas fodder and cottonseed meal, to fattening lambs.

6. Ground Atlas fodder and alfalfa hay proved to be a more efficient roughage than ground Atlas fodder alone for fattening lambs.

7. Ground Atlas fodder produced a little larger gain than Atlas silage on fattening lambs, when both were fed with cottonseed meal and Atlas grain. Both rations produced satisfactory gains.

A manuscript reporting upon the results of this project for the past four years is in preparation. It is hoped next year to continue the study of ground Atlas fodder as the basis of lamb fattening rations, with particular emphasis on the matter of the amount of grain to add and the time during the feeding period to begin adding extra grain.

[Project 111; Department of Animal Husbandry. Leader, Rufus F. Cox; state fund.]

A Study of Pasture Values and Pasture Methods for Live Stock.--A study of several crops suitable for pasture purposes in this section of the country has been made during the past biennium. The crops studied include brome grass, orchard grass, bluegrass, Sudan grass, and sweet clover alone and in combination.

The observations made upon the grasses may be summarized as follows:

1. The field of brome grass planted on an upland area in the fall of 1925, plowed in the fall of 1928, and seeded to sweet clover in the spring of 1929, showed some brome grass in 1929, a fair stand in 1930, a good stand in 1931, and appears to be sod bound again this spring (1932). Despite a favorable grass season, this brome grass field has about one-half the carrying capacity it had last year.

2. Both the orchard and brome grass on the lower land of the 60-acre experimental pasture showed a splendid stand in 1931 after the dry season and heavy grazing of 1930.

3. Check areas of brome and orchard grass of similar size and on similar soil and slope, left until seed was practically mature, produced almost the same tonnage in 1931—orchard grass, 2,454 pounds of cured hay per acre; brome grass, 2,405 pounds. Orchard grass, however, continued to furnish more pasture in midsummer, late fall and winter than brome grass.

4. Brome grass is apparently more palatable than orchard grass during the first half of the grazing season, but little difference was observed after that date.

5. Blue grass furnishes palatable early pasturage on the low lands but is inferior to either brome grass or orchard grass in carrying capacity.

6. Sweet clover is a satisfactory cattle, sheep, and swine pasture crop.

7. Sudan grass is the best midsummer pasture crop adaptable to this section for all classes of live stock, either from the standpoint of palatability or carrying capacity. Where not grazed to lengths of less than 18 inches, it should be clipped with a mowing machine for best results.

8. Everything considered, orchard grass appears to be the best crop for

permanent tame pasture purposes in this section. Some sweet clover might, with advantage, be scattered in orchard grass pastures from time to time.

9. Fall planting of orchard grass is much more satisfactory than spring planting except for the ravages of grasshoppers which occur occasionally and destroy more or less of the young grass in the fall.

[Project 142; Department of Animal Husbandry. Leader, C. W. McCampbell; state fund.]

The Influence of Feed on the Color, Chemical Composition, and Cooking Quality of the Meat of Grass-fat Cattle.--During the biennium an effort has been made to compare the carcasses of cattle full-fed on bluestem grass pasture with those from cattle full-fed in the dry lot. This phase of the project was undertaken during 1930-'31, and the work done during the past year essentially duplicated that of the previous year. Twenty head of Texas calves were purchased in the fall of 1929, all handled alike during the winter, then divided into two lots. Lot I was full-fed corn, cottonseed meal, and alfalfa hay in dry lot, beginning May 1, 1930, and Lot II was full-fed corn and cottonseed meal on bluestem pasture beginning the same day. These cattle were full-fed for 150 days when five from each lot were slaughtered in the station laboratory where the various studies were conducted. Rib samples from each lot were shipped to the United States Department of Agriculture Laboratory at Beltsville, Md., where the work done in the local laboratories was duplicated as a means of checking observations. During 1931-'32 two steers fed on pasture with no supplemental feeds were slaughtered as color checks.

Briefly, the conclusions to be drawn from this project to date are as follows:

1. As feeder cattle and fat cattle, both lots graded almost identically, but on the rail the dry-lot cattle carcasses graded slightly higher than the pasture-cattle carcasses because of a greater degree of finish. (Both years the difference was less than one-third of a grade)
2. The two years' figures indicate a slight advantage (0.69 per cent) in dressing percentage in favor of the dry-lot cattle. These carcasses also shrank 0.13 per cent less during the first 120 hours of storage.
3. The color of lean produced in both lots was a beautiful bright red color, a much wider variation in color being noted within each lot than between lots. The brightest colored carcass observed in the local laboratory to date was produced on grass. All readings secured the second year were much brighter than those secured during 1930-'31. The two steers slaughtered as "checks" produced meat of a very desirable color, but not so bright as the full-fed steers. These cattle were thin and graded only low medium.
4. The color of lean observed in carcasses from yearling cattle contained about 10 per cent more red units than did that from the carcasses of the three- and four-year-old cattle studied during the early part of the project.
5. In color of fat some difference was noted between the two lots. Lot I, dry lot, had a very white covering of fat while the covering of fat of the pasture cattle was described as pinkish white. An analysis of the color by means of the Munsell color wheel showed the presence of a greater number of yellow units (Y 8/6) in the fat of the pasture cattle. This condition is often described as "muddy" by packer-beef men. The color was not objectionable and the difference passed unnoticed by many who looked at the carcasses.

6. Determinations of muscle hemoglobin and residual blood hemoglobin, as made by the Department of Chemistry, using the spectrophotometer with an aqueous solution obtained from the meat sample, show a high correlation with the number of red units in the meat sample as measured by the Munsell discs.

7. Shearing tests as a means of measuring tenderness vary somewhat. The first year's work indicated that the beef produced on grass was more tender than that produced in dry lot, but the second year's work does not confirm this observation.

The chemical investigations in connection with this project were carried out with portions of the rib cut from 28 animals on full-feed in dry lot, full-feed on grass, and grass alone. Cuts from animals not a part of this project were also examined by way of comparison.

The samples used for chemical investigation were separated into component parts, eye muscle, lean, bone, fat, and gristle. The physical separation of the cuts from animals on full feed showed little difference in the percentage of eye, lean, bone, and fat. The flesh from animals on grass alone showed wide variations due, no doubt, to a lack of finish.

The chemical analysis of the eye muscle for protein, fat, moisture, and ash showed a remarkable uniformity of composition. The protein content is the most consistent factor as it varied less than 2 per cent in the flesh from the 28 animals. While the lean tissue had a constant composition, fatty tissue varied considerably in its composition.

The moisture content of the fat from animals on full feed, dry lot, 1930, as compared with the fat from animals on grass showed the latter to have approximately 16 per cent more water than the former. For 1931 the results were reversed in nearly the same proportion, the fat from dry lot animals having the higher moisture content. The greatest contrast was in the case of the fat from animals on grass alone. In general, a statement can be made that the amount of moisture in the fat of an animal is in inverse proportion to the percentage of fat or finish.

The collagen and elastin content of the eye muscle does not appear to show any relationship to feed; however, there does appear to be some relationship between collagen and elastin content and finish or lack of finish. This is particularly true with animals in poor flesh, in which case the collagen and elastin content is always high. The ripening of meat over a 30-day period in 1930 showed a noticeable influence on the collagen and elastin content, although this influence was not so marked as during previous years. It was thought that this lack of uniformity was due to the more or less continuous frozen condition of the meat during most of the ripening period. In 1931, while the meat was held for ripening only 20 days at a fairly uniform temperature above the freezing point, the ripening had apparently no influence on the collagen and elastin content.

It was observed in the progress of this work that lean-meat samples, after treatment in the pebble mill for collagen and elastin determinations, had entirely yielded the coloring matter to the aqueous solution, leaving the insoluble tissue colorless. Spectrophotometric measurements of light transmission through this aqueous solution were made over the range from 500 to 640 millimicrons. The absorption curves were altogether characteristic of muscle hemoglobin as shown by Whipple and coworkers. Any other color absorption was not evident from the analysis.

A special effort has been made to estimate the muscle and blood hemoglobin individually in order to find what part residual blood might play in the color of lean meat. Since muscle hemoglobin develops with age and exercise, an accurate determination of it, free from blood hemoglobin, may be of value.

A yearling steer was bled out with irrigation by physiological salt solution until the solution came through colorless. Standards were prepared from the meat from this animal, known to contain no blood. The extract showed a sharp spectrum absorption maximum at 582 millimicrons, whereas blood hemoglobin shows a similar maximum at 577 millimicrons. It was found that the ratio of the light density at 577 to that at 582 millimicrons varied from 0.88 for muscle hemoglobin to 1.23 for blood hemoglobin, and that the ratio factor was a straight-line function of the relative percentages of the two in prepared

known mixtures. Although the two hemoglobins presented differences, as shown by the quartz spectrograph both in the visible and ultra-violet, the acid hematin derivatives appeared to be identical. Consequently, standards of the two hemoglobins were matched on the basis of their acid hematin derivatives, and the absorption factor for muscle hemoglobin at 542 millimicrons was subsequently evolved from the known value for blood hemoglobin.

Cooking tests on rib roasts have been made according to directions issued for this study. Data collected from the cooking tests have been tabulated in various ways to obtain numerical ratings and averages. In the fall of 1930 a comparison of the fresh roasts with the ripened roasts showed that individually and collectively the ripened roasts graded distinctly higher than the fresh roasts. Roasts from the six animals studied graded higher on desirability of aroma after ripening than before. The fresh roasts from the animals slaughtered in 1931 scored much alike with a slight superiority noted for roasts from animals full-fed in the dry lot. This was noted particularly for flavor of lean, the tenderness, and the juiciness factors. Scores for roasts from animals fed grass alone were slightly lower on the desirability of flavor of fat and of lean. After ripening the roasts scored much the same as when fresh.

Balance studies have been conducted with human subjects to learn whether or not the protein and phosphorus from different cuts of beef are used with equal ease. Three normal young women served as subjects for the human metabolism studies conducted during the biennium. For the first series the subjects consumed a uniform diet for more than three weeks, with the meat the only variable. Ground beef from a tender cut furnished most of the protein for the period, while ground beef from a very tough cut supplied the protein for the second period. From the results of the analyses it seems that human subjects used the nitrogen from the two sources with equal ease.

For the second series beef round and beef liver were used as sources of protein and phosphorus. Differences in coefficients of digestibility for the two cuts of beef were not significant, the average for both being about 82 per cent. Both coefficients of digestibility and nitrogen balances showed marked individual variations. A high collagen and elastin content has been thought to inhibit the utilization of meat. Round was found to contain about twice as much of these proteins as liver, yet the utilization of the two cuts was practically the same. Under the conditions of this experiment the nitrogen of round and liver of beef appears to be utilized about equally well by human subjects.

[Project 165; Departments of Animal Husbandry, Chemistry, and Home Economics. Leaders, C. W. McCampbell, D. L. Mackintosh, W. L. Latshaw, J. L. Hall, Martha S. Pittman, and Martha M. Kramer; Purnell fund.]

Antagonism of Monovalent and Polyvalent Metals in Biological Processes.--The hydrophilic antagonism of minerals in the lipin fraction of meat has been applied to a study of the keeping quality of meat. Meat for this study was procured from beef animals pastured in mineral-deficient areas of Kansas. In 1931 four yearling heifers secured from such areas were slaughtered. Two had been fattened on grass alone, while two others received a bone meal supplement while on pasture. Bone meal appears to improve the condition of animals affected by the deficiency symptoms. The 20-day ripening shrinkage loss in the cuts from the animals receiving bone meal was a trifle less than in the cuts from the animals not receiving the bone-meal supplement in spite of the fact that the former cuts were smaller than the latter. It is significant, also, that the cuts from animals receiving the phosphorus supplement with-

stood decomposition better and were edible after a 30-day ripening period, whereas cuts from the other animals were so decomposed that they were decidedly unfit for eating.

For comparison, cuts of meat from two animals fattened on grass alone from a nonphosphorus-deficient area were ripened. Although they were comparable in finish and size to the cuts from animals from the phosphorus-deficient area, their shrinkage was less than half that for the cuts from animals from the phosphorus-deficient area. Furthermore, they stood ripening beautifully and came through as bright, clean, and sound as corn-fed beef.

These considerations made it seem advisable to investigate those mineral elements in the tissue which might be expected to influence its permeability and hydrophilic nature. A systematic analysis has been made including determinations of sodium, potassium, calcium, and phosphorus in the fat. There was found to be a significantly high Na/Ca ratio where shrinkage losses are high and spoilage most pronounced. This relation is to be expected in view of the hydrophilic antagonism of sodium and calcium. A most unexpected development in this connection is that the electrical resistance of the fresh meat should likewise be outstandingly high in these samples. That this pronounced variation exists, however, indicates that electrical conductivity has possibilities of being developed into an indicator of meat quality. It is interesting to note that the ripening process nearly reduces the electrical resistance of all samples to a common level.

[Project 184; Department of Chemistry. Leaders, H. H. King and J. L. Hall; Adams fund.]

Factors Influencing the Mineral Metabolism of Dairy Animals--Four phases of this project have been active during the biennium, each of which is briefly discussed below.

Milk as a Sole Diet for Calves.—This study was started in 1920. During the first year of the past biennium two lots of three Holstein bull calves were fed whole milk and an increasing quantity of skim milk until the proportion of one-third whole milk and two-thirds skim milk was reached. Lot I received no supplement, but Lot II received a mineral mixture, each calf getting 10 c. c. daily of the mixture which supplied 200 mg. of Fe, 15 mg. of Ca, and 30 mg. of Mn. At about 9 months of age the daily allowance of mineral was increased to 20 c. c.

During the second year four lots of three Holstein bull calves were used. Each calf received whole milk sufficient for its requirements as shown by the Morrison standard, and 10 c. c. of a mineral mixture which supplied 200 mg. of Fe, 15 mg. of Ca, and 30 mg. of Mn. In addition, the different lots were handled as follows:

Lot I: Control—no supplement.

Lot II: Dried brewers yeast—2 per cent of dry matter of ration.

Lot III: Cod liver oil—20 c. c. per calf daily.

Lot IV: Dried brewers yeast—2 per cent of dry matter of ration, and cod liver oil—20 c. c. per calf daily.

During both years the calves were muzzled. They had access to tap water and were given NaCl at frequent intervals. Measurements of body weight and height of withers were secured monthly and, for use in calculating rations, semi-monthly weights were also taken. Blood for hemoglobin determinations was drawn from each calf at two-week intervals, and for plasma calcium at two- to three-month intervals.

During the first year a lack of blood hemoglobin began to show up in all calves, at the end of three months in Lot II, and at six months of age this was marked. In both lots the calves were somewhat below normal weight at six months of age, which might be partially accounted for by the fact that their consumption of milk had not been sufficient to meet their requirements for

nutrients. Lot I showed 81 per cent normal weight and 98 per cent normal height, and Lot II 78 per cent normal weight and 99 per cent normal height.

In Lot I the three calves died at 13½ months, 6½ months and 12½ months, respectively, all showing digestive disturbances but no evidence of spasms. In Lot II one calf died at 10 months of age showing slight spasms. The third calf was withdrawn from the experiment at 18 months of age, at which time it was in good health and about normal in size, weighing 1,044 pounds. The blood of all calves in Lot II was normal in hemoglobin content when they went off the experiment.

The second year's work is still in progress. All but one calf is still living. This calf in Lot IV died at a little over four months of age as the result of a lung abscess caused by a wire or nail which penetrated the wall of the reticulum. At the end of the first six months of experimental feeding all lots were below normal in weight, varying from 68.1 per cent normal in Lot II to 90.4 per cent in Lot III. Only one lot (No. II) was below normal in height of withers, it being 99.3 per cent normal height, while Lot III, the tallest lot, was 107.5 per cent normal considering 101.7 cm. as normal for six-month-old Holstein bulls. The blood calcium and hemoglobin were up to normal in all calves.

Lots III and IV, receiving a supplement, are distinctly superior to Lot I, which received no vitamin supplement. The experiment is being continued.

Studies of the Sugar Content of the Blood of Dairy Cattle.—During the past biennium the work on this phase of the project has consisted of a study of the effect of increased blood glucose on some of the constituents of milk. The increase in blood sugar (average increase from 59 to 108 mg. per 100 c. c. blood) was produced experimentally by pumping glucose solution into the stomachs of lactating cows. The primary purpose was to note the effect on lactose synthesis. The following conclusions may be drawn from the results of this work.

1. Milk drawn at the time of maximum increase of blood sugar showed higher lactose concentration than corresponding milkings on preceding or following days.

2. The increase of lactose in milk was not proportional to the increase in blood sugar.

3. The average amount of fermentable sugar in milk calculated as glucose showed a significant increase for approximately 24 hours after dosage.

4. No consistent significant variation was observed in milk yield or in the concentration of fat or total solids.

5. The concentration of blood glucose was not found to be a primary factor controlling the concentration of lactose in milk.

The Hemoglobin Content of the Blood of Dairy Cattle.—Determinations of the hemoglobin content of the blood of the animals in the college dairy herd, two state herds, and one privately owned herd were made, a total of 335 determinations on 297 head of daily cattle. The average hemoglobin content was found to be 10.96 ± 0.064 grams of hemoglobin in 100 c. c. of blood. Such factors as breed, age, and prolonged fasting did not seem to affect appreciably the hemoglobin content of the blood, and no significant individual variation was observed from day to day. This phase of the project will be discontinued.

The Relation of Phosphorus Intake to the Utilization of Feed.—This work was started in the fall of 1929. During the first year of the present biennium a study was made of the digestion of feed by phosphorus-deficient animals. Three lactating cows were used in this trial, one being a control. During the second year the investigation has been devoted to oxygen-consumption studies of two lactating cows in a phosphorus-deficient condition. Similar studies have been made on the same cows after receiving a phosphorus-supplemented ration for several months.

Influence of the Ration on the Vitamin C Content of Cow's Milk.—During the past biennium approximately 60 guinea pigs were used in testing the vitamin C content of milk produced under pasture and dry-lot conditions. The guinea pigs were fed at the 50 c. c. level daily. In dry lot the cows were further subdivided, receiving a good winter ration with and without silage.

At least two recent investigations would attribute the vitamin C potency of milk from cows in dry lot to the silage which the cows were receiving.

Since the work outlined above is being repeated in all phases at the time of writing, detailed results will be reserved until the present investigation is completed. However, results during the past biennium would indicate that silage-fed cows apparently do not secrete any more vitamin C in their milk than cows without silage. Guinea pigs fed a basal ration plus silage as the only possible source of this vitamin died of scurvy as rapidly as animals on the basal ration. Since five out of seven guinea pigs in the lot receiving milk from cows on pasture died of heat before the completion of the 90-day test, it is hoped the present experiment will furnish more conclusive data.

[Project 147; Departments of Dairy Husbandry, Chemistry, and Veterinary Medicine. Leaders, H. W. Cave, W. H. Riddell, J. S. Hughes, C. H. Whitnah, and H. F. Lienhardt; Purnell and state funds.]

Dairy Cattle-Feeding Investigations.—The investigations conducted under this general project during the biennium have consisted of six phases, each of which is briefly discussed below.

A Comparison of Sorgo Fodder and Sorgo Silage for Milk and Butter-fat Production.—During the biennium two phases of this study have been conducted. In each phase the double reversal system was used with two lots of five cows each, making a total of 20 cows used. In one case 7-day preliminary and 28-day experimental periods were used, and in the other phase the preliminary periods were 10 days and the experimental periods 20 days in length. The rations used consisted of alfalfa hay and a grain mixture made up of 4 parts of corn chop, 2 parts of wheat bran, 1 part of linseed meal, and 1 per cent each of steamed bone meal, ground limestone, and salt.

One lot of cows was started on Kansas Orange sorgo silage while another lot was started on Kansas Orange sorgo fodder. In the first phase the fodder was kept in an open shed, while during the second phase it was brought from the field as used. The cows were fed according to their requirements as shown by the Morrison standard. When the cows were receiving fodder, it was fed in an amount sufficient to furnish dry matter equal to that furnished by silage. All fodder was cut before feeding to a fineness equal to that of silage. Throughout the second phase, which ended late in January, 1932, the fodder contained considerable moisture, it ranging on an air-dry basis from a maximum of 55 to a minimum of 35 per cent. The fodder in the first phase, as taken from the shed, varied from a maximum of 24.5 per cent moisture during January to a minimum of 16.5 per cent during March, when this phase was completed.

The total production of milk and butter fat while the cows were on fodder was almost identical with the production while they were on silage. There was also no significant change in body weight. The results indicate that good ground-sorgo fodder may be substituted for silage for cows receiving a ration of alfalfa hay and grain with satisfactory results. The labor involved in the daily hauling of fodder from the field and grinding for use is greater than in handling silage.

Atlas Versus Kansas Orange Sorgo Silage for Milk Production.—One phase of the work was conducted during the biennium, 10 cows (two lots of five each) being fed through three 29-day periods, 9 days of each being used as a preliminary period during which adjustments in rations were made. Throughout the experiment all the cows received alfalfa hay and a grain mixture made up as follows:

	Lbs.		Lbs.
Corn chop	400	Steamed bone meal.....	7
Wheat bran	200	Ground limestone	7
Linseed meal	100	Salt	7

In addition during periods I and II Atlas sorgo silage was supplied to one lot and Kansas Orange sorgo silage to the other. For the second period the silages were reversed. The usual experimental feeding practices were followed. The cows were kept in ordinary stanchions but were turned in a dry lot during suitable weather.

The cows made some gain in body weight on both kinds of silage. The somewhat smaller gain made by the cows on Atlas silage may be accounted for by the fact that they received 92 per cent less grain than the cows on Kansas Orange silage. The hay and silage consumption while on the two silages differed less than 1 per cent.

The cows produced somewhat more milk and fat while on Atlas silage. The increase was 3.4 per cent in milk and 5.6 per cent in fat, which may be enough to have some significance. Atlas silage will be used in the future to replace Kansas Orange silage for the college dairy herd.

Sorghum Grains Versus Corn for Developing Dairy Heifers.—This experiment was begun in 1927. Its purpose was to determine whether the sorghum grains could replace corn satisfactorily in the ration for growing dairy heifers. Heifer calves that have been raised to six months of age on a grain ration containing 50 per cent corn, cane, or kafir were continued on through the first and second lactation periods on the same grain. Alfalfa hay and silage made up the balance of the ration. For one month prior and subsequent to freshening, half a pound of linseed meal was included daily in the ration. Weight and height determinations were made at regular intervals.

Except for a short period, before and after freshening, the heifers have made a creditable production record, considering the fact that the rations fed contained no high-protein concentrate. The one exception was an animal in the sorgo group that lacked both volume and persistency of production from the start. The evidence accumulated to date does not bear out the popular belief that feeding sorgo (cane) seed promotes the drying up of dairy cow.

All animals are in good condition at the time of writing, and no noticeable differences attributable in any way to the respective rations can be detected between the different groups. The experiment will be continued for another year until all cows have completed their second lactation period.

Soybean Versus Alfalfa Hay for Milk and Butter-fat Production.—During the second year of this biennium a third phase of work was conducted comparing the relative value of soybean and alfalfa hay for milk and butter-fat production. Previous phases were conducted in 1928 and 1929. The usual experimental feeding procedure was followed with the double-reversal system used.

Alfalfa hay was slightly more efficient for milk production, figuring on the basis of the amount of digestible crude protein (D. C. P.) and total digestible nutrients (T. D. N.) required per unit of production. A higher percentage of fat, however, made the soybean hay slightly more efficient in the production of butter-fat.

Ground Wheat Versus Ground Corn for Dairy Cows.—During the biennium three feeding experiments of 90 days each have been conducted, comparing ground wheat with ground corn for dairy cows. A total of 28 cows was used. The double-reversal method of feeding was used, with a 10-day preliminary period and a 20-day period from which data were used. The lots in all cases were divided as evenly as possible on the basis of breed, age, weight, stage of lactation, and milk and butter-fat production.

The ration used was made up of alfalfa hay, sorgo silage, and a grain mixture as follows:

	Lbs.		Lbs.
Ground corn or wheat.....	400	Ground limestone.....	7
Wheat bran.....	200	Steamed bone meal.....	7
Linseed meal.....	100	Common salt.....	7

The wheat used in the ration was ground to a medium fineness, since preliminary tests showed this to be the most palatable.

The results indicate that wheat may be substituted pound for pound for

corn up to 57 per cent of the grain ration. There seemed, however, to be some tendency for the cows to go off feed while on the wheat ration.

Silage Weight Determinations.—The object of this study, which has been continued over several years, is to determine the weight per cubic foot of untramped silage at various depths and different points in a silo. By means of special apparatus weights were taken of silage at the center of the silo, six inches from the fall, and at a point midway between these two points for each foot of depth in the silo. Air-dry moisture determinations were also made of the silage taken from different points in the silo.

Determinations made in seven silos during the biennium indicate that with untramped silage the weight of the silage is greater at the center of the silo and decreases toward the outer edge. The weight at the outer edge averages 3.2 pounds or 7.8 per cent less than at the center. The weight midway is 0.8 of a pound or 1.9 per cent less than at the center.

Additional data will be obtained and eventually it is hoped that tables for the standard weight of untramped silage at different depths in different kinds of silos may be formulated.

[Project 34; Department of Dairy Husbandry. Leaders, J. B. Fitch and H. W. Cave; state fund.]

Silage Investigations.--This project was planned to study the influence of stage of maturity of Kansas Orange sorgo on quality and composition of silage made from it.

Due to the unusual growing conditions brought about by the dry weather during 1930 it was possible to secure sorgo in the bloom, milk, and developed-seed stage of maturity. Samples of cut sorgo representing the several stages of maturity were collected and brought to the laboratory for analysis. Samples of the same material were placed in automobile inner tubes, the tubes were sealed and placed in the silo. Other samples of sorgo representing the several stages of maturity were permitted to dry for varying lengths of time before they were run through a cutter. Samples of this material were also brought to the laboratory and other portions placed in tubes as previously described.

The more mature sorgo showed the least loss in weight as a result of siloing. The greatest loss in weight of material was with the less mature plants. In general the less mature sorgo made silage with the highest acid content. The loss in carbohydrates from siloing was greatest in the less mature samples. One sample of very green sorgo that had not reached the bloom stage made excellent silage although somewhat high in acid content (3.43 per cent).

The sucrose of all samples of silage had disappeared at the time of examination. The reducing sugars were much less in amount. However, the amount of this sugar varied from 0.19 to 3.43 per cent. The starches and reducing sugars were found in greatest amounts in silage made from the more mature plants.

The loss in dry matter as a result of siloing increased with time. This loss varied from 6.41 to 12.90 per cent for mature plants with a time interval of 70 to 243 days; for sorgo in the milk stage, from 6.26 per cent to 8.91 per cent with a time interval of 70 to 292 days; for sorgo in bloom stage, from 10.35 to 12.57 per cent with a time interval of 70 to 292 days; while very green plants lost 18.13 per cent in 57 days. These results indicate the greatest loss in dry matter with the less mature plants for a definite period of time in silo. In general, the protein, ether extract, crude fiber, and ash content of silage show a slight increase over that found in the green sorgo. This increase is readily accounted for in the decrease in dry matter in the form of carbohydrates.

[Project 34; Departments of Chemistry and Dairy Husbandry. Leaders, J. B. Fitch, H. W. Cave, and W. L. Latshaw; state fund.]

Normal Growth of Dairy Cattle.—This project, started in 1922, has been continued as previously reported. It involves a study of

the weight and measurement of all female calves in the dairy herd at monthly intervals from birth to two years of age. Similar measurements are made of male calves until 12 months of age. Data are being collected on the Ayrshire, Guernsey, Holstein, and Jersey breeds. Commencing with 1931 all females over 24 months of age are being weighed and measured twice a year, in January and July, respectively. To date more than 7,000 combined weight and height determinations have been made. These data are extremely valuable to dairy-cattle breeders and for experimental investigations involving growth, and it is planned to continue this study indefinitely. [Department of Dairy Husbandry; Leader, W. H. Riddell; state fund.]

Ice Cream Investigations.—The work during the biennium has consisted of a study of different methods of processing and mixing ice cream and sherbet and different methods of determining their quality. Six phases of these problems have been studied, each of which is briefly discussed below.

The Use of Fresh Eggs in Ice Cream.—Whole fresh eggs in amounts up to 4 per cent of the ice-cream mix by weight and egg yolks up to 2 per cent were found to have a beneficial effect on the whipping properties of the mix and improved the texture of the ice cream. Good results were obtained when the eggs were thoroughly mixed together, added to one-third to one-half of the cold ingredients, and the temperature raised to 180 degrees F. for 15 minutes, at which time the remaining ingredients were added and the mix pasteurized and homogenized in the usual way.

Samples of egg yolks were preserved by adding 5 per cent of corn sugar. One per cent of glycerine and 0.5 per cent of gelatine were also added to other samples in addition to the corn sugar and the yolks stored at 0 to —10 degrees F. The 5 per cent of corn sugar proved effective in stabilizing the yolks and made it possible to incorporate them satisfactorily into the ice-cream mix. The ice cream made from the stabilized frozen yolks whipped, on the average, 2 minutes faster than that made from the check mix without eggs, or slightly faster than the check mix containing the unstabilized yolks.

Investigation of Chocolate Ice Cream.—The work on this phase of the project during the biennium has consisted of (1) a study of the relationship between pasteurization temperature, holding time, and the homogenization pressure in relation to the viscosity and whipping properties of chocolate ice-cream mixes; (2) a study of samples of chocolate ice-cream mixes to determine the relationship between the source of chocolate flavor and the quality of the finished ice cream; and (3) a study of the relationship between the composition of chocolate ice-cream syrups and quality of the finished product.

Experiments conducted with a chocolate ice-cream mix calculated to test 12 per cent fat, 10 per cent serum solids, 15 per cent sugar, 0.35 per cent gelatine, and 2.34 per cent fat-free chocolate indicate that the pasteurization and homogenization temperature, the length of the holding period, and the homogenization pressure very materially influence the viscosity and whipping properties of chocolate ice-cream mixes.

Pasteurization temperatures of 155 degrees F. or below invariably yielded mixes with a high viscosity, which failed to whip satisfactorily in the freezer. Processing temperatures of 175 degrees F. or above produced heavy viscous mixes of the same general character as the mixes processed at the lower processing temperatures, if the holding period exceeded 15 minutes. It was possible to hold chocolate ice-cream mixes for one hour at 165 degrees F. without producing any abnormal viscosity, whereas a temperature of 175 degrees F. for one hour on a portion of the same mix caused it to become exceedingly viscous.

In a series of chocolate ice-cream mixes homogenized at 2,000, 2,500, and 3,000 pounds pressure at a temperature of 165 degrees F. the overruns at the end of 13 minutes were 97, 92, and 86 per cent, respectively, indicating that lower homogenization pressures have a favorable effect on the whipping properties of chocolate ice-cream mixes.

When a series of chocolate ice-cream mixes were pasteurized at 155 degrees F., 165 degrees F., and 175 degrees F. for one hour and homogenized at these temperatures under 2,000 pounds pressure, the overrun at the end of 13 minutes were 92, 100, and 90 per cent, respectively. It may be concluded from these studies that a chocolate ice-cream mix of the composition used in this investigation should be pasteurized and homogenized at a temperature of 165 degrees F., using a homogenization pressure of not over 2,000 pounds, if a low viscosity and fast whipping are desired.

A Study of the Use of Vegetable Stabilizers in Ice Cream.—The chemical composition of five vegetable stabilizers has been determined. Three have been used in commercial ice-cream mixes to determine their effects on certain properties of the mix and on the quality of the finished ice cream.

The analyses of the stabilizers indicated that their stabilizing action was due to the gum which they contained. The vegetable stabilizers were compared in commercial ice-cream mixes with gelatine and with mixes with no stabilizer. The effects of the stabilizers on certain properties of the ice-cream mix were determined and found to be as follows:

1. The initial viscosity of the mixes containing the vegetable stabilizers was considerably higher in all cases than the initial viscosity of the other mixes. After aging for a period of 24 hours at 40 degrees F., the viscosity of all the mixes was increased, but the greatest increase occurred in the mix stabilized with gelatine.

2. The mix containing no stabilizer froze and whipped considerably faster than any of the other mixes.

3. No significant differences were apparent in the quality of the finished ice cream in any of the samples containing stabilizers. The sample to which no stabilizer was added scored approximately 2 points below the other samples on body and texture.

4. No appreciable differences were noted in the ability of the ice-cream samples to resist melting when exposed to an average room temperature of 80 degrees F., with the exception of the sample containing no stabilizer. This sample started to melt 8 to 9 minutes sooner than any of the other samples.

An Investigation of Gelatine in Sherbet Mixes.—Seventeen gelatine samples of known Bloom strength were secured from three gelatine manufacturers and tested for their gel strength by the Dahlberg test. The gelatine samples were also tested by a modification of the Dahlberg test, worked out at this station, for determining the proper amount of gelatine to use in sherbet mixes. It was found that the correct amount of gelatine to use in a sherbet may be obtained by multiplying the pounds of water contained in the sherbet mix by the percentage of gelatine indicated by the modified Dahlberg test.

The Effect of Pasteurization Temperature on the Bacteria Flora of the Ice-cream Mix.—The object of this study was to determine the relative efficiency of different pasteurizing temperatures, and to determine which groups of organisms survive pasteurization.

The results of 30 trials with temperatures ranging from 145 to 180 degrees F. for periods of time ranging from 0 to 30 minutes seem to indicate no superiority for any temperature or time, since all the counts on any given mix were within the limits of error inherent to the plate count. It was found that the acid group (weak acid) survived pasteurization more readily than any other group—some mixes after pasteurization showing over 90 per cent acid formers.

Pasteurization under plant conditions is now being carried out. Also there is some pure culture work with about 10 cultures of the weak acid-forming organisms, studying the physiological and morphological characteristics and the action on sterile ice-cream mixes.

Testing Ice-cream Mixes for Butter Fat.—Half-pint samples of the same ice-cream mix were tested intermittently over a period of one month using four modified Babcock tests. The Mojonnier test was used as a check. The four modified Babcock tests used will be referred to as the Minnesota A, Minnesota B, the Nebraska, and the Garrett Overman tests, respectively. The only differences between the Minnesota A and B tests is in the reagent used. The directions supplied with these tests were carefully followed in all cases.

The results indicate the tests to rank as follows with respect to reliability: (1) Nebraska, (2) Minnesota B, (3) Minnesota A, (4) Garrett Overman. The Nebraska test proved quite satisfactory during the entire testing period with the exception that the fat columns were frequently charred and dark. The use of two test reagents instead of one is an objectionable feature of the Nebraska test. The reagent cost for this test is high, because of the fact that a relatively large quantity of one of the reagents is required.

The test designated as Minnesota B gave very clear tests entirely free from charred or curdy material. The use of only one reagent, which is easily prepared, is a decided advantage in its favor. The Minnesota A test did not yield clear tests, as they were invariably curdy, a difficulty that was impossible to overcome by increasing the amount of reagent used or by increasing the length of the heating period before the samples were centrifuged. The Garrett Overman test involves the use of two reagents. This is objectionable. The results with this test were satisfactory at the beginning of the testing period when the reagents were fresh, but toward the end of the testing period the tests were inclined to be curdy. Since one of the reagents used in this test, contains ammonium hydroxide, it is possible that this reagent loses its strength rather rapidly.

[Project 124; Department of Dairy Husbandry. Leaders, W. H. Martin and W. J. Caulfield; state fund.]

A Bacteriological Study of Ice Cream.—The work during the past biennium has followed the lines of investigation outlined in the Fifth Biennial Report. One new aspect having an important bearing on the bacteriology of ice cream has been added to the avenues of research. The work during the biennium may be classified under the following headings: (1) Study of oxidation-reduction potentials of dairy products; (2) the application of the methylene-blue reduction test to ice cream; (3) studies with chlorine disinfectants; and (4) effect of sugar on thermal resistance of living cells.

The studies of the oxidation-reduction potentials of dairy products have provided a fundamental basis for the second phase of these investigations; namely, the application of the methylene-blue reduction test to ice cream. It has been shown in these studies that methylene blue plays a secondary role in the reduction process. After a certain number of bacteria have developed in dairy products the oxidation-reduction potential suddenly swings to more negative potentials, and in doing so passes through the zone of reduction of methylene blue. If the dye be present it will change from blue to white and thereby present visible evidence that this drop in potential has taken place.

The studies have consisted of following the progress of changes in electromotive force induced in dairy products as a result of bacterial growth. By studying the effect of various factors, such as fat, sugar, light, and bacterial flora, on the nature of the potential time curve, some very fundamental observations have been made.

The results obtained in potentiometric studies indicate that if the methylene-blue test is to be applied to ice cream it may necessitate some alteration in the concentration of the dye employed. As a part of the studies leading

directly toward the application of the methylene-blue reduction test to sweet-cream and ice-cream mixes, experiments have been performed to determine the effect of methylene blue on the bacterial count of these products. Although increasing amounts of dye prolong the reduction time, there was no evidence that the dye curtailed bacterial growth even when extremely high concentrations were employed. This fact has an important bearing on the possible alterations in the test as applied to ice cream.

Results of experiments have shown conclusively that the presence of high concentrations of sugar materially increases the resistance of bacteria to heat. These results are being investigated further because of their possible relation to the destruction of bacteria by pasteurization or sterilization of such dairy products as ice cream or sweetened condensed milk which contains large amounts of sugar. It has been shown that not all sugars or salts induce this protective action. The problem presents a fundamental study of the factors involved in thermal tolerance, which not only has a bearing on the immediate problem, but involves the basic principles of many biological problems.

Continuing the studies with chlorine disinfectants outlined in the last biennial report, the work has followed two major lines: (1) An effort to produce sodium hypochlorite from chlorine gas and trisodium phosphate, and (2) the perfection of a simple test for the efficiency of chlorine disinfectants which could be applied by nontechnically trained help in a dairy plant. The excellent cleaning properties of trisodium phosphate combined with the disinfecting properties of chlorine gas suggest the possibility of using this sodium salt as a source of sodium in the manufacture of chlorine disinfectant. The previous studies using sodium hydroxide as a source of sodium for sodium hypochlorite were continued using the trisodium phosphate. The results were wholly negative, as the resultant solution was too unstable to be of practical value. The widespread use of chlorine disinfectants in dairy practice and the high probability of using impotent solutions have demonstrated an imperative need for a simple test for the available chlorine content. Such a test has been devised and found to be highly practicable.

[Project 124; Department of Bacteriology. Leader, A. C. Fay; state fund.]

A Study of the Effectiveness of Lye as Compared with Chlorine for Sterilizing Milking-machine Parts.—A total of 16 trials in which comparisons were made between a 0.5 per cent lye solution and a commercial sodium hypochlorite solution containing 200 parts of chlorine per million showed that either solution was effective in sterilizing the rubber parts of milking machines. The lye solution not only inhibited bacterial growth, but also killed the majority of organisms that were present at the time the lye solution came in contact with the rubber. Solution racks were used in conducting these trials. Similar trials in which a 0.3 per cent lye solution was compared with a sodium hypochlorite solution containing 100 parts of chlorine per million showed that either solution was an effective sterilizing agent when used in connection with the solution racks.

The loss of strength in the lye solution after it had remained in the teat cups and rubber tubes of the milking machine for a period of 48 hours was a negligible factor. Sodium hypochlorite solutions, however, under the same conditions had lost all of their available chlorine at the end of 48 hours. Since the bacteriological condition of the machines sterilized with sodium hypochlorite solutions was satisfactory in all cases this loss in strength is not especially significant.

Four trials were made in which a 0.5 per cent lye solution was compared

with a chlorine disinfectant solution containing 200 parts of chlorine per million when the rubber parts were immersed in the solutions. The lye solution, because of its greater stability, was decidedly superior to the chlorine disinfectants in these trials. The sodium hypochlorite solution containing 215 parts chlorine per million at the beginning, was reduced to 35 parts of chlorine per million at the end of the four trials. A 0.52 per cent lye solution contained 0.454 per cent sodium hydroxide at the end of the same period.

The loss of strength under actual farm conditions, of lye and chlorine solutions, when the immersion method of sterilizing milking machines is used, was determined. The results of this study showed that the strength of a lye solution testing 0.56 per cent sodium hydroxide was reduced to 0.44 per cent at the end of one week. The life of a chlorine solution containing approximately 200 parts of chlorine per million was found to be 48 hours or less under similar conditions.

The superiority of the rack method as compared with the crock method of sterilizing milking-machine parts was clearly demonstrated in these trials, irrespective of whether chlorine or lye was used as the disinfectant. The rack method is more convenient to use, more sanitary, less expensive, and if a chlorine sterilizer is used, is decidedly more dependable.

[Department of Dairy Husbandry. Leaders, W. J. Caulfield and W. H. Riddell; state fund.]

Butter Investigations.—The treatment of old off-flavored cream by the addition of chlorine compounds for the purpose of improving the flavor of butter made from the cream has been studied during the past two years. Five trials consisting of 16 individual chummings were made, using Santimine, Diversol, and Wyandotte sterilizer for deodorizing the cream.

Previous studies had indicated that the best procedure was to add the deodorizers to the cold cream before the acid was neutralized. It was also found that it was more satisfactory to treat each individual lot of cream, rather than mix all the cream together and treat it in one lot. The results during the biennium tend to verify earlier studies that no marked improvement in the score of the butter could be noticed as a result of this treatment. On the other hand, the results tend to show that, while it may be possible to show some improvement in the flavor of the butter when freshly made when it is held in storage for 60 days or longer a fishy and rancid flavor may develop.

Chemical deodorization of cream may have some merits in connection with the removal of certain off flavors such as onion, weedy, and oily flavors. The improvement in flavor is most noticeable when the butter is freshly made, however, and if the butter is to be held for any length of time, deodorization may accelerate the rate of deterioration.

From the standpoint of color and texture, the addition of deodorants tends to bleach the color and produce a sticky body.

[Project 175; Department of Dairy Husbandry. Leader, W. H. Martin; state fund.]

The Inheritance of Standard Characteristics of Poultry.—During the past two years a study of the inheritance of crookedness of the keel bone in chickens has been continued, and a new study undertaken of the possibility of distinguishing sex at hatching in purebred chicks. An effort was made to increase the percentage of defective keel bones of chicks in this "crooked-keel" strain previously reported. Although the incidence of defective breast bones is high in the crooked-keel strain it has not been possible to increase it to 100 per cent.

During the 1930 season 392 individuals were reared from three matings of crooked-keel males with crooked-keel females. The percentages of crooked-keel individuals in the three matings were 53, 64, and 65, respectively. From these matings birds were selected for the 1931 matings. The individuals chosen were from the pair matings in 1930 which gave the highest percentage of defective keels.

Three matings were again made in 1931 from which 627 offspring were reared to maturity. Of the total number of offspring, 69.9 per cent possessed crooked keel bones. Record was also kept of the direction of the crook in the breast bone and a summary of all three matings showed the number being bent to the left to be practically identical with that of those bent to the right.

Since during several years' selection it has not been possible to obtain a mating which would produce 100 per cent crooked-keel offspring it seems probable that a large number of genetic factors are responsible for this character, or that some genetically "crooked" birds do not show the deformity. It is planned to cross the crooked-keel strain with another strain which has been observed for several years and found to be practically free from the deformity. From the crossing of these two strains it is hoped to be able to analyze the mode of inheritance of this character.

Methods of distinguishing sex at hatching by means of sex-linked factors in crossbred chicks has been known for some time. The method utilizing the growth of flight feathers in day-old chicks was worked out at this station in 1930. The desirability of being able to recognize sex in day-old purebred chicks has long been realized.

In a flock of Single Comb Rhode Island Reds at this station some males were found which showed early-feathering tendencies when examined at 10 days of age. These males were thought to be homozygous for the recessive early feathering. To test this theory, one was mated to five Single Comb Rhode Island Red females known to be homozygous for late feathering which is characteristic of this breed. If sex-linked differences be involved here the male offspring should be late feathering and have practically no wing-feather development at hatching and the females should be early feathering, showing a conspicuous growth of the flight feathers when hatched.

On the day of hatching, the 63 chicks from this mating were separated into an early- and a late-feathering group and autopsies were performed to check upon the accuracy of recognition of sex. All the chicks placed in the early-feathering group were found to be females and in the late-feathering group there was a single error of including one female in this group. A single error in 63 chicks indicates that sex may be recognized with a high degree of accuracy when using this method in purebred chicks. The occurrence of early-feathering birds in Rhode Island Reds is relatively common, and individuals with this characteristic have also been noted in White Wyandottes and White Plymouth Rocks. This would indicate that the method of recognizing sex may be followed in at least three breeds.

[Project 77-3; Department of Poultry Husbandry. Leader, D. C. Warren; state fund.]

Inheritance of Breed Characteristics in Poultry.—Thirty-four relationships have been tested for linkage, and for the most part attention has been confined to those characters which are recognizable in the day-old chick. This avoids the loss of material due to mortality between hatching and maturity. In most of the crosses the number of offspring was large enough to make the test adequate.

The nine characters upon which attention has been centered are naked neck, rumplessness, white skin, leg feathering, rose comb, pea comb, crest, polydactyly, and dominant white. In each case only the dominant member of an allelomorph pair has been named. In no case was there found any evidence for linkage. With a single exception all possible tests for linkage

have been made between the nine characters mentioned above. Unless this single lacking test indicates linkage these nine characters may be considered as markers for nine independent linkage groups in the fowl.

Other characters upon which some relations have been tested are silky plumage, silky white, recessive white, albino, blue, and flightless. It is planned to complete all possible tests among these these and the characters previously mentioned.

[Project 77-4. Department of Poultry Husbandry. Leader, D. C. Warred; state fund.]

Inheritance of Egg Production in Single Comb Rhode Island Red Chickens.—After five and six generations of selections for both early- and late-maturing strains of Rhode Island Reds, crosses were made between the strains during the 1930 and 1931 seasons for the purpose of studying the mode of inheritance of this character. The average age at sexual maturity was measured by the age at which the first egg was laid. There was in the two years approximately 24 and 44 days' difference, respectively, between the two strains in the age at which the females produced their first egg. The studies to date have been limited to the first generation of the crosses. During each of the two years reciprocal matings have been made between the two strains—late-strain males by early-strain females and early-strain males by late-strain females.

A comparison of the results on age at first egg of the daughters from reciprocal crosses between the early- and late-maturing strains should reveal whether sex-linked factors are involved in the inheritance of this character. Work done at the Massachusetts Agricultural Experiment Station has indicated that one of the major factors determining the age at which a female begins to lay is sex linked. Since a female receives her sex-linked factors only from her sire, then those resulting from the cross of a male from the early-maturity strain to females from the late-maturity strain should mature earlier than those from the reciprocal cross.

During 1930 the female offspring from reciprocal crosses had a maturity age more or less intermediate between that of the two strains. There was no difference between the two crosses since they matured at 232.6 and 232.5 days, respectively. The birds hatched during 1931 did show a difference in age at first egg, depending upon the direction of the cross. The females sired by an early-maturity male had an average age at first egg of 222.6 days, which was even slightly less than the average (224.5 days) age of the offspring of the pure early-maturity strain. Those from the reciprocal cross (late male by early female) laid their first egg at an average age of 246.2 days. Thus, the female offspring of the former cross matured 23.6 days younger than those from its reciprocal. The difference is in the expected direction if sex-linked factors are involved. The difference between the two years' results cannot readily be explained unless it was due to a difference in the genetic constitution of the males used.

[Project 77-5; Department of Poultry Husbandry. Leader, D. C. Warren; state fund.]

Poultry Flock Management.—The object of this study, started in 1923, has been to demonstrate a method of management that will yield high production of market eggs during the fall and winter months from a flock of pullets, and good hatchability in the spring from a flock of hens. Single Comb White Leghorns have been used the past two years.

The pullets have been confined in the laying house from October 1 to April 15 each year while the hens have had free range continuously. Both hens and pullets have been trapnested and hatchability tests made to compare results from the confined and free-range lots. When handled in this manner, the pullets averaged 32.6 eggs each more than the hens during the fall and winter months, when eggs were worth most on the market. While the fertility of the hens' eggs was slightly higher, the pullet eggs gave a much better hatch.

[Project 77-6; Department of Poultry Husbandry. Leader, L. F. Payne; state fund.]

Turkey Production.—Turkey production studies during the past biennium have centered around the question of management. Eight hundred and fifty turkeys were reared to maturity. Six distinct phases of work have been undertaken, each of which is reported upon briefly below.

The Effect of Age and Holding Temperatures on the Hatchability of Turkey and Chicken Eggs.—During the 1930 breeding season turkey eggs were held in the basement of a dwelling at temperatures ranging between 55 and 60 degrees F. for from 30 to 34 days before setting. During the season of 1931 the eggs of Single Comb White Leghorns were added to the experiment and the egg-chilling rooms of a local packing establishment used for the holding period. In 1931, lot 26, turkey eggs, and lot 27, chicken eggs, were held at a mean temperature of 36.3 degrees \pm 0.2 degrees F. and a mean wet-bulb reading of 35.3 degrees \pm 0.2 degrees F. Lot 28, turkey eggs, and lot 29, chicken eggs, were held at a mean temperature of 54.2 degrees \pm 0.26 degrees F. and a mean wet-bulb reading of 52.5 degrees \pm 0.25 degrees F. The results of the study are shown in table VIII.

It would appear from the results secured from this study that turkey eggs may be held up to 34 days before setting without markedly reducing hatchability, when held between temperatures of 55 and 60 degrees F. or at a mean temperature of 54.2 degrees. The hatchability of the Leghorn eggs held at 54.2 degrees decreases rapidly after holding for 20 days. It is observed that the vitality of the turkey and chicken embryos was markedly reduced when held beyond the sixth day at 36.3 degrees F.

TABLE VIII.—THE EFFECT OF AGE AND HOLDING TEMPERATURE ON HATCHABILITY OF TURKEY AND CHICKEN EGGS.

DAYS HELD.	Percentage of fertile eggs hatched.				
	Turkey eggs, 1930.	Turkey eggs, 1931.		Chicken eggs, 1931.	
		Lot 26 36.3° F.	Lot 28 54.2° F.	Lot 27 36.3° F.	Lot 29 54.2° F.
0-6	89.25	65.63	70.97	63.33	69.35
7-13	89.71	52.38	65.00	5.26	66.66
14-20	84.78	26.79	74.60	.00	67.95
21-27	84.00	5.88	67.31	.00	44.30
28-34	85.71	.00	61.11	.00	32.05
Mean	87.87	27.98	68.47	12.17	55.10

The Temperature Requirement of the Incubating Turkey Egg.—Approximately 40 turkey and 40 Single Comb White Leghorn chicken eggs were used in this study consisting of two trials of four lots each. For the first week turkey eggs were incubated at 98 degrees F. in lot 1, in lot 2 at 99 degrees, in lot 3 at 100 degrees, and in lot 4 at 101 degrees. The temperature was raised one degree for each successive week in all lots. In each case the chicken eggs were set seven days after setting the turkey eggs, thus the chicken eggs were incubated at the last three temperatures given for each lot. The turkey and chicken eggs of the same lot were incubated in the same compartment of the incubator. The trays were so arranged as to bring the turkey and chicken eggs on the same level with respect to the bulb of the thermometer. The turkey eggs were candled on the tenth and twenty-fifth days of incubation and the chicken eggs on the seventh and eighteenth.

The percentage hatch of fertile eggs set for the turkey eggs in trial one was 71.4, 69.4, 81.6, and 75 for lots 1, 2, 3, and 4, respectively, and for chicken eggs 61.3, 56.2, 75.7, and 82.4. In trial two the percentage hatch of turkey eggs was 54.9, 61.5, 78.4, and 58.3 and for chicken eggs 37.5, 64.9, 59.2, and 68.8 for lots 1, 2, 3, and 4, respectively. These data would indicate that turkey eggs hatch better in subnormal temperatures than do chicken eggs and that the temperature requirement for the incubating turkey egg, at least for the first week, is less than that required for chicken eggs.

A Comparison of the Confinement and Semiconfinement Rotation Systems of Growing Turkeys as Measured by Growth and Mortality.—This study involved 343 poults. Two lots of poults were brooded in confinement under identical conditions for the first four weeks. Lot 1 (semiconfinement, group) was placed on range at start of fifth week. Lot 2 (confinement group) was moved to the nutrition building at the start of the fifth week and continued there until the start of the seventeenth week, after which the group was moved to the range. The rate of growth by sexes was determined at intervals of four weeks for 24 weeks.

The mean weights at 24 weeks of age were as follows: Males, lot 1, 16.11 pounds, lot 2, 15.11 pounds; females, lot 1, 10.72 pounds, lot 2, 10.56 pounds. Both lots grew at approximately the same rate for the first eight weeks. From the ninth to the seventeenth week, lot 2 failed to gain as rapidly as lot 1 but responded in growth when placed later on the range.

The Rate of Growth and Mortality of Young Turkeys as Influenced by the Ingestion of Fibrous Material.—Early poult mortality due to impaction in the digestive tract has been one of the limiting factors in artificial brooding of turkeys. Observations made at this station indicate that straw and fibrous green feed are the primary causes. In this study 100 day-old poults were divided into four lots. All lots received the same basal all-mash ration. Lots 1 and 2 were brooded on hardware cloth. Lot 2 received lawn clippings twice daily. Lot 3 was brooded on peat litter. Lot 4 was brooded on oat straw litter.

The mean weights at four weeks of age for lots 1, 2, 3, and 4, respectively, were 273.2, 256.8, 247.7, and 230.0 grams. The individuals in lot 1 grew very evenly. This was not true of lots 2, 3, and 4. The percentages of mortality for the four lots were 8.33, 4.17, 12.0, and 24.0, respectively.

The Effect of Age of Breeding Turkeys on Percentage Production, Distribution of Production, Egg Size, and Hatchability.—It was thought advisable to make this comparison with turkeys. The turkey breeding flock, consisting of 17 old hens ranging from two to four years of age and 16 pullets, was divided into two lots, lot 23 made up entirely of old hens and lot 24 of pullets. Young males were alternated weekly between the two lots to minimize any differences that might arise due to the influence of the male.

The mean percentage production for lot 23 was 36.71, compared with 39.58 for lot 24. The mean weight of eggs from lot 23 was 93.02 grams, as compared with 89.31 grams for lot 24. The average percentages of hatchability were 50.8 and 57.2, respectively, for lots 23 and 24.

The Value of Tobacco Powder (Nicotine Sulphate) in the Prevention of Enterohepatitis in Turkeys.—Previous to the year 1930 heavy losses occurred in the station flock of growing turkeys due to the disease blackhead (enterohepatitis). This study was prompted by the splendid results obtained in 1930, when 4 per cent tobacco powder was incorporated continuously in the mash after the poults were eight weeks of age.

Six lots of 24 poults each were used in the experiment. All lots received the following all-mash basal ration *ad libitum*:

	Lbs.		Lbs.
Yellow corn meal.....	20	Meat and bone scrap.....	15
Ground oats	15	Dried buttermilk.....	10
Ground wheat.....	20	Alfalfa leaf meal.....	5
Wheat bran	15	Cod-liver oil.....	1

Lot 18 received the basal ration plus 0.0195 per cent nicotine (1 pound of tobacco powder to 100 pounds of basal ration); lot 19, basal plus 0.0390 per cent nicotine (2 pounds of powder); lot 20, basal plus 0.0585 per cent nicotine (3 pounds of powder); lot 21-A, basal plus 0.0780 per cent nicotine (4 pounds of powder); lot 21-B, same as lot 21-A; lot 22 received the basal ration alone. The tobacco powder contained 1.95 per cent nicotine sulphate. All percentages of nicotine are expressed as nicotine sulphate.

The experiment continued for five months. Feed was mixed monthly and stored in tight containers. The original supply of tobacco dust was kept in air-tight containers at all times. Tobacco powder was added to the basal ration of all lots except the control group (lot 22) at the start of the fifth week. All lots were brooded in hail-screen compartments for the first to the fourth week, inclusive. Rearing to the twenty-fifth week was completed in six breeding pens. Chickens had previously occupied these pens during the breeding season for a number of years. All lots except 21-B were rotated from one pen to another weekly.

The mortality data and diagnostic observations are presented in Table IX. The following observations seem justified.

1. The organism causing enterohepatitis can apparently bring about heavy mortality independently of the ceca worm.

2. Tobacco powder analyzing 1.95 per cent nicotine sulphate when fed continuously at levels of 2 to 4 per cent appears to be an effective anthelmintic for the ceca worm.

3. Although the growth data are not submitted, the feeding of tobacco powder at a 4 per cent level does not appear to inhibit normal growth.

TABLE IX. -DIAGNOSIS OF MORTALITY IN POULTS RECEIVING VARIOUS LEVELS OF NICOTINE SULPHATE.

Lot No.	Number of poults started.	Total mortality.	Diagnosis of mortality.			
			Number due to unknown causes; blackhead negative.	Number due to coccidiosis alone.	Number due to coccidiosis plus blackhead.	Number due to blackhead alone.
18.....	24	10	2	0	3	5
19.....	24	16	3	1	3	9
20.....	24	20	3	0	9	8
21A.....	24	15	3	0	5	7
21B.....	24	5	2	0	0	3
22.....	24	12	2	1	1	8

[Project 77-15; Department of Poultry Husbandry. Leader, H. M. Scott; state fund.]

Turkey Nutrition Investigations.--During the biennium a study has been made of the effect of certain vitamin deficiencies upon the growth and development of turkeys. This study divides itself into four phases, each of which is briefly discussed below.

The Effect of Feeding a Vitamin-A-low Ration to Growing Poults--An experiment was conducted to determine the effect of feeding a vitamin-A-low ration to growing poults as measured by general health, rate of growth, and blood analysis. Single Comb White Leghorn chicks were compared with the turkeys. Each lot consisted of 17 individuals. In each trial the experimental poults and chicks received a basal ration low in vitamin A. It consisted of white cornmeal 30 parts, ground wheat 25 parts, wheat bran 20 parts, and meat and bone scraps 25 parts. As a source of vitamin A the control groups received 30 parts of yellow cornmeal which replaced an equal amount of white cornmeal in the basal ration. All groups were irradiated 30 minutes or longer daily. Weekly growth values were determined for eight weeks. Blood analyses were made during the fifth week.

The poults on the inadequate ration developed deficiency symptoms earlier than the experimental chicks. The chicks receiving 30 per cent of yellow corn showed no signs of vitamin A deficiency, whereas the poults receiving the same amount developed deficiency disorders. These results would indicate that the vitamin A requirement of growing turkeys is greater than that of Single Comb White Leghorn chicks.

The Effect of the Lack of Vitamin D on Growing Poults.--Two lots of 25-day-old poults and two lots of 25-day-old Single Comb White Leghorn chicks were fed a ration low in vitamin D. It was composed of yellow cornmeal 74 parts, dried skim milk powder 25 parts, and common salt 1 part. Lot 9, control poults, and lot 10, control chicks, were irradiated 15 minutes daily during the eight-week experimental period.

The femur and tibiae bones of six chicks and a like number of poults were dissected out at the beginning of the experiment for calcium and phosphorus determinations. At the close of each succeeding two weeks the bones were removed from four representative individuals in each lot for calcium and phosphorus analyses. At the conclusion of the fourth week and at intervals of two weeks thereafter, blood samples were obtained by cardiac puncture for calcium and inorganic phosphorus analyses.

Young turkeys receiving a ration low in the antirachitic factor developed characteristic signs of rickets in a shorter period of time than did chicks kept under identical conditions.

Rickets in young turkeys is characterized by an awkwardness of movement, by the softness of the beak, and by the ruffled appearance of the feathers. In rickets the femur and tibiae bones of turkeys were found to be low in ash. The analysis of blood revealed a low calcium and inorganic phosphorus content.

The Effect of Feeding a Vitamin-A-low Ration to Mature Bronze Turkey Pullets and Single Comb White Leghorn Hens.--The object of this study was to determine what effect the feeding of a vitamin-A-low ration would exert on the general health, egg production, and body weight of female turkeys as compared with chickens.

Two lots of mature turkeys consisting of 10 females each were placed in separate 20 by 20 foot pens. Two lots of 10 Single Comb White Leghorn yearling hens were placed in like pens. All groups were confined within the building and irradiated daily with a Cooper-Hewitt work lamp.

Lot 14, control turkeys, and lot 15, control chickens, received the following ration adequate in vitamin A:

	Lbs.
Ground white corn.....	63
Wheat bran.....	15
Meat and bone scraps.....	10
Alfalfa leaf meal.....	10

Lot 16, experimental turkeys, and lot 17, experimental chickens, received the same ration with the exception that 10 pounds of synthetic meal, low in vitamin A and having the same percentage of protein, fiber, and ash, as alfalfa leaf meal replaced the 10 pounds of alfalfa leaf meal. The first deficiency symptoms appeared in the experimental chickens at the end of the second month. By the fourth month all chickens in this group except one had died of A-avitaminosis. This individual died a month later. The first symptoms were observed in the experimental turkeys toward the close of the fourth month. Nine experimental turkeys were alive at the conclusion of the fourth month, five survived the fifth month, and four the sixth.

The experimental turkeys did not start to lay until March 31, whereas the experimental chickens were laying when placed on the deficient ration. This may have influenced the length of time required for the deficiency disorders to appear as the vitamin storage in the body may be more rapidly depleted when drawn upon for egg production. The lack of vitamin A greatly reduced egg production in both experimental groups.

Blood analyses of the turkeys on the deficient ration, 14 days after the last egg was produced, showed a calcium level typical of birds in production. The range of calcium for these individuals was from 23 to 33 mg. per 100 c. c. of plasma. Observations made through an incision between the last two ribs of these females showed fully developed ova in the ovary although no eggs had been produced in the previous two weeks. It appears that in some may the lack of vitamin A prevented ovulation although fully developed ova were present in the ovary.

Towards the latter part of the experiment it was observed that the experimental turkeys produced a large number of thin-shelled eggs with very few of the characteristic brown spots on the shell. This would seem to indicate that the lack of vitamin A impairs the function of certain regions of the oviduct. The average egg weight of the control turkeys was 83.1 grams as compared with 78.8 grams for the experimental lot of turkeys.

A Quantitative Study of the Vitamin A Requirement for Growing Poults—Five lots of 13 poults each and five lots of 20 Leghorn chicks each were used in this study. The various lots received from 0 to 60 per cent yellow corn in the ration as a source of vitamin A. Lot 30 poults and lot 31 chicks received the following vitamin-A-deficient ration with water to drink:

	Lbs
Ground white corn.....	60
Ground wheat	10
Wheat bran	10
Meat and bone scraps.....	20

Lot 32 poults and lot 33 chicks received the same ration except that half of the ground white corn was replaced by a like amount of yellow corn. In lots 34 and 35 the replacement was two-thirds, in lot 36 poults and lot 37 chicks it was five-sixths, and in lot 38 poults and lot 39 chicks all of the white corn was replaced by yellow corn. Thus the various groups received 0, 30, 40, 50, and 60 per cent yellow corn as a source of vitamin A. All groups were irradiated 30 minutes or longer daily. The experiment was continued for 11 weeks during which time individual weekly weights were recorded.

All of the poults and 12 of the chicks receiving the ration containing 0 parts of yellow corn died during the experimental period. Deficiency symptoms were observed in lot 30 poults during the third week and in lot, 31 chicks during the sixth week. Chicks receiving 30 per cent yellow corn developed normally whereas the poults receiving this ration failed to grow at a normal rate although they did not develop the advanced stages of vitamin A deficiency. The poults receiving 50 and 60 per cent yellow corn grew normally.

With the particular sample of yellow corn used and as the only source of vitamin A, the data suggest that between 50 and 60 per cent of the ration should consist of yellow corn for the best growth of turkeys, while 30 per cent or less is adequate for chicks.

[Project 77-17; Department of Poultry Husbandry and Chemistry. Leaders, H. M. Scott and J. S. Hughes; state fund.]

A Study of the Rate of Growth and Embryonic Development of Bronze Turkey Embryos.—Eggs obtained from a flock of turkeys that received ordinary care on the college farm were incubated in a Buckeye forced-draft incubator at a temperature of 100 degrees F. and a relative humidity of 59 per cent. Starting with the fifth day and for every other day up to and including the twenty-sixth day, from four to six embryos were extracted from the shell for weight and nitrogen determinations. The results of these determinations are presented in Table X.

TABLE X.—THE RATE OF GROWTH OF BRONZE TURKEY EMBRYOS AS MEASURED BY WET WEIGHT, DRY WEIGHT, AND NITROGEN CONTENT.

AGE OF EMBRYOS IN DAYS.	Values per embryo.			
	Wet weight (grams).	Increment of growth (grams).	Dry weight (grams).	Nitrogen (grams).
5.....	0.0202	0.1247	0.0011	0.00015
7.....	.1449	.5288	.0076	.00089
9.....	.6737	.3403	.0451	.00420
11.....	.9140	2.3164	.0877	.00920
13.....	3.2304	1.8753	.2349	.01820
15.....	5.1057	4.5472	.3865	.04150
17.....	9.6528	7.5855	.9500	.....
19.....	17.2483	3.4834	2.2250	.23150
21.....	20.7317	10.9324	3.4750	.27600
23.....	31.6641	8.9609	6.1875	.60600
25.....	40.6250	2.8000	7.7872	.71100
26.....	43.4250	.....	8.8500	.82350

A comparison of the rate of growth of the turkey embryo as determined in this experiment and the rate of growth of the Leghorn embryo from the work of others shows that the turkey embryo is much smaller than the chicken embryo at any given day of incubation up to the twenty-first day.

The logarithm of the average wet weight expressed as a function of the logarithm of the incubation age in days approximates a straight line. This has been found to be true by other workers working with the chicken embryo.

[Project 77-19; Departments of Poultry Husbandry and Chemistry. Leaders, H. M. Scott and J. S. Hughes; state fund.]

The Comparative Nutritive Value of Certain Grain Sorghums, Corn, and Wheat in Poultry Production.—The purpose of this study was to compare the value of certain grain sorghums with white corn, yellow corn, and wheat as grain for chickens. The work has consisted of feeding these grains to chicks from date of hatch to maturity and through a 9-month laying period. The criteria for measuring the value of the grains have been rate of growth, livability, egg production, and hatchability.

Twelve hundred White Leghorn chicks hatched May 14, 1930, were divided into four lots of 300 each and the pullets were reared to maturity in a long

brooder house equipped with sanitary runways. The chicks did not come in contact with the soil for the duration of the experiment.

The basal ration was composed of bran, alfalfa leaf meal, meat and bone scraps, dried butter milk, steamed bone meal, calcium carbonate, salt, and cod-liver oil. To this basal ration was added the different grain as follows:

- Lot I-50 per cent ground kafir.
- Lot II-50 per cent ground milo.
- Lot III-50 per cent ground white corn.
- Lot IV-25 per cent ground yellow corn.
 25 per cent ground wheat.

An outbreak of coccidiosis among the small chicks proved fatal to a large number before the disease was checked. While only healthy birds were kept for the experiment, this disease and a subsequent infestation of tapeworms probably interfered with the results and caused heavy mortality among the adult birds.

The chicks were weighed every four weeks and the average weights per pullet at six months of age were 2.98, 2.99, 3.08, and 2.91 pounds for lots I, II, III, and IV, respectively. These differences do not appear to be significant. The hatchability and egg production records do not give any of the lots a significant advantage.

[Project 77-18; Department of Poultry Husbandry. Leader, L. F. Payne; state fund.]

Influence of Hybridization Upon Vigor in Poultry.—This project embraces two phases of work, each of which is briefly discussed below.

The Effect Upon Vigor of Crossing Distantly Related Strains of the Same Breed.—Studies have been made of the effects of crossing three strains of Single Comb White Leghorns. Each of the three had been independently bred for a period of years and have been designated as West Coast, East Coast, and Kansas strains. Results are available from two experiments, one involving the West Coast and Kansas strains and the other the West Coast and East Coast strains. In each experiment comparisons of the vigor of each pure strain and reciprocal matings between the two have been made.

Vigor was measured by hatchability of eggs, viability of chicks, rate of growth, and egg production of the pullets. In general it may be said that the cross-strain offspring show qualities more like that of the superior of the two strains used. The degree of stimulation from crossing of strains of the same breed is not so great, however, as is exhibited in crosses of different breeds.

Considerable improvement was shown in vigor, as measured by annual egg production in the cross-strain females. The average annual production of females completing the 365-day period was as follows: West Coast strain, 204.6 eggs; Kansas strain, 200.3 eggs; Kansas male by West Coast female, 226.3 eggs; West Coast male by Kansas female, 222.9 eggs.

The Hybrid Expression of Characteristics of Vigor of Different Strains of White Leghorns When Crossed to the Same Strain of Barred Plymouth Rocks.—This study was planned to determine to what degree distinctive strain characteristics of vigor were expressed in their resulting hybrids. Three different strains of White Leghorns were crossed to the same strain of Barred Plymouth Rocks.

Eight breeding pens were headed by Barred Plymouth Rock males from the same strain. Within each pen the White Leghorn females were equally distributed among the three strains. White Leghorn chicks from the three strains were produced at the end of the hatching season. The three White Leghorn strains will be referred to as West Coast, Kansas, and East Coast strains. The hatchability of eggs producing hybrids from the different strains were West Coast, 78.1, Kansas, 80.4, and East Coast, 86.1 per cent. The same

females when mated to males of their own strain gave hatchability of 60.9, 71.2, and 83.3 per cent, respectively. In growth the pure Kansas and East Coast strains were very similar while those of the pure West Coast strain outgrew either of the other two. At all stages the hybrids from the West, Coast strain consistently outgrew the hybrids from the other two. The Kansas-strain hybrids also outgrew those from the East Coast strain.

The average egg productions of the three groups of crossbred females were: Kansas 220.0, West Coast 217.2, and East, Coast 224.7, while the average egg records of these three pure strains during the same year were 182.5, 213.5, and 178.8, respectively.

The general results appear to indicate that the stimulation from hybridization is to a degree conditioned by the relative vigor of the strains used in the cross. For each criterion of vigor the outstanding group of hybrids is usually that resulting from the use of the strain which is superior for this quality.

[Project 173; Department of Poultry Husbandry. Leader, D. C. Warren; Purnell fund.]

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

Inheritance Studies in Guinea Pigs.—During the past few years a rather careful study has been made of the genetic modifiers that are responsible for the production of cherry reds. Animals of this shade represent the kind exhibited at pet-stock shows, and are a much deeper shade than is usually found in laboratory stock. When crossed with lighter reds the F_1 generation is intermediate in shade. Large numbers of F_2 's have been produced up to the present, but as yet none of the grandparental types have been recovered. From the evidence obtained thus far the indications are that a fairly large number of modifiers are responsible for the dark shade of the cherry reds.

Another character that has been studied rather carefully during the past few years has been the long-haired condition. Two separate modifiers have been discovered. One, *Po*, causes the long hair to be found only in the posterior region of the back, while its allelomorph, *po*, is responsible for the long hair being found over the entire dorsal surface. Another modifier, *in*, causes a reduction in the number of long hairs, thus making them interspersed over the back. Its dominant allelomorph, *In*, causes all, or nearly all, the hairs in a particular region to be long.

A new nervous character has been discovered. It has been called "trembling," and is due to a recessive factor, *tr*. Animals homozygous for this factor are in a continual tremor from the time they are born. They become somewhat less violent with age.

In the inbreeding experiment a female has been produced whose offspring consist of 16 females and two males. Other evidence seems to indicate that it will be possible to change the sex ratio by selection. The above female is being mated to her son and it is hoped eventually to produce a true breeding strain of plus female producers.

Inheritance and Physiology of Reproduction in Rabbits.—The experimental work in cooperation with the Department of Bacteriology which has been carried on during the past few years, attempting to induce eye defects in rabbits, has been completed. The last phase was to inject calf lens material into both male and female rabbits and to mate these, either while the series of injections were in progress or after they had been completed. Over 150 offspring were produced, all of them normal eyed. The offspring have been mated, but no defective young were produced. One peculiar incident may have an important bearing on the subject. Three animals, constituting a whole litter, had an infection in their eyes, and for all three of them the eyes were either lost or became defective. Two of these animals have survived, and will be mated when they reach sexual maturity.

The attempt is still being made to study the inheritance of bad temper in rabbits. New crosses have been made between animals that are bad tempered and those that are not. The offspring produced have not shown any bad temper thus far, although they may do so when they are older. It seems probable that the condition is due to a recessive factor rather than to a dominant one, as was previously stated.

Another character that is being studied is wry neck. Animals of this character come from normal-necked parents, and when mated to normals produce normal offspring. Complete evidence cannot be obtained until the normal offspring have been inbred.

Inheritance in Cattle.—A complete review is being made of the literature dealing with inheritance in cattle. It will be written up in three parts, and the first part, devoted to a critique of color, is almost completed. In the meantime data have been collected on white spotting in Holsteins, Ayrshires, Shorthorns, and Herefords. A new white spotting modifier, "pigmented leg," has been discovered in Ayrshires and Shorthorns. This modifier is also responsible for the "brockle" face found in certain Shorthorn-Hereford crosses. Two new color factors have also been postulated. These are *Bs*, black spotting, found in Jerseys and Ayrshires, and the whitening factor found in Jerseys. The latter is inherited as a recessive and causes the extremities and the ventral side of the body to be whitish in appearance.

Recently there has been initiated an attempt to study persistency of lactation in dairy cattle. Lactation curves will be made for as many animals in the dairy herd as possible, and with these as a basis the mode of inheritance will be studied.

[Project 93; Department of Animal Husbandry. Leader, H. L. Ibsen; state fund.]

Studies in the Inheritance of the Grouse Locust.

The work during the biennium has consisted of breeding several species of the grouse locust in rather large numbers. Progress has been made in the location on the chromosomes especially of a lethal factor in *Apotettix eurycephalus*. This lethal factor has been definitely located on the chromosome in relation to the other factors.

Concurrently with the location of this lethal factor, further information about the location of the other factors has been accumulated. A paper is in preparation which will describe not only this lethal factor, but will show the location of the several other new factors discovered since 1925.

New patterns have been added and considerable new data obtained relating to inheritance in *Paratettix texanus*. Two very subtle factors for recessives have been worked out.

Work with the slow and difficult breeding local grouse locust *Acrydium arenosum* has been practically discontinued, and a paper recording the results of the seven years arduous endeavor to work out the inheritance of the color patterns of this group is about ready for publication.

[Project 72; Department of Zoology. Leader, R. K. Nabours; Adams fund.]

Effects of Climate on Inheritance in the Grouse Locusts.—

Work on the influence of X-raying, and on the effects of violet and white light on inheritance of grouse locusts has been in progress during the biennium.

By means of X-raying mature males, about 6,000 R units, a complete translocation of a portion of a chromosome over onto another of a different pair has been produced. After the translocation was definitely determined genetically, Dr. W. R. B. Robertson, cooperating from Iowa University, discovered the

exact cytological arrangement, showing that the piece of chromosome bearing the factors O, T, and G had actually been dislodged from one and carried over and attached to another of an entirely different pair. This discovery, genetical and cytological, is of very great interest and value. It has enabled us to ascertain that all the factors hitherto studied in *A. eurycephalus* are on the smallest pair of chromosomes, and that the translocation of the piece has been over to one of the three larger pairs.

It has been determined that both violet light from a mercury vapor lamp, and white light increase the reproductive cycles of the northern grouse locusts. An extra generation may be bred by the use of such lights, and the nymphs grow more rapidly than in the ordinary daylight. This discovery promises to be of interest in connection with insect reproduction and growth in general.

[Project 104; Department of Zoology. Leader, R. K. Nabours; Adams fund.]

Bee Investigations.—Work during the biennium has consisted of studies of wintering problems, observations of honey plants, and studies of the characteristics of different races of honey bees.

A comparison of masonite and celotex as insulation materials for winter protection of colonies of honey bees shows that one-layer cases are not much better than hives unprotected by insulation materials. It has been found that the minimum number of layers of these materials should be two or three thicknesses to enable the colony to come through the winter with little loss of bees in cold winters. The celotex is the more durable of the two materials in handling.

Newspapers were found to make satisfactory insulation material when wrapped tightly about the hive and covered with some waterproof paper such as sisalkraft or tar paper. Dry straw packed tight in poultry wire and kept dry by the use of shade boards on top of hives was also found to be an economical and satisfactory method of protection.

Data are being accumulated relative to nectar secretion of plants and meteorological conditions which affect this phenomenon. During the past two years the predominant conditions were extreme heat and dryness. Hot, dry weather following quickly cool, moist weather in 1931 brought the white sweet clover honey flow to a close within two weeks. A moist July and August in 1930 was favorable for a light smartweed honey flow.

Studies of races of bees were carried out with Caucasians and Italians. The Caucasians have a 25 per cent greater tongue length and build up in strength in number of bees more rapidly and in a shorter time in the spring than the Italians. After the honey flow is past brood rearing is lessened to a certain extent, whereas the Italians continue vigorously with brood rearing. In these two facts the Caucasians have a tendency to conserve honey stores throughout the year. In general the average surplus production of honey per colony is greater for the Caucasians. The Caucasians have a tendency to build more burr comb than the Italians. They cap honey with white comb whereas the Italians make "watery" honey cappings. Propolization of the entrance by the Caucasians can be prevented by putting in place entrance blocks the latter part of August or the first part of September. They build more queen cells in the preparation of swarming than Italians. They are not resistant to the brood disease caused by *Bacillus larvae*.

The Carniolian race is now being studied along with Caucasians and Italians. Due to the long culture of Carniolians in small quarters in their native country, this race of bees has a tendency to swarm early and when the colony is small.

[Project 126; Department of Entomology. Leader, R. L. Parker; state fund.]

DISEASES, INSECTS, AND OTHER PESTS INJURIOUS TO PLANTS

Injurious insects, plant diseases, and other pests cause losses amounting to millions of dollars annually to the crops of Kansas. The development of methods of control that will reduce these losses is an important part of the work of the station. Some of the more important features of this type of work are described on the following pages.

Cereal and Forage Crop Disease Investigations.—The phases of this project dealing with wheat flag smut and foot rot and with the root, crown, and shoot disease of milo, are in cooperation with the Division of Cereal Crops and Diseases, Bureau of Plant Industry, United States Department of Agriculture. The work upon each phase of the entire project for the past two years is briefly discussed below.

Oat Smut Investigations.—Studies on oat smuts were chiefly confined to investigations of physiologic forms. It has been shown that the occurrence and spread of one of these physiologic forms of *Ustilago avenae* in Kansas is responsible for a rapid increase in the susceptibility of Kanota oats to smut. This form of covered smut has undoubtedly entered Kansas from the southern states. It has been found that the loose and covered forms of smut of oats are not so readily distinguished in the field by smutted panicle characters as literature indicates. There are many specimens of oat smut in the field that may be arbitrarily identified as either species. When these are examined microscopically, the fungus present indicates that it may be a hybrid of the two species of smut. This seems to be borne out by the microscopic characters of the spore walls.

Bunt of Wheat Investigations.—Collections of bunt, or stinking smut of wheat, *Tilletia loevis*, have been made from many counties in the state. The matter of learning of the different physiologic forms, their distribution and prevalence in Kansas has been undertaken. Several years of field data have proved that at least five distinct forms of bunt occur in Kansas. A key for their separation has been constructed by using 12 differential hosts. Several, but not all, of the physiologic forms may be distinguished by their growth on artificial media.

Approximately 75 hybrid lines of wheat among several hundred which have been grown for smut reaction over a period of years have maintained their resistance. These hybrids do not represent the most suitable wheats for Kansas conditions. Therefore, other crosses will be made and studied.

Wheat Flag Smut Investigations.—Flag smut of wheat has been known to occur in Kansas for a number of years. It is confined to the soft wheat areas of northeastern Kansas. An extensive varietal nursery has been planted in infested soil and the reaction of varieties will be determined. Two selections of Harvest Queen and one of Shepherd appear to be resistant. It is possible that one or both of these could be used to replace the local Harvest Queen on those farms where flag smut has become troublesome.

Wheat Foot Rot Investigations.—It has been found that alfalfa stems and leaves when chopped and mixed with infested soil tends to control take-all disease caused by the fungus *Ophiobolus graminis*. When this material is kept moist in a container, allowed to decay, and a water extract made from the decayed material, the extract does not control take-all. Apparently the fibrous material in the infested soil is necessary for control. Greenhouse studies show that when wheat is grown in infested soil which has been dried for six months take-all is even more severe than in similar soil that has been kept moist. Soils infested with take-all, when mixed with various amounts of noninfested soil, produced take-all in direct proportion to the amount of infested soil

present. Chicken manure, when mixed with infested soil and planted to wheat, gave good control of take-all. It is a question whether this manure affects the wheat plant or the parasite or both. Over two hundred varieties of wheat have been grown in the field in infested soil. No variety has been found to be resistant.

Helminthosporium Foot Rot Investigations.—The *Helminthosporium* foot-rot was less abundant in 1931 than in 1930. It is widely spread, and during seasons of favorable environment, as in 1930, the loss from this disease is tremendous. Evidence is accumulating to show that a delayed date of planting (approximately the fly-free date) has a marked influence in reducing infection and loss from this disease.

Corn Disease Investigations.—Numerous inbred lines of corn are being maintained because of their homozygous condition with respect to smut reaction. Numerous lines representing high resistance or susceptibility to smut have been obtained. Some F₁ hybrids between various corn lines have been studied. Results indicate that various inbred lines can be combined in crosses which will give a more desirable variety with respect to smut resistance than the variety from which the inbred lines were isolated.

Corn seed treatment with chemicals for the control of corn diseases has been continued. Semesan, Jr., Barbax, Sturdidust, Coppercarb, and untreated check treatments were used and the corn planted on three different dates. The results indicate, as they have in numerous other experiments in the past, that little if any advantage can be expected from the treatment of seed corn with chemicals under Kansas conditions.

Sorghum Disease Investigations.—Five physiologic forms of *Sphacelotheca sorghi* have been discovered. These may be separated by a key, using varieties of sorghum as differential hosts. There is evidence that several physiologic forms also occur in *Sphacelotheca cruenta*. These smuts are being studied on differential sorghum varieties and on media in artificial culture. Such varieties as milo, feterita, hegari, and certain hybrids of these varieties are either highly or somewhat susceptible to one or more of the physiologic forms. Several hybrids of Red Amber X feterita, and Spur feterita have remained resistant to all physiologic forms of *Sphacelotheca sorghi* so far tested. Seed treatment studies have shown so conclusively that the use of copper carbonate or flowers of sulfur will control the common kernel smut, regardless of the physiologic forms, that there is little need to investigate further chemical measures for control.

It has been found that *Sphacelotheca cruenta*, the loose kernal smut of sorghum, materially affects the normal development of certain varieties of sorghum. Two collections of this smut show that they are entirely different and may be regarded as physiologic forms. White Yolo is very susceptible to one collection and highly resistant to the other. Several hybrids of Red Amber X feterita show moderate susceptibility to one form and resistance to the other.

A new disease of milo has appeared at Garden City, Kan. It has been given the name, "root, crown, and shoot disease of milo." All varieties of milo and practically all crosses in which milo is one of the parents are highly susceptible, in contrast to most other sorghums which are practically immune. The disease is recognized by the dwarfing of the plants and the preventing of heading. It is not connected with chinch bug injury. Plants generally obtain a height of 10 or 12 inches in the field before any symptoms of the disease appear. The lowest leaves turn yellow along the margins and gradually the color spreads over the entire leaf. Badly diseased plants remain stunted and produce no heads. The gradual drying and decaying of the plant follows. A red discoloration of the central cylinder of the roots and the interior of the crown is characteristic.

Several facts point to the parasitic nature of the disease. Both susceptible and resistant varieties of sorghum show no disease symptoms when grown in soil where the disease has not been present. Susceptible varieties grown in

infested soil produce 100 per cent diseased plants, while resistant varieties in the same soil have shown no symptoms of the disease. When infested soil is sterilized by steam or formaldehyde, susceptible varieties may be grown free of the disease. When diseased plant material, or a small quantity of infested soil, is added to sterilized soil and planted to susceptible varieties, the disease becomes evident.

Strains of *Fusaria*, chiefly *Fusarium moniliforme* Sheld, have been consistently isolated from diseased plants, although cultures of bacteria have frequently been obtained. To date none of these organisms, separately or combined, when used for inoculum, has produced the typical milo disease.

A few plants of milo have been discovered that are highly resistant to the disease. They are being propagated for seed purposes.

[Project 76; Department of Botany. Leaders, L. E. Melchers, Hurley Fellows., Charlotte Elliot, J. A. Faris, and F. A. Wagner.]

Fruit and Vegetable Disease Investigations.—During the past biennium, control studies have been continued on the diseases of potatoes and sweet potatoes. Investigations on the biology and pathogenicity of *Rhizoctonia solani* have been continued. Tomato breeding work was started in an effort to develop an early-maturing, wilt-resistant variety satisfactory for Kansas conditions. Studies have been made of a newly discovered phenomenon of inhibition of growth of the potato by a volatile substance from apples.

Potato Disease Investigations.—Test to determine the relative efficiency of various fungicides for controlling *Rhizoctonia* of potatoes have been made during both years of the biennium. Results were measured both by the amount of disease present on the plants and by yields from the plants.

From these results it is evident that seed treatment is beneficial in reducing *Rhizoctonia* infection and in increasing yields. Corrosive sublimate was more efficient than other treatments in controlling *Rhizoctonia*. The acidulated corrosive sublimate treatment tested in 1931 gave very promising results, and owing to the fact that this treatment requires only a 10-minute soak it may prove a more practicable treatment than the old 90-minute corrosive sublimate method.

Investigations have been under way to obtain information on the question of how much *Rhizoctonia* infection on potato plants is produced by the *Rhizoctonia* organism that persists in the soil from year to year. The amount of infection from the soil was found to vary in different fields and for the two seasons. Previous tests in 1928 and 1929 had resulted in an average of 53 per cent and 50.5 per cent, respectively, of the plants infected from the soil-borne *Rhizoctonia*. In 1930 five test plots were located in fields where potatoes had not previously been grown. An average of 17 per cent of the plants became infected by the soil-borne organism. In 1931 the test plantings were made in 18 commercial potato fields where potatoes had previously been grown. *Rhizoctonia* infection developed on an average of 36.2 per cent of the plants from the noninfected seed and on 85.5 per cent of the plants from infected seed. The yields from these two kinds of seed were at the rate of 169.5 bushels and 143.5 bushels per acre, respectively, or a decrease in yield of 26 bushels per acre for the plants from infected seed.

Studies have been made of the biological and pathological characteristics of *Rhizoctonia solani*. Numerous cultures of this organism have been obtained from various host plants in different parts of the United States. These cultures have been studied both from the viewpoint of comparisons in pathogenicity and of cultural and morphological variations. It has been noted that wide differences occur between certain cultures both in pathogenicity and in biological aspects. Groupings into similar strains have been indicated. Growth differences occur between the different strains when these strains are grown on various laboratory cultural media and under varying environmental conditions.

These differences are expressed in morphological variations in the mycelium, in temperatures required for maximum growth, in growth response, and in the production or nonproduction of sclerotia.

The potato-scab control test that had been in progress since 1926 was completed in 1930. The results obtained indicate (1) that sulfur application to the soil causes decreased potato yields and increased scab freedom, (2) that leguminous fertility crops produce increased potato yields but do not control the scab disease, and (3) that with a combination of sulfur and leguminous fertility crops, scab control due to sulfur is maintained and potato yields are greater than where leguminous crops have not been grown. The highest yields of salable potatoes were obtained on soil treated with sulfur on which legume crops had been grown.

Sweet Potato Stem-rot Control.—The seriousness of sweet potato stem rot in Kansas has indicated the necessity of developing measures for the control of this disease. In 1930 a sprout-treating test with the susceptible variety Nancy Hall grown in soil severely infested with the stem-rot organism resulted in the following infections and yields: Bordeaux, 10 per cent infection and 203 bushels per acre; mercury hydroxide, 14 per cent infection and 251 bushels per acre; untreated check, 35 per cent infection and 174 bushels per acre. In another field where stem rot was absent and where the test was made to find the effect of the treatments on the plants themselves, the yield from the dipped sprouts were: Bordeaux, 241.5 bushels; mercury hydroxide, 287 bushels; untreated check, 225 bushels per acre.

These results, as well as those secured in 1931, indicate that certain fungicidal substances are beneficial in preventing stem-rot infection and in causing increased yields. Bordeaux, while satisfactory as a preventive for stem-rot infection, causes plant injury under certain conditions.

Growth Inhibition of Potatoes by a Volatile Substance from Apples.—During tests to determine the effect, of temperature on the pathogenicity of *Rhizoctonia* on sprouting potatoes, it was discovered that a volatile substance from apple fruits produces inhibition of growth of the potato. Subsequent studies have given sufficient evidence to prove that this is true. It was found that the inhibitory volatile substance is present in ripe fruits but not in green or rotted fruits. Potato growth inhibition was not obtained from the juice of apples but the inhibition was obtained from apple pulp that had been pressed under 19,000 pounds pressure. Peeled fruits produced as positive inhibition as did unpeeled fruits.

The effect of the inhibitory substance upon the potato is transitory. When removed from the presence of apples, the potatoes will immediately begin normal growth. The effect upon sprouting potato-seed pieces is a production of small tuber-like growths instead of normal sprouts. Nongerminating seed, when placed in a suitable environment for growth, under the influence of the inhibitory volatile substance will produce abortive sprouting, and bud dominance is largely overcome so that feeble multiple sprouting occurs.

Six varieties of potatoes that had been grown in six different states in the United States were tested and growth inhibition resulted in all. Four apple varieties were tested and they all produced the inhibitory substance. In addition, pear and hawthorne fruits produced an inhibition similar to that produced by apple fruits. No other fruits have been found to cause such inhibition of growth. Studies have been under way to determine the specific substance that produces this growth inhibition, but so far these tests have been unsuccessful.

The practical value of this discovery is being studied. It appears that potatoes may be prevented from sprouting late in the season by confining them in an atmosphere with a sufficient concentration of the volatile substances from apples. Tests are under way to determine the necessary dosage.

[Project 130; Department of Botany. Leader, O. H. Elmer; state fund.]

Resistance of Winter Wheat to Leaf Rust.—From this study, which has been conducted in cooperation with the Division of Cereal

Crops and Diseases, Bureau of Plant Industry, United States Department of Agriculture, many pure lines and hybrids have been produced that have proved to be resistant to certain physiologic forms. Those with the greatest promise are compound crosses carrying resistance to several forms. Among the more promising are F3 and F4 lines of (Kanred X Fulcaster) X Tenmarq. Certain single crosses such as Kanred X Kawvale, Kanred X Fulcaster, Mediterranean X Webster, and Fulcaster X Marquis also have shown promising resistance.

Considerable progress has been made in developing stiffer-strawed resistant lines in crosses with Hard Federation but usually somewhat at the expense of winter hardiness. Certain lines of the Oro X Fulhard and Hussar X Black-hull crosses proved to be resistant to both leaf rust and bunt but seemed to be rather late in maturing. Some pure lines of Mediterranean from Texas, Fulcaster, Kawvale CI 8180, and several other soft red winter wheats have proved to be highly resistant to leaf rust both in the greenhouse and in the field. Among the varieties of hard red winter wheat, resistance to leaf rust has been found only occasionally. Kanred and Malakof CI 4898 have proved to be resistant to certain forms but usually are heavily rusted in the field in the southern Great Plains.

It has been proved that leaf rust of wheat overwinters in a moderate amount in the eastern half of Kansas nearly every year, but heavy early spring infections are prevented by unfavorable temperatures. Wheat has usually advanced to about the heading stage before temperatures become high enough to favor rapid development of leaf rust. Very early varieties, therefore, frequently escape heavy infection.

Oversummering of leaf rust seems to occur in abundance and with considerable regularity in the eastern half of the state. In both 1930 and 1931 very heavy fall infections occurred in many localities. In the spring leaf rust spores are carried into Kansas from states farther south by the high winds of April and May. In most seasons this seems to be a more important source of inoculum than the rust that overwintered in the state.

[Project 171; Department of Botany. Leader, C. O. Johnston; Purnell fund.]

Climate and Injurious Insect Investigations.—The study of temperature and humidity conditions in various types of rearing cages was completed and published in the *Journal of Agricultural Research*, 43:547-557, 1931. This study revealed the fact that though temperatures outside and inside cages varied but little, humidity differences were very great. This involved special study of the methods of obtaining the relative humidity, especially in small cages.

Further observations were made of the effect of the hot surface of the soil on insects. The degree of resistance to the heated soil was found to increase with the size of the nymph or larva and is fairly constant for each species.

Fair progress was made during the biennium toward the completion of the insect population studies, with reference to climatic conditions in the state. Most of the tables, which comprise the main features of the report, are completed. The final report will be a summary of insect abundance in Kansas from about 1900 to 1931.

The study of insect abundance in comparison with weather data in the state has resolved itself into an assembling of all the information about the population of injurious insects in the state and the study of weather and other conditions in years when they were particularly damaging. The study has been greatly hindered by lack of sufficient information regarding the popu-

lation of insects in the state for each year, and because information available is not mathematically expressed or recorded. An attempt, therefore, has been made to make use of all of the most reliable sources of information in the state on the insect population in the publication of annual summaries beginning with 1931 and to express this population mathematically by counties. It is planned to make the 1931 summary the first of an annual series to record, in mathematical terms, the population of the more common or injurious insects of the state for each year.

[Project 6; Department of Entomology. Leader, R. C. Smith; Hatch fund.]

Hessian Fly and Other Wheat Insects.--During the past biennium major emphasis has been placed upon further studies of the Hessian fly, although the wheat-stem maggot and the wheat-straw worm have been studied also.

Studies of Hessian Fly.--The drought in western Kansas during the summer of 1930 and the fall of 1931 was perhaps responsible for a reduction in fly population. In 1930 plants were received from time-of-planting plots in 11 counties. Four of these showed no infestation. The remainder were in agreement with the usual results. In 1931 most of the time-of-planting tests in western Kansas failed to germinate in time to receive an infestation and few counts were made from such plots. The time-of-planting plots at the Agronomy farm at Manhattan had infestations as follows: September 7, 42 per cent plants infested; September 14, 58 per cent; September 29, 13 per cent; October 6, 4 per cent; October 17, 0 per cent.

A study was made of a heavy fly infestation on varieties of wheat planted in a variety test in Leavenworth county in 1931. This test consisted of a duplicate planting of 234 varieties in 8-foot rows and duplicate plot plantings of 10 varieties. The lowest infestation (29 per cent) was found on Kawvale, while the highest (97 per cent) was found on Harvest Queen. This is the first time that observations have been made of the resistant variety, Kawvale, under conditions of heavy infestation. Its high resistance as shown in this test was most promising.

Studies of the Wheat-stem Maggot.--A summary of data on varietal infestation of wheat-stem maggot shows a considerable range among different varieties of wheat. A study of the infestation of kinds of grasses as shown by number of adults present during the year gives Crested wheat grass, Brome grass, slender wheat grass, tall oat grass, and the blue grasses, in the order named, as the most favored host plants. There appears to be three generations of the insect a year.

Studies of the Wheat-straw Worm.--Experiments this year were concerned especially with methods of handling, tropisms and habits of the adults, relation to varieties, and depth of planting. Preliminary experiments show that, at least in the younger plants, infestation rarely takes place in those plants in which the crown is well buried in the soil. Oviposition nearly always takes place in the developing bud and if this cannot be reached egg laying is suppressed.

[Project 8; Department of Entomology. Leader, R. H. Painter; Hatch and state funds.]

The Corn Ear-Worm and Other Insects Injurious to Corn.--Data were taken during the biennium on the extent of damage done by the corn ear-worm to corn planted on the time-and-method-of-planting plots at the agronomy farm. At the 1930 harvest practically all ears had been infested, though the later planted rows showed greatest damage. The series planted at the ordinary time

showed irregular injury, but rows planted very early (March 31) were least injured. In 1931, out of 3,453 ears examined, only 20 ears were untouched by the corn ear-worm. Some of the infested areas, however, were scarcely damaged while others were completely destroyed. A considerable difference was apparent in rows where the plants were spaced at different distances. The greatest injury occurred in the closely spaced corn and diminished gradually with the least damage in the corn widely spaced.

About 300 ear-worm larvae were collected and reared to adults, when they were studied to ascertain their feeding habits. Solutions of diluted honey and various arsenicals were fed and their killing effect noted. Volatile oils including extracts of native plants were obtained from the Department of Chemistry and made available to the corn ear-worm moths to determine attractiveness or repellance. Oil of wintergreen caused most violent agitation among confined moths. The silks of sweet corn will be sprayed with this material during the coming year to determine the repellent effect at the time of oviposition.

Two new insects, enemies of the corn ear-worm, were reported for the first time as a result of a study of insect enemies of the corn ear-worm made during 1930. The research was continued in 1931 which resulted in additional parasites not yet identified.

A study has been made of the lepidopterous enemies of corn. This study was for the purpose of observing the life history and habits of these insects on corn, and to study in particular the nature of the parasites of these insects. The smartweed borer (*Pyrausta ninsliei* Heinrich) which is a very close relative of the European corn borer, and which during the past five years has been found in abundance in Kansas, has been studied carefully. This insect is occasionally found feeding on corn and is abundant in corn fields where smartweeds (*Polygonum* sp.) are present. The close relationship of this lepidopterous insect to the European corn borer suggests the possibility of the transference of its parasites to the corn borer in case the corn borer is introduced into Kansas. Of the 23 recorded host plants the smartweeds are preferred. Four species of parasites of the smartweed borer have been reared, one of which is undescribed and reported for the first time. The complete results of this study have been published in the Journal of the Kansas Entomological Society, Vol. IV, No. 2, pages 25-28 April 1931.

Studies on the life history, ecology, and hibernation of the southern corn root worm were continued. Efforts to find this insect during the winter, as well as attempts to carry the insect over winter, have not been successful.

Investigations were continued in an effort to determine the cultural practices which encourage or which inhibit the activities of wire worms and corn-seed beetles. During the summer of 1930 a field of pop corn was visited in which two species of corn-seed beetles were present in large numbers. A study of this field indicated that inadequate drainage aids these beetles in their work.

[Project 9; Department of Entomology. Leaders, D. A. Wilbur and H. R. Bryson; Hatch fund.]

Fruit and Vegetable Insects.--Work during the biennium on this project has centered around (1) the biology and control of apple curculio in northeastern Kansas, and (2) the biology of strawberry leaf roller.

The destruction over a period of years of the June drop of apples has proved a means of lowering somewhat the infestation of the apple curculio. Hibernation studies in the early spring of 1932 have shown that overwintering adults are in decaying organic matter when it is present. Only a few adults in hibernation are found in blue grass sod.

Life-history studies of the strawberry leaf roller are being continued. Very

few of these insects have been available since June, 1929, when they were extremely heavily parasitized. A few more leaf rollers have been observed this past year than were observed during the previous year.

[Project 13; Department of Entomology. Leader, R. L. Parker; Hatch fund.]

Insects Attacking the Sorghums.--Investigations conducted on sorghum insects during the past biennium were as follows: (1) A survey of insects of the sorghum field, (2) studies of the life history and habits of *Aphis maidis* Fitch, (3) life history studies of the southern corn root worm, and (4) studies of seed treatment to prevent insect attacks.

A survey was made of insects present in sorghum fields in an attempt to determine their relation to the environmental complex of the sorghum field. This survey resulted in the collection of a large number of insects, and many data were obtained on the number of insects present and the seasonal distribution of the different species. Some time was spent in classifying these insects and in the summarization of the data on the insects collected during the past three years. Some progress has been made toward the compilation of a key to the insects attacking the sorghums in Kansas.

Studies on the life history and habits of *Aphis maidis* Fitch indicate that it is more nearly a sorghum insect than a corn insect. Some progress has been made in summarizing notes which have accumulated relative to this insect. Life-history studies on the southern corn root worm were confined to a study of the seasonal appearance of this insect and to determine how and where the insect spends the winter. Attempts to carry it over winter in hibernating cages or in the greenhouse have not been successful.

Additional studies were conducted on the treatment of seed to prevent insect attacks. No satisfactory material has been found which can be recommended for this purpose.

[Project 92; Department of Entomology. Leader, H. R. Bryson; state fund.]

Insects Attacking the Roots of Staple Crops.--Improved methods of rearing wireworm larvae in drain tile cages have made possible an increase in the number of adult click beetles secured during the biennium. Approximately 300 collected larvae representing at least four species belonging to the genus *Melanotus* have been reared to the adult stage. Improvements in the methods of rearing wireworms from the egg stage to the adult have made it possible to secure accurate data on the life history of individuals representing four species; namely, (1) *Drasterius elegans*, (2) *Monocrepidus vespertinus* (3) *Monocrepidus lividus*, (4) *Melanotus* sp.

It is interesting to note that the one species of *Melanotus* reared from the egg to the adult stage is generally thought to have a larval stage extending over a period of from 4 to 6 years, but in this instance the life cycle required but 3 years. Since this insect is a common pest of corn, a knowledge of its shorter life history will be a distinct advantage in devising field practices for control.

Much time was spent during the 1931 season in an attempt to determine the food habits, moisture requirements, and a more efficient technique for rearing wireworms from the egg stage to the adult. At least 6,000 larvae were handled individually but the mortality was extremely high.

The original series of 27 one-thousandth acre plots devoted to soil insecticide studies were retreated in the spring of 1930 with the same quantities and

kinds of insecticides with which the plots were treated in 1927. Twenty additional plots, some of which had previously been treated in 1928, were also treated during the 1930 season.

A summary has been made of the effects of the chemicals upon the soil, the germination of the seed, and the growth of the plants with each treatment. These data embodying results of five years' work have been brought together, summarized, and correlated in preparation for publication at the end of the 1932 season.

Counts of injury from wireworm were taken on corn planted by different methods and in different rotations at the college farm. These observations indicate that factors other than the crop determine or encourage the increase in wireworm infestations in certain areas. A field which showed a heavy infestation of wireworms in 1924 and which had been in alfalfa since 1925 was found to be infested when sorghums were planted on this field in 1930 and again when planted to corn in 1931. Although the infested areas were small, nevertheless, they were in the same location as those in 1924. Since alfalfa is sometimes recommended as a crop to include in a rotation in land populated with wireworms, this study would indicate that the soil or some other factor may be responsible for the beetles seeking this alfalfa field in which to lay their eggs.

Ecological studies conducted for a period of four years to determine the activities of burrowing insects in relation to their operations upon the surface of watered and unwatered one-thousandth acre plots were summarized and submitted for publication. These studies show that insects commonly found frequenting dry, barren areas were attracted to the unwatered plot. Insects which ordinarily establish permanent burrows were also active on this plot.

Observations show that the burrowing activities were begun in February and continued as late as November. More burrowing occurred on the unwatered plot during the early part of the season than on the watered one. The period of greatest activity during the year was between July 16 and August 16. During this period more soil was brought to the surface on the watered plot than on the unwatered one. There were also more burrows constructed on the watered plot than on the unwatered one during this same period.

The results of preliminary studies on the interchange of soil and subsoil by burrowing insects were summarized and published. These studies indicate that all burrowing insects which go below the ordinary plow depth of 6 inches effect a gradual interchange of soil and subsoil in varying amounts.

The taxonomic studies of the click beetles were expanded in an attempt to build up a working collection of click beetles known to occur in the United States, with particular attention to those of economic importance. With the addition of 300 specimens reared from collected larvae, considerable material is available for further study.

[Project 100; Department of Entomology. Leader, H. R. Bryson; state fund.]

Insects Injurious to Alfalfa and Allied Plants.--The work during the biennium has consisted of (1) the collection, identification, and estimation of the population of all insects in alfalfa fields in the vicinity of Manhattan, (2) rearing and study of life histories of all the important injurious insects of alfalfa, (3) field observations on the seasonal abundance and numerical fluctuations of the injurious insects of alfalfa, (4) the testing and attempted improving of control measures which are commonly applied for certain pests and the development of new ones, (5) observations on the natural enemies of alfalfa insects, and (6) providing illustrations (drawings and photographs) for use in future publications on these insects. The results secured with some of the more important insects are briefly described below.

The Pea Aphid.—There was a small, scattered outbreak of the pea aphid during the spring of 1931. These outbreaks occurred around Tipton, Dodge City, Great Bend, Ellinwood, Lyons, Salina, Kinsley, and Lakin.

During 1930 a chain drag, an original control device for pea aphids, was made at this station. The drag consists of a platform of planks 6 feet wide and 3 feet long, with a series of short, heavy automobile chains stapled to the hind plank and a second series stapled to an extension of the platform. The chains, 3 1/2 feet in length, were stapled 1 1/2 inches apart to the under side of the plank and to the extension. This gave a double series of chains and doubled the rubbing action of the equipment. Heavier chains, including log chains, were tried, but they appeared to give no better rubbing action than the lighter chains and bounced around more.

When it was learned that an outbreak of pea aphids was in progress at Great Bend, the chain drag was taken there for tests. It was used with excellent results. The reduction in the number of aphids varied with the amount of alfalfa growth. Where alfalfa was a foot tall, or more, the stand very dense, and the infestation heavy, a kill of about 50 per cent was made. Where the stand was thinner the kill was estimated at 70 per cent. On very short alfalfa a kill somewhat better than 70 per cent was obtained. The driver was given a broom to sweep the aphids off the drag at frequent intervals. From 1 to 3 gallons of aphids were thus disposed of each time. It has been found that the alfalfa should be dragged in two directions at right angles to each other. The interval between the two draggings allows the aphids to crawl up on the alfalfa and expose themselves fully to the dangers of the second dragging. The tests at Great Bend indicated that two draggings were sufficient. A reduction of no more than 50 per cent gave them such a check that the ladybird beetles and other enemies of the aphids kept them under control.

A portion of the field at Great Bend was harrowed to compare the work of the harrow with that of the chain drag. The results were wholly in favor of the chain drag and the harrow was discontinued. The chain drag is far superior to a brush drag, any type of harrow, roller, or cultipacker so far tried. It is believed that this chain drag is the most important mechanical development in the course of this project, and wide usefulness is predicted for it. The experimental model cost 88.50 to build and required two horses to pull.

A paper summarizing the various control efforts on pea aphids since 1921 has been published in the *Journal of Economic Entomology*. Establishment of priority for this station for the design and use of the chain drag seems worth while. The paper also includes the results of tests with harrows, rollers, cultipackers, brush drags, burning, cutting, and the use of calcium cyanide flakes. Only the latter, with the exception of the chain drag, has given good results in tests. Sowing cyanogas flakes at not less than 50 pounds to the acre in infested spots, and then jarring the aphids to the ground with a drag or hand rake, has given 80 to 95 per cent kill. The results are immediate and no burning of foliage of consequence ordinarily results. Since cyanogas costs between 35 and 60 cents a pound, it cannot be used economically except where the heavy aphid infestations are confined to small spots in the fields.

Alfalfa Thrips.—It was found that, three species of alfalfa thrips are involved in damage to alfalfa. *Frankliniella tritici* Fitch is the larger yellow species common in the blossoms. It is primarily responsible for the reduction in seed production. The leaf damage on young plants was done mainly during the early summer of 1931, by a smaller black species *Frankliniella fusca* Hinds, and by a second, also a dark species, *Aeolothrips bicolor* Hinds. The foliage damage on very young alfalfa was severe during the season. This damage is common in greenhouse experimental plantings.

Variiegated Cutworm.—Some rather unusual damage by variegated cutworms occurred in the horticultural orchard during 1931. The outbreak started in a field of vetch and in the orchard cover crop of vetch. The larvae climbed the grape vines, damaged the grape foliage severely and ate off many small bunches of developing grapes. Others climbed the apple trees, ate the bark in places and the young apple on the trees. Others concentrated on the

dropped apples and ate them to the core. Others climbed the Mahaleb cherry trees and ate large patches of bark from these trees. These feeding habits are believed to be unreported for these larvae. Several sowings of poisoned bran mash of the formula usually recommended gave excellent results. The vetch was plowed up and the outbreak brought under control a few days after its discovery. The larvae particularly in the vetch field, showed a parasitism of approximately 30 per cent by *Apanteles militaris*.

Garden Webworms.—There was a local outbreak of the garden webworm in alfalfa fields in early July, 1931. The outbreak was unique in that the first generation of larvae instead of the second did the greater part of the damage.

The Clover-leaf Weevil (Hypera punctata Feb.)—The clover-leaf weevil appears to be on the increase. The larvae have been plentiful during the springs of both the years included in this report. A small outbreak occurred at Alma, more extensive ones at St. Marys and Marysville during the spring of 1931, and one was reported at Iola in the spring of 1932. The damage done at St. Marys was unique in that the adults did more defoliation than the larvae. The adults were clustered in numbers under clods, loose stones, and cornstalks in surprisingly large numbers. During the night the adults, assisted by the variegated cutworms, defoliated the fall-sown growth of alfalfa. Some doubt as to the efficacy of spraying with arsenate of lead, standard formula, for the control of this pest has arisen. This is a common recommendation, but small-scale tests have indicated that the spray, aside from the question of practicability, does not destroy sufficient numbers to make it worth while.

Grasshoppers.—The most important experiment attempted on the subject of grasshopper control was the substitution of ground corn cobs for bran in making bran mash. While bran is low in price, it requires a cash outlay by farmers. Most farms have plenty of cobs, and most communities have some kind of feed-grinding mill by which cobs can be ground.

The Department of Agricultural Engineering ground up some cobs in two grades—fine and coarse. The grinding was not particularly difficult, though dry cobs are very hard. It is thought soaking them would make grinding easier. The two grades of ground cobs have been subjected to several comparative tests with ordinary wheat bran against cutworms and grasshoppers and the preliminary tests with the finer grade of cobs gave results fully equal to bran or superior to it.

[Project 115; Department of Entomology. Leader, R. C. Smith; state fund.]

Insects Injurious to Grasses and Allied Plants.—The study relative to insects injurious to grasses and allied plants was started in 1930. Since little is known concerning insects of grasses, the first problem was to find what insects are present on grasses, which are specific to specific grasses, when and in what abundance these insects are present, what injury they cause and how they are affected by the various grass-management practices, such as fertilizing, cutting, pasturing, burning, etc. With these studies as objectives, five series of surveys were made in 1930 of grasses growing on experimental plots of the Department of Agronomy as follows:

1. Grass variety plots—18 collections were made on 40 plots of pasture grasses and legumes. Thirty of these plots were of different plants in young stands while 10 were duplicates in old stands.
2. Time of burning plots—17 collections were made on five plots of native upland prairie grasses burned at different times—early winter, early spring, medium spring, late spring, and check.
3. Grass clipping plots—17 collections were made on nine plots of native grasses clipped at different heights and at different frequencies.

4. Pasture fertilization plots—17 collections were made on nine plots of native grasses fertilized by varying amounts of different fertilizers.

5. Comparison of insect fauna of upland prairie grasses (little bluestem dominance) and lowland prairie grasses (big bluestem dominance)—45 collections on two plots from March through November.

All of the insect material obtained from the various collections was sorted, identified when possible or, when the species was not definitely known, prepared to be sent to specialists for identification. The only group to date completely identified and summarized is the leaf hoppers of the Homopterous family Cicadellidae.

The leaf hoppers greatly outnumbered any other family of insects taken during the survey, both in number of species and in number of individuals. A total of 44,051 leaf hoppers were examined for species, adult or nymph, sex of adult, parasites, etc.; this information recorded and the whole related to the host grass from which the specimens were taken. The summaries from the leaf-hopper material indicate marked differences between various pasture variety plots growing side by side in the character and abundance of the leaf-hopper fauna which each grass supports.

A considerable difference existed between the leaf-hopper fauna of the native prairie and of the tame grasses, as Kentucky blue grass, brome grass, timothy, red top, and the like. Rarely were any of the native prairie leaf hoppers found on the tame grasses and in no case were nymphs present. The leaf hoppers of the tame grasses were present on the prairie grasses in abundance during the latter part of May and again in September, but practically no breeding took place. It is interesting to note that such species as *Deltocephalus immicus*, *Deltocephalus straitus*, *Cicadula divisa*, and *Euscellis obscurinervis*, which are found practically over all of North America and in some cases in South America and Europe, can develop on the grasses found far above timber line in the Rocky Mountains, yet do not adapt themselves to the native Kansas prairie grasses save for limited adult feeding.

The native prairie areas when lightly grazed and typical of the primitive prairies have a comparative scarcity of insect fauna of all kinds. When these grasses are modified, however, by such manipulations as grazing, cutting, or fertilizing, the insect fauna increases rapidly.

In the fertilizer series of plots, those heavily fertilized with the nitrates yielded nearly twice the leaf hoppers found on the checks. In the grass-clipping plots considerable differences occurred among the various frequencies and heights of clipping, those clipped frequently and rather close being much more desirable to the leaf-hopper fauna than the unclipped. No differences were apparent, in the leaf-hopper population in the time-of-burning plots.

[Project 115-B; Department of Entomology. Leader, D. A. Wilbur; state fund.]

Shade Tree Insects.—Studies have been made during the biennium of cankerworm emergence, biology of sumac flea, beetle, the ash sawfly, and the arbor vitae aphid.

The winter of 1930-'31, as well as that of 1931-'32, was mild in temperature. The first fall cankerworm female was taken on January 17, 1931, and January 4, 1932. The first spring cankerworm female was taken on February 16, 1931, and February 5, 1932. The greatest number of females on one tree for 1931 was 120, that for 1932 was 715.

The biological control of the sumac flea beetle is being studied and a number of parasites have been reared from this host. As a general rule the parasites keep the insect fairly well under control. Hibernation, egg laying, egg capacity, and other habits of the insect have been studied. A collection of other insects attacking sumac (*Rhus glabra*) in pastures has been made.

A local outbreak in 1930 of the ash sawfly did serious damage to several green ash trees on the campus. The last record of this insect was in 1889, on

the Marlatt farm near the present horticulture farm. This insect decreased in numbers through 1931. There was no damage in 1932.

An extremely heavy infestation of plant lice began attacking Chinese arbor vitae in February, 1931. During the first three weeks of April the attack was at its height. A number of predacious insects were collected feeding upon the aphids. Derrisol 1-3000 and nicotine sulfate plus penetrol at the rate of 1-3000, as with the derrisol, gave 100 per cent control. Aphex, 8 per cent dust, gave a 60 per cent control. Pyrethrum and "Evergreen" solutions at the rate of 1-400 gave a 50 to 60 per cent control, as did "Plantgard," a sodium silicofluoride. A good stream of water from a hose with three thorough applications gave 100 per cent control. During the spring of 1932 no specimens of this aphid were found.

[Project 116; Department of Entomology. Leader, R. L. Parker; state fund.]

Codling Moth Investigations.—This project, in cooperation with the Bureau of Entomology, United States Department of Agriculture, has been terminated due to the inability of the Bureau of Entomology to continue cooperation. The following is a brief summary of the results secured during the progress of the study (1926-1932).

Lead Arsenate (Acid).—Acid lead arsenate, without a spreader or sticker, when used at the rate of 1 pound to 50 gallons of water, was apparently of assistance to codling moth larvae in cutting into the apple. When 1 1/2 pounds to 50 gallons of water were used a fairly satisfactory kill was obtained, but a large number of stings prevailed on harvested fruit. A 2-50 solution produced a good, practical control with comparatively few stings at the time of harvest. A 2 1/2-50 solution gave slightly better control than did the 2-50. A 3-50 solution gave a better control than the 2 1/2-50, and with practically no stings. For practical control, 2-50 produced the best results from a production-cost standpoint.

Substitutes for Acid Lead Arsenate and Combinations with Lead Arsenate.—Of all the substitutes tried none gave so good results as acid lead arsenate 2 pounds to 50 gallons of water. Paris green, London purple, calcium, magnesium, manganese, barium, aluminum, cupric, iron, and zinc arsenates, zinc arsenite, lead arsenate oleate, barium fluosilicate, cryolite, Ortho K (Volck), Verdol, derrisol, nicotine sulfate, pyrethrum extracts, lead arsenate-nicotine sulfate, lead arsenate-oleoresin of pyrethrum, lead arsenate-derrisol, lead arsenate-fish oil, lead arsenate-Verdol, lead arsenate-Ortho K, nicotine sulfate-Verdol, oleoresin of pyrethrum-Verdol, and derrisol-Verdol, colloidal lead arsenate, and copper cyanide were used as substitutes.

Supplementary Control Measures.—Supplementary control measures are essential, such as scraping and banding of trees to reduce codling moth population. Untreated burlap necessitates the operation of bands every 10 days to kill the larvae. Bands treated with beta-naphthol and lubrication oil obviates the necessity of killing the larvae by mechanical means. The oil and beta-naphthol do not deter the larvae upon entering the bands. The banding with chemically treated corrugated paper bands gives no injury to the trees, whereas burlap bands which are treated with oil and beta-naphthol cause some injury. Lubrication oil treatment of bands did not give so good results as the oil beta-naphthol treatment. The four-inch treated corrugated paper band gave best results. After entering the chemically treated bands the larvae are killed.

Time of Spraying and the Dosage.—The codling moth can be controlled in southern Kansas, if the sprays are applied in proper amounts, at the proper strength, and at proper intervals when a six or seven spray schedule is carried out. The dosage should be not less than 2 pounds of acid lead arsenate to 50 gallons of water, applied at the rate of about 20 gallons of liquid per tree to 20-year old trees, and at intervals of less than two weeks following the

calyx spray until four sprays have been applied; thereafter at two-week intervals, allowing an 18-day interval between the fourth and fifth cover sprays.

Spray residue under these conditions will be heavy, which will necessitate the use of fruit-washing machines for the removal of the spray residue in excess of the world tolerance.

Index of Spraying Efficiency.—A method has been developed where a mixture of 2 pounds of acid lead arsenate to 50 gallons of water is used to determine the efficiency of spraying. The count is made of the worms on two or three trees in the orchard or section in question. If an adequate amount of spray has been used and the spray schedule has been maintained with a dosage of 2:50, the ratio of wormy fruit to the total number of worms found on those fruits as indicated by the worm holes, should be approximately at 8:10. Any ratio below 7.5:10 shows inadequate control methods. This method of checking control is based upon known relationships in the distribution of worms within the tree under any condition of infestation. If dosage is held at 2:50 the amount of spray on any one tree will vary with the control in the relation that the control ratio, as indicated above, will equal approximately 5.25 times the square root of the amount of spray used per tree.

Dispersion of Adults in Orchard.—Evidence is available that the codling moth does not increase in numbers by accumulation within a small area. Each tree presents an independent problem each year. Within the tree the distribution of injury is proportional to the quantity of fruit occurring on any given section, that the distribution of the codling moth within the tree is a chance relation, and there seems to be no tendency of accumulation, either on any given section or upon certain fruits. It appears that the movement from tree to tree is largely restricted and that the overwintering larvae on each tree largely supply the breeding population for that tree during the ensuing year. The breeding population of a tree may show differences of several hundred per cent between numbers of larvae entering into hibernation and those which survive the winter to enter the pupal period, due to such factors as exposure to the various factors of weather, winter feeding activities of birds and favorable conditions for the development of fungus. Within the tree there is a tendency for damage to accumulate on the top sections and in portions receiving the most sun, especially in the earlier part of the season. There is no evidence to show whether this is a worm response or one that is found in the adult moth.

Climatological Factors.—The adults begin to emerge the latter part of April and first part of May in southern Kansas, with the peak at about May 20 to 25. Egg laying in the spring is heavy when the temperature in the early evening is 65 degrees F. and the air quiet. An air movement of about 4 miles per hour will inhibit egg deposition. After May 25 the temperature every night usually is 65 degrees F., or over, which gives conditions favorable for egg laying during the remainder of the season.

Light may have some influence on the activities of the adult, but temperature is the stronger of the factors. During periods of extreme high temperatures in the summer the moths will not lay eggs until there is a change in temperature from the coolest point toward warmer temperatures. This reaction usually takes place between six and seven o'clock in the morning.

[Project 163; Department of Entomology. Leaders, P. M. Gilmer, R. L. Parker, and G. A. Dean; Purnell fund.]

The Resistance of Crop Plants to Insect Injury.—During the biennium studies have been made of the resistance of crop plants to injury by chinch bugs, corn ear-worm, and Hessian fly.

Through the cooperation of the Division of Dry-land Agriculture, Bureau of Plant Industry, United States Department of Agriculture, there was an opportunity for testing varieties and hybrids of sorghums at Lawton, Okla., where chinch bugs were abundant.

Nurseries of about 80 strains of sorghums, most of which were planted at three dates, were available for study at Lawton during the summer of 1930. Notes were taken at intervals on the progressive death of the plants in the various rows, plant heights, number of heads produced, etc. Plants and chinch bugs were preserved for later study. The percentage of dead plants varied from 20.2 for Atlas and a Kansas Orange X D. Y. milo selection, to 100 for the milos and some other very susceptible varieties. Among the other varieties with low damage are Western Blackhull, Blackhull kafir, Kansas Orange, Red Amber X feterita, Dawn kafir, and Pink kafir.

Plants were preserved in 4 per cent formaldehyde for the purpose of studying the differences in the numbers of punctures made by the chinch bugs. In preparing the plants for study they were washed in water, bleached with chlorine gas and stained with Analin blue. They were again washed until the stain was removed from the plant tissue, but not from the stylet sheath at the point of the puncture. Counts of punctures on nine milo plants showed:

	Punctures.
Leaf sheath	3,060
On leaf blade.....	940
	4,000

On Kansas Orange the count showed:

	Punctures.
Leaf sheath	1,954
On leaf blade.....	1,912
	3,866

The difference in distribution of punctures on leaf blade and sheath rather than in the totals is perhaps significant.

Damage by corn ear-worm has been severe both years of the biennium. While no variety has been outstanding in resistance, Hays Golden has been one of the best. For the season of 1931 a method was worked out for classifying the ears into six degrees of damage. This method has proved satisfactory and will be continued.

In a group of hybrids between inbreds from early-maturing varieties there appeared to be significant variation in the length of shuck. This character was studied in 1931 in its relation to corn ear-worm injury. There was a difference of 12 centimeters in the length of shuck between the row with the longest and the row with the shortest shuck. The four rows with the longest average shuck had an average infestation class of 3.4. The four rows with the shortest average shuck had an average infestation class of 3.8. In this group of hybrids the range in class of infestation was from 2.7 to 4.6 and certain parents gave hybrids that were consistently low.

A large space-planted nursery of F_3 hybrids between resistant and susceptible wheats was grown in 1930. Notes were taken on the infestation with fly of individual plants in the fall. These were marked for study at the time selections were made at harvest time. In addition a large greenhouse test was made of Tenmarq X Kawvale plants grown from the same lots of seed. Of the 97 F_3 families from individual F_2 plants studied in this way, six had no infestation and 16 others had less fly than the resistant parent. Some of the noninfested plants were saved for study of their progenies. In the 1931-'32 nursery most of the rows of Tenmarq X Kawvale which were planted were selected from those families which had the lowest infestation in the greenhouse test. In the heavy infestation in the fall of 1931 none of the rows from the fly-free F_3 families had more than 10 per cent infestation. In general the rows from plants which in 1930 were free from fly had a light infestation in the following year or none at all. The rows of hybrids for which little or no fly data were available at planting time showed less than half the rows resistant to fly.

During the past year interesting information was obtained concerning the

infestation of different species of wheat. The club wheats and the common spring wheats were almost uniformly susceptible. The small number of varieties of Durum wheats and Emmers used showed a range of susceptibility and resistance comparable to that among the common wheats. Marquillo, a common wheat type from a cross between Marquis spring wheat and Jumillo Durum, possesses much more resistance to soft-wheat-belt fly than any other common wheat tested and also possesses resistance equal to the best, to fly from the hard wheat belt.

[Project 164; Departments of Entomology and Agronomy. Leaders, R. H. Painter, A. M. Brunson, and J. H. Parker; Purnell fund.]

Investigations of Injurious Mammals.—Studies have been pursued on (1) the reproductive cycle of the thirteen-lined ground squirrel and the effect of pituitary implants, (2) the inhibition of hibernation by pituitary implants, (3) the growth and development of young ground squirrels in the laboratory, (4) the maintenance of pregnancy by means of a corpus luteum extract on rats and ground squirrels after the latter animals have been ovariectomized in various stages of pregnancy, (5) the effect of pineal gland implants on growth and reproduction, (6) the difference in effect of injections of a bovine anterior pituitary extract on the growth of normal and castrated young mice, and (7) the effect of thymus gland implants on growth and reproduction in young rats. Work has been begun on the effect of ovarian residue extract on young mice, and a study of the reproductive cycles of moles and pocket gophers has been undertaken.

The chief results of the above studies are, very briefly stated, as follows: (1) Ground squirrels in nature have a short breeding season shortly after they come out of hibernation, after which sexual activity declines. In the laboratory the sex organs may show the normal spring enlargement as early as November or December in rare cases, but in January to May in most of the animals. Breeding very rarely takes place in the laboratory even in animals under ultraviolet light, given special protein diets and kept from becoming fat by careful rationing.

2. Implantation of anterior pituitary glands into ground squirrels inhibited hibernation greatly.

3. Injection of an extract from corpora lutea of sows showed a decided aid to the maintenance of pregnancy in rats and ground squirrels after the ovaries were removed. This indicates that the corpora lutea in mammals furnish the hormone responsible for fetal nutrition and retention in the uterus.

4. Pineal glands implanted into young rats apparently cause some retardation of sexual development as determined by the age of sexual maturity, measurements of the gonads and histological study of the testes.

[Project 84; Department of Zoology. Leader, G. E. Johnson; state fund.]

DISEASES OF FARM ANIMALS

Some of the more important features of the work of the Agricultural Experiment Station during the past biennium relating to animal diseases and parasites are discussed below.

Miscellaneous Animal Disease Investigations.—During the past biennium work on this project has consisted of post-mortem and laboratory examinations of diseased animals and tissues, and of investigational trips to determine the cause of mysterious animal

diseases as they made their appearance. During the biennium 26,641 specimens have been received and examined.

Work has been done on losses of baby pigs. This work, while inconclusive, suggests the following generalities: (1) That infection seems to be responsible, in part at least, for heavy losses sustained; (2) that the infective agent is not specific; and (3) that the sow may possibly be a carrier of the organisms that are associated with the inflammation of the stomach and intestines. Two sows were purchased and bred on the farm where baby-pig losses were heavy last year. One of the sows farrowed on the farm before she could be brought in for a complete examination of the membranes, etc. The other sow was immediately brought in and farrowed later in the hospital. While both of these sows had lost their entire litters during the previous farrowing period, neither of them lost any of their pigs while under observation and care. All of the losses encountered have been in immunized sows.

Some further work has been done on corn-stalk disease. Twelve outbreaks of so-called corn-stock disease have been investigated. The histories in all cases were similar and showed that animals were turned out on corn stalks and within a few days one or more animals were found dead either in the morning or during the day. In some cases, but not all, losses appeared after cool or frosty nights. Autopsy examination of these animals showed gastro enteritis, petechia of pericardium and endocardium, and some subendocardial hemorrhages. The liver in some cases showed degenerative changes. Bacteriological examination of the liver, kidneys, heart blood, and in some instances also the lungs, spleen, and muscles, showed no constant bacteriological flora.

Guinea pigs and rabbits were fed with 5 to 10 c. c. of the expressed rumen fluids and of decanted abdominal contents of sick animals. All the experimental animals lost weight during the 7 to 10 days feeding period. One guinea pig fed abdominal contents died. On autopsy gastro enteritis was found. The heart blood of this animal was sterile. Two calves also were fed the rumen contents of a sick steer. The rumen content was removed from the sick animal through a rumenotomy opening and immediately administered to the normal calves by means of a stomach tube and pump. The calves remained well and healthy.

From the examination of these few cases it seems that the etiological factor is not bacteriological in nature and that any toxic material that may be present is rapidly absorbed or destroyed.

[Project 102; Department of Veterinary Medicine. Leaders R. R. Dykstra and H. F. Lienhardt; state fund.]

Abortion Disease Investigations.—Considerable time during the past two years has been devoted to the establishment of abortion-free herds in Kansas, and although business conditions have been unfavorable the number of cooperating herds has increased over 200 per cent. At the close of the biennium there were 130 cooperating herds, 11 of which were accredited abortion free. These herds are located in 51 counties and are attended by 59 practicing veterinarians.

In some herds the sale or the complete isolation of the infected animals seems to be impossible and a modification of the Kansas Plan is being followed. This modified plan calls for the isolation of cows at calving time and necessitates dual maternity sheds. Excellent results are being obtained in two state-owned herds, and in one of these the infection dropped 10.8 per cent during the first year after the plan was started. In a herd containing 94.7 per cent reactors a blood-negative heifer-replacement herd has been raised and the old infected herd will be eliminated and replaced by its own offspring in the near future.

The success of this operation is consistent with the remarkable success which attended the reclaiming of calves from blood-positive cows in the college dairy isolation herd. Fourteen dairy calves born in the isolation (blood-positive) herd were in each case blood-positive, but, when removed to clean areas and their milk supply changed to that of blood-negative cows, were able to throw off the Bang infection and at maturity were still noninfected. The longest period of time required for a calf to become blood negative was 90 days. This answers a most important question of cattle replacement.

The number of blood samples tested has increased steadily during the past two years, although the largest herd has been accredited abortion free and is now only tested once annually.

Studies seeking a drug, chemical, or biological agent which will cause a blood-positive cow to lose her reaction to the agglutination test have been continued. Three massive doses of a thermol-killed Bang bacteria were given at weekly intervals intravenously to two high-blood reactors. In each cow a maximum temperature response of 105 degrees F. was reached within 12 hours after the injection. At the end of one year both cows are still high-blood reactors, and although each cow gave birth to a healthy calf, the abortion germ was recovered from the milk and the products incident to calving in both cases. This experiment was started to prove or disprove the contention of a biological house that massive dosage of a cow with Bang germs will be followed by a negative test in less than a year.

One cow was given three grams of Guaiacol intravenously twice daily for one week to determine the effect upon her high-blood reaction. No effect was noted upon the agglutinin content of the blood and no toxic effects noted.

This year a method of standardizing rapid abortion antigen has been perfected, based upon the centrifugalization of a measured quantity of bacterial wash to yield a definite quantity of precipitate. A uniform product is thus insured and the keeping qualities are excellent for at least 30 days.

The opinion is common that cattle injected with hemorrhagic septicemia bacterin will react to the agglutination test for infectious abortion, and since many states have rulings to the effect that blood-positive cattle cannot enter their states it was thought advisable to determine the true facts of the case. Two blood-negative heifers were purchased and injected with the hemorrhagic septicemia bacterin of commercial origin in the maximum dosage. Two injections were made. These animals were kept under observation for one year. At no time did either cow react positive to the agglutination test for Bangs disease although both of them continued to react in dilution of 1-200 against an antigen prepared from pure cultures of *Past. bovissepticus*.

[Project 135; Department of Veterinary Medicine. Leaders, C. H. Kitselman and H. F. Lienhardt; state fund.]

Blackleg Investigations.—The work on this project during the biennium has consisted of: (1) The production of and distribution of blackleg filtrate, blackleg bacterin, and antiblackleg serum; (2) investigations of outbreaks of blackleg in the state; (3) a bacteriological study of material obtained from a blackleglike disease in swine in Iowa, Indiana, and Nebraska; (4) a study of the keeping qualities of formolized blackleg products; (5) a study of the use of blackleg filtrate and bacterin in the immunization of horses for the production of antiblackleg serum; (6) the study of the action of a number of antiseptics on blackleg cultures and their action on the aggressive substances produced in blackleg cultures; and (7) a study of the use of reduced iron in culture media used for the growth of anaerobic organisms.

A total of 35,244 doses of blackleg filtrate, 38,446 doses of blackleg bacterin, and 34,500 c.c. of antiblackleg serum were produced and distributed.

Losses from blackleg were unusually high in 1931; similar high morbidity rates were observed in other states, especially in Montana. One extensive outbreak of blackleg occurred in Chase county where there was a loss of between 30 and 50 head among herds totaling about 1,500 head of cattle shipped to pasture. There were losses from blackleg in four herds treated in part with college products when the calves were 3 to 4 months old, the losses occurring when the calves were 6 to 8 months of age.

From reports of losses during the past 14 years, the losses following the use of phenolized blackleg products were less than 1 in 10,000 head of vaccinated animals; the losses since 1929 when formalin was used as a preservative have been considerably less, reports indicating that losses have been less than 1 in 20,000.

Metaphen, chlor-picrin, merthiolate, and acetaldehyde were added to blackleg cultures to determine their action in the sterilization of these cultures and on the aggressive substances developed in the cultures. Metaphen was found to be of insufficient strength to produce satisfactory sterilization. Chlor-picrin and merthiolate were fair to good sterilizing agents, but had no or only a slight action on the aggressive substances. Merthiolate was found to be a good preservative for use in antiblackleg serum. Acetaldehyde sterilized blackleg cultures in four days and had a moderate stimulating action on the aggressive substances.

[Department of Veterinary Medicine. Leader, J. P. Scott; state fund.]

Shipping Fever Investigations.—The work during the biennium has consisted of: (1) Continued field investigations of outbreaks of shipping fever; (2) bacteriological examinations of material obtained in the course of these field investigations; and (3) immunological experiments on guinea pigs, rabbits, and larger animals.

From a study of the conditions of housing and care given animals on farms where the disease occurred, it was soon evident that the number of sick animals was always higher when inadequate shelter was provided for recently shipped-in animals. The number of sick animals and the proportion of deaths was highest when inadequate shelter was accompanied by carelessness in the feeding and watering of the animals. In four cases where inadequate shelter and poor feeding conditions prevailed, native cattle were confined in close quarters with the sick shipped-in animals; some of these native cattle sickened with clinical cases of shipping fever. In other cases of shipping fever no symptoms of the disease developed in the native stock.

The incidence of shipping fever was greatest during wet, cold weather, especially during changeable spring and fall weather. The length of the rail transportation during the wet, cold months had apparently some correlation with the severity of the disease as it manifested itself on the farm. Especially heavy losses occurred among cattle shipped from southern Texas and from Canada during October and March. In at least one of these cases delays in receipt and movement of the cattle occurred. Cattle shipped direct to the feeder from the ranch on which they were raised, without being handled at local or public stockyards, had fewer clinical cases, but even under these conditions at least one such shipment suffered a severe outbreak of shipping fever.

A careful history of the condition of the shipped-in animals was obtained and it was ascertained whether the animals had been vaccinated before shipment, or at the stockyards, and whether any biological products had been used since arrival. Table XI shows a comparison of the losses incurred from shipping fever among animals that had been vaccinated at the yards or on the farm, and among untreated animals. The nature of the product used at the stockyards could not be ascertained except in a few cases, so all vaccinations, whether bacterin, mixed vaccines or aggressin, are listed under one head. The losses among vaccinated cattle were about three times as high as

among untreated cattle. Among 5,661 vaccinated animals there was a loss of 3.58 per cent and among 4,119 untreated animals the loss was 1.02 per cent. The losses were higher in the vaccinated group during every month in which outbreaks occurred and in only one month, February, when the weather was fair and cool, did the losses in untreated animals approach the losses among the vaccinated group.

TABLE XI.—LOSSES FROM SHIPPING FEVER IN UNVACCINATED AND VACCINATED CATTLE.

MONTH.	Not vaccinated.				Vaccinated.				Weather.
	No. of animals.	No. of herds.	Mortality.		No. of animals.	No. of herds.	Mortality.		
			No.	Per cent.			No.	Per cent.	
1930									
October.....	404	3	9	2.2	718	8	19	2.6	Rain.
November.....	963	11	11	1.1	1,249	18	38	3.4	Snow—rain.
December.....	1,357	8	5	.3	1,052	17	40	3.7	Snow—rain.
January.....	596	7	6	1.0	1,232	12	39	3.1	Cold—fair.
February.....	149	4	3	2.0	684	7	19	2.8	Fair—cool.
March.....	217	3	2	.9	292	5	6	2.5	Changeable.
April.....	212	1	1	.5	.....	.....	.....	.....	.....
July.....	.....	.....	.....	.....	100	1	6	6.0	Mostly fair— warm. Hot—dry.
August.....	70	1	2	2.9	133	2	6	4.5	Hot—dry.
1931									
January.....	126	2	1	.7	.....	.....	.....	.....	Clear—cold.
February.....	25	1	2	8.0	.....	.....	.....	.....	Mostly fair— warm.
March.....	.....	.....	.....	.....	201	1	30	14.8	Changeable.
Totals...	4,119	41	42	1.0	5,661	71	203	3.6	.....

Three general groups of organisms were found in the examination of material from shipping fever cases. The most constant organism found was *Pasteurella bovisseptica*, which was isolated from 21 (81 per cent) of the 26 cases examined. The second most common organisms were of the colon-aerogenes type. These were isolated in 10 (38 per cent) of the cases. Colon-type cultures were found in all material which took more than 15 to 24 hours to reach the laboratory. In most cases where the material reached the laboratory promptly, the only organism isolated was *P. bovisseptica*. The third class of organisms found were gram-negative rods which did not ferment any of 22 carbohydrates examined. A number of these organisms were compared with *Alcaligenes bronchisepticus* and found to correspond culturally and antigenically with this organism. Ten of these cultures were found and six of them belonged to the *A. bronchisepticus* species.

Immunization of rabbits by heat-killed agar and broth cultures, boiled antigen, and other preparations of *Pasteurella bovisseptica* showed that these preparations produced only a low titer of agglutinin in rabbits and that the active immunity developed was weak. It was found that guinea pigs and rabbits varied greatly in their susceptibility to injections of virulent cultures of *Pasteurella bovisseptica*. Rabbits injected with three to eight times the does of culture which would kill one rabbit, remained healthy for several weeks after injection.

Infection experiments on calves indicated that the amount of feed taken

by the calf before injection had some relationship to the rapidity of the resulting infection. Calves on a reduced hay and grain ration for 48 hours before injection were very resistant to the infection, developing only high temperatures and some symptoms of congestion of the lungs and in all cases recovering. A calf that was exposed to a cold bath and exercise 12 hours before inoculation developed a very high temperature but recovered rapidly.

[Project 176; Department of Veterinary Medicine. Leaders, R. R. Dykstra, H. F. Lienhardt, J. P. Scott, and Herman Farley; state fund.]

Anaplasmosis Disease Investigations.—During the past biennium work in this project, which is in cooperation with the Bureau of Animal Industry, United States Department of Agriculture, has consisted of an attempt (1) to develop an immunizing agent against anaplasmosis, (2) to determine the length of time that blood of a carrier or recovered animal will remain noxious, (3) to establish the means of transmission of anaplasmosis through studies on vectors, and (4) to develop a test to detect carrier or infected animals.

Repeated inoculations of composite blood from animals that have recovered from anaplasmosis have proved effective in protecting susceptible cattle. These inoculations have consisted of citrated blood from carriers held in a refrigerator 15 days, citrated blood treated with 0.25 per cent of pure formalin and kept in a refrigerator 30 days, citrated blood treated with 0.10 per cent pure formalin held in a refrigerator 14 days, and laked defibrinated blood, which was acidulated with 0.75 per cent of hydrochloric acid, kept in room temperature 8 hours, then in refrigerator 24 hours, neutralized with 0.1 sodium hydroxide, tested with litmus, and kept in a refrigerator one week. None of the attempts to attenuate virulent blood seemed to be effective in producing a product helpful to the cattle after exposure to the disease.

Four calves, born from experimented cows which were carrying the foetus during their acute illness with anaplasmosis, have been saved. One is now over 3 years old, and subsequent to his reaching the age of 6 months has received virulent carrier blood or blood from an acute case at intervals of 6 months or a year with no reaction or indications of the disease. One calf, so treated when about a year old, had a very subacute form of anaplasmosis and recovered. Two are now 3 months old, but have not been tested. Results from these calves point strongly to the transfer of the infection to the foetus while in utero.

Considerable effort has been made to grow the parasite on normal blood under paraffin oil, incubated at a temperature of 101.5 degrees F. In most cases dextrose solution was added to the medium. Carrier blood was used to inoculate. Little success has attended these efforts. Hemolysis occurs in 24 to 48 hours, making the study by smears inconclusive.

[Project 180; Department of Veterinary Medicine; Leaders, R. R. Dykstra, C. A. Pyle, and H. F. Lienhardt; state fund.]

Poultry Disease Investigations.—Seven phases of work were in progress during the biennium, each of which is briefly discussed below.

A General Study of Poultry Diseases.—The same general procedure which has been followed in the past is being carried out in the routine examination and study of diseased fowl. Much valuable material from the field cannot be properly utilized because of lack of assistance and physical equipment. Inadequate housing and isolation facilities present a serious obstacle in this respect. The studies on several definite problems during the past few years

have been continued and some new problems of current interest and importance have been given attention.

Data on intestinal parasitism shows a variation from year to year, although a general increase is observed in total numbers. While there has been an apparent decrease during the past biennium in the percentage of ceum worm (*Heterakis papillosa*) infestation that of large round worm (*Ascaris lineata*) seems to have remained nearly stationary. On the other hand tapeworm infestations have shown a slight increase while coccidiosis is far more prevalent and serious. Capillariosis, previously not detected, has been found in several cases in Kansas flocks during the two-year period. Observations on the relative injury induced by worms in all classes of chickens place tapeworms first, large round worms second, and cecal worms third. Capillaria are apparently more harmful in infestations of the same number and extent than the other two common nematodes.

No observations of significance with reference to A-avitaminosis of the domestic fowl have been made, but a limited number of artificially induced cases of A-avitaminosis in mature turkeys have been presented from the Department of Poultry Husbandry. Some of the differences in lesions and pathogenesis as compared to chickens are: (1) less tendency for the collection of urates in the kidney tubules and ureters, and (2) earlier and more extensive involvement of the respiratory tract, particularly in the formation of false membranes in the trachea. Lung involvement, including organization of isolated lobules and abscessation were frequently observed in the turkey. Such changes have not been observed to be common or significant in the chicken.

Further studies on omphalitis of baby chicks led to the following observations. The incidence of the disease is usually greater in the heavier breeds. A high relative humidity in the incubator or hatchery delays rapid and proper closure of the umbilicus and thus favors entrance of facultative pathogenic organisms, particularly those grossly present in the feces. The anaerobic flora as determined by cultural methods appeared more constant than the aerobic, *Clostridium sporogenss* and *Cl. tertias* being isolated frequently.

A further study of so-called "slipped tendon," a condition associated with a high mineral content of the ration, showed occasional involvement of the bone marrow with hemolytic streptococci. Isolation of the organism was accomplished quite readily in 33.5 per cent of the cases examined by guinea-pig inoculation.

Studies of Pullorum Disease.—The testing for carriers of pullorum disease has been largely directed toward a comparative study of whole blood (plate) and serum agglutination tests. The latter were used as standards. Upon finding a rather common and constant disagreement in a considerable number of tests it was decided to attempt a study of the probable factors accounting for the discrepancies. The physical factor of turbidity of the antigen-blood mixture, interfering with the probable detection of positive agglutination, had been suggested as the reason for disagreements in this test as compared to the far less turbid antigen-serum mixtures in the standard test.

The results indicate that the problem involved is concerned with factors other than that of the simple difficulty of physical interpretation of the tests. A further study of this problem is planned.

A Study of Fowl Cholera.—A study of fowl cholera has included a study of the artificial means of enhancing the resistance of the domestic fowl to cholera and the use of various media for the propagation of stock cultures of *P. avicida*.

The use of formalized tissue (spleen and liver) "aggressins" prepared from birds dead of experimentally induced (intravenous inoculation) fowl cholera gave results that are prompting continued trials with these products.

Although absolute immunity to subsequent artificial inoculation of *P. avicida* was not established by aggressin vaccination, the average survival time was 25.6 hours in birds vaccinated intraperitoneally and 35 hours in birds vaccinated subcutaneously, as compared to 16 hours for unvaccinated controls.

In one natural outbreak of cholera losses ceased abruptly within two days after "aggressin" vaccination.

Studies of Fowl Paralysis.—The study of the disease "Range Paralysis," (*Neurolymphomatosis gallinarum*) was confined to a study of the changes in the nervous tissue from spontaneous cases because of failure to transmit the condition in the laboratory. The characteristic lesion is a round cell infiltration into the nervous tissue of the body, more particularly the peripheral nerves and the ganglia of the nerves to the legs, wings, and eyes.

The cellular elements accumulate because of emigration from the outside and of proliferation of local cells. The former appear to be of the plasma or endothelial cell type, the latter fibroblasts and some reticulo-endothelial cells. The accumulation of cells may be in response to a tumor-inciting virus or to a neurotoxic substance. The degeneration of the nervous tissue probably results from a pressure necrosis due to the great accumulation of cellular elements.

In some cases similar accumulations of cellular elements are observed in many tissues of the body. In these cases the condition resembles a tumor. The early lesions are almost entirely perivascular in any position, the cell accumulations rarely originating around lymph spaces. This is the most characteristic lesion and may be considered diagnostic for the disease, although there are many instances of perivascular infiltration of round cells without symptoms of paralysis. The paralytic symptom developing only in the final stages.

The exact etiological factor in this disease is still in doubt, but it appears to resemble a virus and may be the same as the virus of certain types of tumors. It is in no way related to the condition known as "slipped tendon."

Experiments with Fowl Pox.—Studies of the effect of storage on the viability and virulence of pox virus (dry pox scabs) showed that unground scabs kept at room temperature for eight months and subsequently used for field vaccination did not show significant change or marked injury. Extensive attempts by means of various chemicals to kill bacteria naturally present in pox scab virus without significant injury to the pox virus, gave results of little promise.

Attempts to standardize pox virus by employing serum from pox hyperimmune birds have not been successful. However, standardization by means of a method suggested by Kligler, I. J., *British Journal Exp. Path.*, XI (1930), 1, pp. 10-13, seemed to be satisfactory. In connection with this phase of the work 75,533 doses of fowl pox virus were distributed for field use during the biennium.

Studies on Tracheobronchitis (Larylotracheitis).—During the past year extensive investigations have been made of this disease which is common in Kansas in both chicks and adult birds. The symptoms of the disease are labored respiration and "gaspings" for air, with suffocation and death in a short time. The post mortem lesions consist of an inflammation of the trachea and bronchi. The cause is a filter-passing virus. While attempts to infect chicks through the egg have been unsuccessful, the evidence gained from a study of outbreaks in young incubator chicks indicates that the disease is transmitted in this manner. It is also apparently widely disseminated through the air of the incubator during hatching. The disease may be controlled by sanitation in the hatchery and feeding stations. In the incubator the disease is held at a minimum by means of formaldehyde fumigation and high humidity during the hatching period. In feeding stations it may be reduced by protecting the birds against excessive drafts of cold air, reducing crowded conditions in feeding batteries, and exercising great care in culling and rejecting all birds showing signs of sickness.

A Study of Tuberculosis of Fowls.—This study consisted of an examination of several cases of spontaneous and experimental disease. The cultures used were of normal virulence and produced typical lesions and sensitized the birds to tuberculin.

The lesions produced appear in a variety of forms, due not so much to the difference in organism as to the tissue in which it is located. The lesions are progressive although the rate is variable. In some there is an acute, rapid growth, in others they appear to be very chronic. In the early lesions the bacilli are almost universally within the large epitheloidal cells and giant cells. Wherever the tubercle bacillus is localized in the tissue it soon becomes surrounded by a zone of epitheloidal cells, although it is difficult to demonstrate any injury of the surrounding tissues. The accumulation of the endothelial leucocytes is an attempt of the tissues to neutralize the toxins of the organism. The organisms multiply enormously within these leucocytes and result in their destruction. The centers of the tubercle soon undergo necrosis due to lack of blood supply, and the cells of the tubercle are arranged in a series of zones, which are easily recognized. Apparently the extension of the process into surrounding tissues is due largely to pressure necrosis.

[Project 85; Department of Bacteriology. Leaders, L. D. Bushnell and C. A. Brandy; state fund.]

The Etiological Factors Involved in the Malformation of Bones in Young Chickens.—The study of this problem, which was begun in the spring of 1930, has been continued. More than 1,500 Rhode Island Red Chicks were studied in seven different experiments. A number of theoretical causes of malformed leg bones in young chickens, such as the feeding of rations high in protein, confinement brooding, high room temperature, low humidity, bacterial infection, and brooding on wire floors were eliminated.

In 1931 different sources of protein were studied to determine if the source of protein was a factor in the problem. Protein from five sources was used as follows: Dried buttermilk, meat and bone scraps, meat cracklings, corn gluten meal, and tankage. As a result of this work it was found that the source of protein seemed not to affect the occurrence of slipped tendons. It was observed, however, that the number of cases of slipped tendons usually increased as the amount of phosphorus in the ration increased. That is, phosphorus seemed to be more of a disturbing factor than either calcium or the Ca-P ratio. It was further noted that the majority of cases developed at the age of three and four weeks, that the right leg was most frequently involved, and that the affliction predominated among males.

This study was followed by an experiment to determine whether the phosphorus content of the ration was more responsible than the calcium content in producing this malformed condition.

The college all-mash starting ration was used as a basal feed and to this was added either bone meal, calcium carbonate, starch, or sodium hypophosphate to increase the percentage of phosphorus from a low to a high level and to maintain a fairly constant ratio between calcium and phosphorus. The exact amounts of these elements as determined by chemical analysis after the rations were mixed are given in Table XII.

The results of this study verify the work of the previous year by indicating that slipped tendons increase as the amount of phosphorus in the ration increases. The rate of growth also declined as the amount of phosphorus was increased. It appears that 0.5 to 1 per cent of phosphorus is adequate for optimum normal growth when the calcium is about double that amount.

It was found in this experiment that 90.6 per cent of the crooked legs developed between the third and fifth weeks. The right leg was affected in 35 per cent of the cases, the left, in 11 per cent, and both legs were involved in 54 per cent. Of the birds affected 52 per cent were males and 48 per cent were females.

There is considerable evidence that a high percentage of fiber in the ration tends to reduce the malformed condition. This phase of the work will be studied together with further investigations of the calcium and phosphorus content of the rations.

TABLE XII.--THE AMOUNTS OF CALCIUM AND PHOSPHORUS, THE Ca-P RATIO, THE NUMBER OF BIRDS WITH SLIPPED TENDONS, AND THE AVERAGE WEIGHTS IN GRAMS OF YOUNG CHICKENS FED RATIONS OF VARYING PERCENTAGES OF PHOSPHORUS.

LOT	36	37	38	39	40	41
Per cent calcium in ration.....	1.468	2.005	2.607	2.860	2.238	2.800
Per cent phosphorus in ration.....	.720	.904	1.310	1.445	1.190	.905
Ca-P ratio.....	2.03:1	2.21:1	1.99:1	1.97:1	1.88:1	3.09:1
Number slipped tendons.....	(a) 3	(a) 6	16	22	15	13
Per cent slipped tendons.....	12	24	64	88	60	52
Av. weight of birds at 8 weeks of ago.	.724	.721	.618	.512	.614	.615

(a) Only one chick in lot 36 and four in lot 37 showed slipped tendons more than one week during the experiment.

[Project 127; Departments of Poultry Husbandry, Chemistry, Veterinary Medicine, and Bacteriology. Leaders, L. F. Payne, J. S. Hughes, H. F. Lienhardt, and L. D. Bushnell; Adams and state funds.]

The Inheritance of Slipped Tendons.—Two matings of Rhode Island Red Chickens were made in 1931. One lot consisted of a male and eight females, none of which had ever shown signs of slipped tendons. These were designated “normal.” The second lot included a male and seven females, all of which developed severe cases of slipped tendons as young chicks. These were designated “abnormal.” Chicks were hatched from the two matings and reared to six weeks of age. They were fed an all-mash ration known to produce slipped tendons. Out of 102 individuals produced from the straight-leg mating, 19 individuals developed slipped tendons, while from 112 individuals from the crooked-leg mating, 56 chicks developed slipped tendons. The percentage of abnormal in the straight-leg mating was 18.63 ± 3.129 as compared with 56.0 ± 3.186 in the crooked-leg mating. The actual difference in percentage of abnormal in the two lots was 37+, which is more than eight times the probable error of the difference. This indicates that genetic factors may be partially responsible for this deformity. [Department of Poultry Husbandry. Leader, L. F. Payne; state fund.]

Histopathology of Poultry Diseases.—During the past biennium the work on this project has consisted of a study of the malformation of the bones in young chickens in cooperation with the Departments of Poultry Husbandry and Chemistry on Project 127 reported above.

Two chicks a week were taken for a five-week period from the birds used in Project 127. These chicks, together with control or normal chicks of the same age, were carefully examined for evidence of disease. Sections were made from the heart, liver, spleen, intestine, proventriculus, kidney, adrenal, pancreas, lung, thyroid, thymus, brain, pituitary body, lymph nodes and hock joints.

From a strictly pathological point of view the malformation of bones in

young chickens seems to be quite characteristically confined to the bones of the leg and particularly to the tibia and metatarsal bones. Here the tendon which regularly rests in the groove formed by the condyles of the tibia is found to have slipped and is pulled to the inside of the leg. After this tendon has slipped it loses its proper tension and gradually shrinks, thus pulling the leg, which is growing at a rapid rate, out of shape and produces the characteristic "crooked leg."

Histopathological specimens taken from the bones above referred to reveal the presence of a picture of a very rapid bone development, in that there is presented an irregular line of ossification and imperfect bone development. This is also seen in irregularities of the bone and also in the distorted shape. The deformity in the leg bones seems to be in direct proportion to the rapidity of development of bone, and the bending process produced by the contracture of the tendon proceeds as rapidly as bone development progresses. Normal or control chickens on the same rations show a normal rate of bone growth and an orderly advance of lines of ossification, thus permitting a more gradual development of bone and tendon and obviating the stress on the tendon necessary to cause it to slip from its groove in the condyles. With the exception of the lesions referred to above, microscopic sections from other organs in the body of affected chicks appear to check with the control slides and present a normal appearance.

[Project 168; Department of Veterinary Medicine. Leader, H. F. Lienhardt; state fund.]

The Relation of Adequacy of Diet to Disease.—The study of the cause of the high uric acid in the blood of hens in the last stage of avitaminosis A has been continued. The blood and urine of a number of hens in the last stages of this disease have been analyzed for uric acid, urea, ammonia, creatinine, the total nonprotein nitrogen. The results of the chemical analysis indicate that the increase in the nitrogenous constituents of the blood of the hens in the last stages of avitaminosis A is due, in a large measure, to the clogging of the ureters by crystals of uric acid.

Work is now under way in which the ureters are being ligatured to see if this mechanical means of stopping the flow of urine gives the same results as those obtained in avitaminosis A. If the results are not the same, it will indicate that some function of the kidney has been altered by changes due to lack of vitamin A. The project will be discontinued and the results prepared for publication.

[Project 131; Departments of Chemistry, Bacteriology, and Poultry Husbandry. Leaders, J. S. Hughes, C. A. Brandly, and L. F. Payne; state fund.]

Parasitological Investigations.—During the past biennium the work has consisted of (1) testing the viability of developing eggs of the intestinal roundworm (*Ascaridia lineata* Schneider) at lower and higher temperatures in refrigerators and incubators operating at known temperatures and in soil out of doors during the various seasons of the year, and (2) studying the morphology and life history of the fowl nematode *A. lineata*. Some of the principal results obtained were as follows:

1. Incubation and refrigeration of *A. lineata* eggs in water. Constant refrigeration of fertile eggs in water cultures for one month at 0 degrees C. so lowers the vitality that, on being incubated subsequently at 30 degrees C.,

they divide slowly and soon die; keeping the eggs at 10 degrees C. for one month has no deleterious effect on them when incubated subsequently at 30 degrees C. Fertile eggs exposed in ice at -12 degrees C. were killed in 24 hours. Eggs in water were killed at 54 degrees C. in two minutes.

2. Out-of-door exposure of *A. lineata* eggs in soil. Eggs exposed in less than one-half inch of soil were killed in ordinary Kansas winters (with sub-zero Fahrenheit weather); those exposed in mild winters (no sub-zero weather) may remain viable. Eggs in two inches of soil failed to survive normal winters, but remained viable in a mild winter. At four-inch depths the *Ascaridia* ova survived both normal and mild winters.

Spring exposures of ova in four inches or less of soil were invariably favorable for the viability and development of the eggs. Similar exposures of eggs at less than one-half inch of soil in unshaded locations were lethal to eggs in three weeks, but in unshaded situations similar to those about drinking fountains the ova remained viable from spring to autumn (114 days). At depths of two to six inches the viability of the ova is increased markedly, especially in seasons of heavy precipitation or with copious subsoil moisture.

Eggs deposited in the autumn (October) failed to reach the infective stage before winter.

3. Studies on the morphology and life history of the fowl nematode *A. lineata*. Studies begun several years ago on the morphology and life history of the fowl nematode *Ascaridia lineata* (Schneider) were completed during the past biennium. Included in the studies was a taxonomic examination of specimens from various parts of this country and of the specimens available in the British Museum, London. The results of the study indicated that the common large roundworm of chickens in this country, England, and Africa is *A. lineata* (Schneider). Some of the principal points determined in this study were as follows:

(a) Eggs arising in the anterior ovary pass into the posterior uterus; similarly, eggs from the posterior ovary pass into the anterior uterus.

(b) In young females eggs may be fertilized at any place in the uteri; in adults fertilization occurs near the distal ends of the uteri.

(c) With the aid of a micromanipulator, a small structure in one pole of the mature egg, previously described as an opening, an opercular plug in the shell, or as an internal thickening of the shell, was found to be a solid, conical appendage of the vitelline membrane, free from the shell.

(d) In hatching, the embryo may escape from any part of the egg shell, either in the duodenum of the host or in water cultures; newly hatched larvae swallowed by the chicken seldom become established; infestations normally result from the ingestion of embryonated eggs.

(e) The habitat of *A. lineata* is in the duodenum, especially the portion which is a few centimeters posterior to the entrance of the bile ducts; determination of hydrogen-ion concentrations showed that the nematodes live in nearly neutral media (av. 6.7).

(f) Penetration of the duodenal mucosa by larvae 10-17 days old is frequent in young chickens; occasionally a larvae goes on through the intestinal wall to the liver and lungs, but ordinarily, after the seventeenth day the young worms withdraw from the mucosa into the lumen of the intestine.

(g) Young *A. lineata* grew to maturity in 50 days in chickens parasitized when about a month old; in six 8-day periods following hatching of the larvae the average daily growth in length per period was about 0.12 mm. in the first period, 0.75 mm. in the second, 1.5 mm. in the third, fourth, and fifth periods, and 3 mm. in the sixth period.

(h) At least three moults occur before the adult form of the nematode is developed. Important morphological changes associated with the moults include, after first moult, presence of preanal swelling (males), and of anal prominence in both sexes; after second moult, lips with oral papillae and denticular ridges, projecting lateral folds (alae) present in newly hatched larvae replaced by nonprojecting lateral lines, females with vulva and shorter tail proportionately, and males with preanal sucker and three pairs of cadual

papillae; after third moult, external characters similar to those of the adult *A. lineata*.

4. Age resistance of chickens to *A. lineata*. Much experimental evidence has been collected, during the biennium which confirms the earlier findings that chickens 10 weeks or more of age on an adequate diet become very resistant to the infectivity and growth of the fowl nematode *Ascaridia lineata*.

5. Program for raising nematode-free chickens. From the results of this project and those of other projects in parasitology a program for raising nematode-free chickens should include (a) early rearing of baby chicks so that they are 10 weeks of age by the time the nematode eggs in the soil reach the infective stage (approximately May 15 at Manhattan, Kan.); (b) or rearing the chickens in confinement until they are 10 weeks of age; (c) placing the chickens on a diet that is adequate in vitamin A and the vitamin B (complex) to insure maximum resistance of the chickens against the worms; (d) supplying the chickens with vitamin D (sunshine, ultra-violet light, or cod liver oil) to reduce the effects of any *Ascaridia lineata* that may gain access to the chickens; (e) supplementing the animal proteins in the ration by skimmilk (or its equivalent) to insure the maximum resistance of the chickens to the infectivity and growth of any *A. lineata* taken up as eggs by the fowls.

[Project 79; Department of Zoology. Leader, J. E. Ackert; Adams fund.]

Resistance of Chickens to Parasitism.—During the biennium food accessories and blood loss have been tested as factors in the resistance of chickens to the large roundworm *Ascaridia lineata* (Schneider). Some of the more important phases of work are the following:

Resistance of Chickens to Parasitism Affected by Vitamin A.—The principal results secured during the past biennium are: In six experiments on 187 chickens vitamin A (cod liver oil) was proved to be an important factor in the resistance of growing chickens to the infectivity and growth of the nematode *A. lineata*. Chickens from the same hatch that were parasitized by the same number of worm eggs and kept on a diet adequate except for vitamin A had significantly more worms and longer worms at the conclusion of the experiment than did those chickens to which vitamin A was supplied. These results indicate that the resistance of the chickens to the worms has been lowered by the lack of the vitamin in the diet.

*Resistance of Chickens to *A. lineata* Affected by the Vitamin B Complex.* In four experiments carried on in a similar manner 225 chickens were used to test the vitamin B complex (yeast) as a resistance factor. In these experiments vitamin B was found to be a factor in the resistance of chickens to the infectivity (number) of the nematodes. The chickens on a diet lacking vitamin B had significantly more worms at the close of the experiment than did the chickens on the plus B ration, indicating that the resistance to the young worms had been reduced. Concerning the growth of the worms, it was found that those in the chickens supplied with vitamin B (yeast) were significantly longer than the worms in the chickens whose diet lacked this vitamin. This result indicated the possibility of a growth factor in yeast which caused more rapid growth in the intestinal worms.

The hypothesis that yeast might furnish a special growth factor for the intestinal nematodes (*A. lineata*) has been tested by two experiments involving 262 chickens. In neither experiment was there any evidence that yeast in the presence of an adequate amount of vitamin B complex contains a special growth factor that affects *A. lineata*. There was evidence that the excessive yeast kept the chickens in a slightly more healthy condition, but this did not significantly increase either the resistance of the chickens or the growth rate of the worm parasites.

Skimmilk a Factor in the Resistance of Chickens to Parasitism.—Results of experiments recently summarized show that skimmilk given *ad libitum*

as a supplement to a ration in which the animal protein is furnished in meat meal greatly increased the resistance of the chickens to the infectivity and growth of *A. lineata*. In chickens from the same hatch, kept on a diet in which the animal protein was supplied wholly by meat meal, and given the same number of nematode eggs, the resulting infestations of worms were markedly larger and the growth of the worms more rapid than in chickens whose diet included the skimmilk.

Blood Loss a Factor in the Resistance to Large Doses of A. Lineata Eggs.—Experiments carried on prior to this biennium indicated that loss of blood decreased the resistance of young chickens to the intestinal nematode *A. lineata*. To test this hypothesis three experiments involving 360 chickens were carried out. Chickens from the same hatch were divided into two lots, one lot being bled weekly, beginning with 0.5 c.c. and increasing until 5 c.c. were taken. The other lot (unbled) served as a control. Five groups, each containing bled and unbled chickens, were parasitized. One group received 500 worm eggs per chicken; a second group 300; a third 100; a fourth 50; and the fifth 25. At the close of the experiment the results showed that blood loss had significantly lowered the resistance of the chickens that were fed 500 and 300 eggs, respectively. While differences occurred in the other groups, they were not constant.

Other points ascertained from these experiments were that no more worms survived in chickens when 500 eggs were fed than when 300 were fed. It was found that suitable infestations resulted from feeding 50 eggs, thus greatly reducing the labor involved in experiments of this character.

Worm Infestations Increase Resistance.—Results of a series of experiments begun in 1928 and conclude during the past biennium show that a previous infestation of *Ascaridia lineata* tends to increase the resistance of the chickens over that of chickens of the same hatch that have not been previously parasitized.

[Project 169; Department of Zoology. Leader, J. E. Ackert; Purnell fund.]

Studies on the Embryology of Parasitic Worms.—During the past biennium the work has consisted of studies on the filaria worm *Onchocerca cervicalis* as a possible factor in the causation of the disease fistulous withers in horses.

A high percentage (83) of the ligamentum nuchae removed from cases of fistulous withers contained the parasitic worm *Onchocerca cervicalis* or calcified areas characteristic of previous infestations of this worm. Studies on the anatomy of living or of well-cleared specimens of *O. cervicalis* have given the following new diagnostic characters for this species: (1) Four very small oral papillae, (2) three prominent terminal papillae on the tail of the female, and (3) location of the nerve ring.

[Project 119; Department of Zoology. Leader, J. E. Ackert; state fund.]

STUDIES IN HOME ECONOMICS

Several lines of investigational work that have for their purpose the development and improvement of the rural home have been conducted by the Agricultural Experiment Station during the past biennium. Some of the more important features of this work are briefly discussed below.

A Determination of the Vitamin Content of Some Common Fruits and Other Foods.—During the past biennium work has been done to determine (1) the vitamin A content of Early Richmond

and Montmorency sour cherries, (2) the vitamin A content of butter made of cream treated with chlorine to remove objectionable odors, and (3) the vitamin B (B₁) content of wheat and its milling products.

It has been shown that Kansas-grown cherries, raw, frozen, or canned by methods used in the home, are fairly rich in vitamin A.

In a study made to determine quantitatively the vitamin B (B₁) content of milling products made from Kansas hard red winter wheat, where growth rate for rats was used as the unit of measure and where the materials to be tested were incorporated in the diets prepared according to the newer methods of Chase and Sherman, it was shown that patent flour contains small measurable amounts of vitamin B (B₁). First, clear flour was about 0.4 as rich; low grade flour, 1.5 times as rich; middlings and germstock, 4 times as rich; and bran, 2.5 times as rich as the whole wheat.

Four yeast breads made of wheat products without milk were tested according to the same method. (1) White bread made from patent flour contained 2 to 3 times as much vitamin B (B₁) as could be accounted for by the amount of patent flour present in the bread. The yeast is apparently responsible for this increased amount of B (B₁). (2) Whole wheat bread, 50-50 per cent, (half patent flour and half whole wheat flour) contained about 50 per cent more vitamin B (B₁) than could be accounted for by the whole wheat flour present. As the vitamin in the patent flour at the low level of feeding was almost negligible, the yeast must have supplied the additional B (B₁). (3) Whole wheat bread, 100 per cent whole wheat flour, contained at least as much extra vitamin B (B₁) as did the 50-50 per cent bread. The large percentage of yeast used, sugar in the formula and the very thorough mixing account for this. (4) Germ-stock bread, of 10 per cent germ stock and 90 percentage patent flour, was about 50 per cent richer in vitamin B (B₁) than could be accounted for by the germ stock alone.

Calculations may be made in terms of the vitamin B (B₁) secured by the consumer of these yeast breads. When equal weights of wheat products are consumed in the form of different yeast breads, vitamin B (B₁) is obtained in amounts indicated in Table XIII.

TABLE -XIII-THE VITAMIN B (B₁) CONTENT OF DIFFERENT KINDS OF BREAD MADE FROM EQUAL WEIGHTS OF WHEAT PRODUCTS.

KIND OF BREAD.	Vitamin B (B ₁).
White.....	Two to three times as much in the patent flour used in making the white bread.
Whole wheat, 50-50 per cent germ stock.....	Twice as much as from white bread.
Whole wheat, 100 per cent	Four to five times as much as from white bread.

[Project 158; Department of Home Economics. Leader, Martha M. Kramer; Purnell fund.]

The Utilization of Calcium and Phosphorus from Various Forms of Milk and Milk Products.--During the past biennium a study has been made of cheese as a source of supply of calcium and phosphorus in the diet. Cheese is usually said to be a rich source of calcium and phosphorus, but exact data are scanty in the literature. Samples of cheese made under controlled conditions have been available through the cooperation of the Department of Dairy Husbandry.

Various types of cheese, including Neufchatel, cream, rennet cottage cheese, acid cottage cheese, American cheddar, and processed cheese, which were made in the laboratories of the Department of Dairy Husbandry, were analyzed for calcium, phosphorus and nitrogen. A few commercial cheeses were obtained and studied in the same manner as those manufactured in the laboratory. Results show wide variations in calorie values and protein contents of different types of cheese. The percentage of calcium in the cheddar cheese is approximately 10 times that of the soft cheeses, while the phosphorus is slightly more than twice that of the soft cheeses. Phosphorus varies according to the amount of protein, while the percentage of calcium varies according to the method of manufacture. There is no significant difference between the percentages of calcium and phosphorus in the rennet and in the acid types of cottage cheese. About 20 per cent of the calcium and 37 per cent of the phosphorus of the milk are retained in the soft cheeses while 80 per cent of the calcium and 38 per cent of the phosphorus of the milk are retained in cheddar cheese.

An animal experiment is under way, feeding to three series of rats three diets, one of which contains milk. These diets previously were the subject of investigation with human subjects, favorable results with human subjects having been reported for the three diets. The animal-feeding experiment is a long time one in the life of the rats and should reveal details not possible in a comparatively short experiment with human subjects. The experiments are not completed. It is evident that the animals which received milk were superior in many ways, particularly as regards the calcium stored in the body. These animals also reproduced successfully and grew normally while the others did not.

[Project 159; Department of Home Economics. Leaders, Martha M. Kramer and Ruth McCammon; Purnell fund.]

The Protective Value of Certain Clothing Fabrics.—During the past biennium work has been completed on that phase of the project dealing with the effect of fitting upon the protective value of clothing.

It was shown that the protective ratio of canton flannel increases with the increase in the looseness with which it is fitted about the body, from a tightly fitted cover to one fitted with one-fourth inch space in every direction.

Work has also been completed on the phase of the project dealing with the effect upon heat loss of the nature of the surface in contact with the body. This work has shown (1) that the position of the nap of canton flannel with relation to the body is a factor in its protective ratio in tightly fitted garments and those having one-eighth and one-fourth inch space in every direction between the body and the fabric and (2) that the effect of the position of the nap of canton flannel with relation to the body decreases as the looseness of the covering increases. The results of these studies were published in the *Journal of Agricultural Research*, Vol. 41, No. 2 (July, 1930) and in the *Melliand Textile Monthly*, Vol. II, No. 12 (March, 1931).

A comparative study of the protective value of certain blanket materials is now in progress. Various types of blanket materials, made of finished and unfinished fabrics furnished by various milling companies are being used.

[Project 161; Department of Home Economics. Leader, Katharine Hess; Purnell fund.]

A Comparison of Cooking Equipment for the Farm Home.—Studies were made during the past biennium on the use of top burners of the kerosene stove. Tests were made to obtain information concerning the efficient use of these burners, in terms of fuel consumption, efficiency, and time of bringing water to a boil. Va-

rious factors were found to affect these tests. Some of the results obtained may be briefly stated as follows:

1. The temperatures obtained with any wick setting were lower when the stove was operated in a closed room. When the door was opened, and new air was allowed to circulate in the room, the temperatures were higher. These results would indicate that it is better to use kerosene stoves in an open room, and not in a small inclosed room like a pantry or kitchenette. On the other hand, excessive air currents cause flickering and hinder cooking by cooling the cooking utensils. Also, allowing cold air to enter the room and then to enter the chimney causes a lower flame temperature. This reduction in temperature is due, in part at least, to a portion of the heat of the flame being used to heat the cold air entering the chimney.

2. There was a direct relationship between the temperatures obtained and the kerosene consumed. This means that the heat given off is directly proportional to the fuel consumption.

3. The heat given off from a burner within proper limits is proportional to the wick height. The most heat is given off when the wick is enough out of its container so that it receives an adequate air supply.

4. At a definite wick setting the temperatures gradually decreased as the burning continued, thus the heat being given off at the end of an hour was not as great as that given off at the beginning. This decrease in heat may be explained by the facts that (a) the wick becomes charred and more charred as time progresses, and the char on the wick slows up evaporation of the fuel, (b) if the room is air tight the oxygen supply becomes more or less exhausted and perfect combustion is not obtained. Another possible explanation may be that the usable or unusable wick height is not as great at the end of the hour as at the beginning. A test made using a dirty, charred wick gave temperatures averaging about 200 degrees F. lower than the temperatures obtained with a clean wick set at the same height.

5. It was found that at least 10 minutes were required for the flame temperatures to become uniform. In other words it takes ten minutes for the metal parts of the burner to become heated so that a uniform rate of evaporation takes place. As the metal parts become heated the height of the flame increases. This fact explains why a wick should not be set too high when it is first lighted.

6. The burner efficiencies (with wick set at 0.2 centimeter above the standard) were greater for a kettle 9 inches in diameter than for kettles of 7 and of 5.5 inches in diameter. The efficiencies of the 7- and of the 5.5-inch kettles were about the same. The burner efficiencies using the 9-inch kettle were greatest when using 9 to 15 pounds of water. With 18 pounds of water the efficiency began to decrease.

Studies with gas stove top burners similar to the work with kerosene burners have also been made. They were made to obtain information concerning the relationships of size of burners, rate of flow of gas sizes and shapes of covered and uncovered kettles, as expressed in terms of fuel consumption and efficiency as indicated by the time required to bring water to a boil. The results of the study are as follow:

1. It was more efficient to use gas at the rate of 10 cubic feet per hour than at the rate of 16 cubic feet per hour, but the time required to bring water to a boil was greater when the consumption rate of gas was 10 cubic feet.

2. The giant burner was less efficient than the regular burner.

3. In general the larger the kettle the greater the efficiency in the use of gas for the same amount of water.

4. Black-bottomed kettles were more efficient than those not blackened.

5. The curved shaped kettle was more efficient than the slanting or straight-sided ones.

6. It took more gas to keep water boiling on the regular or giant burners than on the simmering burner.

[Project 174; Department of Home Economics. Leader, Mary Taylor; Purnell fund.]

BRANCH EXPERIMENT STATIONS

Four branch experiment stations, located at Hays, Garden City, Colby, and Tribune, are maintained primarily for the purpose of supplementing the work of the central station with special reference to conditions that prevail in the western part of the state. At all of these stations, with the exception of Tribune, cooperative assistance from the Division of Dry-land Agriculture, Bureau of Plant Industry, United States Department of Agriculture, is obtained for the investigation of tillage and rotation problems. In addition cooperative assistance at the Fort Hays and Colby stations is obtained from the Division of Cereal Crops and Diseases for investigation of problems with cereal crops. At the Fort Hays station cooperative assistance is also obtained from the following agencies of the United States Department of Agriculture: Forest Service in the production and distribution of trees; Division of Forage Crops and Diseases, Bureau of Plant Industry, with forage crop problems; and Bureaus of Agricultural Engineering and Chemistry and Soils with moisture conservation and erosion problems.

As a result of reasonably liberal support from the state, efficient management, and helpful cooperation as indicated above, the experimental work at these stations has been maintained upon a high plane. The results of the work have been rather effectively presented to the public through field days, bulletins, and press reports. A total of 21 field meetings attended by 5,887 persons have been held at the branch stations during the biennium. Something of the character and extent of the work of each of the branch stations is presented below.

FORT HAYS BRANCH EXPERIMENT STATION

The Fort Hays Branch Experiment Station, originally consisting of 3,600 acres, was established on the old Fort Hays military reservation by legislative enactment in 1902. A state park was established by the same enactment, and after a few years the park was temporarily placed under the care of the superintendent of the station. The legislature in 1931 authorized the State Board of Regents to establish boundaries for a new Fort Hays Kansas Frontier Historical Park, taking in the old state park as then established and such new land as was deemed necessary. As a result approximately 160 acres were designated for park purposes and boundaries established, thereby reducing the acreage handled by the station to 3,440 acres. Approximately 2,000 acres are under cultivation, the remainder being pasture, roads, and creek bed. The station is equipped to conduct experimental work with soils, crops, horticulture, forestry, and live stock. Brief statements regarding the more important projects follow.

Dry-land Agriculture.—The dry-land work which is conducted cooperatively with the Division of Dry-land Agriculture, Bureau of Plant Industry, United States Department of Agriculture, has consisted largely of a continuation of investigations established in previous years, the first 100 plots of which were established in 1906. At this time 566 one-tenth-acre plots are utilized

for experiments in (1) seed bed preparation for the staple crops; (2) tillage experiments bringing into use a number of implements, including some of the newer ones such as the killifer chisel and the one-way disk, for comparison with the moldboard plow and lister; and (3) rotation experiments embracing all the principal crops adapted to this area, together with the use of green manure, barnyard manure, and commercial fertilizers.

Results of many years show conclusively that timeliness and thoroughness of operation are of much more importance in the preparation of a seedbed for wheat than is the kind of implement used. The one-way disk, sometimes called the one-way plow, is one of the most valuable of the newer implements introduced for the preparation of the seedbed for wheat. This implement is proving valuable for the destruction of vegetation on trashy ground, and when used properly compares favorably with the plow and lister for the first operation in the preparation of wheat stubble land for wheat.

Some of the more recent work includes a study of the effect on the subsequent wheat crop of leaving the standing row-crop stover on the land over winter to catch snow, as compared to removing the stover before planting. On continuously cropped wheat land studies are being made of the effect of working into the soil, by different methods of tillage, all of the straw from the wheat crop, and the effect of burning off the straw on (1) the physical condition of the top soil, (2) the storage of moisture in the soil, (3) the development of nitrates in the soil, (4) the resulting yield of winter wheat, and (5) the protein content and quality of the grain.

Nitrate studies during the past four years indicate that there is a close relationship between the yield of winter wheat and available nitrogen in the soil at seeding time. Protein determinations made on samples of wheat from a large number of plots show an average for the 1929 and 1930 crops of 12.3 per cent protein in wheat grown after wheat, 16.1 per cent protein in wheat grown on fallow, and 17.3 per cent protein in wheat grown on manured fallow or in wheat grown after green-manure crops.

Cereal Investigations.—The cereal project conducted in cooperation with the Division of Cereal Crops and Diseases, Bureau of Plant Industry, United States Department of Agriculture, is engaged in the production and improvement of cereal crops through introduction, selection, and plant-breeding methods. Special effort is being directed toward developing an early variety of grain sorghum suitable for harvesting with a combine. Studies are being made on threshing, shattering, and keeping qualities of the grain sorghums. The keeping qualities of these crops are exceedingly important in view of the increased use of the combine in harvesting the crop. Sorghum grain cannot safely be stored when the moisture content is more than 12 per cent. After light freezes and drying weather in the fall the grain on the standing sorghum crop readily reaches this state of dryness. When dew or light rains occur the moisture content of standing grain will frequently rise from 3 to 5 per cent above this maximum.

Investigations with winter wheat include (1) varietal testing; (2) date-of-planting tests with four varieties having a wide range of maturity, (3) lodging and shattering studies, (4) nursery row trials of new and valuable introductions, and (5) winter wheat pasturing experiments.

Three selections of barley show considerable promise. The Flynn is a smooth-awn, high-yielding type. The Vaughn is a partial smooth-awn, high-yielding selection especially adapted to combining because of its stiff straw. The Stavropol is a selection from the old common six-row barley which has been grown in western Kansas for many years. This variety is not well adapted for combining. For this reason other good varieties are needed.

Forage Crops Investigations.—The forage project is conducted in cooperation with the Division of Forage Crops and Diseases, Bureau of Plant Industry, United States Department of Agriculture. A comprehensive and detailed study is being made of all feed crops of possible value in this region. The work is concerned chiefly with experiments designed for the solution of many of the important problems associated with the production of alfalfa on bottom land and sweet clover, grasses, and sorghums on upland. Testing and

developing improved strains of these crops, methods of seedbed preparation, dates of planting, and other cultural practices are being conducted. Other lines of investigation with forage crops include the reestablishment of native grass pastures and lawns and the testing of imported grasses and legumes.

Results obtained during the biennium indicate that alfalfa should be seeded in August on land which has been fallowed for a year or more in advance, in order to insure the permanent reestablishment of productive stands on bottom land. The dry layer of soil separating the surface and subsoil moisture is mainly responsible for failures in renewing stands on old alfalfa bottom land. Replenishing this moisture before attempting to reseed insures heavy production of new stands for a long period of years. The assurance of sustained profitable production by using fallow methods fully justifies the initial expense in starting the crop. Average yields of four tons to the acre may be expected on bottom land where the alfalfa roots receive the benefit of subsoil water, as compared with an average of one ton for only a few years where the crop is wholly dependent upon the annual rainfall.

Many promising new strains of sweet clover, which show marked superiority to the commercial varieties have been tested. The more outstanding strains are being increased, but seed is not yet available for general distribution. Studies of various methods of preparing seedbeds for sweet clover show that excellent stands of this drought-resistant crop may be cheaply and easily obtained by following certain definite practices. For best results, scarified seed should be used and sown about May 1 on Sudan grass, corn, or sorghum stubble land.

Buffalo grass is the best dry-land lawn grass for western Kansas. Either of the following methods of reestablishing the grass has proved to be successful at this station: Four-inch cubes of the sod, set out at intervals of three feet and kept closely clipped, will spread to cover the entire area in a period of two to three years. A more practical method consists of disking the land to be sodded and broadcasting small pieces of the sod by hand or with a manure spreader, and packing the land afterwards with a surface packer.

Hundreds of domestic and imported grasses have been tested at this station for years in an effort to discover a tame perennial pasture grass for western Kansas. All but one of these introductions have proved to be failures. The exception—*Agropyron pungens*—is a perennial grass introduced in 1927 from a cold, dry section of Siberia and shows much promise as a palatable, vigorous, heavy producing pasture crop for this region. Although this grass appears very promising, much additional testing will be necessary before the station will be prepared to recommend it.

Soil Erosion and Moisture Conservation Investigations.—This work, established in 1929, is conducted in cooperation with the Bureau of Agricultural Engineering and the Bureau of Chemistry and Soils of the United States Department of Agriculture.

The objects of these investigations are to determine how to prevent soil erosion and to conserve water on the land on which it falls. In carrying out this work it is hoped to develop (1) economical methods of constructing terraces, (2) improved types of terraces so that the land on which they are located may be more readily farmed, and (3) improved terracing equipment in order that the cost of terracing may be reduced.

Since the project was established 15 miles of terraces of varying heights, widths, and vertical spacing have been constructed on slopes ranging from 0.2 to 9 per cent. Twenty-six automatic measuring flumes, weirs, and tipping buckets have been installed to measure the amount of run-off and erosion from areas of one-twentieth of an acre to 1,500 acres. Some of the areas are cultivated and some are in native grass. In addition to the automatic recorders, extensive equipment has been installed to measure the amount of run-off and erosion from numerous small controlled areas.

Soil moisture tests are being made to determine the penetration of rainfall on the various slopes and land surface coverings, and to determine the effect of storing the run-off water in the terraces. The amounts of soil and water lost from land handled in different ways as a result of a single rain of 2.51 inches on June 8, 1932, are shown in Table XIV.

TABLE XIV.--PERCENTAGE IN RUN-OFF AND TONS OF SOIL PER ACRE LOST UNDER DIFFERENT CONDITIONS DUE TO A SINGLE TORRENTIAL RAIN OF 2.51 INCHES.

June 8, 1932.

CROP.	Rainfall, 2.51 inches.	
	Per cent run-off.	Tons of soil lost per acre.
Wheat.....	41.00	0.686
Wheat on badly eroded soil.....	79.81	7.768
Fallow.....	66.02	11.238
Kafir.....	63.97	13.751
Native sod, clipped.....	2.27	.021
Native sod, unclipped.....	.24	.0035

It will be seen that the surface condition and the extent to which the soil has eroded greatly influence the amount of run-off and the amount of erosion. On native sod the loss of water and soil is negligible, whereas on fallow or row-crop land the losses of both water and soil are severe. A closely planted crop such as wheat or hay aids materially in reducing run-off and soil losses.

Pure Seed Distribution.--The sale and distribution of pure seed continues to be one of the major functions of the station. In 1930-'31 the station sold 407,769 pounds of pure, certified seed, distributed among 93 counties and 13 states and embracing 1,274 seed orders. Sorghum comprised 230,975 pounds of this seed, the remainder was Kanred wheat. The 1931-'32 seed sales amounted to 188,397 pounds, of which 50,869 pounds was the new Wheatland milo recently released by this station to the farmers of Kansas as a grain sorghum suitable for harvesting with a combine. These various seed stocks were distributed in 83 counties in Kansas and 28 states. This annual distribution of pure seed to the farmers of western Kansas is bringing about marked improvement in the production of the sorghum crops in this area.

State Forest Nursery.--The work in the forest nursery has been a continuation of the work of previous years in the experimental planting of new untried varieties of shrubs; ornamental, forest, and fruit trees; and the propagation and distribution of hardy types adapted to western Kansas.

The total number of ornamental trees and shrubs distributed in the spring of 1931 amounted to 19,925 units, going to 76 counties; and in the spring of 1932, 14,466 units distributed to 65 counties. The forest tree seedling distribution in 1931 amounted to 61,856 units, sent to 69 counties, and a total of 43,288 forest tree seedlings were distributed to 73 counties in the spring of 1932. The distribution of forest tree seedlings is carried on in cooperation with the Forest Service of the United States Department of Agriculture.

In the experimental vineyard 11 of the original 21 varieties under observation have been discarded, and others are being tested in their place. The most promising varieties so far tested are the Lenoir, Niagara, American, and Edna.

The demonstration orchard, planted on a terraced hillside in the spring of 1930, now contains over 1,040 trees, and includes 23 varieties of plums and cherries. The sweet cherries and a few varieties of plums show a low percentage survival, the hybrid plums and cherries being more vigorous. Five varieties of plums and cherries are bearing fruit this year.

In the testing blocks of trees and shrubs more than 250 varieties are under observation. More than 50 varieties that proved to be failures were discarded this year, and these will be replaced by untried kinds. Plant materials that have shown their hardiness over a period of years are added to the list for distribution or recommendation.

A testing block of iris containing 88 varieties was started in the spring of 1931. During the growing season of 1931 and the spring of 1932, a total of 36 varieties made a vigorous growth with a fair bloom, 16 were classed as medium, and the remainder as poor or failures. Hardy iris can very easily be successfully grown on farms in western Kansas, and can be used where only a minimum of water is available.

Dairy Cattle Pasturing Investigations.—During the 1930 season 14.2 cows, on the average, were pastured on 15 acres of Sudan grass for 119 days. The cows averaged 30.51 pounds of milk per head per day and each cow averaged 1.04 pounds of butter fat per day for the 119 days. In addition to the pasturage provided, the field produced 2.16 tons of hay per acre.

In 1931 15.6 cows, on the average, were pastured for 108 days on 13.6 acres. The daily milk production per cow was 30.33 pounds and the average daily butter fat production per cow was 1.05 pounds. In addition to the pasturage supplied, the field produced 2.25 tons of hay per acre.

The average carrying capacity of Sudan grass pasture on summer fallowed land at Hays during a period of seven seasons of investigation was one cow per acre for 101 days with an average production of 1.5 tons of Sudan hay per acre in addition. The average daily milk production per cow per day was 27.1 pounds for the seven-year period.

Beef Cattle Feeding Investigations.—The beef cattle feeding experiments as in the past have been concerned largely with the utilization of western Kansas feeds for the maintenance of beef cattle. The 1930-'31 and 1931-'32 feeding trials were planned to study (1) the comparative value of kafir fed to stock cattle in the forms of dry fodder, chopped fodder, ground fodder, and silage; (2) the comparative value of corn silage, kafir silage, and Atlas silage as roughage for stock cattle; (3) corn silage versus ground corn fodder as roughages for stock cattle; and (4) the comparative value of wheat, milo, barley, kafir, and cottonseed cake as supplements for kafir hay and Atlas sorgo silage when fed to stock cattle.

Group 1 is a repetition of similar experiments conducted in 1928-'29 and 1929-'30 and findings check closely with results of those years. In this experiment kafir fodder chopped with a silage cutter produced 3.72 per cent more gain per acre than whole kafir fodder, whereas ground kafir produced 4.75 per cent more gain per acre. Kafir fodder silage produced 75.22 per cent more gain per acre than whole kafir fodder and 67.32 per cent more than ground kafir fodder.

One acre of corn, fed in the form of silage, was equal to 1.63 acres fed in the form of dry fodder. Kafir silage was equal to corn silage on a ton basis and produced 11.32 tons of silage per acre while the corn produced but 5.72 tons of silage. Two pounds of ground wheat was worth 1.2 pounds of cottonseed cake when fed as a supplement to kafir hay to stock calves.

Results of the 1930-'31 feeding season proved that 2 pounds of grain fed as a supplement to Atlas sorgo silage was worth slightly more than 1 pound of cottonseed cake when fed to calves. A comparison of the different grains fed shows that ground milo was worth 85 per cent, ground kafir, 87 per cent, and ground barley, 94 per cent as much as ground wheat.

GARDEN CITY BRANCH EXPERIMENT STATION

The Garden City Branch Experiment Station occupies 320 acres of upland five miles northeast of Garden City, Finney county. The experimental work is divided into two main projects: Dry-land agriculture and irrigation agriculture.

Dry-land Agriculture.—The Division of Dry-land Agriculture, Bureau of Plant Industry, United States Department of Agriculture, has cooperated with the station since 1907 in conducting cooperative experiments under dry-land conditions. The dry-land project consists of approximately 35 acres of land divided into one-tenth-acre plots or fractions thereof. The work consists of

studies of rotations of adapted crop varieties, tillage, methods of seedbed preparation, methods and frequently of fallow preparation for sorghums and wheat, and moisture conservation in relation to tillage work.

Rotation studies are conducted on the effect of one crop following another and crop response to methods of seedbed preparation and tillage practice. Various methods of tillage are practiced in the rotation and under continuous cropping conditions, including the time and depth of plowing, one-waying, and listing to study the effect on conservation of soil moisture and crop yields.

Experimental methods for crop production have definitely proved the following :

1. Timely and proper cultivation to keep down weed growth is the most important method of conserving moisture.

2. Fall or early spring breaking of the soil for row crops is preferable to late spring breaking.

3. A medium depth of planting is best for listed row crops. Deep listed row crops are slow in starting and likely to be covered by soil washed from the ridges.

4. Sorghums average higher annual yields when planted with furrow openers on a surface planter than when listed.

5. Grain sorghums should be planted as near June 1 to 10 as soil and weather conditions will permit. Forage sorghums can be planted up to June 15 to 20 and secure maximum yields.

6. Fallow has increased the average yield of kafir 77 to 92 per cent, milo 75 per cent, sorgo forage 77 per cent, and wheat 87 per cent, over the best method of continuous cropping.

7. Fallow stabilizes farm incomes by producing a crop in dry years when crops fail on continuously cropped land.

New wheat seedbed tillage experiments started in the fall of 1931 are now under way, using different tillage implements at varying times and depths for the preparation of seedbeds for winter wheat. Frequency of fallow and organic matter are being studied for the purpose of determining the effect of continuous cropping on soil organic matter and the depletion of soil fertility. Fall listed fallow has proved to be the highest producing method of preparing a fallow for winter wheat. It is, also, the method requiring the minimum amount of cultivation in order to maintain a clean seedbed. Production of wheat on fallow as compared to continuous methods (13-year average) is as follows:

	Bus.
Early fall plowed.....	8.6
Early fall listed.....	9.5
Spring plowed fallow.....	12.1
Fall listed fallow.....	17.8

In addition to the work mentioned above considerable attention is given to the testing of different varieties of corn, grain sorghums, forage sorgos, small grains, and sweet clover. Early-maturing varieties of corn have produced higher average yields than the late-maturing varieties. Dwarf Yellow milo has averaged the highest of all sorghums in grain yield but is losing in favor with the farmers because of its tendency to crook neck and to lodge soon after maturity. Wheatland and Beaver combine-type milos are well liked by the wheat farmers who are practicing some diversification of crops, because these milos are adapted to harvesting with the combine. Standard Sumac, Honey, and Kansas Orange sorgos continue to show their supremacy in the production of forage.

Kanred and Blackhull winter wheats have produced best among the older varieties, and Tenmarq is a promising new variety. Kanota oats, Club Mariout, Flynn, Coast, and Vaughn barleys are among the most promising of the spring small grains. No variety of spring wheat has been satisfactory.

A variety test of sweet clover was started in 1931. Twenty varieties and strains were planted in 44-inch rows on unirrigated land, and the same twenty, plus two additional varieties, were planted on irrigated land. Good stands were secured and an excellent growth was produced by most varieties. The

amount and character of growth was studied and several varieties appear to be much more leafy and to have finer stems than the common white flowered variety that has been so much used in the past.

Irrigation Agriculture.—Water for irrigation is being pumped from the underflow of the Arkansas river valley. A deep well irrigation plant in which the depth to water is 70 feet, the draw down, when pumping, 42 to 57 feet and the total lift 112 to 127 feet, has been in operation since 1911. The expense of pumping water from that depth is great but it has enabled the station to conduct some very valuable experiments in the use of irrigation water.

A new irrigation plant in the low-lying salt-grass area of the experiment station was completed late in 1930. Six wells, spaced 75 feet apart, are connected by means of a horizontal suction line to a high efficiency centrifugal pump and are capable of supplying a total of 1,000 gallons of water per minute. This plant has been thoroughly tried out and found to be much more economical of operation than the deep well plant. The elimination of expensive machinery necessary in the deep well pumping plant and the lower water lift are largely responsible for the saving that is being made in operating costs. A 10-inch pipe line is being extended from the lowland irrigation system to the high line ditches and will make it possible to irrigate all the lands under experiment from the new plant. The new system will provide a cheaper and more dependable water supply for experimental purposes than the deep well system that has been in use since 1911.

Rate and season of watering experiments with alfalfa; rotations with alfalfa, sorghums, sugar beets, and other crops; irrigated pasture experiments; and winter irrigation tests have been conducted. Experiments indicate that alfalfa requires approximately 40 inches of water annually in addition to rainfall, sugar beets, 20 to 24 inches, grain sorghums, 18 to 20 inches, and forage sorgos, 18 to 24 inches for best results. When the above amounts of water have been used alfalfa has averaged 6.9 tons per acre, sugar beets in rotation with alfalfa, 20.3 tons, sugar beets grown continuously on the same land to which barnyard manure is applied every second year, 18.2 tons, sugar beets grown continuously on the same land without fertilizer, 15.2 tons, forage sorgo grown in rotation with alfalfa, 22.2 tons, forage sorgo grown continuously on the same land and without fertilizer, 16.8 tons, and Dwarf Yellow milo in rotation with alfalfa, 87.0 bushels. Maximum yields secured thus far are: Alfalfa, 9.7 tons, sugar beets, 23.2 tons, forage sorgo, 29.9 tons, and Dwarf Yellow milo, 132.8 bushels.

The disease of milo that was mentioned in the previous report continues to be a serious problem. It has been determined during the past year that this disease is quite widespread and is rapidly becoming a serious problem on the agricultural experiment stations in western Kansas, and is present in south central and northwestern Texas, northwestern Oklahoma, northwestern New Mexico, and southeastern California.

The project for the study of this disease has been enlarged somewhat each year and now includes a test of 160 varieties and new strains of sorghums for resistance to the disease, a soil sterilization test in which formaldehyde and acetic acid will be used as the sterilizing agents, the inoculation of seed with pure cultures of different fungi and bacteria that have been isolated from diseased plants, and the planting of milo on land that has had one year of fallow, followed by one year of wheat and an additional period of fallow from the time of removal of the wheat crop to sorghum planting time. Previous experiments have shown that kafirs, feteritas, and forage sorghums are resistant to the disease, while milos and sorghums crossed with milo are generally highly susceptible. It also has been shown that one year of summer fallow is not sufficient to control the disease.

The development of resistant varieties appears to be the most promising method of control at this time. Some progress has already been made in the production of a resistant milo, and in 1931 two pure-line selections of Wheatland showed indication of having resistance to the disease. Some varieties of kafir-milo crosses are being segregated for resistance and susceptibility to the

condition, and good progress is apparently being made in developing strains that will be fully resistant, if not immune, to the disease.

Bacterial wilt of alfalfa has been a serious disease in east central Kansas for several years, but it has been a problem in the Arkansas valley of western Kansas for only the past four or five years. Nine varieties and strains of alfalfa that have shown considerable resistance to the disease in eastern Kansas, Nebraska, and other alfalfa-growing regions where the disease is prevalent, are being grown here largely to determine their relative value for the production of hay under western Kansas conditions and to produce seed of the better ones as rapidly as possible. A French variety, lately named Kaw, Ladak, and some of the Turkestans are considered most promising at this time.

Ten strains of Red clover, from as many states, were seeded in 1930 and the results obtained show that none was superior and few equal to Colorado Red clover. Several strains winterkilled badly, some showed slight damage, while Michigan and Colorado strains, came through the winter of 1930-'31 without loss. Wisconsin and Idaho strains showed the greatest loss of the 10 under test.

Loss of alfalfa pasture due to bacterial wilt has made it necessary to discontinue, temporarily, the pasture experiments with hogs. The results from 1924 to 1931, inclusive show that hogs make very efficient use of alfalfa pasture and that pasturing is a profitable practice. Hogs on alfalfa pasture in 1931 made rapid gains at a cost of \$3 per hundredweight. Alfalfa pasture was charged for at the rate of \$32.50 per acre, that charge being based upon an estimated yield of 6.5 tons cured hay per acre at \$5 per ton.

Pasturing experiments with dairy cattle during the past several years show that satisfactory pastures can be maintained with sweet clover or with a mixture of perennial grasses on irrigated land. Both sweet clover and fertilized pastures of perennial grasses have furnished good grazing for two cows per acre for a six-month period.

COLBY BRANCH EXPERIMENT STATION

The Colby Branch Experiment Station contains 274 acres of land lying immediately southwest of Colby, Thomas county. The work of the station is divided into three major projects: Dry-land agriculture investigations, crop adaptation, and dairy herd improvement. Some of the minor projects consist of variety tests of tree fruits, shrub and ornamental tests, and tests with different varieties of evergreen and deciduous trees.

Dry-land Agriculture Investigations.—Field experiments in crop rotation and cultural methods in cooperation with the Division of Dry-land Agriculture, Bureau of Plant Industry, United States Department of Agriculture, were continued with some changes and additions. The results of the experiments for the 15 years from 1915 to 1929 were summarized in September, 1931, and published as United States Department of Agriculture Circular 184. These results showed that spring wheat was the only crop grown that did not produce creditable yields when grown on fallow. The yields of winter wheat on fallow averaged about twice as much as on plots cropped continuously. Delaying the plowing for fallow until late June, without previous cultivation, resulted in a decrease of six bushels in yield. Under comparable conditions listing was practically equal to plowing as a method of handling fallow. Corn made higher average yields of grain than milo, kafir, and feterita, the grain sorghums under trial.

Up to the year 1931 the work was conducted on an area of approximately 25 acres divided into 180 tenth-acre plots. In 1931 changes were made in 10 of the original rotations and 90 new plots were added. The project now covers about 35 acres. The new plots are devoted to cultural practices with winter wheat, dealing chiefly with problems arising from the combine method of harvesting.

Crop Adaptation.—The work in crop adaptation consists of both nursery and variety testing. Each year of the biennium some 1,800 rows of winter wheat were grown in the nursery. Many of these strains were grown in order to test their winter hardiness. Since this station is subject to the most severe winters of any of the stations in the state it affords the best means of making such a study. This work supplements that done at Manhattan and Hays.

About 1,000 rows of barley were grown each year in the nursery. The strains grown were, for the most part, selections from known varieties. In the corn nursery approximately 300 rows of hybrids between varieties of western Kansas corn were grown. Some of these strains show considerable promise.

Other cereal nursery work was carried on in cooperation with the Division of Cereal Crops and Diseases, Bureau of Plant Industry, United States Department of Agriculture. These included the uniform winter hardiness studies, leaf rust and stem rust nurseries with winter wheat, and the rust nurseries of oats and spring wheat. A sweet clover nursery consisting of 17 varieties was planted in the spring of 1931.

During the biennium 14 varieties of winter wheat, 11 of spring wheat, 5 of oats, 21 of barley, 15 of corn, 20 of grain sorghum, 5 of forage sorghum, and 5 of popcorn were tested. A drill test, in which a comparison of the yields with winter wheat and barley was made, was conducted during both years. The drills used were the 8-inch common, the 11-inch furrow, and the 14-inch furrow. Lower yields were secured both years and with both crops where the 14-inch furrow drill was used.

Dairy Improvement.—The dairy herd improvement project as outlined in the last report was continued through the biennium. The herd now consists of 16 grade cattle and 16 purebreds. The herd has produced well and has made good use of the feed produced on the station. The average production of the milking herd in 1931 was 338.11 pounds of butter fat per cow.

Grade cow No. 29 produced 13,513 pounds of milk containing 540.17 pounds of butter fat in 1930, and 13,336 pounds of milk containing 495.81 pounds of butter fat in 1931. These records were made under general herd conditions and on two milkings daily. Cow No. 29 is a third-generation cow from the original stock purchased in 1915. Other grade cows in the herd have produced more than 400 pounds of butter fat in a single lactation period.

TRIBUNE BRANCH EXPERIMENT STATION

The Tribune Branch Experiment Station, consisting of 110 acres, is located 16 miles from the Colorado line and approximately midway between the north and south boundaries of the state. It represents the high-plains area which extends from the Smoky Hill to Arkansas rivers. The normal annual precipitation is about 17 inches, but the precipitation was below normal in 1930 and also in 1931. The 1930 wheat crop, however, was one of the largest grown in years and other crops were about average for both 1930 and 1931. Some of the results secured for the last two years, substantiated by longer summaries, are as follows:

1. Grain sorghums do not produce so high an average grain yield as corn. Sorghums, however, produce a larger grain yield than corn on years when precipitation is below normal. The best variety of corn for this area, Cassel White, averaged 12.5 bushels per acre in 1930 and 1931 and Dwarf Yellow milo planted on June 5 averaged 24.2 bushels.

2. Leoti Red sorgo gave a higher yield of forage than any of the other sorghums in 1930 and 1931 and for a six-year period. Plans are under way to develop a dependable supply of pure seed of this variety.

3. A new variety of sorghum, Pink Freed, developed at the station from a cross of Freed sorgo and Pink kafir, has continued to be the best-yielding grain sorghum.

4. In 1930 and 1931, and over a seven-year period, milo produced a larger grain yield when planted in rows alternating 42 and 84 inches apart, or by the plant two, skip one row method, than when planted in rows 42 inches apart. Milo planted June 5 has given a better grain yield than when planted May 20. June 5 has proved to be a good date to plant forage sorghums.

5. Sudan grass has proved to be a profitable hay crop to grow on summer-fallowed ground. In 1930 Sudan grass on fallow produced 3,144.4 pounds of hay per acre, and in 1931, 2,670 pounds, compared to 733.3 pounds and 1,180 pounds, respectively, on Sudan-grass ground. Over a nine-year period Sudan grass produced an average of 3,437 pounds of hay per acre on fallow ground and 1,718 pounds on Sudan-grass ground. During the nine-year period the fallow ground failed to produce a ton to the acre only one year, while the continuous Sudan-grass ground failed to produce a ton to the acre six of the nine years.

6. Kanred has yielded higher than any other variety of wheat over a 10-year period. However, Turkey averaged only 1.4 bushels less than Kanred. In 1931 some of the newer varieties, Tenmarq, Early Blackhull, Oro, and a Nebraska selection, outyielded Kanred.

7. Over a six-year period wheat seeded on September 1 has given a higher yield than that seeded later.

8. When winter wheat fails there is often a temptation to plant spring wheat as a catch crop. Marquis spring wheat, planted after corn, has averaged 5.1 bushels per acre over a seven-year period, compared to 15 bushels for Kanota oats, 11.3 bushels for Stavropol barley, 11.7 bushels for Dwarf Yellow milo, and 18.8 bushels for Cassel White corn.

9. Corn is one of the important crops of this area. Cassel White, Colby, and Hays Golden were the three best-yielding varieties in 1930 and 1931 and also over a period of six years. Cassel White has averaged nearly 4 bushels more than any other variety over a 15-year period.

10. Corn was planted in rows spaced 52 inches, 84 inches, and 42 and 84 inches alternating (the plant two rows, skip one method). The plant two rows and skip one spacing has given the highest yield over an eight-year period.

11. Experimental work with potatoes during the last two years has indicated (1) that the Irish Cobbler is the best variety and (2) that the difference in yield between potatoes produced from northern-grown seed and home-grown seed is so much in favor of northern-grown seed that it does not pay to use home-grown seed.

STATION PUBLICATIONS

The results of investigations by the Agricultural Experiment Station are reported in four series of publications: Biennial reports, bulletins, research or technical bulletins, and circulars.

Biennial Reports.—At the close of each biennium a report is made giving a brief survey of all the work of the station. It consists primarily of progress reports on the various projects active during the biennium.

Technical Bulletins.—Reports of detailed scientific investigations, too technical for the average reader but of value to the investigational and technically trained reader, are published as technical bulletins. Eight such bulletins were issued during the biennium.

General Bulletins.—The reports of specific investigations for popular distribution are published as bulletins. The material is presented in such a manner as to be readily understood by the average reader. Six new bulletins were printed during the biennium.

Circulars.—Brief popular reports of experimental results and popular discussions on various agricultural problems are published as circulars. Eight circulars were published during the biennium.

The following are the regular station publications listed by series and showing the title, size of edition, and the number of pages issued during the biennium:

BIENNIAL REPORT				
No.	Title.	Edition.	Pages.	Total pages.
	Biennial Report of the Director.....	1,750	164	287,000
TECHNICAL BULLETINS				
25	Principal Poisonous Plants in Kansas.....	7,500	67	502,500
26	A Study of Factors Influencing Inoculation Experiments with Azotobacter	5,000	66	330,000
27	Resistance of Varieties of Winter Wheat to Hessian Fly, <i>Phytophaga destructor</i> (Say)	7,500	58	435,000
28	Some Factors Influencing the Mid-season Potato Market,	2,500	104	260,000
29	Dissemination of Pullorum Disease in the Incubator....	5,000	60	300,000
30	Twenty Years of Testing Varieties and Strains of Winter Wheat at the Kansas Agricultural Experiment Station	7,500	73	547,500
31	A Study of Mortality Among Young Pigs.....	3,500	22	77,000
32	Identification of Certain Native and Naturalized Grasses by Their Vegetative Characters	4,000	73	292,000
GENERAL BULLETINS				
251	Types of Farming in Kansas.....	15,000	111	1,665,000
252	Crossbred Poultry	15,000	54	810,000
253	Tame Pastures in Kansas.....	20,000	39	780,000
254	Growing an Orchard in Kansas.....	15,000	43	645,000
255	Dairy Farm Organization in Southeastern Kansas.....	7,500	76	570,000
256	Farm Production and Consumption of Poultry in Kansas,	7,500	33	247,500
CIRCULARS				
157	Information Regarding Recent Publications.....	15,000	4	60,000
158	Judging Price Risks in Marketing Cattle.....	15,000	41	615,000
159	Trend of Real Estate Taxation in Kansas, 1910 to 1929	6,000	15	90,000
160	Preparation, Testing, and Use of Chlorine Disinfectants,	6,000	8	48,000
161	Raising Dairy Calves	20,000	13	260,000
162	Strawberry Growing in Kansas.....	10,000	14	140,000
163	Korean Lespedeza	15,000	6	90,000
164	Infectious Abortion of Cattle	15,000	11	165,000

SOME INFORMATION REGARDING EACH PUBLICATION ISSUED

BIENNIAL REPORT

FIFTH BIENNIAL REPORT OF THE DIRECTOR: For the Biennium July 1, 1928, to June 30, 1930.—This report outlines the scope of the work of the Agricultural Experiment Station for the biennium, including brief summaries of the results on some projects and brief statements of progress regarding each of the others. Brief statements are made covering the cooperation of the Kansas station with other agencies and the changes in personnel for the period. The annual financial statements and a list of the publications of the station and of contributions to other scientific publications by members of the station staff are also included. The main body of the report is grouped under nine headings as follows: Studies in the Economics of Agriculture; Conservation of the Soil; Investigations in the Plant Industries; Investigations in the Live-stock Industries; Diseases of Plants; Injurious Insects and Other Pests; Diseases of Farm Animals; Studies in Home Economics; and Branch Experiment Stations. (By L. E. Call, Director, Agricultural Experiment Station of Kansas State College of Agriculture and Applied Science. 164 pages; 27 tables; 2 figures.)

TECHNICAL BULLETINS

TECHNICAL BULLETIN 25: Principal Poisonous Plants in Kansas.—This bulletin outlines the different types of poisons that may affect animals from the botanical, chemical, and physiological standpoints. Some general recommendations that should be followed after animals have consumed poisonous plants are included, along with the treatments that should be used to combat poisoning from loco, sorghums, and cockleburrs. The greater part of the bulletin consists of the names, descriptions and illustrations of the various poisonous plants that are known to occur in Kansas. The plants are grouped into their respective families. With each plant

description there are also included paragraphs on the effect on animals, remedial measures, and general remarks. (By Frank C. Gates, Department of Botany. 67 pages; 64 figures.)

TECHNICAL BULLETIN 26: A Study of Factors Influencing Inoculation Experiments with Azotobacter.—This bulletin reports ten years of experimentation aimed to establish the role of soil reaction in limiting the distribution of Azotobacter in soils. Three principal lines of investigation were followed; namely, (1) the addition of basic materials to acid, non-Azotobacter-containing soils, (2) the addition of acid materials to basic Azotobacter-containing soils, and (3) the mixing in varying proportions of acid non-Azotobacter-containing and basic Azotobacter-containing soils. A study of the ability of such treated soils to support the growth of Azotobacter subsequent to treatment indicated very definitely that, irrespective of the treatment, if the resulting H⁺ of the soil was less than pH 6.0, the soil was capable of supporting the growth of Azotobacter whereas if the H⁺ was greater than pH 6.0, Azotobacter were incapable of surviving therein. (By P. L. Gainey, Department of Bacteriology. 66 pages; 57 tables.)

TECHNICAL BULLETIN 27: Resistance of Varieties of Winter Wheat to Hessian Fly, *Phytophaga Destructor*, Say.—This bulletin gives the results of nine years of experiments in field and greenhouse on the reaction of varieties, selections, and crosses of winter wheat to Hessian fly. Methods of providing heavy and uniform infestations of fly are described, also methods of observing, measuring, and recording varietal differences.

About 400 strains of wheat were tested for resistance to Hessian fly from the hard-wheat belt. For convenience the strains tested were placed in three classes, (1) highly resistant, (2) medium infestation, and (3) very susceptible. Such varieties as Beechwood, Dawson, Fulhard, Horner, Illini Chief, Kawvale, Michigan Wonder, Purkof, Red Rock, and Shepherd are in group 1 and have an average fly infestation of only 0 to 3 per cent. The medium infestation or tolerant group, with infestation of 7 to 19 per cent, includes Blackhull, Superhard Blackhull, Early Blackhull, Buffin No. 17, Gluten, Harvest Queen, Nigger Poole, Red Winter, Silver Sheaf, and Treadwell. The very susceptible group, with fly infestation of 33 to 62 per cent, includes Burbank, Hussar, Iobred, Kanred, Kharkov, Minturki, Nebraska No. 60, Oro, Sherman, Tenmarq, Turkey, and Prelude X Kanred.

Evidence is presented which shows that factors for resistance are inherited and that fly resistance may be combined with other desirable characters.

Detailed information is given concerning two distinct biological strains or populations of Hessian fly, one in the hard-wheat belt of central and western Kansas, and one in the soft-wheat belt of eastern Kansas. (By Reginald H. Painter, Department of Entomology, and S. C. Salmon and John H. Parker, Department of Agronomy. 58 pages; 25 tables.)

TECHNICAL BULLETIN 28: Some Factors Influencing the Mid-season Potato Market.—This bulletin deals with the effects of various aspects of supply, such as total supply, position of supply, movement of supply, and quality of supply, on price in the case of Kaw valley potatoes. Effects of quality and grade on demand are also noted. The discussion part of the publication concludes with a consideration of means of improving the mid-season marketing situation for potatoes. In the statistical appendix the bulletin contains considerable detail as to correlation methods used in studying supply, demand, and price relationships. (By E. A. Stokdyk, Department of Agricultural Economics. 104 pages; 51 tables; 24 figures.)

TECHNICAL BULLETIN 29: Dissemination of Pullorum Disease in the Incubator.—This bulletin presents experimental data on pullorum disease dissemination in the incubator. The discussion deals chiefly with the best methods of incubator fumigation to control the spread of the disease.

For fumigation it is recommended that 0.4 c. c. of formalin and 0.2 gram of potassium permanganate be used per cubic foot of incubator space. It is not necessary to close the ports of the incubator during fumigation, since this amount is effective in killing or rendering harmless all *S. pullorum* organisms

within a period of exposure of 5 minutes. This fumigation does not appear to affect living chicks within a period of 10 minutes, but larger amounts for longer periods may cause severe injury. The value of humidity is emphasized in formaldehyde fumigation. Wet-bulb thermometer readings of 88° to 90° F. and dry-bulb thermometer readings of 98° to 100° F. give the most satisfactory results. (By L. D. Bushnell, Department of Bacteriology, and L.F.Payne, Department of Poultry Husbandry. 60 pages; 10 figures; 29 tables.)

TECHNICAL BULLETIN 30: Twenty Years of Testing Varieties and Strains of Winter Wheat at the Kansas Agricultural Experiment Station.—This bulletin reports the comparative yields of varieties and strains of winter wheat tested at Manhattan as well as at numerous other places in Kansas for a period of 20 years. Emphasis is placed upon the reasons for differences in yield, and evidence is given to show that factors such as early maturity to escape drought and high temperature, resistance to winter killing, and resistance to disease are directly correlated with yield. The adaptation of varieties in the state is shown to be dependent upon such factors.

It is pointed out that there is an urgent need for more information as to the factors that affect yield and the way in which they influence the crop. It is suggested, therefore, that the most successful wheat improvement program will be directed mainly toward getting such basic information rather than merely recording comparative results of varieties. Data are presented showing the importance of seasonal variation in variety testing and the hazards of short-term experiments. The authors state that high-yield record over a period of 10 or 12 years may not always be a safe basis on which to recommend a variety. (By S. C. Salmon and H. H. Laude, Department of Agronomy. 73 pages; 14 figures; 27 tables.)

TECHNICAL BULLETIN 31: A Study of Mortality Among Young Pigs.—The investigation reported in this bulletin was conducted to determine if the death rate of young pigs could be lowered by increasing the amount of vitamin B in the ration of pregnant and lactating sows. Wheat-germ meal was used to increase the amount of this vitamin in the ration. The data cover four years of experimentation and include data on number and strength of pigs farrowed and weaned, the milking ability of the sows, and some observations on the control of pig anemia. (By C. E. Aubel, Department of Animal Husbandry; J. S. Hughes, Department of Chemistry; and H. F. Leinhardt, Department of Veterinary Medicine. 22 pages; 3 figures; 9 tables.)

TECHNICAL BULLETIN 32: The Identification of Certain Native and Naturalized Grasses by Their Vegetative Characters.—This bulletin contains information for identifying 26 of the more important Kansas native grasses in their vegetative stages of growth. The main vegetative characters have been determined for each species and these have been combined into an identification key.

The bulletin contains two full-page drawings of the distinguishing vegetative characters for grasses and one full-page drawing of each species showing the principal vegetative characters. The illustrations are accompanied by economic information on and an outline of the more important vegetative characters for each species. (By R. F. Copple and A. E. Aldous, Department of Agronomy. 73 pages; 28 plates.)

BULLETINS

BULLETIN 251: Types of Farming in Kansas.—The state is divided into 12 well-defined type-of-farming areas based upon crop and live-stock production during recent years, together with the trends of such production over a period of years. Trends in land utilization, size of farm, and selected equipment are also shown. The underlying causes of the present type of farming and recent trends in crop and live-stock production are explained in terms of such physical factors as soil and climate, together with such economic factors as transportation and improved farm equipment. Typical farming systems, by

size groups, are given for each area. Data were obtained from the reports of the Kansas State Board of Agriculture, assessors' rolls, the reports of the Census Bureau, and other appropriate sources. (By J. A. Hodges, F. F. Elliott, and W. E. Grimes, Department of Agricultural Economics. 111 pages; 42 figures; 20 tables.)

BULLETIN 252: Crossbred Poultry.—The two major subjects treated in this publication are the characteristics of vigor in crossbred poultry and methods of utilizing sex-linked inheritance for distinguishing sex at hatching. Vigor is measured by hatchability, chick mortality, rate of growth, and egg production. In addition to the previously known color factors for distinguishing sex at hatching, there is described a new method utilizing the growth of flight feathers for identifying sex in day-old chicks. (By D. C. Warren, Department of Poultry Husbandry. 54 pages; 21 figures; 12 tables.)

BULLETIN 253: Tame Pastures in Kansas.—The range, value, and use of the different tame pasture plants in Kansas are presented in this bulletin. It also contains information on the rate of seeding, the preparation of the seedbed, and the planting of all grasses and legumes and mixtures of grasses and legumes that are suitable for seeding Kansas pastures. Weed and brush control are discussed briefly. (By A. E. Aldous and J. W. Zahnley, Department of Agronomy. 93 pages; 10 figures; 4 tables.)

BULLETIN 254: Growing an Orchard in Kansas.—This bulletin treats of the choice of varieties and the culture and protection of young fruit trees, placing special emphasis on soil management. Experimental work with commercial fertilizers and cover crops is reported. Pruning and spraying are not discussed, as other publications of the Agricultural Experiment Station treat of these subjects. Orchard sanitation and diseases not controlled by spraying are briefly discussed. Though the material presented applies primarily to the apple, special points are given on other deciduous tree fruits adapted to Kansas to a limited extent. (By R. J. Barnett, Department of Horticulture. 43 pages; 13 figures; 5 tables.)

BULLETIN 255: Dairy Farm Organization in Southeastern Kansas.—In this bulletin the development of dairy farm organization in a typical area of southeastern Kansas is traced and the results obtained from selected farms are shown. Feed and labor used in live-stock production, together with labor and materials used in crop production, are given. On the basis of these requirements and in view of the economic conditions, suggested systems of farming for various sizes of farms are presented. Data were obtained by an intensive two-year study of a small group of farms together with supplementary data, from the reports of the Kansas State Board of Agriculture, the Census Bureau, and the assessors' rolls. (By J. A. Hodges, R. S. Kifer, and R. D. Nichols, Department of Agricultural Economics. 76 pages; 15 figures; 31 tables.)

BULLETIN 256: Farm Production and Consumption of Poultry in Kansas.—This bulletin reports the results of a study of farm flocks in nine Kansas counties. It shows the breeds of chickens kept and their relative importance; also the size of flocks. The composition of the farm flock, egg production per flock and per hen, and the disposal of eggs produced are discussed. The time of hatching, the number of chicks hatched and where hatched are given. Average sales per month of poultry and eggs are shown, together with the values. The per capita farm consumption of eggs and poultry is shown by the month and for the year. Death losses of both mature birds and baby chicks are discussed. (By Morris Evans and H. L. Collins, Department of Agricultural Economics. 33 pages; 12 figures; 15 tables.)

CIRCULARS

CIRCULAR 158: Judging Price Risks in Marketing Cattle.—The risks in marketing cattle due to the change in price during the next 30 to 60 days are discussed for each month of the year. Prices for two grades of steers are used; namely, choice fat light steers and choice light stockers. Prices are for the

Kansas City markets since 1908. The calendar arrangement by months makes the circular a handy reference at any time of the year for cattlemen who have cattle about ready to market. (By Homer J. Henney, Department of Agricultural Economics. 41 pages; 15 figures; 5 tables.)

CIRCULAR 159: The Trend of Real Estate Taxation in Kansas from 1910 to 1929.—In this circular some of the data in Kansas station Bulletin 235, "The Trend of Real Estate Taxation in Kansas from 1919 to 1923," have been brought up to January 1, 1930. In addition, a few important facts concerning the 20-year period now covered by the study are summarized. The purpose of the author is to make the discussion in the circular sufficiently complete to satisfy the demands of the busy reader who is likely to be interested primarily in summary statements. For details of the study one should refer to Bulletin 235. (By Harold Howe, Department of Agricultural Economics. 15 pages; 10 figures; 8 tables.)

CIRCULAR 160: The Preparation, Testing, and Use of Chlorine Disinfectants.—Three methods of preparing home-made chlorine disinfectants are given in detail in this circular. A simplified test for determining the strength of stock and rinse solutions of chlorine and a simple formula for calculating the proper dilution of stock solutions are presented. The precautions which should be observed in the intelligent use of chlorine disinfectants are briefly discussed. (By A. C. Fay, Department of Bacteriology. 8 pages, 1 figure.)

CIRCULAR 161: Raising Dairy Calves.—This circular discusses the approved methods of feeding and management of dairy calves until time of weaning. It deals especially with the raising of calves on skimmilk. Some suggestions are made for the care of the cow before the calf is born. A schedule of the amount of milk to feed a calf of a given age is included and suitable grain supplements are listed. Common diseases of calves are discussed and simple methods of treatment given. (By H. W. Cave, Department of Dairy Husbandry. 13 pages; 6 figures; 2 tables.)

CIRCULAR 162: Strawberry Growing in Kansas.—Circular 162 is a revision of Circular 116 and treats of the production of strawberries under Kansas conditions. The cultural practices recommended are adapted to either the commercial or the home patch of this fruit. Brief discussions of harvesting and marketing strawberries, however, are of commercial interest only. (By R. J. Barnett, Department of Horticulture. 14 pages; 5 figures.)

CIRCULAR 163: Korean Lespedeza.—This circular describes Korean Lespedeza and discusses its adaptation to Kansas conditions. Methods of producing and handling the crop are briefly treated, while the place of this legume on farms in the eastern third of Kansas and its utilization for pasture and hay are discussed specifically. (By A. E. Aldous, Department of Agronomy. 6 pages.)

CIRCULAR 164: Infectious Abortion of Cattle.—The nature, cause, symptoms, and treatment of infectious abortion of cattle are presented in this circular in the form of a series of questions and answers. The questions used are those asked daily by persons interested in the practical breeding and handling of cattle. Circular 164 is Circular 135 not only revised but enlarged, practical methods of control having been added to the older edition. (By C. H. Kitselman, Department of Veterinary Medicine. 11 pages.)

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 DEPARTMENT

Serial No.	Year of issue.	Department of Agricultural Economics
		<i>Title, author, and publication.</i>
58	1929	The Effect of the Combined Harvester-Thresher in a Wheat Growing Region. W. E. Grimes. <i>Sci. Agr.</i> , 9:773-782.
59	1931	Some Factors Influencing the Mid-Season Potato Market. E. A. Stokdyk. <i>Kan. Agr. Expt. Sta. Tech. Bul.</i> 28 1-104.
61	1930	Types of Farming in Kansas. J. A. Hodges, F. E. Elliott, and W. E. Grimes. <i>Kan. Agr. Expt. Sta. Bul.</i> 251:1-111.
62	1930	Factors Affecting the Timing of Wheat Price Movements. R. M. Green. <i>Proc. Internat. Conf. Agr. Econ.</i> , 2:724-732.
63	1930	Machine Production and the Price of Wheat. W. E. Grimes. <i>Proc. Internat. Conf. Agr. Econ.</i> , 2:700-705.
64	1931	Dairy Farm Organization in Southeastern Kansas. R. S. Kifer, J. A. Hodges, and R. D. Nichols. <i>Kan. Agr. Expt. Sta. Bul.</i> 255:1-76.
65	1931	Some Effects on Wheat Marketing of Changes in Production and Harvesting Methods in the Southwest. R. M. Green and H. J. Henney. <i>Univ. Jour. Business</i> , 4:48-55.
66	1931	Social and Economic Aspects of Large-scale Farming in the Wheat Belt. W. E. Grimes. <i>Jour. Farm Econ.</i> , 13:21-26.
67	1931	The Effect of Rainfall and Temperature on Corn Yields in Kansas. J. A. Hodges. <i>Jour. Farm Econ.</i> , 13:305-318.
68	1932	Farm Production and Consumption of Poultry in Kansas. Morris Evans and H. L. Collins. <i>Kan. Agr. Expt. Sta. Bul.</i> 256:1-33.
70	1932	Forecasting the Yield of Winter Wheat Seven Months Prior to Harvest. H. J. Henney. <i>Jour. Farm Econ.</i> , 13:319-330.
71	1931	Judging Price Risks in Marketing Cattle. H. J. Henney. <i>Kan. Agr. Expt. Sta. Circ.</i> 153:1-41.
72	1931	Taxation of Intangibles in Kansas. Harold Howe. <i>Natl. Tax Assoc. Bul.</i> , 16:194-198.
73	1931	The Trend of Real Estate Taxation in Kansas from 1910 to 1929. Harold Howe. <i>Kan. Agr. Expt. Sta. Circ.</i> 159:1-15.
75	1932	Certain Aspects of the Outlook for American Agriculture During the Next Ten Years. W. E. Grimes. <i>Jour. Farm Econ.</i> , 14:69-80.
77	1932	An Application of "Movement Theory" in the Behavior of Prices to Corn Prices. R. M. Green. <i>Jour. Farm Econ.</i> , 14:358-361.
..	1932	Tax Study in Thirteen Lessons. Harold Howe and Jens P. Jensen. <i>Kan. Chamber of Commerce Bul.</i> , March.
..	1932	Questions and Answers on State Income Tax. Harold Howe. <i>Kan. State Teachers Assoc. Bul.</i> , March. 11 pp.
Department of Agricultural Engineering		
..	1930	Studies on the Qualities of the Combined Wheats as Affected by Type of Bin, Moisture and Temperature Conditions. C. O. Swanson and F. C. Fenton. <i>Jour. Cereal Chem.</i> , 7:428-448.
Department of Agronomy		
191	1930	Interrelation of Nutrients and Soil Reaction on Growth and Inoculation of Alfalfa. M. C. Sewell and P. L. Gainey. <i>Soil Sci.</i> , 30:297-305.
192	1930	Effect of Different Chipping Treatments on the Yield and Vigor of Prairie Grass Vegetation. A. E. Aldous. <i>Ecology</i> , 11:752-759.
192-a	1931	Inheritance of Smut Resistance and Juiciness of Stalk in the Sorghum Cross, Red Amber x Pterita. A. F. Swanson and John H. Parker. <i>Jour. Heredity</i> , 22:51-56.
194	1930	The Reaction of Alfalfa Varieties to Bacterial Wilt. S. C. Salmon. <i>Jour. Amer. Soc. Agron.</i> , 22:802-810.

Serial No.	Year of issue.	Title, author, and publication.
198	1931	Tame Pastures in Kansas. A. E. Aldous and J. W. Zahnley. Kan. Agr. Expt. Sta. Bul. 253:1-39.
199	1931	Cyanamide and Urea: Their Production, Characteristics, and Use. M. C. Sewell Amer. Fert., 74:13-14.
200	1931	An Instrument for Determining the Breaking Strength of Straw, and a Preliminary Report on the Relation Between Breaking Strength and Lodging. S. C. Salmon Jour. Agr. Res., 43:73-82.
201	1931	The Effect of Drying and Ultra Violet Light on Soils. A. E. Mortenson and F. L. Duley. Soil. Sci., 32:195-198.
202	1931	Resistance of Winter Wheat Varieties to Hessian Fly. <i>Phytophaga Destructor</i> (Say). R. H. Painter, S. C. Salmon, and J. H. Parker. Kan. Agr. Expt. Sta. Tech. Bul. 27:1-58.
203	1931	The Effect of Lime, Superphosphate, and Potash on Reaction of Soil and Growth and Composition of Alfalfa. M. C. Sewell and W. L. Latshaw. Jour. Amer. Soc. Agron., 23:799-814.
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43	1930	Information Regarding Recent Publications. Kan. Agr. Expt. sta. Circ. 157:1-4.
44	1930	Fifth Bien. Rpt. Dir. Agr. Expt. Sta., 1928-'30. L. E. Call, pp. 164.
45	1932	Coöperation in the Conduct of State-Wide Agricultural Programs. L. E. Call. Ex. Service Rev., 3:20-21.
46	1932	Enriching Land in Poor Times. L. E. Call. Quarterly Rpt. Kan. State Bd. Agr., 51:49-62.

BIENNIAL REPORT OF DIRECTOR

FINANCIAL STATEMENT, 1930-'31

(The Kansas Agricultural Experiment Station in account with federal and state appropriations.)

	Federal appropriations.	State appropriations and receipts.	Totals.
Main station	\$90,000.00(a)	\$76,639.14	\$166,639.14
Branch stations, appropriations .....	.....(b)	54,443.94	54,443.94
Branch stations, sales .....	.....	66,290.42	66,290.42
Totals	\$90,000.00	\$197,373.50	\$287,373.50
Salaries	\$50,000.00	\$34,278.79	\$84,278.79
Labor	29,671.30	70,634.46	100,305.76
Stationery and office supplies	93.14	3,854.76	3,947.90
Scientific supplies, consumable	1,570.12	2,905.36	4,475.48
Feeding stuffs	827.80	9,021.51	10,759.31
Sundry supplies	593.45	6,464.48	7,057.93
Fertilizers .....	.....	.....	.....
Communication service	5.30	2,423.86	2,429.16
Travel expenses	2,034.30	5,024.02	7,058.32
Transportation of things	226.44	2,911.08	3,137.52
Publications	24.64	697.70	722.24
Heat, light, water, and power	68.20	6,213.07	6,281.27
Furniture, furnishings, fixtures	153.29	2,431.75	2,585.04
Library	6.76	303.56	310.32
Scientific equipment	177.76	981.47	1,159.23
Live stock	1,125.65	1,897.85	3,023.50
Tools, machinery, and appliances	3,093.64	12,416.98	15,510.62
Buildings and land	299.80	21,860.34	22,160.14
Contingent expenses	28.51	1,807.71	1,836.22
Balance, June 30, 1931 .....	.....	10,339.75	10,339.75
Totals	\$90,000.00	\$197,373.50	\$287,373.50

(a) Includes a balance on hand June 30, 1930, of \$7,353.68.

(b) Includes a balance on hand June 30, 1930, of \$3,693.94.

FINANCIAL STATEMENT, 1931-'32

(The Kansas Agricultural Experiment Station in account with federal and state appropriations.)

	Federal appropriations.	State appropriations and receipts.	Totals.
Main station	\$90,000.00(a)	\$89,795.73	\$179,795.73
Branch stations, appropriations .....	.....(b)	89,147.67	89,147.67
Branch stations, sales .....	.....	39,014.62	39,014.62
Totals	\$90,000.00	\$217,958.02	\$307,958.02
Salaries	\$50,000.00	\$41,486.43	\$91,486.43
Labor	31,736.05	63,925.16	95,661.21
Stationery and office supplies	61.22	1,609.84	1,671.06
Scientific supplies, consumable	1,501.03	1,686.34	3,187.37
Feeding stuffs	351.04	10,193.71	10,544.75
Sundry supplies	344.01	6,060.53	6,404.54
Fertilizers .....	.....	147.70	147.70
Communication service	122.16	1,548.43	1,670.59
Travel expenses	1,464.68	6,927.53	8,392.21
Transportation of things	27.42	1,772.54	1,799.96
Publications	154.40	2,182.65	2,337.05
Heat, light, water, and power	5.84	5,063.35	5,069.19
Furniture, furnishings, fixtures	394.19	1,647.07	2,041.26
Library .....	.....	123.04	123.04
Scientific equipment	1,199.43	1,327.35	2,526.78
Live stock	961.15	2,460.79	3,421.94
Tools, machinery, and appliances	712.34	10,146.16	10,858.50
Buildings and land	418.01	11,502.06	11,920.07
Contingent expenses	557.03	4,313.87	4,870.90
Balance, June 30, 1932 .....	.....	43,833.47	43,833.47
Totals	\$90,000.00	\$217,958.02	\$307,958.02

(a) Includes a balance on hand June 30, 1931, of \$11,695.73.

(b) Includes a balance on hand June 30, 1931, of \$2,647.67.

