

AGRICULTURAL EXPERIMENT STATION

**KANSAS STATE COLLEGE OF AGRICULTURE
AND APPLIED SCIENCE**

M A N H A T T A N, K A N S A S



SEVENTH BIENNIAL REPORT OF THE DIRECTOR

1932-1934

KANSAS AGRICULTURAL EXPERIMENT STATION

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* On leave.

LETTER OF TRANSMITTAL

OFFICE OF THE DIRECTOR,
June 30, 1934.

To His Excellency, Alfred M. Landon, 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, 1934. The report includes brief descriptions of the work in progress during the biennium, summaries of some of the more significant results, changes in the personnel of the station staff, a list of the publications of the station and of the published scientific contributions of the station staff, and a statement of receipts and expenditures during the biennium.

W. E. GRIMES, *Acting Director.*

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DIRECTOR'S REPORT'

INTRODUCTION

A brief statement of the work of the Kansas Agricultural Experiment Station, including the four branch stations, for the biennium ending June 30, 1934, is presented in this report. The work has been conducted on the project basis and includes studies in five distinct fields as follows: Agricultural economics, soil conservation, the plant industries, the animal industries, and home economics. A brief statement of the progress of each of the more important studies and of the results secured is given.

COOPERATION WITH OTHER AGENCIES

Coöperation with a number of related agencies working in the same or closely associated fields of work was continued throughout the biennium. Agencies with whom coöperative relations have been maintained include other state agricultural experiment stations, the United States Department of Agriculture, other departments of the state of Kansas, other research agencies, and farmers. These coöperative relations have been satisfactory and helpful and have resulted in more efficient conduct of the work.

The coöperative work with the United States Department of Agriculture during the past biennium has included studies with the Bureau of Plant Industry relating to (1) production and breeding of small grains and corn, and the control of cereal diseases in coöperation with the Division of Cereal Crops and Diseases; (2) studies of crop production and soil management in the drier sections of the state in coöperation with the Division of Dry-land Agriculture; and (3) alfalfa improvement, the control of alfalfa diseases, and forage crop production in coöperation with the Division of Forage Crops and Diseases.

Work in coöperation with the Division of Survey of the Bureau of Chemistry and Soils included the preparation for publication of the results of soil surveys made during the preceding biennium. In coöperation with the Division of Soil Erosion Investigations of the Bureau of Chemistry and Soils and the Bureau of Agricultural Engineering studies of soil erosion and water conservation have been conducted. The Bureau of Animal Industry coöperated in the following studies: Factors influencing the palatability and quality of meat, with the Division of Animal Husbandry, and anaplasmosis in cattle, with the Division of Pathology. In coöperation with the United States Forest Service the work in the propagation and dis-

1. Contribution No. 52 from the director's office.

tribution of forest trees was continued. Coöperative work with the Bureau of Agricultural Economics included studies of farm organization, cost of producing farm products, land utilization, and the marketing of farm products.

The coöperative relations with the Kansas State Board of Agriculture have been continued. The Agricultural Experiment Station provided facilities and personnel for analytical determinations of feedings stuffs, live-stock remedies, fertilizers, and dairy products. A state seed-testing laboratory has been maintained in coöperation with the Board. Studies of live-stock diseases have been continued in coöperation with the state live-stock sanitary commissioner. In coöperation with the Brookings Institution, of Washington, D. C., a concurrent study of the operation of the agricultural adjustment act was made. Farmers from all sections of the state coöperated in studies of problems in which they were particularly interested.



FIG. 1.—New dairy barn and dairy experimental laboratory.

SOIL SURVEYS AND RELATED WORK

The state soil survey was discontinued during the biennium in response to the need for reduced expenditures. This important work should be resumed at the earliest possible time. It provides indispensable information needed in any program involving adjustment of Kansas agriculture. It is exceptionally helpful to farmers who are in need of farm-mortgage credit and to the agencies extending such credit. Associated with this work should be surveys of crop adaptation of the land, soil-erosion surveys, and surveys of economic factors pertaining to the land. These surveys should be conducted simultaneously in regions for which soil surveys have not been made and are urgently needed to supplement the soil surveys that have been completed. The information secured in these surveys is essential for the development of a satisfactory land utilization program for Kansas.

BUILDINGS AND EQUIPMENT

A new dairy barn and dairy experimental laboratory (fig. 1) was built during the biennium at a cost of \$45,000. The barn is constructed of native stone, the inside walls being finished with glazed tile. It is a two-story structure with a central portion 41 by 215 feet, with two wings, each 30 by 35 feet. Seventy head of cattle can be housed in the central portion of the barn, which is conveniently arranged for handling four breeds. The wings provide facilities for young stock, box stalls for mature animals, and room for digestion stalls for experimental work. Midway and to the front of the main barn and connected with it by a vestibule is a milk house containing facilities for handling the milk from the herd, an office for the herdsman, sleeping rooms for student caretakers, a milk-testing laboratory, and a locker room with shower baths.



FIG. 2.—New crops-and-soils laboratory building at the Fort, Hays Branch Experiment Station, Hays, Kan.

Midway and to the back of the main barn is the feed storage room, which consists of four 16 by 40-foot cement stave silos, 11 bins for grain, and a feed elevator, grinder, and mixer. Mow space to hold approximately 200 tons of loose hay and 100 tons of baled straw is available. The barn is equipped with an automatic control forced ventilating system. The barn is not designed as a model dairy barn, but to provide facilities for the college herd and for experimental work with dairy cattle.

During the biennium a new fireproof soils and crops laboratory 42 x 54 feet was erected at the Fort Hays Branch Experiment Station (fig. 2) at a cost of \$10,500. The appropriation for the building was \$12,000, and it could have been fully completed if the total amount of money appropriated had been made available. As a part of the economy program a 25 per cent reduction was made in

the appropriation during the second half of the biennium. As a result, only the basement was finished. The building is made of concrete and hollow tile, faced with mingle-shade rug brick. The roof is covered with French pattern red tile. The floors are made of reinforced concrete. The building has two stories and full basement. Four large laboratory rooms equipped with electricity, gas, and water have been provided in the basement. The basement also provides a large forage-drying room, 9 x 12 x 9, supplied with an automatically controlled gas-fired dessicating unit which can be controlled within 2° C. The unit is capable of providing and maintaining a temperature of 100° C. inside the oven.

The second floor contains five rooms. Two of these are office rooms and are provided with radiation and can be heated if de-

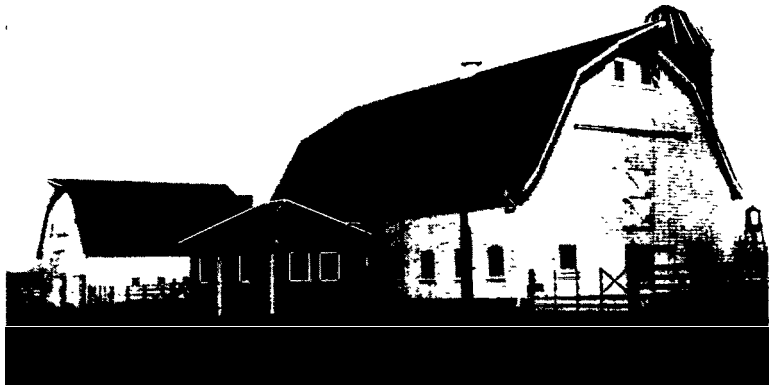


FIG. 3.—New dairy barn, milk house, and silo at the Colby Branch Experiment Station, Colby, Kan.

sired. Two rooms provide storage for experimental seed stocks, and a large room equipped with electric motors and numerous electric outlets has been provided as a work room. This entire floor is utilized by the cereal and forage-crops projects.

One large room has been provided on the top floor. This space is used by the cereal and forage-crops projects, and is used as a storeroom for head and plant samples of grain and forage crops.

The basement and two rooms on the first floor are heated by a gas-fired boiler located in the basement. This building, although not completed, provides a greatly needed improvement at the Fort Hays branch station.

During the fall and winter of 1932-33 an irrigation plant was installed in the nursery at the Fort Hays station on the banks of Big creek for the purpose of irrigating small trees, seedling trees, and other nursery stock. The plant, complete with piping system to all parts of the nursery, was put in at a cost of \$2,500. Were it

not for this irrigation plant thousands of units would have been lost during the spring and summer of 1934 because of drought.

A new dairy barn with a silo and a milk house was built at the Colby Branch Experiment Station. (Fig. 3.)

New equipment secured during the biennium included equipment for research laboratories in horticulture, poultry husbandry, and dairy nutrition, and additional equipment for research in botany, plant pathology, entomology, landscape gardening, and zoölogy.

PERSONNEL

Dr. E. L. Tague, assistant in protein chemistry, died on January 11, 1934. He had served as protein chemist since 1914. In his death the station lost one of its most careful and productive workers.

Appointments. —The average number of persons regularly employed on the scientific staff of the station during the biennium was 108. Three new appointments were made during the biennium. Those appointed were:

- J. E. Anderson, assistant in milling industry.
- C. L. Lefebvre, plant pathologist.
- Bernice Kunerth, technician in home economics.

Resignations. —Six members of the staff resigned during the biennium. Those resigning were:

- F. G. Ackerman, foreman agronomy farm.
- C. W. Oakes, miller.
- E. W. Johnson, forestry investigations.
- W. L. Latshaw, analytical chemistry.
- Ruth McCammon, technician in home economics.
- F. B. Wolberg, official dairy tests.

RELATIONS WITH THE RECOVERY PROGRAM

The Agricultural Experiment Station has been used extensively in connection with the national recovery program. Numerous requests have been made for information to be used in formulating various portions of the program as they relate to agriculture. In this work the Agricultural Experiment Station is serving its function in providing needed facts concerning the many agricultural problems facing the farmers of the state and of the nation. Members of the staff have been consulted freely concerning various phases of the agricultural adjustment and farm credit programs. In several instances members of the staff have been borrowed for brief periods to furnish advice and suggestions to those responsible for the programs. Other members of the staff have been granted leaves of absence and have been connected with the work of the Farm Credit Administration or of the Soil Erosion Service of the Department of the Interior. Those granted leaves of absence to serve with the Farm Credit Administration include:

- L. E. Call, director of the station, to serve as president of the Federal Land Bank of Wichita.²

² He served in this capacity during the last six months of the biennium, during which period W. E. Grimes was acting director of the station.

- R. M. Green, agricultural economics, to serve as vice president of the Production Credit Corporation of Wichita.
- W. E. Grimes, agricultural economics, to serve as special investigator for the Farm Credit Administration.

Those granted leaves of absence to serve with the Soil Erosion Service are:

- F. L. Duley, soils, to serve as regional director of Soil Erosion Service, Mankato, Kan.
- I. K. Landon, outlying experiment fields, to serve as agronomist for the Soil Erosion Service, La Crosse, Wis.
- C. A. Logan, agricultural engineering, to serve as agricultural engineer for the Soil Erosion Service, Mankato, Kan.

SCOPE OF THE STATION WORK, JULY 1, 1932, TO JUNE 30, 1934

A list of the principal active projects carried during the biennium ending June 30, 1934, is given below, together with statements of the sources of financial support and references to the discussions included in this report:

NAME.	Project No.	Department.	Leader.	Funds.	Discussed on page—
Studies of Factors Affecting the Organization and Operation of Kansas Farms.	95	Agricultural Econ.....	W. E. Grimes..... J. A. Hodges. Morris Evans.	Purnell and State....	18
Investigations in Land Tenure and Other Related Problems....	132	Agricultural Econ.....	Harold Howe.....	Purnell.....	18
The Marketing of Kansas Wheat.....	143	Agricultural Econ.....	R. M. Green.....	Purnell.....	20
The Economics of the Poultry Industry in Kansas.....	144	Agricultural Econ.....	Morris Evans.....	Purnell.....	24
The Marketing of Kansas Live Stock and Live-stock Products,	149	Agricultural Econ.....	H. J. Henney.....	Purnell.....	21
The Marketing of Kansas Fruits and Vegetables.....	177	Argicultural Econ.....	George Montgomery....	Purnell.....	22
A Study of Factors Governing the Marketing of Kansas Dairy Products.	185	Agricultural Econ.....	George Montgomery....	Purnell.....	23
Soil Fertility Investigations.....	17	Agronomy.....	F. L. Duley..... W. H. Metzger.	Hatch and State....	26
Plant Nutrition Investigations.....	152	Chemistry.....	H. H. King..... A. T. Perkins.	State.....	28
The Influence of Legumes and Free-living Nitrogen-fixing Organisms on the Growth of Plants and on the Nitrogen Balance.	172	Argonomy..... Bacteriology.....	H. E. Myers..... P. L. Gainey.	Purnell.....	30
The Relation of the Absolute Reaction of the Soil Solution upon the Growth and Activity of Azotobacter.	128	Bacteriology.....	P. L. Gainey.....	Adams and State....	28
A Study of the Soil Solution as Governed by Ion Concentration.	155	Chemistry.....	A. T. Perkins.....	State.....	31
A Study of Replaceable Cations and Anions in Some Kansas Soils.	179	Chemistry.....	A. T. Perkins..... H. H. King.	Purnell.....	32

SCOPE OF THE STATION WORK—CONTINUED

NAME.	Project No.	Department.	Leader.	Funds.	Discussed on page—
Soil and Crop Experimental Fields.....		Agronomy..... Horticulture..... Botany..... Entomology.....	R. I. Throckmorton..... R. J. Barnett..... L. E. Melebers..... G. A. Dean.....	State.....	33
Temperature Relations of Crop Plants.....	157	Agronomy.....	H. H. Laude.....	Purnell.....	36
Small Grain and Sorghum Improvement.....	67	Agronomy.....	J. H. Parker.....	Hatch.....	36
Inheritance of Factors Affecting Quality of Wheat.....	178	Agronomy..... Milling Industry.....	J. H. Parker..... C. O. Swanson.....	Purnell.....	38
Sorghum Varietal Tests.....	120-1	Agronomy.....	H. H. Laude.....	Hatch.....	39
Small Grain Varietal Tests.....	120-2	Agronomy.....	H. H. Laude.....	Hatch.....	39
Soybean Production Tests.....	120-3	Agronomy.....	J. W. Zahnley.....	Hatch.....	40
Miscellaneous Legumes for Forage.....	120-4	Agronomy.....	J. W. Zahnley.....	Hatch.....	41
Corn Production and Improvement.....	156	Agronomy.....	A. M. Brunson.....	Purnell.....	42
Alfalfa Investigations in Relation to Winter Hardiness and Bacterial Wilt.	183	Agronomy.....	C. O. Grandfield.....	Purnell.....	43
Pasture Improvement Investigations.....	96	Agronomy.....	A. E. Aldous.....	Purnell.....	44
Weed Eradication with Chemical Sprays.....	160	Agronomy.....	J. W. Zahnley.....	State.....	47
Coöperative Experiments with Farmers.....		Agronomy.....	A. L. Clapp.....	State.....	48
The Influence of the Method of Harvesting and Baling Alfalfa Hay Upon Quality.	182	Agricultural Engineering.....	F. J. Zink.....	Purnell.....	49
A Study of the Efficiency of the Combined Harvester-Thresher for Harvesting Grain Sorghums.	181	Agricultural Engineering.....	F. J. Zink.....	Purnell.....	50
Shrinkage and Damage of Wheat in Farm Storage.....	143	Agricultural Engr..... Milling Industry.....	F. C. Fenton..... C. O. Swanson.....	Purnell.....	50

SCOPE OF THE STATION WORK—CONTINUED

NAME.	Project No.	Department	Lender.	Funds.	Discussed on page—
Chemical Factors Influencing the Quality of Wheat and Flour,	60-A	Milling Industry	E. B. Working	State	51
Varietal Factors Influencing the Milling and Baking Qualities of Wheat.	60-B	Milling Industry.	C. O. Swanson.	State.	52
Factors Influencing the Protein Content of Wheat.	60-C	Milling Industry.	C. O. Swanson.	State	52
Tempering Factors Affecting the Quantity and Quality of Wheat Flour.	170	Milling Industry.	C. O. Swanson	Purnell.	53
A Physiological Study of the Hard Winter Wheat Plant.	180	Botany.	E. C. Miller.	Purnell.	54
Orchard Investigations.	25	Horticulture	R. J. Barnott G. A. Filinger. W. F. Pickett.	State	55
Small-fruit Investigations	26	Horticulture	W. F. Pickett G. A. Filinger.	State	58
Flower and Vegetable Investigations.	27	Horticulture	W. B. Balch	State	60
Nutritive Requirements of Swine.	38	Animal Husbandry. Chemistry	C. E. Aubcl. J. S. Hughes.	Adams	60
Swine Feeding Investigations.	110	Animal Husbandry	C. E. Aubcl. W. E. Connoll.	State.	61
Sources of Calcium for Growing Pigs. . . . .	.....	Animal Husbandry.	C. W. McCampbell. C. E. AUBEL	State.	62
Investigations in the Use of Silage for Fattening Beef Cattle.	78	Animal Husbandry	A. D. Wober W. E. Conncll.	State	63
Methods of Utilizing Native Pasture in Beef Cattle Feeding.	151	Animal Husbandry	C. W. McCampbell. W. E. Connoll.	State	65
A Comparison of Different Levels of Protein Intake for Fattening Steer Calves.	.....	Animal Husbandry	A. D. Wober W. E. Connoll.	State	65

SCOPE OF THE STATION WORK --CONTINUED

NAME.	Project No.	Department.	Leader.	Funds.	Discussed on page-
Lamb Feeding Investigations	111	Animal Husbandry.. . . .	Rufus F. Cox.. . . . W. E. Connell.	State.	66
The Influence of Feed on the Color, Chemical Composition, and Cooking Quality of the Meat of Grass Fat Cattle.	165	Animal Husbandry.. . . . Chemistry... Home Economics.. . . .	C. W. McCampbell.. . . . D. L. Mackintosh. J. L. Hall. Martha S. Pittman. Martha M. Kramer.	Purnell and State.. . . .	67
Factors Influencing the Mineral Metabolism of Dairy Animals.	147	Dairy Husbandry. Chemistry. Veterinary Med.. . . .	W. H. Riddell, H.W. Cave J.S. Hughes. C. H. Whitnah. H. F. Lienhardt.	Purnell and State.. . . .	71
Dairy Cattle Feeding Investigations.. . . . I	34	Dairy Husbandry	H. W. Cave. J. B. Fitch.	State.	73
Normal Growth of Dairy Cattle.		Dairy Husbandry.	W. H. Riddell	State..	77
Calf Feeding Investigations.		Dairy Husbandry	W. H. Riddell	State..	77
Ice Cream Investigations.	124	Dairy Husbandry.	W. H. Martin... W. J. Caulfield.	State.	78
A Bacteriological Study of Ice Cream.	124	Bacteriology.. . . .	A. C. Fay.. . . .	State.	70
The Influence of Homogenization on the Curd Tension of Milk		Dairy Husbandry.	W. J. Caulfield.. . . .	State..	81
Studies on the Curd Character of Milk.		Dairy Husbandry	W. H. Riddell.. . . .	State	82
A Study of the Formation, Isolation, and Properties of Milk Sugars.		Chemistry Dairy Husbandry.	C. H. Whitnah W. J. Caulfield.	Purnell..	83
Protein Investigations.		Chemistry	H. H. King.. . . .	Purnell....	85

SCOPE OF THE STATION WORK—CONTINUED

NAME.	Project No.	Department.	Leader.	Funds.	Discussed on page—
The Inheritance of Standard Characteristics of Poultry.....	77-3	Poultry Husbandry.....	D. C. Warren.....	State.....	86
The Inheritance of Breed Characteristics in Poultry.....	77-4	Poultry Husbandry.....	D. C. Warren.....	State.....	86
Physiology of Reproduction in Poultry.....	77-6	Poultry Husbandry.....	H. M. Scott..... D. C. Warren.	State.....	86
Influence of Hybridization Upon Vigor in Poultry.....	173	Poultry Husbandry.....	D. C. Warren.....	Purnell.....	89
Turkey Production.....	77-15	Poultry Husbandry.....	H. M. Scott.....	State.....	87
Turkey Nutrition Investigations.....	77-17	Poultry Husbandry..... Chemistry.....	H. M. Scott..... J. S. Hughes.	State.....	89
Improvement and Conservation of Farm Poultry.....	77-20	Poultry Husbandry.....	L. F. Payne.....	State.....	89
Studies in Animal Reproduction and Inheritance.....	93	Animal Husbandry.....	H. L. Ibsen.....	State.....	90
Studies in the Inheritance of the Grouse Locust.....	72	Zoölogy.....	R. K. Nabours.....	Adams.....	91
Effects of Climate on Inheritance in the Grouse Locust.....	104	Zoölogy.....	R. K. Nabours.....	Adams.....	92
Bee Investigations.....	126	Entomology.....	R. L. Parker.....	State.....	93
Cereal and Forage Crop Disease Investigations.....	76	Botany.....	L. E. Melchers..... C. L. Lefebvre.	State.....	94
Fruit and Vegetable Disease Investigations.....	130	Botany.....	O. H. Elmer.....	State.....	97
Resistance of Winter Wheat to Leaf Rust.....	171	Botany.....	C. O. Johnston.....	Purnell.....	99
Climate and Injurious Insect Investigations.....	6	Entomology.....	R. C. Smith.....	Hatch.....	100
Hessian Fly and Other Wheat Insects.....	8	Entomology.....	R. H. Painter..... H. R. Bryson.	Hatch.....	101
Corn Ear-worm and Other Insects Injurious to Corn.....	9	Entomology.....	D. A. Wilbur..... H. R. Bryson.	Hatch.....	103

SCOPE OF THE STATION WORK—CONTINUED

NAME.	Project No.	Department.	Leader.	Funds.	Discussed on page—
Fruit and Vegetable Insects.....	13	Entomology.....	R. L. Parker.....	Hatch.....	105
Insects Attacking the Sorghums.....	92	Entomology.....	H. R. Bryson.....	State.....	96
Insects Attacking the Roots of Staple Crops.....	100	Entomology.....	H. R. Bryson.....	State.....	106
Insects Injurious to Alfalfa, Grasses, and Allied Plants.....	115	Entomology.....	R. C. Smith. D. A. Wilbur.	State.....	107
Biology and Control of the Western Apple Curculio.....	187	Entomology.....	R. L. Parker.....	Purnell and Hatch...	109
Resistance of Crop Plants to Insect Injury.....	164	Entomology..... Agronomy.....	R. H. Painter..... J. H. Parker.	Purnell.....	110
Investigations of Injurious Mammals.....	84	Zoology.....	G. E. Johnson.....	State.....	111
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Miscellaneous Animal Disease Investigations.....	102	Veterinary Med.....	H. F. Lienhardt..... E. R. Frank. E. E. Leasure.	State.....	112
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STUDIES IN THE ECONOMICS OF AGRICULTURE

Studies in the economics of agriculture have been conducted during the past biennium under the leadership of the Department of Agricultural Economics. These studies are discussed briefly in the following pages.

Studies of Factors Affecting the Organization and Operation of Kansas Farms.--These studies have proceeded along the following lines during the past biennium.

1. Data secured in a study of the business operations of a number of farms in southwestern Kansas were analyzed and prepared for publication. Two manuscripts are ready for publication. One manuscript deals with the use and the cost of using farm machinery in the southwestern winter-wheat producing area of the state and the second with ways of reducing the costs of wheat production in this area. This study is in cooperation with the Federal Bureau of Agricultural Economics.

2. Records from the farms making up the two Farm Management Associations have been summarized and analyzed for the years 1931, 1932, and 1933. These records show material improvement in farm incomes from 1931 to 1933 as indicated below:

<i>Year</i>	AVERAGE NET FARM INCOME <i>Northern Association</i>	<i>Southern Association</i>
1931	\$408	13
1932	133	4
1933	1,249	1,292

3. In cooperation with the Federal Bureau of Agricultural Economics a Study was made of areas in the hard winter wheat belt to determine their relative advantage in wheat production. Analysis of these data have not been completed.

4. A study was made of the agriculture of McPherson county to determine the changes needed to adjust to changed conditions and to give a more stable and self-sufficient agriculture.

5. A limited number of farm accounts kept by cooperating farmers was summarized for income, expenses and inventory data. These data continue the series maintained by the Department of Agricultural Economics, which show income and other data for a selected group of farms for each year.

6. The type-of-farming files were brought up to date and the type-of-farming map of the state was revised in the light of information made available by the 1930 census. The type-of-farming files contain data on crop yields, crop acreages, prices, numbers of live stock, and numbers of tractors and combines. Many of these series have been completed back to 1910, while some of them extend back to 1875.

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

Investigations in Land Tenure and Other Related Problems.--During the last two years the studies in taxation and agricultural finance have been continued, except that during the last six months of the biennium, January 1 to June 30, 1934, work was devoted almost entirely to cooperating with the Federal Bureau of Agricultural Economics in conducting Federal CWA Project F-6 (Farm Mortgage and Land Values) in the state of Kansas.

Other research work growing out of emergency conditions included a CWA project dealing with an inventory of the physical, economic, and social resources of Wichita county, Kansas. This work was begun early in April, 1934,

in cooperation with the Kansas State Planning Board and the Departments of Agronomy and Economics and Sociology.

The following are some of the results secured in the studies of agricultural taxation, public expenditures, and public administration.

A study of the taxation systems of this and other states was made for the purpose of preparing a tax program to be used as a guide for future research into methods of improving the Kansas taxation system. The program is divided into four parts, each dealing with a governmental problem. These problems are: (1) to reduce the cost of government; (2) to revise the revenue system; (3) to improve tax administration; and (4) to control tax levies. A manuscript embodying the major conclusions of this program is available in mimeographed form.

Information on total rural tax levies was found necessary in the study of various tax limitation measures. By the questionnaire method, information was obtained on the total tax rate on assessed values in 3,751 rural communities in 48 counties well distributed over the state. In 62.1 per cent of the communities the total tax rate was 15 mills or less, while in 37.9 per cent of the communities the total rate was more than 15 mills.

The distribution by size of levy of total rural tax levies in 48 Kansas counties for the tax year, 1932-'33, was as follows:

	<i>Number</i>	<i>Per cent</i>
10 mills or less	451	12.0
10.1-12.5 mills	1,027	27.4
12.6-15.0 mills	853	22.7
15.1-17.5 mills	685	18.3
17.6-20.0 mills	362	9.7
More than 20 mills	373	9.9
	3,751	100.0

Because the general sales tax is attracting more and more attention as a means of raising revenues, a study of this form of tax as used in other states was made. There are now 21 states with some form of general sales tax. The laws in each of these states were studied to give facts on the type of tax used, the administration, the revenue received, and the method of distribution of this revenue. The incidence and effects of these taxes were also studied. A manuscript embodying the major conclusions is available in mimeographed form.

During the twenty-year period from 1910 to 1929 the average annual increase in taxes levied on farm real estate in Kansas was approximately one million dollars. In 1910 the total tax levied on farm real estate amounted to \$9,706,000. In 1929 the levy had increased to \$29,219,000. Data collected during the last two years indicate that the highest point was reached in 1929. A reduction occurred in 1930 and again in 1931. In 1931 the total tax levied on farm real estate amounted to \$26,583,000.

During the past two years the work in agricultural finance has included the collection of data on methods used by insurance companies, mortgage companies, and trust companies in the extension of long-term credit to agriculture. Some of the information obtained from these companies is as follows:

a. In 1932 approximately 40 per cent of all farm mortgages in Kansas were held by life insurance companies.

b. Approximately 88 per cent of the farm mortgage credit supplied by insurance companies came from life insurance companies whose offices are located outside the state.

c. A large percentage of the insurance companies have not been making farm mortgage loans. This applies to both large and small companies. A number of the companies have not made such loans for three or four years.

d. Five years has been by far the most common length of term for mortgage-company loans.

e. The lump-sum or straight loan, where no payments are made on the principal until the termination of the loan period has been used most frequently. Recently there appears to have been a tendency for more companies to provide for annual reductions in the principal to protect the security

of their loans in a period of declining values. The strictly amortization plan of payment has not been used by the mortgage companies.

Two reports were prepared on various phases of the studies in taxation in cooperation with members of the staff of the University of Kansas and of the Kansas Chamber of Commerce. One of these dealt with general taxation problems of the state and the other concerned the general sales tax. Results of previous work were reported in a paper entitled "Programs of Adult Study of Taxation" published in the January, 1933, issue of the *Journal of Farm Economics*.

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

The Marketing of Kansas Wheat.—The phases of this project that have been active during the past biennium are discussed below.

1. *Economic Analyses of Business Policies and Practices of Farmers' Elevator Associations.*—This study was started in cooperation with the Division of Cooperative Marketing of the Federal Farm Board. Its purpose was to determine the relation of the business policies and practices followed by farmers' elevators to the efficient marketing of grain in Kansas. The Extension Service cooperated in securing the data from the elevators. The financial records of 72 cooperative elevators for the 1932-'33 crop year, and 121 elevators for 1933-34, were secured from the annual audits, and then analyzed to determine the financial condition and operating efficiency of the organization. To obtain information on the cost of handling sidelines, the records of the oil departments of 42 of these elevators were analyzed for a three-year period to establish desirable operating ratios for oil and gas departments. Conclusions concerning the information obtained during the last year cannot be made until summarization of the 1933-'34 analyses is completed. The 1932-'33 analyses indicated the following:

a. Under western Kansas conditions a membership in local cooperative elevators of 150 or more was closely associated with high net income for the elevators.

b. Two-thirds of the cooperative elevators with largest net incomes had 80 per cent or more of their patrons giving them most or all of their business, while only 27 per cent of the lowest income elevators had 80 per cent or more of their patrons giving them most or all of their business.

c. The highest-income group of cooperative elevators consistently maintained a current ratio (current assets to current liabilities) of between 1 1/2:1 and 3:1. Only three of the 21 low-income elevators maintained a current ratio of between 1 1/2:1 and 3:1. In the intermediate-income group, nine of 21 elevators maintained a current ratio of between 1 1/2:1 and 3:1.

d. The largest current ratios, as well as some of the smallest, were found among the lowest-income elevators. The lowest ratios were usually so small as to indicate insolvency. The largest ratios indicated small debts, comparatively small assets, and small volume of business.

e. Other financial and operating ratios were studied in a similar way, and the results are being set up as minimum standards for cooperative elevator managers and boards of directors to use.

2. *The Spread Between Local Prices and Kansas City Prices of Wheat.*—A study was made of local wheat prices by crop reporting districts. Local prices on the first of the month, as reported by special correspondents, were analyzed for the nine-year period, 1925-1933, inclusive, to determine the variation within sections of the state, and also to determine spreads from Kansas City prices. Spreads were determined by finding the difference between the district mode of local prices and the average price for the first five days of the month at Kansas City. It was found that the spread between local prices and Kansas City prices tended to be larger in years of high wheat prices than in years of lower price levels, and the widest spreads occurred in June and July.

3. *Factors Affecting Seasonal Price Fluctuations.*—Work was devoted to studying wheat price series other than top No. 2 hard wheat at Kansas City to further confirm studies in seasonal price fluctuations made with top No. 2 hard wheat prices and to detect variations. Some preliminary findings are as follows:

- a. Price advances in top No. 2 wheat in July, August, and September were more frequently associated with the uptrend phase of the wheat price cycle than were advances in monthly lows for low No. 2 wheat.
- b. Price advances in monthly lows for low No. 2 wheat in October and November were a little more frequently associated with the uptrend phase of the wheat price cycle than were advances in top No. 2 wheat.
- c. In February, top No. 2 hard winter wheat price advances were better indicators of an advancing price level than were advances in monthly lows for low No. 2 wheat.
- d. In March and April, advances in monthly lows for low No. 2 wheat were better indicators of advancing wheat price levels than were advances in top No. 2 hard wheat.
- e. Advances in June were of no particular value in indicating advancing price levels. In both price series half of the advances in June were associated with advancing price levels and half of them were associated with declining price levels. Apparently, the seasonal shift from old to new crop price levels is more important as a strictly seasonal affair than it is in any association with generally advancing or declining wheat price levels.

[Project 143; Department of Agricultural Economics. Leaders, R. M. Green and George Montgomery; Purnell fund.]

The Marketing of Kansas Live Stock and Live-stock Products.—Four phases of this project have been active during the past biennium.

1. *Organizations Engaged in the Marketing of Kansas Live Stock and Live-stock Products.*—The studies have been confined to organizations outside of central markets, that handle live stock on the way to market. Analysis of the data has not been completed. The community or auction sale has developed rapidly in recent years. The total number in the state on May 1, 1934, was 171, with as many as five sales pavilions in one county. Farmers seemed to be pleased with these sales.

2. *When and Where Kansas Live Stock and Live-stock Products Move to Market.*—Data compiled by the Kansas representative of the Division of Crop and Live Stock Estimates of the Federal Bureau of Agricultural Economics were analyzed. This is a continuation of studies previously reported upon, and the results have confirmed the previous findings. The smaller markets increased in importance and small interior packing plants expanded their operations.

3. *Economic Factors Influencing the Time and Place of Marketing Kansas Live Stock and Live-stock Products.*—Special attention has been given in these studies to the place of marketing live stock. Improved highways and reduced trucking charges have contributed to an increase in the volume of live stock coming into markets that are nearer to the point of production. Another factor influencing this trend was in the reduction in selling costs which accompanied the newer methods of sale at local points, when compared with the relatively fixed charges at terminal markets. The shortage of feed in the Southwest during the last two years has tended to result in relatively higher prices for live stock on the Wichita and other Western markets. This has tended to increase receipts of fat animals at these markets.

4. *Price Trends and Price-making Factors in the Live-stock Industry.*—The economic forces causing price fluctuations on the Kansas City market have been studied during the past biennium. These studies have included price changes from month to month and from one ten-day period to the next,

in both the advancing and the declining phases of the price cycle. Also studies have been included of the time when seasonal high and seasonal low prices occur, and the influence of the time of previous high and low prices on high and low prices in succeeding years.

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

The Marketing of Kansas Fruits and Vegetables.—Four phases of this project were studied during the past biennium.

1. *Marketing Methods and Practices.*—Work on this phase during the biennium consisted of a continuation of the study of the distribution of Kaw valley potatoes, and the results secured by cooperative marketing of the crop. The distribution of car-lot shipments of Kansas potatoes showed that the 1932 and 1933 crops moved into market areas somewhat different from those of previous years. More Kansas potatoes were shipped east of the Mississippi river. A larger percentage of the total shipments went to Chicago than in the 1930 and 1931 seasons.

2. *Price-making Factors.*—During the past year the work on this phase has included a continuation of the study of factors affecting potato prices, an analysis of daily prices of apples by varieties and grades at Kansas City and Omaha for the period of 1925 to date, and a summary of monthly apple prices received by producers in the Midwestern and Northwestern apple-producing states. The findings on this phase of the project are as follows:

a. The production of apples in the Northwestern states had more effect on Kansas City apple prices than did production in Kansas, Missouri, and other states nearer the Kansas City market.

b. Kansas production had more effect on prices in local producing areas than it had on Kansas City prices.

c. While prices received by producers were influenced by production in surrounding areas, they did not tend to get far out of line with prices in the larger markets.

3. *Sources and Character of Competition.*—Some of the preliminary findings on this phase of the project were the following:

a. Idaho, Washington, Colorado, Oregon, and California were the principal states shipping apples to Kansas City.

b. Most of the apple shipments into Kansas City occurred during September, October, and November.

c. Total yearly arrivals of apples at Kansas City have been decreasing. There has been a rather steady decrease from 2,000 cars in 1925 to 1,050 cars in 1931.

d. Shipments of apples from Washington have been decreasing while shipments from Idaho have increased.

Apparently there is opportunity for Kansas to supply more of the fruits and vegetables consumed in Kansas City.

4. *Variations in Production.*—A study was made of the factors affecting the production of commercial apples in Kansas. Total production of apples and also yield per tree were compared with variations in temperature and precipitation during the growing season for the years 1922 to 1932, inclusive. Temperatures were compared for the months of March to September, inclusive, and rainfall was compared for the period of June to September, inclusive. Comparisons were made by months and also by 10-day periods. The following are the findings on this phase of the project:

a. Higher than normal temperatures during June were associated with large production.

b. High temperatures during July and the first 20 days of August were associated with smaller than average production. Temperatures below normal for this period were associated with above-normal production.

c. Light rainfall during June was favorable to large production.

d. Heavy rainfall in July was favorable to large production.

e. Comparisons of temperature and precipitation with yield per tree showed results similar to those found for total production.

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

A Study of Factors Governing the Marketing of Dairy Products in Kansas.—Three phases of this project were actively studied during the biennium.

1. *Organization for the Marketing of Kansas Dairy Products.*—During the summer and fall of 1933, when prices of fluid milk were at extremely low levels because of severe competition, efforts were made to develop plans so that dairymen could cooperate to secure the benefits of milk marketing licenses and protect their fluid milk markets from unwarranted competition. Marketing agreements were prepared for a group of six towns in north central Kansas. Work with the dairymen in these markets suggested the following:

a. Price cutting and unfair practices ruined the fluid milk market for many producers. Consumers were obtaining milk at a low price, but they were afforded no protection from an insanitary supply of milk. Since these conditions were more than temporary, there should be regulation of the production and distribution of milk, to protect both producers and consumers.

b. A system of state regulation, with a control committee to work with local organizations, would be the most feasible method of control, since it would avoid local influence and personal controversies such as have prevented effective action on the part of local groups.

c. District supervisors with power to enforce both local and state regulations could organize and regulate local fluid milk markets so that both consumers and producers would be benefited.

2. *A Study of Prices and Price-making Factors.*—The work on this phase of the project included a study of factors affecting butter prices and an analysis of the causes of variations other than seasonal and long-time fluctuations in butter prices. An analysis of profits and losses incurred in butter-storage operations was made to determine the effect of time of storage movement upon prices, and also upon storage operations during the succeeding year. The daily movement of cash and future prices for a four-year period were analyzed to determine the relationship existing between them. Periods of advancing and declining price were compared for length of movement and number of days the two prices moved together. As an aid in making price comparisons and in forecasting prices, monthly figures and index numbers for 25 series of data on production and prices of dairy products were compiled and charted for the period 1925 to date. The following facts were obtained from this phase of the study:

a. The principal cause of fluctuation in butter prices, other than seasonal and long-time fluctuations, was the buying ability of consumers.

b. The influence of receipts and cold-storage holdings on prices was primarily seasonal. Therefore these factors are of secondary importance in explaining price variations which are not seasonal.

c. A price-estimating equation was developed for estimating butter prices for October, November, December, January, and February for the period 1919 to 1931, inclusive. A comparison of the estimated and the actual prices showed that in two-thirds of the cases the errors in the estimated prices were 2.6 cents a pound or less.

d. Profits and losses from butter-storing operations fluctuated a great deal from one year to the next. Profits from storage operations which were hedged were not only larger, but also fluctuated much less than profits on operations which were not hedged. Stored butter which was hedged and was taken from storage during the first half of the season returned more than twice as much profit as that sold out of storage during the last half of the out-of-storage period. Butter which was not hedged and was sold from storage during the

first half of the storage period returned twice as much profit as that taken out during the last half of the period. There was a marked tendency for periods of profits and losses to reverse themselves about every two years.

e. There was a significant relationship between the movement of future prices and the movement of cash butter prices. Future prices tended to indicate turns in the market, and they also led the cash a higher percentage of the time than they followed it.

3. *A Study of Marketing Methods and Practices.*—This phase of the project included the following investigations:

a. To determine the methods and practices of marketing milk in Kansas, a detailed survey was made of the Junction City milk market. Junction City was selected as a typical Kansas town of average size, and one in which practices and methods had not been changed abnormally by competition and price cutting.

b. About 150 consumers in Abilene, Manhattan, and Topeka were personally interviewed to determine the quantity of milk purchased, the price paid, and the sources from which milk was bought.

c. Information on retail prices, buying prices, and the number of producers furnishing milk was obtained by questionnaires from 25 of the larger towns and cities in Kansas. The information secured indicates the following:

(a) The selling of milk in Kansas towns was poorly organized, inefficient, and costly. In Junction City 24 of the 32 producers delivered all or part of their milk themselves. Twenty-two of the producers sold part of their milk to stores. The margin taken by the stores amounted to from one-half to one-third as much as the farmer received for the milk.

(b) The per capita consumption of milk in Kansas towns was low. The per capita consumption in Junction City was found to be 0.46 of a quart per day.

(c) Competition and price cutting were severe. Retail prices ranged from 6 to 12 cents off the wagon and 5 to 10 cents through stores.

(d) Much of the milk sold during 1933 was supplied to consumers at less than cost of production.

(e) An analysis of records of Junction City dairymen indicated that it cost 8 cents per quart to produce and deliver fluid milk to the consumer.

(f) The volume handled by producers, and also by distributors, was too small for economical operation.

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

The Economics of the Poultry Industry in Kansas.—During the past biennium the work has consisted of a continuation of tabulation and analyses of farm poultry records previously reported; continuation of studies of causes for the relatively low farm price of eggs and poultry in Kansas; a study of classification of poultry receipts was begun; the Kansas farm price of eggs and poultry for 1909-1933 was analyzed; the Kansas City prices of first eggs, heavy and light hens, broilers, springs, and roosters, for the period 1908-1933 were tabulated and analyzed. The following are some of the conclusions reached as a result of these studies:

a. Farm records showed that feed purchases were the most important item of cash expense in poultry production with poultry and egg purchases next.

b. Changes in inventory values had a marked effect on profits, reducing them in 1931 and 1932 and increasing them in 1933.

c. Total receipts per flock in 1933 were about the same as in 1932, but receipts per hen declined.

d. In 1931, 1932, and 1933 chickens of medium-weight breeds showed a larger return per hen than those of lighter-weight breeds. However, the margin was small in 1933.

e. Cash sales of eggs per hen were larger for light-weight breeds than for the medium breeds, but poultry sales per hen were the larger for the medium-weight breeds. Egg sales from light-weight flocks were the more evenly distributed throughout the year.

f. There apparently was no uniformity in price cycles for poultry. Data for heavy hens at Kansas City for 1908-1933, and for the Kansas farm price of chickens for 1909-1933 showed six complete cycles. The average uptrend of heavy hens was 32.2 months with a variation of 17 to 63 months. The average downtrend lasted 24.4 months, with a variation of 8 to 49 months.

g. The average uptrend of Kansas farm prices of eggs, 1909-1933, was 17.9 months with a variation of 4 to 62 months. The downtrend averaged 14.2 months with a variation of 4 to 32 months. There were nine cycles.

h. Egg and poultry prices at different points in Kansas varied widely at any given time. However, there was less variation between the averages of different areas. The analysis of 1933 prices by crop reporting districts showed a maximum difference between districts of only 2.1 cents per dozen.

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

A Concurrent Study of the Operation of the Agricultural Adjustment Act.—In July, 1933, in cooperation with the Brookings Institution, Washington, D. C., the Kansas Agricultural Experiment Station began a concurrent study of the operation of the Agricultural Adjustment Act as it applied to Kansas. Through an informal agreement, the Department of Agricultural Economics provided the personnel and facilities for conducting the study, and the Brookings Institution furnished funds for travel and clerical assistance.

The Wheat Allotment Program in Kansas.—The work on this phase has included observing and summarizing the development of the wheat allotment program. Information collected on the wheat allotment program has resulted in the following conclusions:

a. The wheat allotment program was effectively put in operation in Kansas and was administered efficiently.

b. The principles of acreage reduction with benefit payments have received enthusiastic approval and support from farmers and local merchants.

c. The most serious difficulties encountered were delays in plans and rulings from Washington, changing decisions, and difficulty of adjusting contracted acreage to official figures.

d. Irrespective of financial benefits and adjustments in production, the program will be a permanent benefit because of the development of local leadership, and the realization among farmers of the benefits of organization and cooperation.

The Corn-Hog Program in Kansas.—A detailed study has not been made, but such study is planned. Current developments were observed and reported. Observations to date indicate the following:

a. The corn-hog program has been put into operation more slowly, with less publicity, but more systematically than was the wheat allotment program.

b. Experiences gained from the wheat program proved helpful in the organization and educational campaign of the corn-hog program.

c. There has been much criticism of the processing tax by farmers, business men, and marketing and processing agencies.

The Dairy Program.—Developments in the larger milk markets, such as Topeka, Wichita, and Kansas City, as well as reactions in the smaller markets, have been observed. The following conclusions may be made in regard to the dairy program:

a. The policy of the dairy section has been indefinite and unstable.

b. With the exception of the markets in Wichita and Kansas City, the Kansas fluid milk markets have not been improved by the AAA program.

c. The dairy control program of the Agricultural Adjustment Administration has not met with the general approval of Kansas dairymen.

[Department of Agricultural Economics. Leader, George Montgomery; state and Brookings Institution funds.]

SOIL CONSERVATION

The Agricultural Experiment Station has been studying soil problems for many years, but during the past biennium soil conservation has received increased attention in connection with the agricultural adjustment program of the federal government. Brief descriptions of these studies are given in the following pages:

Soil Fertility Investigations.—The field experiments which have been under way in connection with this project since 1910 were continued with only slight changes.

Weather conditions were rather unfavorable during the biennium in that insufficient moisture was available during all or part of each growing season. The 1932 wheat crop was good but the 1933 crop was greatly reduced by drouth and high temperatures. Manure and complete fertilizer treatments resulted in significant increases in wheat yields in 1932, but phosphorus alone was more effective than manure in 1933. This was true of wheat in rotation and in continuous culture. Green manure and rock phosphate were beneficial except where the green manure immediately preceded the 1933 wheat crop in the continuous wheat experiment. In this case the wheat had insufficient moisture for favorable development. Wheat following soybeans in a three-year rotation continued to produce only slightly better yields than wheat in continuous culture, and much lower yields than wheat in a rotation with four years of alfalfa in each 16 years. Alfalfa preceding wheat resulted in a decided increase in protein content of the grain, and the effect was evident for several years after the alfalfa sod was broken.

Corn yields were medium in 1932 and still lower in 1933, because of a lack of moisture. Manure increased yields significantly in rotation and continuous culture each year, but only a complete fertilizer, among other fertilizer treatments, was effective, and the increase in this case was small.

Superphosphate continued to produce increases in alfalfa yields. Stable manure and green manure with rock phosphate were also beneficial. Soybean hay yields were increased slightly by superphosphate or manure treatments in 1933, but the 1932 crop showed only negligible increases from these treatments.

Oat yields in rotation were increased consistently by manure, but manure and rock phosphate gave larger increases. The same effect was noted when manure and rock phosphate were applied to kafir, but to a considerably less extent.

Laboratory studies indicate that after large losses during the first, few years of cultivation the total nitrogen content of the soils devoted to experimental work since 1910 has apparently become stabilized. A 16-year rotation, including four years of alfalfa, maintained a higher content of total nitrogen in the soil than continuous wheat culture. Insufficient data have been obtained at this time to permit further comparisons. The phosphorus data indicated no extensive build-up of the supply of easily soluble phosphorus in the soil for any treatments except rock phosphate.

Fertilizer movement in the soil of an alfalfa experiment unbroken for 14 years and fertilized annually by top dressings was investigated. The results for phosphorus showed: (a) Little downward movement but considerable accumulation at the surface where superphosphate was applied alone. (b) Little accumulation at the surface and no accumulation at lower levels where potas-

sium sulphate was applied with superphosphate. (c) Definite movement of phosphorus downward was indicated where sodium nitrate and potassium sulphate were applied with superphosphate. (d) Marked downward movement to 24 inches was noted where phosphorus was applied as rock phosphate. (e) No significant movement of phosphorus was indicated where manure was applied alone.

Studies of the nitrate content of wheat land in the fall, which were begun in 1925, have been continued through the biennium. Wheat yields were closely correlated with nitrate content of the soil at seeding time. Land in a rotation including alfalfa consistently showed more nitrates than land in a rotation including soybeans or land on which wheat was grown continuously.

The moisture of the deep subsoil of land on which an alfalfa sod had been broken at Manhattan was restored only after the soil had been fallowed for a period of about four years. Rainfall during two of the four years, however, was abnormally low.

A comparison of superphosphate (16 per cent P_2O_5) and treble superphosphate (43 per cent P_2O_5) showed the two to be about equal in value as fertilizer for wheat when applied on the basis of equivalent amounts of phosphorus. Sulphur applied with rock phosphate has increased the efficiency of the latter as a fertilizer for wheat.

Burning stubble and straw resulted in a higher yield of wheat than was obtained when stubble and straw were not burned. The experiment has existed only a short time, and the effect of a continuation of such a practice has not been ascertained.

Nitrogenous fertilizers have consistently and materially increased production of brome grass seed both at Manhattan and in Washington county. Fertilizer placement trials with corn have indicated that no method of application is likely to produce consistent, profitable increases in yield of the crop under such soil and climatic conditions as exist at Manhattan.

Special attention has been given to the study of certain factors affecting run-off and soil erosion. Semi-laboratory methods have been devised for measuring erosion under various conditions. Water is applied by means of sprinkling cans to simulate rainfall.

The effect of the degree of slope on run-off and erosion was first studied. It was found that run-off increased rapidly as the slope of land increased up to about 4 per cent. With further increase in slope, the increase in run-off was slower and more gradual. The erosion loss increased slowly with the first increase in slope and then rapidly when the slope reached 7 to 8 per cent. From these results it would seem that where land has more than 8 per cent slope, erosion is likely to be difficult to control.

The next studies were made on the effect of length of slope on run-off and erosion. It was found that increasing the length of a slope up to 100 feet increased the percentage of absorption and decreased the run-off. The results on erosion losses were not always consistent, but during heavy rains the erosion increased on the longer slopes, where water had time to accumulate in large volume and therefore increase its cutting power.

Later studies were made on the effect of terraces on run-off and erosion. It was found that terraces built from the uphill side, with a channel above the terrace ridge, thus giving a break in the slope above the terrace, permitted more run-off and more erosion than where no terraces were built.

However, where the terraces were built from the lower side, with no break in the grade above the terrace, less water was lost by run-off and less soil lost by erosion than where there were no terraces. Direct comparison of these two types of terraces, one built from above and one from below the terrace ridge, showed that there was decidedly less run-off and less erosion from the terrace built from below and having no distinct channel above the terrace and thus giving no break in the grade.

Where there is a sharp break in the grade above the terrace channel, small gullies start at the peak and continue to develop up the slope. Where the grade is uniform down to the terrace ridge, gullies do not readily start.

[Project 17; Department of Agronomy. Leaders, F. L. Duley and W. H. Metzger; Hatch and state funds.]

Plant Nutrition Investigations.—The work on this project during the biennium consisted of a study of the mineral content of plants as influenced by soil reaction and mineral content of soil.

In 1932-'33 Bates and Summit soils were brought to Manhattan and placed in the greenhouse. These soils were divided into plots, and one plot of each soil was treated with superphosphate, while the other plots were left untreated. Lettuce and bush lima beans were grown to maturity on each plot. After harvesting the crops the soils were heavily limed and a second crop grown on each plot. The crops were analyzed for calcium, phosphorus, and other elements, and from the data obtained the following conclusions were drawn:

- a. The available phosphorus content of the soils was increased by the addition of superphosphate.
- b. The addition of calcium carbonate had no clear-cut effect on the available phosphorus content of either the acid or basic soil.
- c. Calcium carbonate changed the reaction of the acid soil appreciably.
- d. Superphosphate treatment had no lasting effect on the soil reaction of the soils.
- e. The application of calcium to the acid and basic soils decreased the percentage of ash in the lettuce and lima beans.
- f. The superphosphate treatment decreased the percentage of ash in the plants grown on the acid soil but increased it in plants grown on the basic soil.
- g. Calcium carbonate applied to the soils decreased the percentage of nitrogen, potassium and phosphorus in the dry matter of lettuce and lima beans.
- h. The phosphorus content of the dry matter was increased by superphosphate treatment.
- i. The calcium content was decreased in the plants grown on the acid soil by the addition of superphosphate.
- j. The calcium content was increased in the plants grown on the basic soil by the addition of superphosphate.

During the second year of the biennium specially prepared soils were substituted for naturally occurring soils. The Summit soil was taken and portions were treated with ferric chloride solution until the exchangeable calcium was replaced. The soils were then washed until free of soluble ferric chloride, dried, and then various proportions of this iron-treated soil were mixed with the untreated soil. These mixed soils received various applications of mono-basic calcium phosphate and were planted to wheat and later to beans. In each case the plants were grown for about eight weeks and then harvested. The first crop was weighed and analyzed, and the results obtained indicate:

- a. Large amounts of iron in the soil decidedly reduced the per cent of P_2O_5 in the wheat plant.
- b. Phosphate applications tended to increase the amount of phosphate absorbed by the plants on the iron-treated soil, but the applications did not increase absorption on untreated soil.

[Project 152; Department of Chemistry. Leaders, H. H. King and A. T. Perkins; state fund.]

The Influence of the Absolute Reaction of the Soil Solution Upon the Growth and Activity of Azotobacter.—The cylinder experiments started in 1923 have been continued. In 1933 and 1934 they were grown to oats. No significant differences have been noted in the growth in soils inoculated with Azotobacter and uninoculated soils. The past year the soil in all 32 cylinders was

sampled for nitrogen analysis for comparison with samples taken in 1923. The actual analyses have not been completed.

Studies of the bacterial flora and chemical composition of the soil, and the growth, yield of grain, and chemical composition of wheat plants collected from "spots" in wheat fields and immediately adjacent areas were continued during the biennium. The results have shown remarkable agreement from year to year both qualitatively and quantitatively. Samples of soil and of growing plants were collected during the active growing period of the wheat plant, from 165 fields located in 38 counties, and distributed approximately equally over four consecutive seasons, 1929 to 1932. Following are the major comparisons made, given on a relative basis:

	<i>Field</i>	<i>Spots</i>
Height of plants when cut.....	100	167
Weight of dried plants.....	100	268
Percentage nitrogen in plants.....	100	166
Percentage nitrogen in soil.....	100	832
NO ₃ nitrogen in soil.....	100	337
NO ₃ nitrogen formed in laboratory from soils store of nitrogen.....	100	93
NO ₃ nitrogen formed in laboratory from added organic nitrogen.....	100	91
Nitrogen fixing ability.....	100	243
Grain yield.....	100	173
Protein content of grain.....	100	295
Yield of protein.....	100	295

While definite conclusions seem to be warranted by these values, still the data alone do not picture the overwhelming preponderance with which the qualitative results substantiate the quantitative values recorded.

The following comparisons seem especially noteworthy:

- a. Growth on the spots averaged approximately 2.7 times as much as on the surrounding area, and 99 per cent of the comparisons favored the spots.
- b. The plant material from spots contained 1.66 times as much nitrogen per unit weight and was greater in 99 per cent of the comparisons.
- c. The quantity of nitrogen removed by growing plants per unit area of soil was greater from the spots in 100 per cent of the comparisons, and averaged 4.2 times that removed by plants immediately adjacent thereto.
- d. In spite of the greater removal of nitrogen by the growing plants, the soil of the spots averaged 8.5 times as much nitrate nitrogen as the adjacent soil, and was greater in 90 per cent of the comparisons.
- e. Soil from the spots did not contain much more total nitrogen, only 1.08 times as much, yet it was higher in 86 per cent of the comparisons.
- f. Soil from the spots was capable of accumulating nitrate nitrogen from its own store of nitrogen 3.37 times as rapidly as the normal field soil, and this ability was greater in 91 per cent of the comparisons.
- g. No marked difference in the capacities of the organisms in the two soils to nitrify or to fix nitrogen was observed, yet nitrogen-fixing organisms of the *Azotobacter* type appeared to be less abundant in the spots.

From the facts just cited the conclusion seems adequately substantiated that: A limited amount of nitrogen, either available or capable of being readily transformed into a condition available to the wheat plant, finding its way into the soil, is in most instances responsible for the appearance in wheat fields of the "spots" of the type under study. This conclusion points convincingly toward a deficiency in available nitrogen as being a major limiting factor in the production of wheat in many Kansas soils.

Studies of artificially produced spots have been continued. The application of all forms of nitrogen so far tested, including urine, urea, sodium nitrate, ammonium sulfate, "amophos," and calcium cyanamid, at about the time growth starts in spring will result in the production of conditions indistinguishable from naturally occurring spots, provided the soil is not adequately supplied with available nitrogen. Tests conducted in the spring of 1932 on four farms near Manhattan gave the following relative yields when nitrogen at the rate of 50 pounds per acre was applied:

No treatment	160
Urea	189
Sodium nitrate	200
Ammonium sulfate	195
"Amophos"	203
Calcium cyanamid	173

In the season of 1932-'33 extensive tests were conducted in cooperation with the Department of Agronomy on two fields of wheat, in varying the time and rate of surface application of sodium nitrate. The results from one field were rendered valueless because the field was pastured late and the cattle showed such a decided preference for nitrogen-treated wheat that many spots were ruined and the damage to others could not be estimated. On the other field, in spite of the dry season which made it impossible for the wheat plants to utilize fully the nitrogen applied, increases in yield up to 84 per cent were obtained. No application after March 31 gave any response. The heavier applications (1,000 to 2,000 pounds sodium nitrate) were injurious or without effect except the November 28 application of 1,000 pounds. The lighter applications (50 to 150 pounds) were without effect when applied in the fall, but gave maximum response when applied in the early spring. The medium application (500 pounds) gave best results when applied in the fall.

The apparent low *Azotobacter* content of soil from spots led to extensive field and laboratory studies as to the possible cause. The examination of soil from a large number of spots and immediately adjacent areas in the same field showed rather definitely that the *Azotobacter* content of the soil from spots was lower than from the surrounding areas. Laboratory studies of the effect of nitrate nitrogen upon the number of *Azotobacter* in soils indicated that an excessive nitrate content will decrease or even destroy the *Azotobacter* therein. The concentration necessary, however, appeared to be in excess of the quantities found under field conditions. Certain strains of *Azotobacter* in pure culture were found to lose their ability to fix nitrogen upon prolonged growth in laboratory media in the presence of high concentrations of nitrates. Such cultures refused to grow upon nitrogen-free media while the presence of only one part per million of nitrate nitrogen enabled them to grow. These studies are being continued in an effort to explain the lower *Azotobacter* content of soils from "spots."

Greenhouse studies of factors affecting the growth of alfalfa in acid soils, in cooperation with the Department of Agronomy, have been continued the past two years. All evidence points to the conclusion that the absence of certain nutrients in acid soils may play as important a role in the failure of alfalfa to grow as does the reaction of the soil. The most acid soil thus far experimented with, approximately pH 4 supported good growth of alfalfa if the proper nutritive elements were added. However, nodulation was not observed to any appreciable extent below pH 5.

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

The Influence of Legumes and Free-living Nitrogen-fixing Organisms on the Growth of Plants and on the Nitrogen Balance.—The work on this project was conducted in three phases, which are discussed below.

1. *Nitrogen Fixation.*—The work on this phase consisted of field plot work, greenhouse studies and laboratory investigations. The greenhouse work was devoted to a study of the effects of nutrients on the inoculation of alfalfa growing in acid soils. The field work consisted of a continuation of the study of the comparative value of alfalfa, sweet clover, and soybeans as soil-improving crops. One series of field plots devoted to a study of the effect of *Azotobacter* in maintaining soil fertility was abandoned during the past biennium.

The laboratory studies consisted of several phases. All crops removed from the field plots were analyzed for total nitrogen. Nitrate nitrogen and moisture

determinations were made of the soil of all wheat plots at seeding time. During the last year of the biennium, moisture and nitrate determinations were made of the soil of all corn plots at the time the plants were emerging and at two-week intervals for a period of four weeks. In addition, deep-soil samples were taken on several of the plots to study the comparative effect of the various legumes on subsoil moisture. In addition, nitrogen, phosphorus and calcium determinations were made on samples of sweet clover taken from fertility plots in the cooperative experiments. Conclusions have been deferred until further data are available.

2. *Chlorosis Studies.*—The work on this phase consisted of both greenhouse and field investigations. The field work was done principally at the Fort Hays Branch Experiment Station. The greenhouse work was conducted at the main station, using soils from Ford and Grant counties.

The results obtained indicated that the cause of the chlorosis was a deficiency of available iron to the plant. The condition was overcome by spraying with a solution of ferrous sulfate, but not by a normal application of a soluble iron salt to the soil.

3. *Root, Crown, and Shoot Rot of Milo Investigations.*—The work on this phase has been conducted in the greenhouse, using soil from the Garden City Branch station known to be infected with the milo disease organism. The effect of chemical soil treatment on the occurrence of the disease in milo was studied.

No chemical treatment tried prevented the diseased condition, but nitrogen carriers had a favorable effect in prolonging the life of the plants.

[Project 172; Department of Agronomy. Leader, H. E. Myers; Purnell fund.]

A Study of the Soil Solution as Governed by H-Ion Concentration.—The work during the biennium has consisted of a study of the soil solution as governed by various bases added to the soil (H^+ , Fe^{+++} , Al^{+++}), with special reference to phosphorus.

Fractionation of the soil according to size of particles by sedimentation, and further fractionation according to the specific gravity of the particles by means of bromoformcarbon tetrachloride flotation was made. Base exchange capacities and chemical analyses of the various fractions which have been separated were made. These data are being compared with data involving the size and surface area of the particles. Preliminary work has been done on the potassium electrode as a means of determining the activity of various soil particles.

In the fractionation phase of the work attempts were made to isolate the particles active in base exchange activity. Salt precipitation, alcoholic precipitation, preferential wetting by alcohol and carbon tetrachloride, static charges on dry and wet soils and other methods failed to yield positive results.

Fractionation by sedimentation plus bromoformcarbon tetrachloride flotation gave promising results, and considerable work has been done along this line. Three soils, Oswego, Derby, and Crawford, were selected for these separations, and portions of each of these soils were saturated with different anions, H^+ , NH_4^+ , and Ca^{++} . The first separations were made by sedimentation and four fractions were obtained. These were the fractions which would settle through a 24-inch column of water in six and two-thirds minutes, 40 minutes, 4 hours, and 24 hours. The other fractions which settled and those which remain suspended for a six-day period are now in process of separation. The latter fraction—the colloidal fraction—is, from the standpoint of soil investigations, the most important fraction of the soil. The average diameters of the four fractions which were separated were approximately 0.050 mm., 0.025 mm., 0.011 mm., and 0.005 mm. These figures are only approximate, but have been obtained from measurements on the fractions from the nine different soils. The forecasted average diameters of the two fine fractions yet to be separated are 0.002 mm. and smaller than 0.001 mm. These six fractions are being fur-

ther separated according to the specific gravity of the individual soil particles. The particles which have a lesser specific gravity than 2.00 are being separated, as well as those between 2.0 and 2.4; 2.4 and 2.5; 2.5 and 2.6; 2.6 and 2.7; and those heavier than 2.7.

Calculations as to the average surface of these particles, and determination as to the base exchange capacity and SiO_2 , Fe_2O_3 , and Al_2O_3 content are being made. The determinations made to date show that as the size of the particle decreases the SiO_2 content decreases and the Fe_2O_3 and Al_2O_3 content increase. Also, as the size of the particle decreases the actual base-exchange capacity increases, but the base-exchange capacity in relation to the specific surface decreases.

Chemical analyses of the particles which have been separated according to specific gravity show that as the specific gravity of the particles increases the SiO_2 content increases, except for the heaviest particles, which show a decided decrease.

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

A Study of Replaceable Cations and Anions in Some Kansas Soils.—Studies were made of the effect of liming on the solubility of added phosphate in Cherokee loams after the soil had been treated with H^+ , Fe^{+++} , and Al^{+++} . These ions and Ca^{++} unquestionably exert a prominent influence upon the solubility of soil phosphates. Moreover, their influence differs greatly at different pH values. The work was planned with the purpose of determining (1) the pH values at which, or the range of pH values over which, these ions alone and mixed together in varying proportions exert a maximum effect on phosphorus solubility; (2) the concentrations of these ions necessary to produce the maximum precipitating effect upon phosphorus, and (3) other factors which may be varied to produce greater solubilities of phosphate in contact with soils, and perhaps greater availability to plants.

The first work was done with aqueous solutions of H_3PO_4 to which were added known amounts of Ca^{++} , Fe^{+++} , and Al^{+++} ions, and the reactions of which were varied by addition of acid or base; and later, soils which had been leached repeatedly with solutions of CaCl_2 , FeCl_3 , and AlCl_3 , respectively, and then washed free of chlorides were added to the solutions.

In the past considerable work has been done to show that the four ions H^+ , Ca^{++} , Al^{+++} , and Fe^{+++} greatly affect the solubility of phosphates in soils. Much data has been collected concerning the effect on phosphate solubility of CaO , CaCO_3 , and CaCl_2 at different pH ranges controlled by these compounds and HCl or NaOH . Calcium, iron, and aluminum-treated soils have also been studied in relation to phosphate solubility at various pH's. The conclusions drawn are:

a. When Cherokee loam was acid, either as a result of absorbed H or hydrolyzed Al or Fe , added phosphorus remained more soluble if the soil was first limed. This was especially true for lime applications up to 2 tons per acre or heavier lime applications with heavy phosphate applications.

b. The above condition might be reversed in the case of heavy lime applications (5 or 10 tons per acre) and light phosphate applications (250 pounds per acre).

c. Even when heavily limed, the iron- or aluminum-treated soils precipitated large amounts of added phosphorus.

d. If the pH of the solutions was sufficiently low, Ca^{++} ions did not precipitate PO_4^{---} ions from pure solutions even in the presence of a high con-

centration of Ca^{++} ions. Appreciable precipitation began only after the pH reached approximately 5.

e. Maximum precipitation, or minimum solubility, of PO_4^{---} ions by Ca^{++} ions occurred at pH values above 7.

f. Complete phosphate precipitation did not occur at neutrality, even in the presence of a large excess of calcium compound, unless a sufficiently high concentration of Ca^{++} ions was present.

g. The solubility of CaO and its pronounced effect upon the pH value of the solutions caused it to remove all of the phosphorus from solution when only a very slight excess over the amount equivalent to the H_3PO_4 was present.

h. The soil saturated with calcium precipitated phosphorus much as did a sparingly soluble salt of calcium.

i. Addition of CaCO_3 to the Ca saturated soil never raised the pH above neutrality, nor did it completely precipitate the added phosphorus; although CaCO_3 was added at a rate of 671,800 pounds per acre.

[Project 179; Department of Chemistry. Leaders, H. H. King and A. T. Perkins; Purnell fund.]

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

Southeastern Kansas Experiment Fields.—The work on the Southeastern Kansas experiment fields during the past biennium has consisted of variety and fertility tests of alfalfa, clovers, soybeans, corn, sorghum, wheat, oats, flax, and grasses, in addition to some rotation studies. The data obtained throughout the past biennium serve to substantiate those previously reported. The flax seed-bed work at Columbus has continued to show wide differences, not, however, so marked as the first year's results. There has been a slight change in treatments given to two of the plots. Plots 1 and 5, which previously grew soybeans in rows, with the soybeans harvested for seed, were changed to sorghum. As a result there was a marked difference in the yield of flax seed following these crops.

The differences in the flax yields were probably due to differences in the amount of nitrate available in the soil in the spring when the flax was making its growth. Because of these results, tests have been made during the last two years with nitrogenous fertilizers on flax. Linota continued to be the highest-yielding variety of flax grown on the fields, but the seed of Bison, Rio, and Redwing contained a higher percentage of oil.

In the corn-variety tests on the Moran field a local selection of Midland produced the highest average yield. Commercial fertilizers have not consistently influenced the yields of corn on any of the fields. When corn follows alfalfa or sweet clover in the rotation, the yields of corn are higher on those plots that grew the legumes successfully. The increase in the yield of corn under such conditions no doubt was due to the increase in the nitrogen and organic matter returned to the soil by the legume, rather than the direct effect of the fertilizer treatment.

The wheat-variety work was conducted only on the Columbus field. In this test, Kawvale, a new variety, produced practically the same average yields during the last six years as Fulcaster, a local variety that is less winter hardy. Kawvale produced much higher yields than Currell and Harvest Queen. The yields of wheat were materially increased by the use of manure or phosphorus used alone or in combination. Fertilizers carrying potassium did not increase the yields of grain.

The Ladak variety of alfalfa produced the highest average yields, with Grimm second and Kansas Common third, at the Moran field during the last

five years. Applications of fertilizer, manure, and lime on alfalfa increased the yields of hay on all three fields.

In the lime and phosphate tests at Moran, where the rate of applying lime and phosphorus was varied, it was found that the rate of applying lime could be materially reduced when it was used in connection with phosphorus.

Kansas Orange sorgo produced an average of 0.76 of a ton more forage per acre than Atlas sorgo, but the Atlas variety produced an average of 2.8 bushels more grain per acre. Kansas Orange produced the highest yields of forage. A selection of Pink kafir (F.C.I. 9091) produced slightly higher yields of grain than Blackhull. Blackhull kafir produced higher average yields than Kalo and Club.

The summary of all the soybean variety tests conducted since 1924 showed that the A. K. variety produced an average yield of 15 bushels of seed per acre. This is two bushels more than was produced by any other variety. The Hongkong variety is promising, but has been grown for only three years. The Virginia variety produced the lowest average yield of seed. The Laredo variety produced the highest average yields of hay during the last seven years. The tests at the Moran field show that A. K. soybeans produced the highest yields of both seed and hay when planted in 21-inch rows and then cultivated.

Experiments with light applications of lime drilled with alfalfa seed have been started and will be continued to determine if this method, which has been successful with sweet clover, will be satisfactory in alfalfa production. Because of the reduction in funds it was necessary to abandon the Fort Scott field at the close of the cropping season of 1932, and the Parsons field at the close of the season in 1933.

The results secured in the experiments with flax have been published as Circular 173, entitled "Flax Production in Kansas."

[Department of Agronomy. Leaders, R. I. Throckmorton, I. K. Landon, and F. E. Davidson; state fund.]

South Central Kansas Experiment Fields.—This project included the Wichita, Kingman, and Pratt experiment fields in 1932 and the Wichita and Kingman fields in 1933. The work consisted of soil fertility, soil management, crop variety, and method- and date-of-planting studies. Since the project is relatively new, many of the rotations are just becoming established, and results from them are not available.

In the crops work special attention was given to a study of pastures and legumes that may be adapted to this region. The severe drought of 1932 and 1933 interfered with the work on all fields and resulted in low yields of all crops, regardless of the soil treatment or method of production. Since field work on the project did not start until the spring of 1932, results are available for only spring-planted crops for that year.

Applications of manure and commercial fertilizers, or the burning of the stubble, had no significant influence on the yield of wheat on any of the fields in 1933. At the Pratt field fallow resulted in a yield of 18 bushels per acre, compared with 6 bushels where wheat followed barley. Wheat was a failure in 1933 on the Pratt field where it was planted after sweet clover.

The average yields of the wheat varieties on three fields in 1933 were low because of a lack of moisture, severe injury from winter killing, and army worms.

On the Kingman field in 1932 oat yields were increased 11 bushels per acre by the application of sodium nitrate, but the yields were slightly decreased by the same treatment in 1933. Other soil treatments had no appreciable influence on the yields of grain.

All varieties of oats failed to produce a crop on the Pratt field in 1933, and all yields were low in 1932.

Corn was almost a complete failure on all fields in 1933, regardless of soil treatment or method of production. All varieties of corn tested in 1932, except Colby Yellowcap, yielded more when spaced 26 inches apart than when spaced

13 inches. The average yield for the eight varieties on the three fields was 12.2 bushels per acre for the close planting and 19.4 bushels per acre for the thin planting.

Yields of grain sorghums were not influenced by the use of manure, but the yields were influenced by the crop sequence. Planting sorghums with the furrow opener on fall-listed or plowed land was superior to planting with the lister on early-spring-disked land at the Wichita field in 1933. Kafir planted May 23 yielded 27.4 bushels per acre (average of two varieties and three methods of planting), while that planted May 3 yielded 20.1 bushels per acre. Kansas Orange and Atlas have proved to be the outstanding sweet sorghum varieties for this section. The two-year average yields from the Wichita and Kingman fields, have been Atlas, 24 bushels of grain and 4.5 tons of stover, and Kansas Orange, 22 bushels of grain and 5.4 tons of stover.

Flax yields were satisfactory on all fields in 1932, but were low at the Wichita field and a failure at the other fields in 1933. Linota was the highest yielding variety, and the 40-pound rate of seeding gave better results than either the 30- or 60-pound rates. At the Wichita field the Linota, Southwestern, and Bison varieties produced average yields for the two years of 7.8, 7, and 7 bushels per acre, respectively.

Satisfactory stands of alfalfa were secured on all fields, but the yields were low, and were determined by the available moisture and not by variety or soil treatment.

Applications of lime materially increased the yield and quality of sweet-clover hay at the Kingman field. Nodules were not formed on sweet-clover roots at Kingman when lime was not added.

[Department of Agronomy. Leaders, R. I. Throckmorton and C. E. Crews; state fund.]

Northest Kansas Experiment Fields.—The experiment fields in northeastern Kansas were established in 1932. During the biennium three acres were added to the Newman potato field so that potato-scab investigations could be included. A new field was established at Wathena on land owned by the Wathena rural high-school district. It consists of three acres and is being used for strawberry, red raspberry, and black raspberry investigations.

The work on the other fields has been continued according to the original outline as noted in the sixth biennial report of the director.

Less color was noted on Jonathan, Winesap and Delicious apples when ammonium sulfate was applied than when no fertilizer was used. Trees receiving ammonium sulfate yielded slightly larger apples than those to which no fertilizer was applied. Trees growing in bluegrass sod make less girth increase each year than those growing with winter vetch or under a straw mulch. Ammonium sulfate applied to trees growing in bluegrass sod increased growth as measured by increase in the circumference of the trunks.

Apple scab studies have shown the importance of watching weather conditions to determine the number of fungicidal sprays to apply to apple trees. In rainy seasons adequate scab control can be secured only by frequent spray applications. In 1932 one additional lime-sulfur spray increased the percentage of U. S. No. 1 Winesap apples from 33.4 per cent to 62.8 per cent; and on Delicious an additional lime-sulfur spray gave 64.3 per cent U. S. No. 1 compared to 40.1 per cent where the spray was omitted.

In the Atchison orchard trees intercropped with corn are growing into a more desirable shape than those intercropped with red clover, vetch or cow-peas. This may be due to the protection from wind that the corn affords the young trees during the summer.

Crop and soil studies at the McLouth field have shown that increased yields of alfalfa were obtained whenever lime, manure and superphosphate were applied to the soil previous to seeding. If any one of the three materials was omitted the yields were not satisfactory. Superphosphate applied in the row to oats and wheat increased the yields of these crops.

Variety tests of wheat, corn, soybeans, alfalfa, oats, sorghum and various

grasses were included in the investigations at the McLouth field. Brome and orchard grass are promising grasses for this soil type in this section. Korean lespedeza is well adapted. Kentucky bluegrass made a much thicker turf the first season when superphosphate was applied previous to seeding.

Experiments at the Newman field have shown that size of seed piece influences the yield of potatoes. A potato seed piece weighing one ounce gave the greatest return above seed cost the past two years. The yield of potatoes was greatest when the seed piece was planted 4 inches deep, compared with 2 or 6 inches. Straw applied as a mulch to potatoes immediately after planting reduced the yield 48 per cent, compared with potatoes grown where no straw was applied.

The potato-disease investigations of the Newman field are reported under Project 130 (Department of Botany). The apple curculio, strawberry insects and codling-moth investigations at the Blair and Wathena fields are reported under Project 13 (Department of Entomology).

[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 fund.]

INVESTIGATIONS IN THE PLANT INDUSTRIES

The efficient production of crops continues to be one of the important problems of Kansas agriculture. Investigations in the production and improvement of plants continued to be an important part of the work of the Agricultural Experiment Station during the past biennium. Brief descriptions of the work done are given in the following pages.

Temperature Relations of Crop Plants.—The investigations have dealt principally with cold resistance of winter cereals during the fall and early spring.

The evidence indicates that wheat plants are capable of attaining their greatest resistance to cold after a fall growing period of about two months. Plants that were considerably older or younger at the beginning of winter apparently did not acquire so much resistance to cold during the hardening changes. Hardened cereals that were subjected to conditions favorable for growth by moving them into the greenhouse during the winter, lost hardiness rapidly during the first three days, as was shown by artificial refrigeration, and then more slowly, until after 15 days they possessed little, if any, more resistance to cold than plants grown continuously in warm conditions. Wheat and rye lost hardiness more rapidly than oats and barley. A marked reduction in the solids in the expressed juice occurred during the first day that hardened plants were in the greenhouse, probably because of the increased rate of respiration. The moisture content of the plants increased slowly the first day and then more rapidly, reaching the maximum after about six days. The expressed juice increased with moisture and continued to increase three days longer. These data indicated that a part of the increase in expressed juice was probably due to colloidal conditions resulting in changes in the relative amounts of bound and free water.

[Project 157; Department of Agronomy. Leader, H. H. Laude; Purnell fund.]

Small Grain and Sorghum Improvement.—This project is in cooperation with the Division of Cereal Crops and Diseases, of the Bureau of Plant Industry, United States Department of Agriculture. The Departments of Botany, Entomology, and Milling Industry

also coöperated in testing new varieties of cereals for resistance to diseases and insects, and in determining the quality of new wheats.

Winter Wheat Breeding.—Distinct progress was made in wheat improvement during the biennium. Tenmarq is now established as a standard variety on farms in south central Kansas, where it is well adapted. Kawvale is proving satisfactory in southeast Kansas, in the Kaw river valley, and is spreading into northeast Kansas, where it is superior to Harvest Queen in yield, and has the distinct advantages of resistance to flag smut, leaf rust and Hessian fly.

Quivira, an early ripening selection from a cross between Prelude spring wheat and Kanred winter wheat, continued to yield well in nursery and plot experiments at Manhattan. More information is needed on the quality of Quivira before reaching a decision as to its increase and distribution to farmers.

Three selections, Kansas Nos. 2671, 2672, and 2673, from the cross Kanred × Hard Federation, appear promising as combine types, because of their short, stiff straw, earliness and high yields. More information is needed on the winter hardiness and quality of these three selections before any one of them is named or increased for distribution.

Selections from several new wheat crosses appear promising. Among these are crosses of Tenmarq on Kawvale to combine the leaf rust resistance of Kawvale with the desirable characters of Tenmarq; (2) Oro X Tenmarq, to combine the bunt resistance and winter hardiness of Oro with the good features of Tenmarq; (3) Cheyenne + Tenmarq, to combine the shorter straw and greater winter hardiness of Cheyenne with the high yield and superior quality of Tenmarq, and (4) Early Blackhull + Tenmarq, to combine the earliness of Early Blackhull with the stiffer straw and much better quality of Tenmarq.

Oats Breeding.—Chief emphasis in oats improvement has been placed on the crosses of Kanota and Fulghum on Markton, in an effort to produce a new variety with the smut resistance of Markton and the earliness, high yield, high-test weight, and Kansas adaptation of Kanota. Three-year average nursery yields (1931-1933) of four selections of Fulghum X Markton, in comparison with Kanota, were as follows:

<i>Hybrid Sel. No.</i>	<i>Bus. Per acre</i>
303635	70.7
303647	67.7
303531	64.9
303649	63.6
Kanota	59.0

Hybrid Sel. No. 303647 was advanced to field plot tests at the Agronomy Farm. Kanota also was crossed with such rust-resistant varieties as Victoria and Bond to produce new varieties resistant to crown rust, and with Trojan, an early, stiff-straw selection of Burt, to produce a new variety with stiffer straw than Kanota.

Barley Breeding.—Nursery and plot tests at Hays and Colby have shown that Flynn is an early, rather high-yielding variety of barley with smooth awns. Flynn was developed by the United States Department of Agriculture from the cross Lion X Club Mariout. Seed of this variety is now being increased at Hays and Colby for distribution to farmers. Vaughn barley has very stiff straw, but more information is needed on its yielding capacity. Crosses have been made between Flynn and Vaughn and the common six-row or Stavropol barley of Kansas, to produce new varieties having the earliness and smooth awns of Flynn, the stiff straw of Vaughn and the high yield and Kansas adaptation of Stavropol.

Sorghum Breeding.—Atlas continued to be popular in eastern Kansas, but an earlier type is needed. A selection from the cross Atlas X Sunrise appears promising. Selections from the cross Atlas X Early Sumac, which combine the white seed of Atlas with the earliness of Early Sumac, appear promising for western Kansas.

About 130 F₃ rows of the cross Spur Feterita X Blackhull kafir were grown

in the sorghum breeding nursery at Manhattan in 1933. This cross was made to combine the resistance to kernel smut of the feterita parent with the juicy stalks and the other desirable characters of the kafir parent. There were 14 smut-free rows and a few of these appear promising in other respects. A selection of kafir X milo, No. 27318, which had appeared superior to Wheatland in nursery tests at Manhattan, is now being grown in plots and in the five-acre combine test at Hays. Crosses between Darso and Dawn and Western Blackhull and Club appear promising in nursery rows at Manhattan, Hays, and Darlow. These crosses were made to produced new types which will combine the smut resistance and high-yielding capacity of Darso with the white seed of the kafir parents.

A new variety of grain sorghum bred at the Tribune Branch station has been named Greeley, and increased and approved for distribution to farmers in the Tribune area. This new variety combines the earliness of its Freed sorghum parent with the desirable head type and stronger stalks of its Pink kafir parent.

[Project 67; Department of Agronomy. Leader, John H. Parker; Hatch fund.]

Inheritance of Factors Affecting Quality in Wheat.—Studies of quality factors were made of samples of winter wheat varieties, selections and crosses grown in the agronomy nursery rows and field plots at Manhattan, in plots at the Hays branch station, and in cooperative wheat variety tests on farms. These studies included protein determinations and milling and baking tests. Most samples of winter wheat grown in the dry, unfavorable season of 1933 were low in test weight and not typical of the variety under more favorable conditions. For this reason the number of protein determinations and of milling and baking tests from the wheat-breeding nursery was smaller than usual.

Protein Determination.—The protein content of grain of 12 strains grown in the United States Department of Agriculture uniform-yield nursery at Manhattan in 1933 ranged from 16.6 per cent and 16.7 per cent for two selections of Kanred X Hard Federation (Kansas Nos. 2673 and 2671) to 19.16 per cent for Kharkov. Test weights were 53.4 and 54.5 pounds for the early maturing selections of Kanred + Hard Federation, and only 49.6 pounds for the much later ripening Kharkov. The following data on Early Blackhull and Blackhull are of particular interest:

	<i>Date first head</i>	<i>Bushels per acre</i>	<i>Test weight, pounds</i>	<i>Protein per- centage</i>
Early Blackhull	May 11	25.0	57.1	17.25
Blackhull	May 18	23.7	53.4	18.15

Protein determinations were made on 72 samples of grain of winter wheats grown in replicated rod rows of the 1933 nursery. The protein percentages were high, and range from 17.0 for Kanred X Hard Federation (Sel. No. 306353) to 20.1 for two selections of Marquis X Kanred and one of Kanred X Kawvale. The average protein content of grain produced by 12 selections of Kanred X Hard Federation was 17.7 per cent. Selections of this cross, which are early, and which in general have high yields and heavy test weights, tended to be low in protein. The average protein content of grain from 10 Turkey checks was 18.4 per cent, and of 10 Tenmarq cheeks, 18.6 per cent.

Protein determinations were made on 68 grain samples of winter wheats grown in the three-row eight-foot plots in the 1933 nursery. Protein percentages range from 16.3 for a selection of Improved Turkey X Denton and one of Kanred X Hard Federation, to 20.2 and 20.5 for two selections of the back-cross, Kanred X Tenmarq. The average protein content of grain of 14

selections of Kanred X Hard Federation grown in this section of the nursery was 17.6 per cent, which was lower than for the Marquis crosses.

Milling and Baking Tests of Nursery Wheats.—Because of the dry and unfavorable growing season of 1933, yields and test weights of winter wheats grown in the agronomy nursery were low. Adequate grain for milling and baking tests was available from only 12 strains of sufficient importance to justify these tests. In these milling and baking tests, which were made on samples bulked from several rows of the same cross, Tenmarq held its usual high place in loaf volume and texture. The selections of Kanred X Hard Federation had lower protein in the wheat than any other strains, and were not equal to Tenmarq in loaf-volume or texture. The flour of the Kanred X Hard Federation selections had lower ash than any other strain tested. In milling and baking characteristics, Kawvale resembles the hard red winter more than the soft red winter wheats.

Coöperative Baking Tests of Quivira and Tenmarq.—Because of the potential value of Quivira as an early variety of hard red winter wheat, and because of the fact that previous tests had shown that unbleached flour of this variety was yellow, arrangements for coöperative baking tests were made with 17 federal, state, and commercial laboratories. It was planned to use Turkey as the check or control variety, but the grain of Turkey grown at the agronomy farm in 1933 was so poor that it could not be used, and Tenmarq was substituted for Turkey. A six-bushel sample of each variety was milled in the college mill and sample of flour sent to each collaborator. The findings of the 17 coöperating cereal chemists have been summarized and copies of this summary are on file in the Departments of Milling Industry and Agronomy. Quivira consistently made a poorer showing in these tests than Tenmarq.

Wheat Meal Time Fermentation Tests.—Samples of 50 strains of winter wheat grown in the nursery in 1932 were furnished to Dr. Paul Pelschenke, of the University of Halle, Germany, for testing of gluten strength according to his method; that is, time for doughballs to break. The minutes from the time the doughballs were placed in water in beakers to the time they began to disintegrate ranged from 189 for Tenmarq, a variety known to have gluten of excellent quality, to 27 for P 1066 X Burbank, a hybrid selection of questionable quality as a bread wheat. In general, the results of the doughball or wheat-meal time fermentation test were in fairly good agreement with the known "strength" of these wheats as determined in baking tests at Manhattan and in other laboratories. Most of the varieties with "minutes to break" less than 50 were soft to semihard wheats such as Clarkan, Lutescens from Russia, Harvest Queen, Currell, Fulcaster, and Minturki. The Pelschenke method has given interesting and apparently significant results, and may be useful in determining the gluten strength of hybrid wheats in the F_3 to F_5 generations, before there is sufficient grain available for even small-scale experimental milling and baking tests.

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

Varietal Tests of Small Grains and Sorghums.—The work in this project during the past biennium consisted of variety testing and adaptation studies of wheat, oats, barley, spring wheat, flax and sorghum; of tests to study the response of several varieties of wheat to seeding at different times during September and October; and of studies relative to certain stalk characters of sorghum.

Several recently introduced varieties of wheat made higher yields during the last two years than Kanred, Turkey, or Blackhull. Cheyenne averaged 4 bushels, and Quivira 2 bushels, higher than Blackhull. During the last 23 years Kanred outyielded Turkey an average of 2.2 bushels. Since Blackhull was included in the tests 15 years ago it has outyielded Kanred by 1.5 bushels. Tenmarq, which has been included 10 years, has outyielded Blackhull 2.7

bushels, and Cheyenne, included four years, has outyielded Tenmarq 2.8 bushels. In general the early maturing varieties tested were well adapted and made good yields in the last two years. Among the soft wheats, Kawvale outyielded Fulcaster and Harvest Queen in each of the last two years. The average yield of Kawvale for eight years is 1 bushel higher than Fulcaster and 7 bushels higher than Harvest Queen.

A smut-resistant variety of oats developed from a cross of Fulghum X Markton made nearly the same yield last year as Kanota, which outyielded the other varieties as it has done consistently for 17 years.

The spring and summer of 1932 were especially favorable for flax, resulting in yields as high as 21.5 bushels by Linota. This variety has made the highest average yield over a period of four years. Dry weather in 1933, accompanied by high temperature, caused unusually low yields of from 3.8 to 5 bushels per acre for the four varieties of flax.

Atlas and Kansas Orange were superior to other varieties of sorghum tested for yield of forage in both years of the biennium, and averaged 9.1 and 9.8 tons of cured stover per acre. In each season Kansas Orange outyielded Atlas about three-fourths of a ton. Kansas Orange lodged 37 per cent in 1933, compared with 2 per cent for Atlas. An early-maturing selection from the cross Atlas X Sunrise grew slightly taller, produced about the same yield of Stover and ripened at about the same time as Early Sumac.

Club, Ajax, and H. C. 312 [Dwarf feterita X (kafir X milo)], new grain sorghums, ranked high in the few seasons they have been tested. Club averaged 6 bushels more grain than Blackhull in the four years it has been grown.

The experiments on time of seeding wheat showed that early-sown wheat, because of rapid growth during the fall, may deplete the soil nitrates and thus cause nitrate deficiency during the spring when a relatively large amount is needed for high yield and high quality. During the period of fall growth early-sown wheat seemed to advance beyond the stage in its life cycle at which it can acquire the maximum resistance to cold, and consequently was more susceptible to winter injury than when sown somewhat later.

Ten varieties of sorghum were studied for differences in moisture content, juiciness and sweetness of the stalks. Moisture content, as determined from oven-dried samples, and juiciness were not correlated, as is indicated by the fact that Red kafir, Club, Atlas, and Grohoma, which contained the most moisture, ranked seven, three, two, and eight, respectively, in expressed juice. Likewise, Wonder, Kansas Orange, Darso and Ajax, which were the four lowest among the ten varieties in moisture content, ranked ten, one, four, and nine in expressed juice. The sorgos and Darso were high in sugar content. Ajax and Red kafir contained less sugar than the other varieties and considerably less than Blackhull kafir.

Tests of field material showed a high correlation between the refractive index of sorghum juice and its total sugar content. Thus it seems that the refractometer affords a simple and rapid method of estimating relative sweetness in sorghums.

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

Variety and Cultural Tests of Soybeans.—During the last biennium 13 varieties and 79 selections of soybeans have been tested for yield of hay and seed. In addition to this number, 71 recently imported varieties were grown in 1933. Cultural tests included method and rate of planting and growing in mixture with Sudan grass. A study of the effect of time of planting upon lodging was also made.

The varieties which produced the highest average yields of seed in bushels per acre in 1932 and 1933 were I. P. No. 6, 21.7; Austin 21.1; A. K., 20.9; No. 125 selection, 20.7, and Hongkong, 20.5. In hay production, Laredo. Chiquita,

Peking, Hongkong, and I. P. No. 6 ranked in the order named, with yields ranging from 2.33 tons to 1.98 tons per acre. The selection designated as I. P. No. 6 was made from a field of A.K. and has shown some advantage over the parent variety in being less subject to lodging. A few seeds of each of 71 varieties were received from the United States Department of Agriculture. These were collected by Mr. W. J. Morse on his recent trip to the Orient. Some of these varieties are heavy seed producers and are worthy of further testing.

Six rates of planting in close drills with a grain drill, and four rates in wide-spaced rows with a corn planter, have been used. From 46 to 116 pounds of seed were planted with a grain drill, and yields of both hay and seed determined. There was no consistent difference in yield of either hay or seed with seeding rates of 58, 70, 86, 102, and 116 pounds. The hay from the higher seeding rates was of better quality, with fewer weeds and finer stems. In rows spaced 38 inches apart there was no consistent difference in yield of either hay or seed from rates of 19, 26, and 32 pounds of seed per acre.

The close-drilled plots planted with a grain drill have produced significantly higher yields of both seed and hay than the plots planted in wide-spaced rows and cultivated. These results were obtained on land relatively free from weeds and with the best possible soil preparation. In addition, some weeds were removed by hand from the close-drilled plots. Consideration should be given these facts before recommending planting with a grain drill as a general farm practice in growing soybeans.

A moisture of soybeans and Sudan grass for forage was not satisfactory, chiefly because the Sudan became fully ripe before the soybeans were ready to cut for hay. In addition to obtaining a poor quality of hay from the Sudan because of overmaturity, the yield and leafiness of the soybeans were reduced by competition and shading.

Laredo soybeans planted June 10 showed only 40 per cent lodging, while those planted June 1 lodged 95 per cent. Plots planted later than June 10 also gave a higher per cent of lodged plants than those planted June 10. The optimum time for planting to escape lodging will probably vary from year to year, but it is believed that the optimum date of plantings for Laredo will be somewhat later than June 1.

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

Miscellaneous Legumes for Forage.—The work under this project for the last biennium consisted of plot tests of 36 varieties and strains of sweet clover, single- and triple-row plantings of 26 varieties, one-fourth acre plots of 11 varieties for pasture tests, and plantings for seed increase of the most promising varieties. In addition to the sweet-clover work, 16 species and varieties of miscellaneous legumes were grown in small nursery plots. These consisted of six varieties and species of vetch, five species of *Crotalaria*, three of *Trifolium*, and one each of Austrian winter pea, *Sesbania*, and Florida beggarweed.

At least three strains of yellow-blossom and one of white-blossom sweet clover appear to be superior to the varieties now commercially grown in Kansas. Characteristics in favor of these varieties are high yield, leafiness, relatively less coarseness and woodiness of stems than the common white-blossom variety, and more vigorous growth soon after germination, thus enabling them to compete more successfully with weeds in the first season after planting. The most promising varieties are also dependable seed producers. The pasture tests now in progress indicate that those varieties which are most promising in other respects will give highly satisfactory results for pasture, both from the standpoint of palatability and carrying capacity.

Only three of the seven species of vetch made satisfactory growth. The

hairy and wooly pod varieties were about equal in productiveness, both being slightly superior to smooth vetch. Hungarian vetch winterkilled badly in both seasons, while the Austrian winter pea was entirely destroyed by low temperatures. None of the three species of spring vetch grown appeared to give any promise in this section. Of the five species of *Crotalaria* the *C. incana* and *C. grantiana* produced 6,778 and 9,271 pounds, respectively, of air-dry material per acre. This indicates that these species may be valuable for green manure in this section. *Sesbania* planted July 3 produced 4,602 pounds of air-dry material and may be of value as a green-manure crop following a potato crop in the Kaw valley.

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

Corn Production and Improvement.—This project, conducted in coöperation with the Division of Cereal Crops and Diseases, Bureau of Plant Industry, United States Department of Agriculture, has been continued during the last biennium along lines similar to those followed previously. The main phases of work included: cultural experiments and variety tests; production of superior field-corn hybrids from selfed lines; production of an open-pollinated yellow variety similar to Pride of Saline; improvement of pop corn by mass selection, ear-to-row selection, and selection within inbred lines; studies of the possibilities of breeding for insect resistance in corn; and physiological studies with corn.

In the cultural experiments the hot and dry July of 1932 gave an unusual advantage to the late dates of planting. In 1933 all yields were low, with no definite influence of date of planting apparent. In 1932 surface planting produced considerably better yields than listing, whereas in 1933 the listed plots yielded more than twice as much as those surface planted. In both years, 24-inch spacing gave the highest yields with Pride of Saline in 42-inch rows. In these experiments the average results for a period of years are the only safe basis for recommendations, as the seasonal variation is so great that results of individual years mean but little.

Although the seasons of 1932 and 1933 were both unfavorable for the production of hybrid seed and the adequate testing of hybrids, some of the combinations made creditable showings. Late hybrids were represented largely by a series of double crosses and three-way crosses tested for the first time in 1932, and the better ones repeated in 1933. Some of these appeared promising and are being increased in a detasseled crossing block for wide coöperative trials next year. Early hybrids were represented largely by a group of double crosses and three-way crosses tested for the first time in 1933. These were planted in a uniform series of plantings at Manhattan and Colby, Kan., and North Platte, Neb. Considerable differential adaptation was indicated in the results, but in general the highest-yielding crosses at North Platte and at Manhattan usually were not so good at Colby, and the best crosses at Colby were not among the best at the other two fields. The most promising hybrids are being tested again at Colby and Manhattan in 1934.

The new open pollinated yellow variety, Yellow Selection No. 1, was increased in 1932 in Anderson county, Kansas, and near Golden City, Mo., and was tested for the first time in 1933. At Manhattan it averaged 13.9 bushels per acre in comparison with 15.1 bushels per acre for the agronomy farm strain of Pride of Saline. In the coöperative tests with farmers it averaged highest in yield of all yellow varieties in northeastern, north central, and southwestern Kansas, and was exceeded only by one strain of Midland by 1.5 bushels in southeastern Kansas.

Mass selection and ear-to-row selection for popping expansion in pop corn were continued. Apparently the limit of improvement by this method is being

approached, as changes from year to year are now relatively small and unimportant. Some of the pop corn hybrids tested during the last two years have given good yields, considering the seasons, but extremely high, consistent popping expansion in an agronomically satisfactory hybrid has not as yet shown up. Some promising new pop corn inbreds have appeared and were represented in the crossing block for the first time in 1933.

Studies in cooperation with the Department of Entomology on the possibilities of breeding for insect resistance in corn are reported more fully in Project 164 (Department of Entomology). Mass selection for little ear-worm injury and for bad ear-worm injury in Pride of Saline was started in 1932 and continued in 1933. A slight advantage for the worm-free selection was noted in 1933. Comparative tests under conditions of chinch bug infestation indicate that there is a genetic basis for some resistance to or tolerance for chinch bugs in corn, although the differences are not so pronounced as in sorghums. In general, varieties from chinch bug areas seemed to have developed a certain degree of tolerance in comparison with varieties native to northern regions.

In cooperation with the Department of Botany an experiment was conducted in 1933 to study the relative photosynthetic efficiency of upper and lower leaves. Various defoliation treatments indicated that leaves above the ear were two to four times as efficient as an equal area of leaves below the ear as measured by the production of grain.

[Project 1563; Department of Agronomy. Leader, A. M. Brunson; Purnell fund.]

Alfalfa Investigations in Relation to Winter Hardiness and Bacterial Wilt.—This study was in cooperation with the Division of Forage Crops and Diseases, Bureau of Plant Industry, United States Department of Agriculture. The work during the past biennium was continued along the lines previously reported.

Crop Sequence in Relation to Bacterial Wilt.—Because of the dry weather of the past few years no information was gained on the relation of bacterial wilt to the crop rotation and the different periods of fallow followed in this experiment. The deep subsoil moisture samples taken on the fallowed plots showed that four years of continuous fallow replaced the subsoil moisture removed by previous growth of alfalfa. A system of cultivation was used on this experiment, the results of which indicate that by cultivation weeds may be kept out of alfalfa. A new problem that has developed is the deleterious effect of long periods of fallow on the growth of alfalfa seedlings. The alfalfa seedlings growing on ground fallowed three years did not grow well, and on the four-year fallow plots the seedlings died, causing a poor stand. Tests in the greenhouse with this soil showed that the trouble could be eliminated by sterilization.

Variety Tests of Alfalfa.—Starting in 1927 a series of square-rod variety plots was seeded each year for five years. Last fall the 1927 and 1928 seedings were plowed out because of thin stands. A summary of the data for five years show the following varieties to be outstanding in their ability to maintain stands: Dakota No. 12, Ladak, Turkestan 2674, and Cossack 2671.

A series of larger variety plots was seeded in 1930. Three years of yield and stand data are now available. These data show the following varieties to be outstanding in yield and stand: Kansas 308, Ladak, and Turkestans 86696, 19300, 19301, and 19302. On the bottom-land test the above-named varieties have maintained the best stands because of their resistance to bacterial wilt. On the upland test the differences in stand were not so marked, probably due to the dry weather of the past few years retarding bacterial-wilt development. A serious infestation of pea aphids occurred in the spring of 1934, and by taking sweepings it was indicated that this insect was not injuring the Ladak or most of the Turkestans, while all other varieties were being seriously damaged.

Hay moisture samples were taken from the bottom-land plots. These data

tended to show that the Turkestan alfalfas were low in comparative green-weight yields, but were relatively higher in the air-dry and oven-dry weights.

Selection and Breeding Alfalfa.—This experiment included 1,344 rod rows of different strains and varieties of alfalfa recently imported from other countries, and alfalfa selections which have been selfed and are now in the second and third generations. From these selections a few good lines are showing homozygous characters for wilt and cold resistance and appear to be a type of plant that will make a good yield of high-quality hay.

Studies of root reserves in relation to time of fall cutting, winter injury, and wilt resistance in alfalfa were completed in the fall of 1933 and the results are being published in two papers, "The Effect of Time of Cutting and of Winter Protection on the Reduction of Stands in Kansas Common, Grimm, and Turkestan Alfalfas," and "The Trend of Organic Food Reserves in Alfalfa Roots as Affected by Cutting Treatments."

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

Pasture Improvement Investigations.—Seven phases of this project have been actively conducted during the past biennium.

1. *Management of Live Stock on Native Bluestem Pastures.*—In this experiment modified deferred grazing was compared to season-long grazing. Four pastures were used in the experiment. Pasture 1 was grazed moderately during the entire season. Grazing in pasture 2 was deferred until the latter part of June. Pasture 3 was rather heavily grazed during the entire season, and pasture 4 was grazed rather heavily the first part and protected the latter part of the season.

Growing conditions were unfavorable during the past biennium, owing to the dry, hot weather. Deferred grazing during the first part of the season resulted in the highest grazing capacity and gain per acre, compared with protection during the latter part, of the grazing season or grazing the pasture moderately or heavily during the entire season. There was an improvement in the desirable forage species in pastures 2 and 4. In pasture 1, which was grazed moderately during the entire season, there was an increase in buck brush, and in pasture 3, which was grazed rather heavily during the entire season, there was an increase in Buffalo grass. Kentucky bluegrass increased in pastures 1 and 2.

2. *Effect of Burning of Bluestem Pasture Lands.*—In the burning experiments two types of bluestem pasture land, high prairie and mixed prairie, were burned at four periods as follows: (1) late fall, (2) early spring, (3) medium spring, and (4) late spring.

Burning each year caused a decrease in the total yield of vegetation, which on the high prairie ranged from 4 per cent for burning in the late spring to nearly 50 per cent from burning in the late fall. Burning had little effect in controlling weeds and brush unless done in the spring after April 20. The effectiveness of killing weeds was associated with the organic food reserves in the plants. The bluestem grasses were more leafy in the burned areas during the first part of the growing season. This, combined with the absence of dry grass, made the forage on the burned areas more palatable to live stock.

The moisture content of the soil on the burned areas was slightly lower than on the unburned. The plant population was greater on the plots burned in the late fall and least on those burned in the late spring. There was little successional change in the vegetation burned in the early and medium spring. Burning in the late fall caused a gradual change to little bluestem, while late spring burning caused a slow succession to the coarser grasses, mainly big bluestem. Kentucky bluegrass was killed by continued annual burning.

Burning stimulated earlier growth in the spring, owing mainly to higher soil temperatures. This was effective until early in June, when soil moisture, rather than temperature, was the controlling factor in vegetative growth. None

of the burning treatments caused a decrease in the total carbon or nitrogen content of the soil. The study has shown that bluestem pastures in the vicinity of Manhattan should be burned sometime from about the middle of March to the middle of April. The burning should be done when the soil is moist, this being of greater importance than the time of burning.

3. *Eradication of Undesirable Plants from Pastures.*—Most of the work on this subproject during the past biennium was confined to checking the effects of previous cutting treatments on eradication of buck brush, sumac, and iron weed. New plots of iron weed were established, in which additional information can be obtained on the time of cutting for eradicating this weed. The data obtained substantiate the following previous conclusions relative to the eradication of these species: Buck brush can be completely eradicated in three annual cuttings made approximately May 10. Three annual cuttings about June 15 are sufficient to completely eradicate sumac and iron weed.

4. *Effect of the Frequency, Height, and Time of Harvesting on the Yield and Vigor of Pasture Vegetation.*—Experiments on the effects of clipping vegetation at different heights and frequencies were conducted on 11 plots in the mixed-prairie type of native grass land at the Casement pasture, and on 20 plots on the high-prairie type of native grass land at the animal husbandry pasture. The plots were cut at different heights, ranging from one to four inches and at intervals varying from two to six weeks, to imitate various intensities and systems of grazing. The data collected during the past biennium showed that the yield and density of the stand of prairie grasses was indirectly proportional to the frequency of clipping. Increasing the height of cutting compensated to a certain extent for the frequency of clipping. The grass on the plots clipped most frequently was the most palatable and nutritious, until the normal bluestem stand was materially replaced by weedy species. The clipping treatments were not as detrimental as would result from cropping the vegetation of similar height by grazing. The plots clipped most frequently in the mixed-prairie have decreased in density about two-thirds in seven years. In the high prairie the decrease was not so pronounced, owing to a succession to short grasses, mainly black grama. In the plots clipped most frequently in the high prairie, there was a great decrease in little bluestem and a slight increase in side oat grama and sedges. In the high prairie the plots given the most severe treatment have had a successional change to black grama and a great decrease in big and little bluestem, particularly the latter, which is the dominant species in the upland grass land formation.

5. *Effect of Fertilizers on the Yield, Quantity, and Succession of Pasture Vegetation.*—During the past two years studies were continued on the effect of fertilizer applications on two types of native grass land and on one tame pasture. The fertilizer experiments on the tame pasture were discontinued in 1932 and on the mixed-prairie type of bluestem pasture at the end of the season of 1933. The experiments were discontinued on these two areas owing to the rapid incoming of weeds on the plots receiving heavy application of nitrogenous fertilizers and manure.

The greatest response was obtained from the applications of manure and nitrogenous fertilizers. The increase in yield from the application of 6 tons of manure in alternate years ranged from 50 per cent in the tame pasture to 80 per cent on the high-prairie type of bluestem pasture. Sodium nitrate, applied at the rate of 200 pounds an acre yearly, increased the yields of the tame pasture about 20 per cent, the mixed bluestem pasture 25 per cent, and the high-prairie type of bluestem pasture 35 per cent. Where 100 pounds of sodium nitrate were applied the yields were about 8 per cent less than where double this amount was applied. Only slight increases were obtained from the application of superphosphate and none from lime or potash.

The analyses of samples of grass collected May 21, 1932, from the animal husbandry native pasture (high prairie type of prairie grass land) showed significant increases in protein on the plots receiving 200 pounds of sodium nitrate and manure. The differences in the analyses of the samples from the other treatments were not enough to have any significance.

The plots on which 200 pounds of sodium nitrate were applied were more palatable to the live stock. Each year these have been more closely grazed. The grazed fertilizer plots showed little difference in the plant succession, but the protected plots on which manure and heavy applications of sodium nitrate were applied contained a greater percentage of weeds than the plots in any of the other treatments. These treatments have also made a slight increase in the density of the vegetation.

6. *Pasture and Forage Crop Nursery.*—Experiments on this subproject were continued under the following subjects: (1) production of various tame grasses singly and in mixtures with legumes; (2) testing the adaptability and possible uses of various exotic grasses that are received mainly through the Division of Forage Crops and Diseases, of the Bureau of Plant Industry; (3) selection and breeding of native grasses to increase their production of seed; (4) experiments with lespedezas; and (5) reseeding work with tame forage plants in overgrazed pastures in southeastern Kansas.

In the production of tame grasses the highest yield for a seven-year period has been obtained from brome grass and orchard grass, the average annual yield of each having been approximately 3,700 pounds. A mixture of brome, orchard, and alfalfa made an average yield of 7,000 pounds per year for the seven years. The alfalfa appeared to stimulate the growth of the grasses, as well as materially adding to the production of forage.

Of the foreign grasses about five appear to be promising for use in Kansas. These are *Spodiopogon sibiricum* and *Spodiopogon cotulifer*; *Agropyron semicutalum*, *Bromus polyanthus*, *Andropogon intermedium caucasicum*, and *Osterdamia japonica*. The first two, which came from Chosen, Korea, have the appearance of perennial Sudan grass. Seed was saved from all the promising plants to increase the size of the plots, to test their value for grazing, and, if palatable to live stock, to grow seed for distribution.

The investigations with native grasses were conducted at Manhattan and at Garden City. A large quantity of heads was examined from the selected strains at Manhattan and Garden City and of unselected seed of big bluestem growing on bottom land at the agronomy farm to determine the percentage of glumes containing mature seeds. The seed at Garden City was grown under irrigation and the yield obtained was sufficient to make it feasible to produce seed commercially. Cytological work with the two bluestem grasses has shown that fertilization is largely dependent on humidity and temperature. A high percentage of seed is set on humid, rather cool days, and a small percentage on dry, hot days.

The experiments with lespedeza were confined mainly to four native and one cultivated perennial species. The native species include *capitata*, *virginica*, *stuvei*, and *repens*. The cultivated species was *sericea*. These have been grown in rows of different spacing and broadcast to obtain information on yield and leafiness under the different methods of planting. Table I records the leafiness under different methods of planting of all these varieties except *stuvei*.

TABLE I.—PERCENTAGE LEAFLINES OF LESPEDEZAS

SPECIES.	Broad- cast.	4-inch rows.	18-inch rows.
Capitata.....	75.0	72.7	69.3
Virginia.....	79.8	77.8	77.4
Repens.....		82.6	77.9
Sericea.....		60.4	56.2

7. *Coöperative Grazing Experiments.*—The coöperative experiments during the past biennium were confined to investigations on the improvement of overgrazed pastures in southeastern Kansas and the effect of grazing on runoff.

The latter was conducted coöperatively with the Bureau of Chemistry and Soils on the Philip Ranch at Hays, Kan.

In the pasture-improvement investigations, 14 experimental areas were established in the nine southeastern Kansas counties. In these experimental plots, Korean lespedeza, meadow fescue, orchard grass, and Kentucky bluegrass were seeded under different tillage methods and different fertilizer treatments. The results show that a good stand of Korean lespedeza can be obtained without any soil treatment, although double disking and the application of phosphate fertilizer increased the stand and yield of forage. On most of the experiments a good stand of orchard grass and meadow fescue was obtained by double disking and harrowing after seeding. None of the seed of the grasses germinated where the soil was not disked.

In the grazing erosion studies, four one-half acre plots were grazed by sheep. In two of these plots little bluestem was the dominant grass, and two were covered mainly with buffalo grass. One of each of these was heavily grazed and the other two moderately grazed. In the following table is recorded the percentage runoff and amount of soil removed from the plots:

<i>Plot and treatment</i>	<i>Per cent runoff</i>	<i>Erosion—tons per acre</i>
Buffalo—moderately grazed	0.43	0.0045
Buffalo—heavily grazed	1.71	0.0480
Little bluestem—moderately grazed	0.20	0.0006
Little bluestem—heavily grazed	1.09	0.0250

[Project 96; Department of Agronomy. Leader, A. E. Aldous; Purnell fund.]

Weed Eradication.—The work on this project for the past two years has had the following objectives: (1) To determine the influence of early cultivation and the removal of weeds upon the effectiveness of applications of sodium chlorate spray in comparison with treatment of undisturbed areas; (2) to compare the effectiveness of equal amounts of sodium chlorate applied in one, two, and in three treatments; (3) to determine the value of certain recently advertised or new chemical preparations in comparison with sodium chlorate; (4) to study the value of sodium chlorate in the control of Russian knapweed; and (5) to determine the influence of partial fallow, mowing, time of spraying, and amount of solution used upon the effectiveness of sodium chlorate on Russian knapweed.

Results from these experiments indicate that plowing sod several months previous to treatment, cultivating in the spring to keep down weeds, and mowing prior to treatment did not add materially to the effectiveness of the applications of sodium chlorate spray. There were, however, certain advantages in these practices on account of the removal of competitive growth; namely, (1) convenience in locating the bindweed plants, (2) greater convenience in spraying, (3) more economical use of the chemical, and (4) better top growth of bindweed, particularly in dry periods.

There was little difference in the results obtained from two applications aggregating 300 pounds per acre and the same amount of material applied in three treatments in 1933. A single application of the same amount of material was decidedly inferior in its effectiveness. In 1932, when 400 pounds per acre were applied in two treatments and 350 pounds in three treatments, no conclusions could be drawn, since both methods killed all the plants on the plots treated. There are, therefore, comparative results available for only one year, and positive conclusions cannot be drawn.

Four commercial chemical preparations, namely, calcium chloron, ammonium sulfocyanate, sodium C₂ and calcium C₂, were used in tests with sodium chlorate as a check. The results showed that each of the four preparations is

decidedly inferior to sodium chlorate. The first, two named appear to be worthless for combatting bindweed.

Results of treating Russian knapweed with sodium chlorate show that the chemical is fully as effective in killing that weed as in combatting bindweed. Tests with one, two, and three applications, beginning at different stages of growth of the plant, indicate that three treatments beginning after the plant has reached the seed stage should be used. Mowing when the plants were well past bloom and spraying the second growth seemed about equally effective. Fallowing to weaken the plants until midsummer prior to beginning spray treatments in August and September did not give as satisfactory control as where the weeds were left to reach the seed stage undisturbed before beginning treatment.

[Project 166; Department of Agronomy. Leader, J. W. Zahnley ; state fund.]

Coöperative Experiments with Farmers.—This work during the biennium included 987 tests of the principal crops of the state. These tests were conducted in coöperation with farmers in 88 counties.

The variety tests of wheat were located mostly in the western two-thirds of the state, those of soybeans in the eastern one-third, and the corn and sorghum over the entire state. The fertility experiments were practically all located in the eastern one-third of the state.

A reduction in funds available for this work the second year of the biennium necessitated a curtailment in the work. Most of this reduction was made by dropping oats and flax variety tests and reducing the number of other tests.

During the biennium sweet clover fertility tests were established in which 300 pounds of lime per acre were drilled with the seed. Yields were secured in the fall of 1932 and spring of 1933. Potato fertility tests have been conducted since 1931 by the Departments of Agronomy and Horticulture in coöperation with the American Cyanamid Company. In 1933 this work was conducted as a part of the Coöperative Experiments.

Wheat Varieties.—Seven varieties of hard Wheat—Cheyenne, Kanred, Blackhull, Turkey, Tenmarq, Quivira [Prelude × Kanred (Kan. No. 2628, C. I. No. 8886)], and an early selection of Blackhull (Kan. No. 483, C.I.No. 8856)—were included in all tests in both years. The soft and semisoft wheats tested in eastern Kansas were Kawvale, Clarkan and Fulcaster. Tenmarq made the highest yield in 1932, but Kanred slightly outyielded Tenmarq in 1933 in south central Kansas. In 17 tests Tenmarq winterkilled 15.1 per cent and Kanred 8.2 per cent in 1933. This probably accounted for the fact that Tenmarq did not outyield Kanred in south central Kansas, as it had in previous years. Blackhull made the highest yield in north central Kansas in 1932, but the early selection of Blackhull made the highest yield in this section in 1933. The drouth and heat in June, 1933, did not affect the wheat in this section sufficiently early to greatly reduce the yield of this variety but it did reduce yields of the later-maturing varieties. Kawvale made the highest yield in the east central section, where the soft to semisoft wheats were included.

Barley Varieties.—In 1932 Trebi outyielded Flynn, Colby 6-row and Vaughn. Trebi is a comparatively late-maturing barley which, on that account, had an unusual advantage in 1932. All barley variety tests were failures in 1933.

Corn Varieties.—Pride of Saline continued to rank first or second in yield in corn variety tests in the eastern half of the state. Freed White made the highest yield in central and western Kansas in 1932, but Pride of Saline outyielded Freed White in 1933. Three commercial hybrids have been tested in sectional areas of the state for four years. The advantage shown by any of these hybrids has been so small that it cannot be used as a basis for recommending their use.

Midland Yellow Dent strains from Anderson, Coffey, Osage, and Lyon counties were tested in 1933. In the southeastern section of the state the Anderson county strain of Midland made the highest average yield in ten tests

Sorghum Varieties.—Some of the newer varieties of grain sorghums gave relatively high yields in several sections. C. I. No. 901, a selection from Dawn kafir made in 1926 at the Fort Hays Branch Experiment Station, made the highest yield in the grain sorghum tests in the southeastern section in 1932, but was outyielded by three varieties in 1933. C.I. No. 901 has made a high average yield in the north central section for four years. A strain of Red kafir from Meade county has made a high average yield in the southeastern section of the state, although it has been outyielded at various times by other varieties. This strain is now being selected for juicy stalks in preparation for distribution. Atlas has consistently outyielded Kansas Orange in 15 counties south of the Kaw river in eastern Kansas, but the reverse is true in other sections of the state.

Soybean Varieties.—A. K. continued to give the highest grain yield of all soybean varieties tested, but was outyielded in hay by Laredo and Hongkong, the latter by only a small margin.

Alfalfa Variety and Fertility Tests.—Ladak was included in only four tests, where it averaged significantly higher than Kansas Common and Grimm in 1933. The yield of Dakota Common was nearly one-fifth of a ton less than Kansas Common. Arizona Common was distinctly inferior to other varieties.

The alfalfa plot receiving 500 pounds of lime drilled with the seed averaged 0.23 of a ton less than the plots receiving two tons broadcast. The plots receiving phosphate drilled with the seed yielded 0.24 of a ton of hay per acre less than those on which it was broadcast. The drilled lime and phosphate produced 0.16 of a ton per acre less than the broadcast.

Fertilizer Tests with Sweet Clover.—On those soils needing lime for sweet-clover production, the light application of 300 pounds drilled with the seed resulted in a satisfactory stand and growth of sweet clover. General observations and a study of the yields indicated that the stands and growth obtained in each case were about the same as might ordinarily be expected from a broadcast application of a ton or more of lime per acre.

Fertilizer Tests with Potatoes.—Fertilizer tests with potatoes, including six treatments, were conducted on eight farms in 1933. Nitrogen alone or phosphate alone produced practically no increase. The plot receiving potash in addition to nitrogen and phosphorus yielded only 90 pounds more per acre than the plot receiving nitrogen and phosphorus. Those plots receiving nitrogen and phosphorus in the ratios 22-44 and 22-96 made the greatest increases over the no treatment plots. A preliminary study of the effect of fertilizer on the maturity of potatoes indicated that when potatoes grow normally the use of nitrogen and phosphorus will hasten the development of a satisfactory texture and flavor.

[Department of Agronomy. Leader, A. L. Clapp; state fund.]

The Influence of the Method of Harvesting and Baling Alfalfa Hay Upon Quality.—Detailed investigations have been made on the following topics: (1) The mower-crusher, (2) moisture content in hay when leaves shatter, (3) brittleness and pliability, (4) heating of stored hay, (5) equilibrium moisture of alfalfa when exposed to atmospheres of different relative humidities, (6) comparative drying rates of leaves and stems, and (7) development of a device for taking samples of hay from bale or mow storage.

The mower-crusher shortened the time required for drying hay. The heat-

ing of stored hay appeared to continue as long as there was sufficient moisture present in the hay for the support of bacterial growth. Alfalfa hay was found to possess approximately 6, 8, 11, 20, and 50 per cent moisture (dry basis) at relative humidities of 20, 40, 60, 80, and 100 per cent, respectively. Leaves dried much more rapidly than stems. The coarser the stems the slower they dried. Leaves were frequently suitable for storage at a time when the stems had scarcely started to dry. When leaves shattered off they contained about 10 per cent moisture. When the leaves shattered off, the hay, depending upon conditions, contained about 30 per cent moisture. A device was constructed with which a core sample could be removed from hay mow, hay stack, or hay bale.

[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 Sorghum.—During the seasons of 1932 and 1933 several varieties of grain sorghum were grown in 5-acre plots at the Fort Hays Branch Experiment Station for this study. One-half of each was headed with a dump-box header and threshed by a standing thresher, and the other half handled with the combined harvester-thresher. The following data were obtained, based on the average of the varieties grown and threshed by the

<i>Year</i>	<i>Dropped head loss, bushels per acre</i>	<i>Per cent moisture in grain</i>	<i>Per cent of grain cracked</i>	<i>Tailings loss, bushels per acre</i>
1932.....	2.48	14.8	19.2	0.8
1933.....	1.21	11.2	11.6	0.8

In 1932 the crop yields were the largest and in 1933 the lowest of any year of the period of this study. A stubble-base windrower was built and tested in 1932. Due to lodged condition the use of this machine was not satisfactory in 1932. In 1933 the machine was not used because of low yields.

During 1933 a trip was made over the south central Kansas grain-sorghum area for additional information. The average of 20 samples of grain taken at various farms showed 17.3 per cent moisture. The average of 13 samples taken for cracking showed 7.64 per cent cracked grain.

Analysis of equilibria moisture data and weather-bureau humidity records indicates that grain sorghum, in most of the southwest, is on the border line of sufficient moisture content to go out of condition.

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

Shrinkage and Damage of Wheat in Farm Storage.—Three lines of work have been conducted: (1) Comparison of forced draft ventilation with natural ventilation in cooling wheat stored in 1,000-bushel bins at Hays, Kan.; (2) a comparison of the effects of moisture, temperature, and other factors on the quality of wheat; and (3) a study of some factors which affect the diastatic activity of wheat.

Four 1,000-bushel bins were used as follows: (1) Natural ventilation through a screen floor; (2) mechanical ventilation with night air; (3) natural ventilation, side wall and suction cupola; and (4) mechanical ventilation with day air. Natural ventilation was more effective in cooling the wheat when admitted through the floor than if entrance was through the side wall and suction cupola. The most effective method of cooling was forced draft venti-

lation with night air. The forced day-air ventilation had but little advantage over the natural ventilation through the floor.

Wheat from two sources was used in the study of factors which affect quality: (1) Wheat cut at different stages of maturity so as to have various moisture contents; and (2) dry wheat wetted to various moisture contents. The results showed that it was the amount of moisture that affected the quality; whether inherent or added made no difference. Heat in wheat comes from the respiration of the wheat and of the molds. Respiration was greatly increased at 15 to 17 per cent moisture, a moisture content that was favorable to mold growth. Whether wheat respiration alone would cause dangerous temperatures has not been proved. Mold growth causes an increase in fat acidity, and hence this determination may be used as a measure of damage. Mold growth may be prevented by absence of oxygen. Damage may take place in the absence of mold, and such damage is not accompanied by high fat acidity. Low temperature is the best preventive of damage in high-moisture wheat. Viability is very sensitive to unfavorable storage conditions. If viability has not been lowered it is probable that no other injury has taken place.

For the study of factors which affect diastatic activity, wheats were used from the samples obtained in the variety testing and also from other states. The influence of wetting wheats in various ways was also investigated. The diastatic activity of hard red spring wheat was higher than that of hard red winter wheat. Soft red winter varieties did not have higher values than hard red winter wheats. Some white wheats had the lowest and others the highest values of the soft wheats. Durum was highest of all. Diastatic activity is affected both by variety and environmental conditions. Wetting did not increase diastatic activity until the amount of water added and the time were such as to affect the process of germination. Ground wheat meal had a higher diastatic activity than flour milled from the wheat. Flours milled on large commercial mills had a higher diastatic activity than flour milled from the same wheat on an experimental mill.

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

Chemical Factors Influencing the Quality of Wheat and Flour.—The study of the centrifugal method of determining flour absorption was continued. A 30-minute period of soaking the flour suspension was found more satisfactory than the 5-minute period previously used. The larger errors were practically limited to wheat varieties not suited to bread production, or to wheats grown under abnormal conditions.

A study was made of the factors responsible for the improvement in baking quality of certain flours by the addition of malted wheat flour. It was evident that sugar production or strictly diastatic activity was of relatively minor importance, the chief improvement being due to proteolytic enzymes and other factors not yet isolated. As the purest available diastase contains considerable quantities of proteases and other materials, the segregation of the various factors is difficult.

It was reported previously that the action of oxidizing agents in the amounts normally used in flour bleaching and dough preparation greatly increases the amount of water-soluble phosphatide in the flour. This is the only change due to oxidation and capable of changing the physical characteristics of the dough which has yet been demonstrated chemically. Continuation of this work gave evidence indicating that the oxidation of flour by bleaching or by other strong oxidizing agents transforms part of the lecithin of the flour into kephalin. If this can be substantiated it will be an outstanding achievement, since direct oxidation of lecithin to kephalin has never been described.

Study was made of the effect of free fatty acids on bread quality. Unsaturated acids seemed to have no greater effect than saturated. It was noted that dispersions of lecithin in water were precipitated by free fatty acids. This seems to offer a reasonable explanation of the effects of free fatty acids on baking quality, especially since the addition of a small quantity of lecithin seems to overcome the effects of the acids.

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

Varietal Factors Influencing the Milling and Baking Qualities of Wheat.—The varieties tested have been obtained from these sources: The one-fortieth-acre plots on the agronomy farm at Manhattan; the advanced wheat nursery; Fort Hays Branch Experiment Station; coöperating farmers in Kansas; known varieties from other experiment stations; and wheat mixes from mills. The latter two were obtained to help in establishing standards.

The best method of determining milling characteristics has been to determine the protein on break and total flour as well as the wheat, and also the ash content of total flour. In hard wheat the protein content of the break flour was higher than that of the wheat. In soft wheat the protein content of the break flour was lower than that of the wheat, and not much different from the total flour. By this criterion Kawvale mills like a hard wheat and Min-turki like a soft wheat. The ash content of the total flour, and the test weight, together with the percentage of flour yield, serve as bases for calculating the factor for milling value. By this criterion Kanred and Tenmarq have high milling characteristics, while Quivira is not quite so high. This may be due partly to the earliness of Quivira.

The work on the recording dough mixer has served to indicate characteristics desired in hard winter wheat grown for bread production. Curves obtained on Marquis, Turkey, and other well known hard wheats grown in various places, rise gradually, and to a fair height, have a rounded top, taper off gradually, and the dough does not break, but the amplitude persists to the end. Such flours can be used over a wide range of conditions and are considered very strong. When the curve rise is steep, the top makes a sharp turn, and the dough breaks soon after the turn, it indicates that the flour is sensitive to severe mixing and the conditions for its use must be more carefully controlled. Blackhull is typical of this class. Flours suited for cake, biscuit, and crackers have, on the whole, low curves, and break down soon after complete development. Wheats best suited for such flours are not grown in Kansas.

The coöperative work with Quivira and Tenmarq has shown the latter to be a wheat of outstanding qualities, and Quivira is probably equal to Turkey. The one objection to Quivira is the large amount, of carotene in the endosperm. However, since it is not sensitive to bleaching this is not such a serious objection. More coöperative work is needed with Quivira in comparison with Turkey.

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

Factors Influencing the Protein Content of Wheat.—The factors which influence the protein content of wheat have been studied by analyzing samples from the wheat seed-bed-preparation plots, the date-of-seeding plots, Kanred grown in various parts of Kansas, plots to which urea and urine had been applied, fertilizer and rotation plots, plots growing wheat after alfalfa, plots to which

nitrates had been added, and samples from the wheat-breeding nursery.

Seeding the latter part of August or the first part of September gave wheat with both lower protein and lower yield than seeding the last part of September. Seeding in October gave the highest protein but the lowest yield. When wheat is grown in widely scattered areas, the variation among samples is greater than among years. The application of urea and urine increased the protein content nearly 4 per cent. The use of nitrates in increasing the protein content was effective in relation to the need of the soil for nitrogen.

Both the protein per cent and the yield in bushels per acre was greater on the plots which had grown alfalfa than on adjacent continuous wheat plots. On two plots broken from alfalfa in 1924 and 1925, the average increase in protein for eight and nine years was 2.3 per cent, and the increase in yield 0.7 and 0.8 of a bushel. On two plots broken in 1930 and 1931, the average increase in protein was 4.1 per cent and the increase in yield 1.8 and 3.5 bushels. Samples from the wheat-breeding nursery showed a negative correlation between protein content and yield. They also showed that low protein content was associated with a high per cent of yellowberry, and that high protein was associated with a low per cent of yellowberry. Yellowberry may be associated with both high and low yield. Thus the most important factor in determining the percentage of protein of wheat is the available nitrogen in the soil, particularly during the later stages of growth. Climate is the next most important factor in that it determines the conditions for the utilization of the soil nitrogen. The variety which is best adapted to the climatic and soil conditions will give the highest yield with a good protein content.

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

Tempering Factors Affecting the Quantity and Quality of Wheat Flour.—Hard wheat reaches a moisture equilibrium in storage at from 10.5 to 13 per cent. In this condition it cannot be milled, because the bran will pulverize and the flour will be too dark to meet trade requirements. For best separation in milling, wheat must have a moisture content of 14 to 16 per cent, depending on the kind of wheat. At this moisture content the vapor pressure of the absorbed water is generally greater than that of the atmosphere. Hence evaporation continually takes place from wheat and mill stocks. This neutralizes the work of tempering.

There are three main factors involved in tempering: (1) The amount of water required for any particular wheat, (2) the length of time required for this water to penetrate, and (3) the prevention of evaporation from wheat and mill stocks. Supplementary to this are the mechanical processes of milling in which the effects of tempering are indicated.

Investigation in milling is a comparatively new line of work, and therefore considerable effort has been devoted to methods. A modified Crova hygrometer has been developed by which the dewpoints or vapor pressures of small volumes of air, or air in inclosed spaces—such as in gallon bottles, spouts and mill machines—may be measured. Thus it is possible to have a large number of samples of wheat or mill stocks under a large variety of conditions and measure the vapor pressures. This makes it possible to determine the equilibrium conditions which should exist to prevent harmful evaporation during the milling process. As far as the studies have gone, a moisture content of 16 to 16.2 per cent has been found best for milling hard wheat, and the relative humidity should be 65 to 70 per cent.

Electrical conductivity measurements on the Tag-Heppenstal moisture meter have been found useful in determining when the added tempering

water has been completely absorbed. For hard wheat this time has been found to be 15 to 18 hours at 77° F., and hence this is probably the needed tempering time.

Considerable time has been spent on supplementary mechanical processes, particularly the crushing of the endosperm while still held inside the bran. This is done by passing the wheat between rolls run at little or no differential. The bran is thus kept in large flakes, pulverization of bran is minimized, and a better separation secured. While this method has been used and advocated by millers, it has not as far as known been subjected to scientific study. This study has been found useful as an aid in determining tempering effects.

Considerable time has also been given to methods of moisture determination. Present methods give fair results on flour, but have been found inadequate for ground wheat and feed. A modified vacuum oven has been constructed which it is hoped will give more reliable results.

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

A Physiological Study of the Hard Winter Wheat Plant.-

During the past two years investigations have been conducted on the development of the hard winter wheat plant from the seedling stage to maturity. Kanred wheat was sown on October 1, 1931, and beginning four weeks after seeding, samples for chemical analyses were taken every two weeks until April 27, 1932. After that date samples were collected every week until maturity. During the year 1932-'33 the experiment was enlarged to include Harvest Queen, a variety of soft wheat. Plants of this variety were grown in alternate rows with Kanred, and samples were taken in a manner similar to that of the previous year.

Chemical analyses were made upon the collected material for total nitrogen, protein nitrogen, protein-free nitrogen, total phosphorus, water soluble phosphorus, total potassium, water soluble potassium, starch, hemicellulose, total sugars, reducing sugars, and nonreducing sugars. The analyzes for these constituents have been completed for the material collected in 1931-'32. The analyses for the material collected in 1932-'33 are not yet completed.

A summary of some of the data found in regard to the Kanred wheat grown in 1931-'32 is as follows:

- a. Approximately one-third of the total nitrogen was protein-free nitrogen.
- b. The plant continued to draw nitrogen from the soil until maturity. Approximately 57 per cent of the nitrogen in the mature head was absorbed from the soil from heading time until maturity. Thus about 43 per cent of the nitrogen in the head was drawn from the supply in the stem and leaves.
- c. Approximately 75 per cent of the total phosphorus of the plant was in the water soluble form up until the time of heading. It then decreased to approximately 50 per cent of the total phosphorus.
- d. There was little or no increase in the total amount of phosphorus in the plant from the time of heading to maturity. This indicates that there was little or no absorption of that element from the soil during that time, and that all the phosphorus in the grain, which amounts to 75 per cent of the total phosphorus of the plant, was derived from the supply in the stem and leaves.
- e. The potassium content during the vegetative stages and during the early stages of head formation was relatively high, amounting to as much as twice the total nitrogen content. A marked decrease in the amount of potassium in the entire plant occurred during the three weeks preceding maturity. This decrease amounted to as much as 25 per cent. This point will be more thoroughly investigated.

f. About 45 per cent of the total carbohydrates of the mature head was obtained from the reserves stored in the stem and leaves, while the remainder was manufactured in the leaves and moved directly into the developing head.

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

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

1. *Spraying.*—Apple trees were sprayed experimentally for the control of codling moth, apple scab, and black rot or “frog-eye.” The best control of codling moth was obtained with six applications of lead arsenate during the season. Arsenical residue, however, accumulated above the federal tolerance figure of 0.01 of a grain of arsenious oxide and 0.018 of a grain of lead per pound of fruit. Substitutes for lead arsenate tried during the biennium were calcium arsenate, oils, nicotine, nicotine tannate, manganese arsenate, barium fluoroide (Dutox) and sodium aluminum fluoroide (Kalo). Some of the substitutes reduced the arsenic below tolerance, but the control of codling moth was unsatisfactory. Oils used in the spray schedule complicated the removal of arsenical residue at harvest time.

The recommended spray schedule for fungous diseases, consisting of two applications of liquid lime sulphur followed by one or two applications of Bordeaux mixture, gave commercial control of black rot or “frog-eye.” Apple scab and blotch were scarce in the apple orchard.

Two species of apple-leaf miners did considerable damage to foliage during the biennium. They appeared in late summer and infested approximately 75 per cent of the leaves. The miners were identified by Anette Braun of Cincinnati, O., as *Lithocolletis malimalifoliella* Braun and *Onix prunivorella* Chambers. They are a new apple pest for Kansas.

Peaches were sprayed for bacterial leaf spot and plum curculio. Zinc-lime or white Bordeaux, consisting of 4 pounds of zinc sulphate, 4 pounds of hydrated lime, and 50 gallons of water, gave good control of the leaf spot. Oxobordeaux and wettable sulphur also gave commercial control of the disease. An injury much resembling bacterial leaf spot was found to be due to arsenicals applied for the control of plum curculio. Hydrated lime added to the arsenical spray reduced the injury but did not entirely prevent it. Bordeaux and oxobordeaux gave good control of cherry-leaf spot of cherries.

2. *Methods of Pruning Fruit Trees.*—Three methods of pruning young sour-cherry trees, planted in 1929, are being tried out. One group of trees was pruned to the open-head type, and since the first pruning at planting the laterals have been headed back lightly and the trees thinned out as needed. A second group was headed back lightly at planting, and since then the lateral branches have been headed lightly each year and the leaders allowed to grow as they will. The third group was headed back severely at planting, and since then the laterals have been cut back severely each year, attempting to preserve the leaders. The open-headed trees are weak. The severely pruned trees have better leaders than the lightly headed trees, but are dwarfed somewhat.

Jonathan apple trees topworked to Winesap in 1930 set a fair crop in the spring of 1934. A study of the grafts showed that in many cases only one cion per stock remained, indicating that many of the wounds have healed over the stubs sufficiently to allow the removal of all but one cion per stock. Some stocks or branches were removed because of severe sunscald.

3. *Orchard Soil Management Experiments.*—During the past two years the work on this subproject has been devoted to studies of the use of chemical fertilizers on apple-orchard soil, the use of straw mulch on apple-orchard soil, management of orchard cover crops, apple-tree root development in relation to soil characteristics, apple leaf morphology as it may influence the rate of photosynthesis, and apple-leaf area and fruit size.

Nitrate of soda was applied to 29-year-old Winesap apple trees at different dates during the season. The difference in growth and yield of fruit was not significant. These plots were under a clean-cultivation cover-crop system of soil management, and such plots do not respond generally to applications of nitrogenous chemical fertilizers

Since 1921 a straw mulch has been maintained on two rows of apple trees. Although soil moisture usually is a limiting factor in this orchard, the use of straw mulch has certain pronounced disadvantages. Field mice constitute a menace, fire is a hazard, and in wet seasons roots of the trees are injured by water—the subsoil being heavy and nearly impervious to water. Several of the trees have blown over because of the shallow root system.

Rye and winter vetch grown as winter annual cover crops did poorly in both 1932 and 1933, due to drought. One inherent disadvantage of these cover crops was that they make most of their growth in the spring and thus compete with the trees for soil moisture.

Oats were planted as a cover crop for the first time in this orchard in the fall of 1932. This planting failed because of insufficient rainfall. A similar planting in the fall of 1933 made so little fall growth that it did not possess any advantage over rye.

The two-acre plot devoted to the production of winter vetch yielded 1,500 pounds of seed in 1932. Rye was not planted as a supporting crop with this crop of vetch. In general, the use of rye for this purpose has not been satisfactory. If rye were not used a larger portion of the vetch seed was lost, but this served to aid in reseeding the ground for another crop. No consistent or significant differences in the moisture content of the soil in the permanent vetch and permanent rye cover crop plots were found during either 1932 or 1933. In 1933 a plot in the vetch section was not disked until in August. The vetch mulch thus produced did not conserve soil moisture so well as the early disking of the crop. Soil nitrate determinations were made during both seasons on the same dates that the soil moisture data were obtained. With few exceptions, the nitrate content of the soil in the rye plot was greater than that of the vetch plots.

In 1932 studies were made of the root systems of apple trees under two systems of soil management at Manhattan and under one system in Doniphan county. At Manhattan the two systems were clean cultivation—cover crop and straw mulch. The root systems of the trees in the former plots were larger and somewhat deeper than these in the straw mulch.

In some of the plots all of soil horizon A_1 has been eroded away, while in others both A_1 and A_2 have been lost. In other plots an alluvial deposit, up to nearly 18 inches in thickness has been laid down, burying the old A_1 and A_2 layers. In general, horizon B is compact, heavy, plastic, has not developed a pronounced structure, and contains numerous brown concretions, probably iron. This horizon is classed as silty clay loam, and ranges from 14 to 20 inches in thickness. Horizon C is of indefinite thickness, light gray, rather loose, and is classed as sandy clay loam.

These root studies showed that soil moisture and texture have a pronounced influence upon root development. In a few spots where the soil was moist to a considerable depth, the roots responded by extending their growth to such soil. When roots find an abundance of soil moisture close to the surface, as under the straw mulch, they branch freely through the surface soil and show little tendency to go deeper. The subsoil under nearly all trees excavated was a claypan. The impervious nature of such a layer causes the trees to have shallow roots. During the course of these excavations close observations showed that the roots penetrated the B horizon by following the shrinkage cracks between the blocks of clay and formed thread-like branch roots, which spread like a fan, parallel with the blocks of hard clay. The lateral roots spread considerably farther horizontally than the aerial portions of the tree, and in general were entirely in the claypan B horizon. The roots under the straw mulch turn down abruptly at the edge of the mulch.

In contrast to the types of root system found in the experiment station orchard at Manhattan was the type of root system in the deep loessial

soil in Doniphan county. The mature tree excavated there had an immense root growth which spread out and down from the crown of the tree. Few horizontal roots were found. The roots penetrated to a depth of more than 15 feet.

A number of factors are generally recognized as having influence on photosynthesis. These are the carbon dioxide supply of the atmosphere, the kind and intensity of light, temperature, amount of chlorophyll, moisture conditions, and protoplasmic factors. It is also considered that certain morphological features of leaves may influence the rate of photosynthesis. Permanent microscopic slides have been prepared of cross sections of foliage leaves of these apple varieties: Delicious, Gano, Jonathan, Livland, Wealthy, Winesap, and York. To permit a study of the looseness or compactness of the mesophyll, the slides were mounted on a microscope so arranged that it served as a microprojector, and 50 tracings were made of representative samples of the mesophyll of each variety at a magnification of approximately 900 diameters. To secure mathematical descriptions of the relative compactness of the mesophyll, the cross-sectional areas of the intercellular spaces as traced on paper were computed with a planimeter, and their total perimeter measurement was determined with a chartometer.

The differences between the measurements of the intercellular spaces in the mesophyll of some of these varieties were highly significant statistically. Between others, however, the differences were not significant. The differences between the cross-sectional area measurements of Livland and those of Delicious, Jonathan, Gano, and Winesap were significant to the extent that the differences were at least four times their probable errors. The difference between the means of the perimeter measurements of the intercellular spaces of these varieties was not so great as for the measurements of the cross-sectional areas of the intercellular spaces. It was noteworthy, however, that with two exceptions, the seven varieties have the same relative rank in area measurements as in perimeter measurements.

The rate of photosynthesis was studied in three ways: The leaf-punch method, the determination of the total acid hydrolyzable carbohydrate expressed as glucose, and the rate of carbon dioxide absorption by a unit of leaf area. Judging from these data, apple leaves differed in their rate of photosynthesis per unit area, although there was wide variation in these rates from day to day, and there was no consistent agreement between the various methods for any given day. Further study is necessary to determine whether there is a close relationship between leaf morphology and the rate of photosynthesis.

Working with Delicious, Jonathan, Winesap, and York, studies of the influence of leaf area on fruit size and color were made in 1933. On only one variety, Delicious, where the ratio between leaves and fruit was 50 to 1, did the apples reach a diameter of 3 inches or more.

4. *Tests of Certain Varieties of Peach and Nectarine.*—A group of three trees each of a number of unnamed peach and nectarine varieties were provided by the Office of Plant Introduction, United States Department of Agriculture, and were planted March 14, 1925. The following varieties were included: Peach numbers 24807, 36485, (Shalil), 43130, 43289 and 55563; nectarine numbers 26503, 30648, 34685 (Quetta) and 43146 (Sure Crop.)

The soil in which these trees were planted was a rather heavy clay, of medium to low fertility, and poor water-holding capacity. It was partly occupied by peach trees of bearing age, the test trees being set as replants to replace original peach trees killed by borers. The trees were shipped from the nursery at Chico, Cal., and were in bloom; in fact, some had started leaf growth when received. However, they were in good condition and revived quickly after planting and heavy pruning.

Prior to planting these trees, peach-leaf curl had been exterminated from this peach orchard. Five of the varieties developed the disease the first year. All were sprayed the following spring and in 1928. By the summer of 1928 this pest again had been destroyed.

Bacterial leaf spot had been present in the orchard in which these trees were planted for several years. Its attack and perhaps arsenical injury were especially severe during the peach crop years 1931 and 1932. All the varieties under test were attacked in 1932 and were practically equally susceptible. These outbreaks hastened the destruction of this orchard.

All remaining trees of these varieties were pulled and burned during March, 1934. At that time all the fruit buds had been killed, so no further bearing was possible before 1935, and the land was needed for other use. The following trees survived to the end of the test: No. 24807, one tree; 36485, two trees; 43130, none; 43289, none; 55563, three trees; 26503, none; 30648, three trees; 34685 (Quetta), three trees; 43146 (Sure Crop), two trees. These trees were then nine years of age. Three varieties had produced fruit three seasons, one had borne two crops, two gave one crop, and three had failed to produce any fruit.

General conclusions from these tests would be that none of these varieties showed great promise for central Kansas, although several of the nectarines were of unusual hardiness and prolific. S.P.I. 34685, a nectarine, showed sufficient value to warrant tests in other parts of the state; S.P.I. 43146, also a nectarine, was of doubtful value but might prove worth further test under more favorable conditions in Kansas. S.P.I. 30648 proved to have some good characteristics and might deserve further tests in districts of the state better adapted to this fruit.

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

Small Fruit Investigations.—The season of 1932 was favorable for grapes. The season of 1933 was hot, dry, and the crop was practically ruined by hail on June 25; hence all of the data pertaining to crop yields in this report are for the season of 1932.

Some Concord vines planted in March, 1932, were divided into five plots and the canes were cut back to five different lengths as shown in the table below. In February, 1933, the plants in all plots were cut back to a length of two nodes on one cane.

Plot	Number of nodes left per plant, March, 1932	Number of plants	Average weight in grams prunings per plant, February, 1933
A	1	6	241
B	2	9	247
C	3	15	263
D	4	9	268
E	5	6	300

Two years were spent in building up the organic content of the soil before these plants were set. This, together with the favorable growing season, resulted in nearly all plants making good growth.

In 1927 two rows of vines were planted for the purpose of testing the value of Gloire and Clinton root stocks for Campbell and Concord varieties in comparison with own-rooted plants. It was planned to include Moore as one of the cion varieties, but no plants of this variety grafted on the above-mentioned root stocks have been available. Efforts to graft Moore on Clinton in the vineyard have been unsuccessful.

In March, 1933, the prunings from the Campbell and Concord vines in this test were weighed. There was no significant difference between the average weights of the prunings from Concord vines grafted on Clinton and own-rooted Concord. Between the Concord-Gloire vines and the own-rooted Concord there was a significant difference. The difference between either the Campbell-Clinton or the Campbell-Gloire combinations in comparison with the own-rooted plants was not significant.

It was impossible to correlate these pruning records with subsequent fruit production because of severe hail injury, June 25, 1933. The vigorous root

stocks failed to give an increase in fruit production when compared with the own-rooted plants in 1932.

There are three general systems of grape training in use in the station vineyard: The two-cane Kniffin, the four-cane Kniffin, and the Munson. In addition, one-half row is trained to the fan system, and part of the four-cane plants have one trunk and part have two trunks.

With all varieties which were represented in the Munson type of training, except Worden, the Munson type produced the highest yield of fruit per vine.

In the spring of 1930 studies were inaugurated on the influence of the number of nodes left on Concord vines at pruning time on the subsequent fruit production. During 1932 the highest yield was on the plot having 60 nodes per plant after pruning, and from which the weakest flowers clustered on each shoot were removed. The 18 vines in this plot yielded an average of 16.4 ± 3.2 pounds of fruit per vine, or at the rate of 9,840 pounds per acre. Other plots had averages of 30, 40, and 60 nodes per plant. In the latter 60-node plot the flower clusters were not thinned. These last three plots produced 7,860, 9,669, and 9,240 pounds of fruit per acre.

Serious winter injury to the fruiting canes was noted on Niagara, Brighton, and Agawam vines following the blizzard of February 8, 1933, when the temperature dropped to -20 degrees Fahrenheit.

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

Flower and Vegetable Investigations.—The work in this project has been continued in seven different lines as follows:

1. Studies of the enzymatic activities and chemical changes in asparagus roots treated to break the rest period.
2. Greenhouse cucumber, lettuce, and tomato production with various soil treatments to control soil-borne insects and diseases.
3. Field vegetable and flower variety and adaptability tests.
4. Heating of hotbeds with wood, electricity, and steam.
5. Use of electric light for lengthening day and hastening the flowering of certain greenhouse flower crops.
6. The development of a recording atmometer.
7. Forcing certain shrubs and herbaceous perennials to bloom out of season.

Continued studies of the catalase activities of asparagus roots treated in various ways to break the rest period showed statistical differences in the activity due to the various treatments. Studies of the carbohydrate and nitrogen contents of the same roots did not seem to show comparable differences, and little if any relation was found in growth, yield, or response to the treatments. The roots studied were heated in water at 123 degrees F. for three minutes, frozen at 10 degrees F. for 24 hours, or treated with ethylene chlorohydrin gas for 24 hours to break the rest period. Compared with the untreated roots the rest period was broken sooner and the yield of first grade edible stalks was greater with the hot-water treatment. The gas-treated plants seemed to be but little if any better in yield than the controls. While no practical returns were sought from this experiment it seems that a successful method of forcing asparagus for the winter market can be developed from the hot-water treatment of breaking the rest period of the asparagus.

The greenhouse vegetable soil sterilization studies have been concluded with five years of soil treatments. These treatments included steam, acetic acid, creoline, and formaldehyde. One crop of cucumbers, lettuce, and tomatoes was grown each year. The result of the experiment indicated that steam was the only material used which would control nematodes; that formaldehyde, acetic acid, and creoline were of nearly equal value in controlling other soil-borne pests of these crops, and that since creoline is the cheapest its use may be recommended.

The out-of-door vegetable and flower variety tests are being continued.

Little new material has been secured regarding the iris, peonies, dahlias, or gladioli. In the perennial gardens, some herbaceous perennials have been discarded as unsatisfactory. These have been replaced by new kinds which are being studied for adaptability to Kansas conditions.

Two years of study of type of fuel for heating hotbeds indicated that electricity had many advantages but was rather costly. Hot air from wood fuel had a low fuel cost but a high labor cost. Steam was not to be recommended if either of the other sources of heat is available. The plants produced in the various beds do not seem to differ.

Preliminary studies with length of day indicated the need of further study in this direction. Various crops show a very different response to the additional light furnished.

An attempt to produce a workable recording atmometer which can be produced at a reasonable cost, is progressing satisfactorily.

The forcing of shrubs and herbaceous perennials into bloom in the late winter or early spring to be used as pot plants in the trade showed that certain of these plants responded satisfactorily while others were killed by the treatments given.

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

INVESTIGATIONS IN THE ANIMAL INDUSTRIES

Brief discussions of the work of the Agricultural Experiment Station on problems of the livestock industry are given on the following pages.

Nutritive Requirements of Swine.—A study of the phosphorus requirements of growing pigs was conducted during the biennium. During 1932-'33 three groups of six young pigs each were fed individually.

Group I received the basal ration of pearl hominy, 74 per cent; ground tapioca roots, 10 per cent; blood meal, 10 per cent; alfalfa leaf meal, 4 per cent; dried Brewer's yeast, 1½ per cent; and iodized salt, ½ per cent. This ration contained 0.156 of 1 per cent phosphorus and was known as the low-level phosphorus group.

Group II received the same basal ration, plus enough monocalcium phosphate to make the phosphorus content of the ration 0.294 of 1 per cent. This group was known as the medium-level phosphorus group.

Group III received the same basal ration, plus enough monocalcium phosphate to make the phosphorus content 0.599 of 1 per cent. This group was known as the high-level phosphorus group.

In addition, each group received sufficient calcium carbonate to bring the calcium content up to 0.8 of 1 per cent. Cod-liver oil was also given every other day.

It was planned by this test to bracket the phosphorus requirements of the pig between two levels, these to serve as a basis for further more accurate tests. To determine the adequacy of the different levels the following observations were taken: daily gains, a measured growth of the body, analysis of the blood for calcium and phosphorus, and chemical analysis and breaking strength of the bones. Two pigs from each group were slaughtered each two months to secure desired data.

During 1933-'34 the experiment was repeated, using the same basal ration and plan of procedure except that the levels of phosphorus were 0.151 of 1 per cent for the low group and 0.308 of 1 per cent for the high group and 0.230 per cent for the intermediate group. The calcium level for this feeding trial was about 0.7 of 1 per cent for all groups.

The results of 1932-'33 indicated that the low phosphorus level of 0.156 of 1 per cent did not supply enough phosphorus, as the daily gains, consumption

of feed per 100 pounds gain, and growth as indicated by body measurements were decidedly inferior to the phosphorous levels of 0.294 and 0.599 of 1 per cent. Furthermore, the calcification of the bones and the pounds pressure required for breaking them were also less than for the higher levels. The blood phosphorus determinators were also much lower in the low-level group than in the medium and high levels. In the latter two groups the blood phosphorus was about the same.

The results secured in 1933-'34 verified those of the preceding year in showing that the low level of 0.151 of 1 per cent phosphorus in the feed was too low for the best growth and development of the pigs, as indicated by daily gains, feed consumption, blood phosphorus, and calcification of bone. Measured by the same criteria the level of 0.308 of 1 per cent phosphorus in the feed was apparently adequate. The group fed 0.23 of 1 per cent phosphorus gave results intermediate between the low- and high-level phosphorus groups. The data of the two years indicate that the phosphorus content of feed for pigs must approximate 0.23 of 1 per cent to permit a young pig to grow and develop normally.

[Project 38; Departments of Animal Husbandry and Chemistry. Leaders, C. E. Aubel and J. S. Hughes; Adams and state funds.]

Swine Feeding Investigations.—The work under this project included in 1932-'33 the following studies: (1) The value of wheat as a swine-fattening feed on alfalfa pasture; (2) the value of wheat as a swine-fattening feed in dry lot; (3) a study of the comparative value of alfalfa hay, alfalfa meal, and alfalfa-leaf meal in swine-fattening rations in the dry lot; (4) the relative palatability of varieties of sorghum grains; and (5) finishing 200-pound pigs with and without a protein supplement.

In 1933-'34 the work included: (1) a study of the comparative value of alfalfa hay, alfalfa meal, alfalfa leaf meal, and fresh alfalfa in swine-fattening rations during the summer in a dry lot; (2) finishing 150-pound pigs with and without a protein supplement in a dry lot; (3) fattening spring pigs in a dry lot and on alfalfa pasture; (4) alfalfa hay and meal versus sweet clover hay and meal in swine-fattening rations; (5) preparation of grain and control of protein supplements in swine-fattening rations; (6) finishing 200-pound pigs with and without a protein supplement in a dry lot; and (7) relative palatability of sorghum grains.

Results secured during 1932-'33 may be summarized as follows:

a. Hogs self-fed corn made cheaper gains on alfalfa pasture during the summer of 1932 than those fed whole wheat or ground wheat. The daily gains were slightly lower with whole wheat than with corn, while the pigs fed ground wheat made the same gains as those fed corn. (All lots were self-fed tankage on the alfalfa pasture.)

b. Three lots of pigs self-fed grain with tankage in a dry lot for 56 days in the fall of 1932 made the following daily gains with different grain feeds; ground wheat 1.75 pounds, corn 1.6 pounds, and whole wheat 1.52 pounds. The pigs fed ground wheat consumed less grain and also less tankage per 100 pounds gain than either of the other lots.

c. Swine fed a protein mixture of tankage 3 parts and alfalfa-leaf meal 1 part made the largest daily gains, but not the most efficient gains. The tankage and alfalfa hay lot made the most efficient gains, but the lowest daily gains.

d. In a feeding trial in which four pigs were fed individually, each given free choice of nine varieties of sorghum grains, their order of preference for the grains was as follows: red kafir, Wheatland milo, pink kafir, Atlas, Kalo, Blackhull, Grohoma, Club, and Sumac.

e. The pigs receiving corn alone gained 1.55 pounds per head per day. The protein-fed pigs gained 1.56 pounds per head per day. The pigs fed corn alone consumed 464 pounds corn per 100 pounds gain, and the corn and protein pigs consumed 450 pounds corn and 7.7 pounds protein per 100 pounds gain.

Results secured in 1933-'34 may be summarized as follows:

a. Pigs receiving shelled corn, tankage and alfalfa hay made an average daily gain of 1.43 pounds; those receiving tankage as a protein supplement, but no hay, gained 1.31 pounds; those receiving tankage and fresh cut alfalfa twice a week gained 1.35 pounds; those receiving tankage 3 parts and alfalfa-leaf meal 1 part gained 1.35 pounds; and those receiving tankage 3 parts and alfalfa meal 1 part gained 1.25 pounds. The most economical gains were made by the lot receiving tankage 3 parts and alfalfa-leaf meal 1 part.

b. When the protein supplement was removed from the ration of 150-pound fattening pigs, the daily gain and the feed consumed per pig daily were materially decreased, while the amount of feed required per 100 pounds gain and the cost per 100 pounds gain were materially increased.

c. The hogs self-fed corn and tankage on alfalfa pasture during the summer of 1933 made larger and more economical gains than hogs fed corn, tankage, and alfalfa hay in a dry lot.

d. The pigs fed corn, tankage, and alfalfa hay free choice made somewhat faster and slightly more economical gains than those fed corn, tankage and sweet-clover hay. The pigs fed corn, tankage and alfalfa hay did better than those fed a moisture of tankage 3 parts and alfalfa meal 1 part, and also a little better than those fed tankage 3 parts and sweet-clover meal 1 part. The pigs fed sweet-clover meal and tankage mixture made slightly greater and a little cheaper gains than those fed tankage 3 parts and alfalfa meal 1 part. The alfalfa meal or sweet-clover meal moisture was no more efficient for fattening pigs than feeding hay free choice with tankage as a protein supplement.

e. Fattening pigs were self-fed a mixture of 90 parts ground corn mixed with 10 parts tankage up to 120 pounds in weight, then 93 parts corn and 7 parts tankage up to 170 pounds in weight and then 95 parts corn and 5 parts tankage until they were finished. These pigs gained no more rapidly than pigs fed free choice corn, tankage and alfalfa hay throughout their feeding period. However, the cost per 100 pounds gain was greater, due to the cost of grinding and mixing the feed.

f. When the protein supplement was removed from the ration of 200-pound fattening pigs, the daily gain and the feed consumed per pig daily were materially decreased, while the feed required per 100 pounds gain and the cost per 100 pounds gain were increased.

g. In a feeding trial in which four pigs were fed individually, each given free choice of nine varieties of sorghum grain, their order of preference for the grains was as follows: red kafir, Wheatland milo, dwarf milo, Atlas, Feterita, pink kafir, Blackhull, Kalo, and early sumac.

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

Sources of Calcium for Growing Pigs.—A comparison was made of the effect of feeding calcium sulphate, in the form of gypsum, with calcium carbonate in the form of ground limestone, to growing pigs.

During the winter of 1933-'34 eight young pigs, averaging about 55 pounds, were hand-fed individually a basal ration of all the ground corn they would eat, one pound wheat shorts, and six-tenths of a pound of linseed oil meal once each day for 112 days. All pigs consumed the same total amount of basal feeds.

In addition, two pigs received $\frac{1}{4}$ ounce of calcium carbonate daily; two received $\frac{1}{4}$ ounce of calcium sulphate daily; two received increasing amounts

of calcium carbonate, the changes being made at the end of successive 28-day periods as follows: ¼ ounce, ½ ounce, ¾ ounce, and 1 ounce; and two received increasing amounts of calcium sulphate, the changes being made at the end of successive 28-day periods, as follows: ¼ ounce, ½ ounce, ¾ ounce, and 1 ounce.

At the end of 112 days' feeding the pigs receiving calcium carbonate in constant amounts had gained 1.01 pounds per day; those receiving the sulphate had gained 0.97 of a pound daily; those receiving increasing amounts of carbonate had gained 1.01 pounds; and those receiving increasing amounts of sulphate had gained 1.02 pounds daily.

An analysis of the blood of the eight pigs showed no significant difference in the inorganic phosphorus or the calcium content. When the right humerus of one pig from each group was tested for breaking strength, no significant difference was observed. The analysis of the bones for ash, calcium, and inorganic phosphorus has not been completed. The breaking pressure figures indicate that the bones of the pigs of each group were equally strong and well calcified.

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

Investigations in the Use of Silage for Fattening Beef Cattle.—During the past biennium the investigations conducted under this project have consisted of four phases, each of which is briefly discussed below.

1. *Protein Supplements with Silage.*—The relative value of cottonseed meal, linseed meal, and corn-gluten meal when fed separately and in combinations as protein supplemental feeds in calf-fattening rations, the roughage portion of which was largely silage, were compared. The third and final year's study of these feeds was made in 1932-'33. The single protein supplemental feeds are compared in Table II on the basis of average results for three years.

TABLE II.—COMPARISON OF SINGLE PROTEIN SUPPLEMENTS
Three-year averages

PROTEIN SUPPLEMENT.	Cottonseed meal.	Linseed meal.	Corn-gluten meal.
	<i>Lbs.</i>	<i>Lbs.</i>	<i>Lbs.</i>
Average daily gain.....	2.18	2.29	2.20
Average daily ration:			
Shelled corn.....	9.25	9.56	8.94
Protein supplement.....	.98	.98	.98
Corn silage.....	8.00	8.03	7.58
Alfalfa hay.....	1.98	1.99	1.99
Feed cost per cwt.....	\$6.73	\$6.73	\$6.45
Appraised price per cwt.....	9.83	10.25	9.78

It appears justifiable to conclude that corn-gluten meal and cottonseed meal had approximately the same feeding value and that linseed meal was superior to either of them.

Four protein supplemental mixtures are compared in Table III on the basis of average results for three years. Three of the mixtures excelled or equalled all three single supplements. A mixture of equal parts of cottonseed meal and corn-gluten meal was the exception, since this mixture was not equal to linseed meal.

TABLE III.—COMPARISON OF MIXTURES OF PROTEIN SUPPLEMENTS

Three-year averages

MIXTURE OF PROTEIN SUPPLEMENTS.	Cottonseed meal, $\frac{1}{2}$; Linseed meal, $\frac{1}{2}$.	Cottonseed meal, $\frac{1}{2}$; corn-gluten meal, $\frac{1}{2}$.	Linseed meal, $\frac{1}{2}$; corn-gluten meal, $\frac{1}{2}$.	Cottonseed meal, $\frac{1}{3}$; linseed meal, $\frac{1}{3}$; corn-gluten meal, $\frac{1}{3}$.
Average daily gain	Lbs. 2.33	Lbs. 2.23	Lbs. 2.36	Lbs. 2.35
Average daily ration:				
Shelled corn	9.69	9.35	9.44	9.46
Protein supplement . . . . .	.98	.98	.98	.96
Corn silage	7.86	7.80	8.35	8.43
Alfalfa hay	1.99	1.99	1.99	1.99
Feed cost per cwt.	\$6.54	\$6.67	\$6.38	\$6.40
Appraised price per cwt.	10.27	10.00	10.17	10.12

The best results were obtained when linseed meal was included in the mixtures. There were no significant differences in the gains and finish of the lots fed equal parts of corn-gluten meal and linseed meal. Consequently, cost per ton will determine whether cottonseed meal or corn-gluten meal will be more profitable to mix with linseed meal. A mixture of one-third each of cottonseed meal, linseed meal, and corn-gluten meal was as satisfactory in most respects as the two mixtures containing one-half linseed meal.

2. *Oats Versus Corn.*—During the past biennium the work on this phase of the project consisted of: (1) a study of the advisability of substituting whole oats for shelled corn throughout a 200-day feeding period, and (2) a study of the advisability of substituting whole oats or ground oats for shelled corn during the first 100 days of a 200-day feeding period. Steer calves were fed in both experiments. In addition to grain, each lot was full-fed silage and received 1 pound of cottonseed meal and 2 pounds of alfalfa hay per head daily. The following conclusions may be drawn from the results of the work:

a. Calves fed whole oats through the entire feeding period gained as well but did not get so fat as similar calves fed shelled corn.

b. Calves fed oats the first 100 days of a 200-day feeding period consumed more grain than was consumed by those fed corn.

c. The larger consumption of oats, especially ground oats, lessened the appetites of the calves for silage and alfalfa hay. When the lots fed oats were changed to shelled corn the consumption of roughage was similar to the amount consumed by the lot fed corn during the entire period.

d. Calves fed whole oats or ground oats for the first 100 days and corn the last 100 days, gained as well and were almost as fat at the conclusion of the experiment as calves fed shelled corn during the entire period.

e. It was not profitable to grind oats for fattening calves.

f. Whole oats may be used to good advantage in starting calves on feed, but the change to shelled corn should be made before one-half the feeding period has elapsed.

It is planned to continue this study to determine, if possible, how long whole oats can be fed and still produce calves as fat as those fed shelled corn throughout the entire fattening period.

3. *Methods of Feeding Cottonseed Meal.*—During the past biennium a preliminary study was made of the advisability of varying the amount of cottonseed meal fed at different stages of the feeding period. The total amount of cottonseed meal fed per calf during the 200-day period was the same for each lot—274 pounds. In lot, 4 the same amount of cottonseed meal was fed each day; in lot 5, the amount was gradually increased from 0.50 of a

pound to 2.20 pounds per calf daily; and in lot 6 it was gradually decreased from 2 pounds per calf daily to 0.77 of a pound. In addition to cottonseed meal, shelled corn and silage were full-fed in each lot, and ground limestone was fed at the rate of one-tenth of a pound per calf daily.

The results of this experiment may be summarized as follows:

a. In general, reducing the amount of cottonseed meal below the level ordinarily recommended tended to reduce feed consumption and lower the gains.

b. The calves started on a limited amount of cottonseed meal made a marked improvement in general appearance and finish after the amount of cottonseed meal was increased above 1 pound per head daily.

c. During the first part of the experiment the calves fed a heavy allowance of cottonseed meal made larger gains, were fatter, and presented a much more attractive appearance than the calves fed scantily on cottonseed meal. These advantage were lost, however, during the latter part of the feeding period when the allowance of cottonseed meal was materially reduced.

d. The calves fed the same amount of cottonseed meal each day gained much more uniformly throughout the entire feeding period than either of the lots fed varying amounts of cottonseed meal.

e. Although definite conclusions are not justified, the results of this test indicate that feeding the same amount of cottonseed meal per calf each day is a more satisfactory method than to vary the amount at different stages of the feeding period.

4. *Silage Alone as the Roughage Portion of Calf-fattening Rations.*—Calves fed an average daily ration of 10.05 pounds shelled corn, 1.37 pounds cottonseed meal, 13 pounds silage, and 0.1 pound ground limestone gained slightly more than similar calves fed an average daily ration of 10.16 pounds shelled corn, 0.99 pound cottonseed meal, 8.70 pounds silage, and 2 pounds alfalfa hay. The two lots were valued at the same price per hundredweight and returned approximately the same amount per steer above total cost.

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

Methods of Utilizing Native Pasture in Beef Cattle Feeding.—During the year 1932-'33 a three-year study of three methods of utilizing bluestem grass in fattening calves for market was completed. One lot was wintered well, grazed 90 days, and then full-fed 100 days in a dry lot. The second lot was wintered well, grazed 90 days, and then full-fed 100 days on grass. The third lot was wintered well, and full-fed 150 days on grass.

The results of this test show the average return over cattle and feed cost to be: Lot 1, \$11.76 per head; lot 2, \$4.17 per head; and lot 3, \$0.69 per head.

During the year 1933-'34 a new three-year study of utilizing bluestem grass in fattening young cattle for market was inaugurated. In this study one lot of calves wintered well, grazed 90 days, full-fed 60 days on grass and then full-fed 40 days in a dry lot was compared with two other lots—one wintered well, grazed 90 days, and then full-fed 100 days in a dry lot and another wintered well, grazed 90 days, and then full-fed 100 days on grass.

In 1933-'34 the following average return over cattle and feed cost was obtained: Lot 1, \$0.40 per head; lot 2, -\$0.71 per head; and lot 3, -\$4.79 per head.

[Project 151; Department of Animal Husbandry. Leaders, C. W. McCampbell and W. E. Connell; state fund.]

A Comparison of Different Levels of Protein Intake for Fattening Steer Calves.—A basal ration of corn, atlas sorgo silage,

and ground limestone was fed to five pairs of steer calves. Both members of each pair received the same quantity of silage and concentrates per day. However, one member of each pair had 1.28 pounds of the daily allowance of corn replaced by cottonseed meal. No attempt was made to keep all pairs receiving the same quantities of feed per day.

At the end of 140 days, substituting 1.28 pounds of cottonseed meal for an equal amount of corn in a calf-fattening ration of corn, silage, and ground limestone produced the following results:

- a. Increased the daily gain of the steer fed cottonseed meal over his pair mate in all five pairs, the average increase being 0.29 of a pound per day.
- b. Decreased the amount of feed required to produce 100 pounds gain from 537 pounds of corn and 707 pounds of silage to 383 pounds of corn and 589 pounds of silage plus 70 pounds of cottonseed meal, or a saving of 221 pounds of corn and 313 pounds of silage for each 100 pounds of cottonseed meal fed.
- c. Increased the daily intake of digestible crude protein from 1.18 pounds to 1.85 pounds.
- d. Narrowed the nutritive ratio from 1:11.6 to 1:6.9.
- e. Decreased the total digestible nutrients received per calf per day from 8.21 to 8.09 pounds. This decrease resulted from the fact that cottonseed meal is slightly lower in percentage of total digestible nutrients than corn; consequently, one would not expect to improve a grain ration by substituting more cottonseed meal for corn than was necessary to supply the optimum protein requirement.

The results of this experiment indicate that cottonseed meal has a distinct value in a calf-fattening ration aside from any stimulating effect it may have on the appetite.

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

Lamb-Feeding Investigations.—The work conducted during the past biennium has consisted of two experiments in which studies have been made of the value of ground Atlas fodder as the roughage portion of lamb-fattening rations, and of various proportions of Atlas silage and alfalfa hay as the roughage portion of lamb-fattening rations.

The following is a summary of the results secured in 1932-'33:

- a. Ground Atlas grain proved to be slightly more efficient than whole shelled corn for fattening lambs.
- b. Deferring grain feeding 36 days and allowing lambs to eat all the ground Atlas fodder they would in the meantime proved to be approximately equal to full grain feeding from the beginning of the feeding period in producing gains. Because of the grain saved the 30-day deferred grain feeding system produced cheaper gains. Furthermore, it is believed to be a safer method of getting lambs on feed.
- c. Deferring grain feeding for periods longer than 30 days resulted in smaller and more expensive gains.
- d. Lambs fed ground limestone with Atlas silage as the sole roughage made larger and cheaper gains than those receiving no ground limestone with Atlas silage.
- e. Atlas silage and alfalfa hay combined gave larger and cheaper gains than silage alone as roughage, or than Atlas silage plus ground limestone.
- f. Ground Atlas fodder fed as roughage produced larger and more economical gains than Atlas silage as roughage.

g. The ration of Atlas grain, cottonseed meal, ground Atlas fodder and limestone was about 83 per cent as efficient as the standard ration of corn, cottonseed meal and alfalfa as measured by gains produced on the lambs in this test.

The 1933-'34 experiment may be summarized as follows:

a. The lambs full-fed alfalfa made the largest daily gains. The rate of gain decreased as the amount of alfalfa was reduced and the silage increased.

b. With the feed prices prevailing in the fall of 1933, the lambs full-fed alfalfa made the lowest cost gains and the cost of gains increased as more of the alfalfa was replaced with silage. If the price ratio between alfalfa and silage were wider the cost of gains might be in favor of the rations containing more silage.

c. The results of this test indicate that as much as three-fourths of the alfalfa in the ration may be replaced with good quality Atlas silage and satisfactory gains and finish be produced on fattening lambs.

d. The grading of the carcasses of these lambs revealed no important differences in any of the lots except those receiving silage as the only roughage, which yielded more of the lower grade carcasses, with correspondingly fewer of them falling into the top grade.

[Project 111; Department of Animal Husbandry. Leaders, Rufus F. Cox and W. E. Connell; state fund.]

A Study of the Factors Which Influence the Quality and Palatability of Meat.—The cattle used in this project were choice range-bred calves produced in the Panhandle of Texas and received at the Kansas station the latter part of October each year. They were divided into lots in such a way as to insure uniformity in type, quality and weight among the lots. The average initial weight was approximately 400 pounds per head. At the conclusion of the feeding periods these animals were slaughtered, and physical, chemical, and cooking studies were made.

Physical Investigations—Data were secured relative to feeder grade, slaughter grade, carcass grade, shrinkage before and after slaughter, dressing per cent, color of lean and fat, degree of finish and tenderness studies.

During 1932-'33 the cattle used in this project were handled in a manner similar to those slaughtered during the previous biennium. Two groups of good quality yearling steers were wintered alike. Lot 1, consisting of 10 head, was full-fed ground corn, cottonseed meal, and alfalfa hay in dry lot May 1 to September 18, 1932. Lot 2, consisting of 10 head, was full-fed ground corn and cottonseed meal on bluestem grass pasture for a like period. Five cattle from each lot were slaughtered in the station laboratory, and the aforementioned studies made.

During the second year of this biennium, cattle were handled in four different ways; namely, (1) wintered well and full-fed in dry lot May 1 to November 7, 1933; (2) wintered well, grazed on bluestem pasture May 1 to August 1, and full-fed 100 days in dry lot; (3) wintered well, grazed on bluestem pasture May 1 to August 1, and full-fed on pasture 60 days and then in dry lot 40 days; and (4) wintered well, grazed on bluestem pasture May 1 to August 1, and then full-fed on pasture 100 days.

Some of the 1932-'33 results were:

a. Both methods of handling cattle produced carcasses grading choice or higher.

b. The cattle fed in a dry lot showed more finish, and consequently graded slightly higher, than the cattle fed on pasture.

c. No objectionable color of the lean muscle was observed. However, the cattle fed on pasture showed a slightly lower brilliance, chroma and hue than the cattle fed in a dry lot. The greatest difference was in brilliance.

d. The external fat covering of the cattle fed in a dry lot was somewhat whiter than that of the cattle fed on pasture.

e. The tenderness readings were somewhat conflicting and have not been thoroughly analyzed.

Some of the 1933-'34 results were:

a. Keys to the new grading charts used during 1933-'34 have not yet been received from the United States Department of Agriculture; therefore, the data are incomplete at this time.

b. With the exception of two carcasses (one from lot 2 and one from lot 4) which cut dark, the color of the lean muscle was not objectionable.

c. The color of the external fat in lot 1 was a desirable white. Lots 3 and 4 had a decided yellow tinge, and lot 2 was intermediate.

d. In tenderness the lots ranked 4, 3, 2, and 1.

Chemical Investigations.—The chemical investigations have been concerned chiefly with the search for significant relationships between quality and composition of meat. Factors investigated have been keeping quality, shrinkage, tenderness, color, palatability, juiciness, and permeability. Analyses have been made for protein, fat, moisture, and ash both on the rib eye and rib fat. Collagen and elastin determinations have been made on both fresh and ripened rib cuts.

A number of physicochemical measurements have been made, such as particle size by X-ray analysis, colloidal dispersability of lean tissue, electrical resistance, oxidation potential, quinhydrone electrode potential method of determining pH in the muscle tissue, quantity of expressible juice, and the surface tension of the expressed juice. Blood analysis have been made for calcium and hemoglobin. Blood and muscle hemoglobins have been determined in the rib eye. Mineral ratio studies involving sodium, potassium, calcium, phosphorus, and nitrogen were made on the rib fat, in 1932, and on the expressible juice and expressed tissue of the rib eye in 1933.

Analysis of the Rib Eye.—Although the feeding and management program was slightly different for the two years, the rib eye intramuscular fat (ether extract) and moisture indicated contrary trends in relation to pasture and dry-lot feeding. In 1932-33 the rib eye from animals full-fed on pasture averaged higher in moisture and lower in fat. In 1933 this was the case for animals finished 100 days in dry lot.

Analysis of the Rib Fat.—In 1932-'33 a wide variation was found in protein, phosphorus and moisture in rib fat. It was observed that moisture variation was much more strongly influenced by phosphorus than by protein or even by the sodium-calcium ratio. An empirical expression giving a remarkable correlation with experimental data has been found as follows:

Per cent protein + per cent. phosphorus $\times 100 + \frac{(\text{NaCl} + \text{KCl})}{\text{CaCl}_2} =$ per cent moisture. Applied to 16 heterogeneous samples, including ten full-feds, one short-fed, two grass-feds, two milk-fed bulls, and one dark cutter, agreement between calculated and experimental results of less than 1 per cent moisture was found for 12 of them, and up to 2 per cent for the remaining four samples. Moisture ranged from 8 to 18 per cent.

Collagen and Elastin.—In 1932-'33 ripening was accompanied by a radical drop in collagen (with the exception of one carcass) amounting to an average of a 40 per cent decrease in the full-fed animals. Little change occurred in the elastin. In 1933-'34 no significant relation appeared in the effect of ripening on collagen and elastin. The data were inconclusive and unsatisfactory. In four samples substantially higher collagen was found in the ripened sample than in the fresh. No reason for such anomalous results can be given, except possibly inexperience in the manipulation of the autoclave. These fresh samples were among the first analyzed. The data on collagen and elastin covering the last five years, however, indicate that when collagen nitrogen exceeds 4 per cent, ripening is almost certain to lower it. Below 4 per cent little change is likely to occur in ripening.

Colloid Investigations.—In 1932-'33 the X-ray diffraction method of particle size measurement was applied to dried beef muscle tissue. The results indicated an order of magnitude of particles (12.8 to 19.0 Angstrom units in diameter) such as to identify tentatively the basic structural unit as the protein peptide chain. Fineness of texture showed a tendency to accompany large particle size, which relation might be explained by assuming that the longer peptide chains permit a more intricate, compact weaving of tissue structure. A method of measuring the colloidal dispersability of muscle tissue was developed by making spectrophotometric determinations of turbidity on the centrifuged liquor from a pebble-mill digest. Electrical resistance measurements showed some correlation with tenderness, a high resistance indicating lack of tenderness. Ripening was almost invariably followed by a lower resistance and greater tenderness as rated by the palatability committee. The shear, however, frequently registered higher on the ripened raw meat than on the fresh.

Color Investigations of Beef Muscle Tissue.—In 1932-'33 spectrophotometric determinations of blood and muscle hemoglobins in the rib eye showed an average of 18 per cent more muscle hemoglobin in animals full-fed on pasture than in those full-fed in dry lot, and the highest amount was found in animals on grass alone. Similar results were obtained in 1930-'31 and are in harmony with Whipple's findings that exercise is a primary factor in developing muscle hemoglobin. The more intensely red-colored lean meat came from animals on pasture. In 1933-'34 the longer the dry-lot finishing period the lower was the muscle hemoglobin content, except for one abnormally high value in the dry-lot finished lot. This individual (No. 221) contained 25 per cent more muscle hemoglobin than any other individual. No. 221 was abnormal in other respects, having an unusually high blood hemoglobin (18.3 gm./100 c. c.), high shear on the ripened sample, and low amount of fat in the rib cut. These conditions might have arisen because of age, wildness, or nervousness.

Since it was shown in the 1931-'32 report that the dark condition of certain lean tissue was caused by its impermeability to oxygen and the consequent inability of oxyhemoglobin to be formed, an attempt was made to measure the degree of this impermeability. A method was devised for determining the oxidation potential directly in the muscle tissue. The darkest carcass (No. 79), finished on pasture, showed the most negative potential, indicating the strongest demand for oxygen. The potential averages of different lots became increasingly negative the longer the pasture period.

Water-holding Capacity and Shrinkage Loss.—Heretofore attempts have been made, with only fair success, to link ripening shrinkage loss and keeping quality with the mineral balance in the fat. However, an occasional sample showed the lean and fatty tissues to be radically different in water-holding capacity, indicating that they probably are more or less independent systems. Consequently in 1933-'34 mineral balance studies were abandoned on fatty tissue and taken up on the rib eye. A method was developed for determining the quantity of expressible juice under a standardized procedure. The difficulty of overcoming the extrusion of the lean tissue was solved by mixing 100 grams of the finely ground tissue with 3 grams of filter-paper pulp and laminating the mixture in 16 layers between sheets of filter paper in the cylinder of the press. Pressure was applied up to 4,000 pounds per square inch. The volume of juice varied from 33 to 50 c. c. per 100 grams of tissue, and, with one exception (No. 198), followed the same trend as the shrinkage loss. The exceptional animal had been in dry lot the entire season and its fatty tissue was very watery and flabby. Consequently much more of the shrinkage loss in this instance must have come from the fatty tissue than is normally to be expected.

Mineral balance studies were made both on the expressed juice and the residual tissue. The sodium calcium ratios show no satisfactory trend, although in the pressed tissue the lowest ratio occurred in the one yielding the least juice, and nearly the highest ratio occurred in the tissue yielding the most

juice. The same relation holds true for the phosphorus-calcium ratio in the residual tissue. The unsatisfactory results may well be ascribed to analytical difficulties, since there is only about 5 mg. of calcium in 100 gms. of rib eye and 20 to 125 times as much sodium or phosphorus.

Since hydrogen ion concentration definitely affects the hydration of proteins, potentiometric measurements were made on a quinhydrone electrode placed directly in the muscle tissue. Slight differences were found, the pH ranging from 5.76 to 5.99. With one exception, which remained constant, the pH increased (acidity decreased) in the ripened samples, ranging up to 6.20. Acidity does not therefore seem to be a significant factor in the wide variation in water-holding capacity in the meat of the animals studied in 1933-'34.

Cooking Tests.—During 1933-'34 cooking tests on rib roasts were made according to directions issued for this coöperative project. Records were kept according to specified forms, and all roasts were scored by judges of experience.

Data were collected in 1932-'33 from the cooking of 13 fresh and 13 ripened rib roasts. The results indicated that the roasts from the two lots of animals, full-fed in dry lot and full-fed on pasture, were of good quality. The meat was successfully ripened. Average scores were similar for any one item, as texture or intensity of aroma, for all roasts both fresh and ripened. Roasts of both lots showed greater cooking losses after ripening than before, the increased losses being partly as evaporation and partly as drippings.

In 1933-'34 rib roasts from the beef carcasses of the four lots of experimental animals were cooked, following directions of the coöperative project for cooking and serving. The palatability committee was identical with that of 1932-'33. No roasts were undesirable, the lowest average scores appearing for intensity of aroma and intensity of flavor of fat. This indicated blandness, often considered desirable. The roasts were all successfully ripened. Roast 198, from the animal full-fed in dry lot, was not superior to the others, in most respects grading somewhat lower than the average for the other lots. Average scores for the pastured lots were similar for any one item, for both fresh and ripened meat.

Composition and Nutritive Value of Cooked Meat as Compared with the Raw Product.—Analyses of certain cuts of cooked beef are in progress. Uniform slices from beef ribs of graded carcasses, cooked in a standard manner, were available. Samples were saved from the roasts cooked before ripening and also from roasts from the same carcasses after ripening. Analytical data from samples of this kind are much needed, since most of the figures available on composition are for uncooked meat. Results of the analyses of cooked meat, when completed, will show protein, fat, total ash, moisture, calcium, phosphorus, and iron. There appeared to be some loss of nitrogen in the ripened meats.

Utilization by Human Subjects of the Nitrogen and Phosphorus of various Cuts of Meat.—Balance studies have been conducted with human subjects to secure information relative to the utilization of nitrogen and phosphorus from different cuts of beef. The nitrogen and phosphorus balance studies made with beef loin, heel, liver, round, and heart showed good usage of these elements from all cuts. The meats studied furnished approximately 80 to 90 per cent of the nitrogen and 50 to 70 per cent of the phosphorus of the diet. They were fed at a sufficiently low level that differences in utilization could be observed. Because of the great variations noted from day to day in individuals used for subjects in the previous studies, it seemed advisable to determine the extent of this variation in long-time feeding experiments. Accordingly, three young women served as subjects for two 45-day experimental periods; each 45-day period was divided into 15 three-day periods. In this experiment, round of beef supplied approximately 85 per cent of the protein of the diet. In series I the protein was placed at a low level and in series II at a high level, to determine the effect of level on nitrogen usage. The diet has been fed and samples collected. These are now in process of analysis for nitrogen. Calcium and phosphorus also will be studied.

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

Factors Influencing the Mineral Metabolism of Dairy Animals.—Several phases of this project were continued through the biennium. Each of these is discussed briefly below.

Milk as a Sole Diet for Calves.—During the biennium 12 Holstein bull calves, divided into four lots, were fed, until 12 months of age, a diet consisting of milk and certain vitamin supplements. All calves received whole milk according to their requirements for total digestible nutrients as shown by the Morrison standard, and, in addition, 10 c. c. of a mineral mixture which supplied 200 mg. of iron, 15 mg. of copper, and 30 mg. of manganese, to prevent anemia. In addition the different lots were handled as follows: Lot 1, control, no supplement; lot 2, dried brewers yeast (2 per cent of dry matter of ration); lot 3, cod-liver oil, 20 c. c. per calf daily; and lot 4, dried brewers yeast (2 per cent of dry matter of ration), and cod-liver oil, 20 c. c. per calf daily.

Two calves died at 10 and 11¼ months, respectively, but the other 10 were carried to 12 months, at which time they were slaughtered and given a careful post mortem examination. A rib bone and a cannon bone were saved from each animal for breaking-strength tests and for ash analyses.

All calves were muzzled except at feeding time. They had constant access to tap water and frequent access to NaCl. Body weights were taken semi-monthly, height of withers monthly, blood hemoglobin readings every two weeks, and blood calcium and phosphorus determined about every three months. The calf that died at 10 months was obviously abnormal from birth, and was replaced early in the experiment by another calf.

Without exception every calf refused some feed at times toward the latter part of the experiment. This perhaps should have been expected, since, to meet their requirements, a daily consumption of as high as 70 pounds of milk was required. Certain animals refused so much feed that it seriously affected their growth rate. All but lot 4 were above normal in weight at 12 months and this lot was above normal at 10 months of age. In lot 4 one of the calves began refusing his feed at 10 months, and thereafter lost weight rapidly. One calf in lot 3 refused much feed from nine months on and showed a constant loss in body weight as a result. Another calf in the same lot refused some feed after nine months of age and gained very slowly, but the lot averaged slightly above normal in body weight at 12 months of age. In height of withers all lots except No. 4 were above normal, and even lot 4 was only slightly below in the twelfth month after being constantly well above normal from the third month on.

At no time during the experiment was the hemoglobin content of the blood of any calf found low enough to consider it anemic. No lot appeared to be uniformly lower than any other lot at any time. While considerable variation was found in the blood calcium and blood phosphorus, at no time was it found to be abnormally low, except in the case of one of the calves that died, which showed a low blood calcium until it was about six months old.

One significant difference observed between this phase of the experiment and that of previous phases was the lack of any tendency in the calves toward tetany-like spasms, or a highly nervous condition. On this diet, lacking in roughage, the digestive tract showed great underdevelopment and lack of tone. Practically all of the animals showed, upon post mortem, a chronic catarrhal enteritis or gastritis or both. In a number of cases an examination of the omasum showed the presence of active or healed pyloric ulcers.

Influence of the Ration on the Vitamin C Content of Cows' Milk.—This phase, which was started several years ago, deals with the influence of the ration on the Vitamin C content of milk. The principal work on this phase has been completed and the data are being analyzed.

The Relation of Phosphorus Deficiency to the Utilization of Feed in Dairy Cattle.—This part of the project was started in the fall of 1929. Three important phases of the problem of lowered feed utilization in phosphorus-deficient cattle have been completed and reported. The results may be summarized briefly as follows:

- a. Phosphorus deficiency does not depress the digestive functions of the animal. Lactating dairy cows in a condition of a phosphorus deficiency were found to digest their feed as completely as the normal control.
- b. By means of gross energy determinations of the feed and visible excreta no abnormal losses of energy were demonstrated in the excreta of phosphorus-deficient animals.
- c. Oxygen consumption measurements, made by means of a portable metabolism apparatus, indicated a higher energy metabolism for animals in the phosphorus deficient condition.

Blood Sugar Studies in Dairy Cattle.—The original plan of this phase of the project, which was started in the fall of 1929, was to determine the normal concentration of blood sugar in dairy cattle. It has since been extended to include other related phases. One of these was a study of the effect of increased blood glucose on the synthesis of lactose in milk, the work on which has been completed and reported. During the past biennium another phase was included in this project. This involved a study of the changes in the composition of milk following freshening, particularly as to its concentration of lactose, fat, total solids, ash, protein, and changes in acidity, pH, and curd tension. These data are being analyzed and prepared for publication.

The Distribution of Minerals in Frozen Whey.—Mineral analyses were made on various fractions of frozen whey used for milk-sugar studies in project 190. The degree of separation of various minerals is shown by the following minimum and maximum values:

	<i>Minimum</i> <small>of minerals</small> <i>per cent</i>	<i>Maximum</i> <small>of minerals</small> <i>per cent</i>
Total solids	0.18	35.1
Ash .....	.032	3.85
Calcium .....	.105	1.10
Phosphorus less than .....	.001	.27
Alkali chlorides .....	.118	5.57

A recording potentiometer was arranged to control the temperature of an electric muffle for ashing milk and other samples. The thermocouple can be kept within 1 or 2 degrees C. at any value from room temperature to about 600 degrees. It was shown that considerable separation could be obtained. (1) of sugar from ash and (2) of alkali chlorides from calcium and phosphorus. The concentrations of calcium and phosphorus followed each other quite generally, though there were some exceptions.

Relations Between the Composition and Curd Tension of Milk.—The relation between curd tension and protein concentration has been studied because the literature contains some marked exceptions to the rather high correlation between these values.

Composite samples representing one day's milk were collected from 63 cows and the curd tensions measured by members of the department of Dairy Husbandry. The protein analyses were made in the Department of Chemistry. The results apparently confirm the findings of other workers that the correlation is high, but that there are some very definite exceptions.

This problem has been continued to include a study of the relation of curd tension to protein concentration in colostrum. The milk of six cows has been analyzed from day of parturition to three weeks after this date for casein, globulin, albumin, sugar and ash. These values, compared with curd tension and other values measured by the Department of Dairy Husbandry, indicate that the relation of curd tension to protein content was less in colostrum than in normal milk. The data obtained in this test indicated that large differences between individual cows must be expected, both in the composition of the first colostrum and also in the time required for the colostrum to become normal milk.

Some Mineral Constituents of Evaporated Milk.—It is commonly known among concerns producing unsweetened, evaporated milk, that the addition of less than 1 part per 100,000 of salts containing one or more of the elements calcium, magnesium, and phosphorus, often improves the quality of the milk. Among the qualities improved are grain texture and general appearance. This experiment was carried out to determine whether or not calcium, magnesium, and phosphorus must be present in either constant amounts or in constant ratio to produce an evaporated milk of the finest quality. Methods of analysis were developed by which these elements could be determined with a precision of better than 1 part in 100,000. The principal refinement needed to obtain this precision was to control the temperature at which the milk was ashed and at which the various precipitates were brought to constant weight.

The percentages of ash and of the elements calcium, magnesium and phosphorus were determined in triplicate on 10 commercial samples of evaporated milk of good quality. The 10 samples included four samples each from two retail brands and two samples from a third brand.

It was found that the elements studied need not be present in a constant amount nor in a constant ratio to each other.

[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 project during the biennium have consisted of eight phases. Of these, four were carried during both years of the biennium, while four were carried only one year.

1. *Grain Sorghums Versus Corn. for Developing Dairy Heifers.*—This project, started in 1927, was completed during the biennium. Its purpose was to determine whether the sorghum grains would replace corn satisfactorily in the ration for growing dairy heifers. Heifer calves that were fed to six months of age on a grain ration containing 50 per cent of either corn, sorgo, or kafir were continued through their first and second lactations on that grain. Alfalfa hay and sorgo silage made up the basal ration to which the grain was added. Since corn sorgo, or kafir was the sole grain fed in the ration to the animals in each lot, liberal feeding of each grain was necessary during the period of heavy milk production to meet the nutrient requirements of the animal. As a result it was felt that a fair test was made of the value of the sorghums in comparison with corn under the conditions of the experiment. Close observation was maintained on the growth (weight and height at withers), production, reproduction, and general behavior of all animals while on experiment. A total of 10 animals completed one or more lactations during the progress of this experiment.

The number of animals finishing the experiment in the corn and kafir lots was too small to permit the drawing of definite conclusions. This was due mainly to the prevalence of Bang's disease among the cows in the experiment. This disease was also troublesome in the station dairy herd at the same time, and does not indicate any increased susceptibility in the experimental animals. A total of eight animals (corn, two; sorgo, three; and kafir, three) at one time or another were removed from the experiment for this reason alone and, with one exception, all before first calving.

A careful appraisal of the results indicated no marked differences in favor of any one grain as far as production was concerned. There appeared to be little basis for the more or less popular belief that sorgo seed is not a satisfactory feed for dairy cows, promotes short lactation periods or lack of persistency. The average butterfat percentage was higher for the sorgo lot than for the others, though little significance can be attached to this fact, in view

of the number of animals concerned. It is significant that heifers maintained in dry lot four years or longer, without pasture, and fed the simple ration of alfalfa and sorgo silage and the grain ration of ground corn, sorgo or kafir were capable of averaging close to 300 pounds of butterfat or better in a lactation. Also, for the most part, all animals calved within a normal interval between the first and second lactations, regardless of the grain fed. No breeding difficulties were encountered of a significant nature that could be attributed to any one ration fed. Normal calves were produced in every recorded calving.

Evidently sorghums (Kansas Orange and kafir) can replace corn satisfactorily in the ration for growing dairy heifers, as no difference of a significant nature, attributable in any way to the respective grains fed, could be detected between the different lots as to thrift and general condition.

2. *Corn and Cob Meal Versus Corn Chop for Dairy Cows.*—During the first half of the biennium the third and final trial of this subproject, was conducted. Two lots of five cows each were fed by the double reversal method through three 25-day periods. The first eight days of each period were taken as preliminary, and data were used from only the last 17 days in each period. A basal ration of alfalfa hay and sorgo silage was fed, and in addition 3 grain mixture consisting in one lot of 500 pounds corn chop and 100 pounds of cottonseed meal, and in the other lot of 633 pounds of corn and cob meal and 100 pounds of cottonseed meal. By shelling tests it was found that the corn used consisted of 21 per cent cobs. It was planned to feed the lot on corn and cob meal exactly the same proportion of corn grain as the corn-chop lot received. To do this it was necessary to increase the grain allowance 22 per cent to make up for the cobs contained in the mixture. Body weights were secured at the beginning and the end of each 17-day experimental period. Butterfat tests were secured from milk samples secured on the six milkings nearest the center of each experimental period.

Results on the two feeds were remarkably uniform throughout. The body weight was slightly higher while on corn and cob meal, but the difference was only 0.6 of 1 per cent and not significant. The grain consumed during the corn and cob periods was 16.7 per cent greater than during the corn-chop periods, but, of course, even this was not enough to make up for the cob material present. While on corn and cob meal the lots consumed 1.32 per cent more hay, but 0.17 of 1 per cent less silage, neither difference being of importance. Production on the two different feeds was almost identical. There was less than 1 per cent difference in milk, in fat, or in 4 per cent fat-corrected milk.

3. *Prairie Hay Versus Alfalfa Hay for Dairy Cows.*—This was the second trial of this subproject. During the first half of the biennium, two lots of five cows each were fed by the double reversal method through the 30-day periods, the first eight days of each period serving only as a transition period. Both lots received sorghum silage at all times. Lot 1 was started on prairie hay and a grain mixture made up of 2 parts corn chop, 2 parts bran, and 3 parts cottonseed meal. Lot 2 was started on alfalfa hay and a grain mixture made up of 4 parts corn chop, 2 parts bran, and 1 part cottonseed meal. Both grain mixtures contained 1 per cent each of steamed bone meal, ground limestone, and salt. Each 30 days the rations were reversed to the lots. Individual body weights were secured from three days' weights centered on the beginning and end of each 20-day experimental period. Each milking from each cow was weighed and samples for fat tests were taken from the six milkings nearest the center of the 20-day experimental period. The animals were fed according to their requirements as indicated by the Morrison standard. To date 20 cows have been used on this subproject.

The second trial was a duplicate of the first in every possible respect, practically the only difference being the use of an eight-day instead of a 10-day preliminary period.

There was some tendency for a gain in body weight on each hay used, the greater gain being on the prairie hay, but the difference was less than 1 per

cent. The consumption of grain was identical on each feed, but 3 per cent less prairie hay than alfalfa hay was consumed, and 1.7 per cent less silage. An attempt was made to supplement the protein deficiency of the prairie hay with a protein rich-grain mixture, and also to provide mineral supplements which would prevent any danger of a lack of mineral in the prairie-hay ration. It was interesting to note that the milk production was only 2.2 per cent greater on the alfalfa-hay ration, and the fat production was 1.5 per cent greater on the prairie-hay ration. When the production was converted into 4 per cent fat-corrected milk the prairie-hay ration had an advantage of 1 per cent. This would indicate that prairie hay can be supplemented to give results equal to alfalfa hay.

4. *Lespedeza Pasture for Dairy Cows.*—To test out a relatively new pasture crop, Korean lespedeza was sowed on 4 acres of ground, and six cows were pastured on this crop continuously from July 15 to September 11. Water was provided in the pasture and the cows were removed only for milking. In addition to the pasture the cows received a grain mixture.

The total milk produced by the group in eight weeks was 7,809 pounds. It is interesting to note that the cows showed an actual increase in production for a few weeks after being turned on the lespedeza pasture. In the fourth week the production of both milk and fat was greater than in the first week, and the fat production was greater even in the fifth week than in the first. During the later weeks there was a noticeable drop in milk flow. During this same time the pasture became rather short. The hot, dry weather no doubt had a large influence in the lack of growth of the lespedeza.

During the eight weeks the cows showed a decline in body weight which averaged 12 pounds per cow. This loss seemed to occur during the first three to four weeks on pasture. During the last few weeks there was a gradual gain in body weight but not enough to make up the early loss. The total grain consumption of the group was 1,588.5 pounds. This consumption was 1 pound of grain for each 4.91 pounds of milk produced.

5. *Effect of Sorghums on Pregnant Heifers.*—Among cattle raisers it is not unusual to hear the sorghums accused of causing abortion. To secure information along this line three Holstein heifers, pregnant with their first calves, were selected from the college herd. These were started on a diet restricted to products of the sorghum plant on the 207th, 214th; and 231st day, respectively, of their gestation periods. They were fed a limited amount of Atlas sorgo silage and Atlas sorgo fodder. In addition they received all the ground Kansas Orange sorgo grain that they would clean up. This method of feeding was continued to within a few days of calving. Most of the time the heifers stood in their regular stanchions, but on a few days they ran in a dry lot.

The body weight of the animals remained remarkably constant throughout the trial. The consumption of grain increased for about three weeks, after which it remained constant for some two weeks, and then fell rather rapidly. Toward the close of the trial the heifers refused most of the grain, seeming to much prefer the roughage. The fodder consumption after two weeks was very constant. As the animals started refusing their grain, the silage ration was increased somewhat and was relished throughout the trial. All three heifers dropped normal, healthy calves at the end of these gestation periods, and showed no tendency to retain the afterbirth.

6. *Wheatland Milo Versus Corn Chop for Dairy Cows.*—Wheatland milo is a crop with a relatively heavy yield of grain and is adapted to regions that are unsatisfactory for corn. Much of this grain is now being fed to dairy cows and other live stock. In an attempt to determine the value of Wheatland milo as compared with corn this trial was conducted during the second year of the biennium.

Ten cows were divided into two lots of five cows each and were fed through three 25-day periods, the first five days of each period being considered the preliminary period. The short transition period was considered sufficient, due to the marked similarity of the two feeds being compared. Lot

1 was started on a grain mixture made up of 4 parts of Wheatland milo, 2 parts wheat bran, and 1 part cottonseed meal. Lot 2 was started on the same mixture except that corn chop replaced the milo. All grain mixtures contained 1 per cent each of steamed bone meal, ground limestone, and salt. At the end of each 25-day period the grain rations were reversed to the two lots. Besides the grain mixture the cows received alfalfa hay and sorghum silage. The ration was calculated to meet the requirements of the animals as indicated by the Morrison standard.

Body weights were secured on three consecutive days centered on the first day and the last day of the 20-day experimental period, and samples for fat determinations were secured from the six milkings nearest the center of these periods. One cow in lot 2 died before the close of the experiment, so data were secured from only nine animals.

While on the milo the cows made an average gain in body weight of 9 pounds per period, and while on corn chops a loss of 7 pounds per period. This was a difference of 1.5 per cent in favor of the milo. In feed consumption the cows, while on the milo ration, consumed 1.8 per cent less grain but 1.1 per cent more hay and 1.3 per cent more silage. These differences are of minor importance. While on the milo ration the cow made a somewhat better showing in production than while on corn chop. This increase was 3.2 per cent in milk and 4 per cent in fat. Calculated to the basis of 4 per cent fat milk the advantage shown by the milo ration was 3.7 per cent.

7. *The Utilization of Atlas and Kansas Orange Sorgo Seed by Dairy Cows.*—The weight of seeds in Atlas and Kansas Orange silage was determined by hand picking the seeds from 5-pound samples of the silage. The amount of seeds not utilized by dairy cows was determined by washing the seeds out of samples amounting to 10 per cent of the weight of the feces. The utilization of the whole seed fed as grain was also determined. Results of chemical analyses and germination tests of the seeds before and after passing through the animals were obtained.

a. Approximately 43 per cent of the seed in Kansas Orange sorgo silage and 36 per cent of the seed in Atlas sorgo silage were voided in the feces of dairy cows when fed in the dairy ration with alfalfa hay and a grain mixture; when fed alone, in the form of silage, 30 per cent of the seeds in Atlas silage were lost. When the two grains were fed as the sole concentrate with alfalfa hay, 62 per cent of the Kansas Orange seed and 51 per cent of the Atlas sorgo seed were voided in the feces.

b. In the experiments reported 19 per cent more of the Kansas Orange seeds and 15 per cent more of the Atlas seeds were utilized by the animals when silage was fed than when the whole grain was fed.

c. The animals used a negligible amount of the food nutrients from the whole seeds recovered in the feces. In this experiment the ensiling process destroyed the germination of the Kansas Orange and Atlas seeds. When the seeds were fed without being ensiled the digestive tract greatly reduced the germination of the whole seeds which were voided in the feces.

8. *Silage Weight Determinations.*—The object of this phase of the project was to determine the weight per cubic foot of untramped silage at the various depths and at different points in a silo. Weights were taken in three silos at the dairy barn during the first year of the biennium. On account of an abnormal crop during the fall of 1933 weights were not taken of the silage fed during 1933-'34.

A spring balance was used in determining the weight of a cubic foot measured by the "Kansas apparatus." Weights were taken from the center of the silo, near the outside and at a location midway between these two places. These weights were taken about every 1½ feet in depth. Moisture determinations were made on an air-dry basis from samples taken at irregular intervals.

The weights show that the silage at the center of the silo was heavier than that at the edge by 3.36 pounds per cubic foot, or 9.12 per cent. The silage from the center was heavier than that taken from an intermediate location by 1.03 pounds, or 2.8 per cent. Additional data will be obtained to supplement

this and other data obtained during the past six years. Eventually tables giving the weights per cubic foot for untramped silage will be formulated.

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

The Normal Growth of Dairy Cattle.—This project was started in 1922. Weight and height determinations are taken on all male and female calves in the college dairy herd at monthly intervals until 24 months of age. Following this the measurements are made twice a year, in January and July, respectively.

No summary of the data was made for this biennium. The last summary appears in the biennial report of 1932. It is planned to continue this project indefinitely. The data become more significant with each year's accumulation of figures, and are particularly valuable in experimental work involving growth, and as a measure of the normal growth of the leading dairy breeds.

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

Calf Feeding Investigations.—This project dealing with the use of milk substitutes in the calf ration was started in the fall of 1931 and completed during the past biennium. It is of particular interest to dairymen in market milk areas, who are dependent, to a great extent, on the use of milk substitutes for calf raising.

It is a fairly common practice at the present time to feed the dry-milk powders in the remade form, that is, dissolving the powder in warm water and feeding in that form to the dairy calf. Experience has shown this to be an entirely satisfactory method. The principal objection of the dairyman was the extra work involved in remaking the milks. The principal object of the present investigation, therefore, was to determine the practicability of feeding the milk powders in the dry form in the grain ration. Dried skim milk and dried buttermilk were the products used. They were fed at approximately the 25 per cent level in the grain ration. In addition, as a means of comparison, other lots of calves received these products in the remade form. Some experimental work was done also in the feeding of remade semisolid buttermilk.

In the case of the lots receiving the dried product in the grain ration, a limited amount of whole milk was fed for the first four or five weeks, after which the calves were weaned and placed on a grain mixture including skim milk or buttermilk powder and alfalfa hay.

The groups receiving the dried products and semisolid buttermilk in the remade form were changed from whole milk at two weeks of age. Their grain mixture was the same as above, minus the dried milk. All received good quality alfalfa hay. All calves were continued on experiment until six months of age, following which they were maintained under herd conditions. Regular weight and height determinations were made on all individuals.

The calves receiving the remade products appeared normal in every respect, and with few exceptions were normal in growth. This substantiates the work at other stations.

The calves receiving the dried milks in the grain mixture, while about 20 per cent below normal in weight, averaged nearly normal gains in height at six months. While somewhat rough in appearance, they were a thrifty lot, and after transfer to the general calf herd were approximately normal in size at one year old.

While semisolid buttermilk is sometimes advertised as a calf feed, and at least one station has reported satisfactory results in feeding this product, the results of the present experiment were not so successful. It was fed at the rate of 1 pound to each 3 pounds or more of water. It was not found possible to

feed the remade product successfully to calves without first neutralizing the acid present. Unless this was done, the calves scoured badly, became weak and very unthrifty, and would have died if they had not been changed back to whole-milk feeding. When the acid present was neutralized with lime water to the acidity of milk the results were more successful. It required about 0.65 of a pint of saturated lime-water solution to neutralize 10 pounds of the semi-solid product. However, even then it was not very palatable, and was apt to produce digestive disturbances. It is not to be recommended where skim milk or the dried products are available.

[Department of Dairy Husbandry. Leader, W. H. Riddell; state fund.]

Ice Cream Investigations.—During the biennium several phases of this project were investigated, each of which is discussed briefly below.

Use of Milk Protein in Ice Cream.—Several delactosed products, sometimes called milk protein or sodium caseinate, have been recommended for use in ice cream. Some of these products have certain merits, and may make it possible for the ice-cream maker to overcome difficulties. On the other hand, they add to the cost of the ice cream and may result in certain off flavors in the finished ice cream. They do not replace gelatin satisfactorily as a stabilizer, and if used in excessive quantity may result in certain freezing difficulties. The use of sodium caseinate in ice cream is covered by a patent.

Effect of Pasteurization Temperature on the Bacterial Flora of Ice Cream.—Pasteurization exposures of 145 degrees F. and 150 degrees F. for 20, 25, and 30 minutes, 160 degrees F. for 10, 15, and 20 minutes, and 170 degrees F. for 2, 5, and 10 minutes, and 180 degrees F. for an instant, yield results not sufficiently different to be measurable by the plate count. In mixes made from raw dairy products the flora after pasteurization was about equally divided between peptonizing and alkali forming and inert groups of bacteria, whereas in mixes made from previously pasteurized products the flora after pasteurization consisted largely of slow acid formers.

Testing Ice Cream for Butterfat.—This work was started in 1931, and additional work was done during the past year. The accuracy and desirability of various butterfat tests for ice cream are being determined. The tests under observation include the Illinois, Minnesota, Nebraska, and glacial acetic sulphuric-acid test. These are being checked against the Mojonnier method.

Samples of vanilla ice cream were sent to laboratories of several colleges and universities to be tested. Also a large number of samples were tested at this station. All the various modified Babcock methods were subject to considerable variation. The Mojonnier test gave consistent results between laboratories, and with one exception did not vary much more than + 0.1 per cent from the mean. Fat determinations were made on samples of the same mix before pasteurization, after pasteurization and homogenization, and after freezing and hardening.

No definite recommendations can be made at this time. From results obtained to date it appears that it will be necessary to further standardize reagents and procedures if satisfactory results are to be obtained. For example, the Minnesota test gives clear fat columns, and is simple and easy to run, but for some reason tests from the various laboratories on the same sample seemed to vary widely. The Illinois test, also a nonacid test, as a rule gave good fat columns, but was more complicated and time-consuming and was subject to wide variation between laboratories. The glacial acetic, sulphuric-acid method and the Nebraska tests gave results which checked more closely with the Mojonnier test and were subject to less variation between laboratories, but had certain disadvantages. These acid tests did not work satisfactorily for some mixes unless the procedure was varied to take in consideration changes in composition of the mix.

Effect of Drawing Temperatures on the Texture of Ice Cream.—Ice cream mixes of various compositions were prepared and frozen in a direct expansion freezer in the usual manner. Each trial consisted of three individual mixes which were cooled to different degrees of temperature before the refrigerant was shut off. The temperature and rate of overrun incorporation were noted and the finished ice cream was scored. Six trials were made.

In each trial an attempt was made to cool one batch to about the correct temperature for satisfactory overrun incorporation, before shutting off the refrigerant (24.8 – 25.7 degrees F.). A second batch was cooled about 1 degree lower and a third batch about 2 degrees lower. Regardless of the temperatures at which the refrigerant was shut off, the final drawing temperatures were all practically the same. When the mixes were cooled too low the ice cream became so stiff that overrun could not be incorporated readily. This prolonged the whipping time and made it difficult to secure the desired overrun.

There was no marked improvement in quality of the finished ice cream resulting from the freezing temperature at which the ammonia was shut off. This, no doubt, is accounted for by the fact that each mix warmed up to a certain point at which overrun could be incorporated. Differences which did exist in texture scores were, for the most part, due to the variations in compositions of the mixes used, rather than to the temperature of drawing.

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

Bacteriological Study of Ice Cream.—The work on this project during the past biennium was divided into five major phases, each of which is described briefly below.

1. Factors Affecting Thermal Resistance of Micro-organisms.—In connection with the studies on the bacteriology of ice cream, observations have been made repeatedly to show that bacteria may be more resistant when heated in ice-cream mix than when heated in other menstrua, such as water, broth, milk, or ice-cream mix without sugar. In view of the fact that the thermal exposure employed in pasteurization of milk allows only a very small margin of safety, any increase in the thermal resistance contributed to the organisms by the ingredients of ice-cream mix should be evaluated. Data have been accumulated which show that the environmental conditions imposed by the ingredients of ice-cream mix make possible an increase in the thermal tolerance of certain bacteria over that which obtains when suspended in milk, water, or broth.

Although the primary interest in this problem has centered about its possible relation to the survival of bacteria in the pasteurization of ice-cream mix, a relatively small percentage of the experimental work has involved the use of this product as a heating medium. Due to the lack of specific information on the effect of certain physical forces on thermal resistance, the study has more or less evolved into an analysis of the fundamental, rather than the practical, aspects of the problems of cell destruction.

The results of many experiments demonstrated that certain sugars afforded cells more protective action against heat than others, suggesting, therefore, that the protective action was not solely a function of osmotic pressure. The protective action of dextrose and of sucrose increased with the concentration of the respective solutions employed.

If the death of the cell is the result of coagulation of the protoplasm, agents which manifest protective action should therefore retard coagulation of other coagulable proteins. Egg albumin was mixed with equal volumes of dextrose solutions and sucrose solutions of various molalities. When these mixtures were heated at 60 degrees C., the time required for coagulation of the egg albumin increased with greater concentrations of the two sugars. In harmony with the protective action on cells, sucrose was more effective than dextrose in retarding coagulation of egg albumin.

The same parallelism between protective action afforded cells by sugar solutions and the retardation of coagulation of non-living proteins has been

demonstrated with the enzyme rennin. When mixtures of rennin and sugar solutions are subjected to temperatures which ordinarily inactivate the enzyme, dextrose and sucrose solutions retard this inactivation.

Obviously the problem presents an approach to the fundamental factors involved in the death of the cell. The study has been directed along lines of attack designed to reveal something about the mechanism of the death of a cell. The extremely fundamental nature of the problem justifies extensive investigation. The effect of various cations and anions on the thermal resistance is being studied. The results suggest a possible relationship between the charge on the cell and its thermal resistance.

The future development of this problem will entail an extensive analysis of the effect of physical and chemical factors on thermal resistance. Although the need for information of such a fundamental character is not limited to ice cream, the increasing tendency to require pasteurization of the ice-cream mix justifies a continuation of this study.

2. *Application of Methylene-Blue Reduction Test to Ice-cream Mix and to Ice Cream.*—A continuation of the studies on the application of the methylene-blue reduction test of ice cream revealed that the reduction time was a function of bacterial numbers only when the organisms involved induce the same, or approximately the same, reducing intensities. Series of samples of ice-cream mix were inoculated with increasing numbers of a pure culture of bacteria. The reduction times observed on these samples before and after freezing exhibited a definite relationship with the numbers of bacteria added. When the increases in bacterial numbers were effected by the alternate addition of several cultures with different, reducing intensities the reduction times were not in harmony with bacterial numbers. Although from a theoretical point of view the methylene-blue reduction test as applied to milk is complicated by the same inconsistency, practically it is not so likely to interfere with the interpretative value of reduction-time determinations. The factors responsible for high bacterial numbers in milk are usually the result of inadequate refrigeration, and therefore usually result in the growth of *S. lactis*. As a consequence, the short reduction times observed in several samples of poor milk are likely to be caused by the same type of organism. On the other hand, high bacterial counts in ice cream are usually the result of poorly cleaned equipment, the use of poor products or ineffective pasteurization. The organisms which dominate the flora of several samples of ice-cream mix may be different with each sample, hence the reduction time will not necessarily reflect the number of organisms present.

3. *Enumerating Bacteria in Ice Cream.*—As an outgrowth of the studies at this station on the bacteriology of ice cream a method of enumerating bacteria by means of the microscope has been developed. The method consists of spreading 0.1 c. c. of melted sample, plus two to four drops of water, over the entire area of a 3x1-inch glass slide. This preparation is stained by Newman's method and examined with a microscope, the field of which is standardized to a diameter of 0.157 mm. The average number of bacteria per field multiplied by the factor 1,000,000 gives the number of bacteria per c. c. If more convenient, the total number of bacteria found in a strip across the short dimension of the slide may be multiplied by the factor 5,000 to give the count per c. c.

4. *Sterilizing Dairy Equipment with Chemical Agents.*—The studies on the methods of sterilizing dairy equipment with the use of chemical agents have been completed and the results prepared for publication.

5. *Standard Procedures for Bacteriological Analysis of Ice Cream.*—Part of the work of the American Dairy Science Association Committee on Bacteriological Methods for Dairy Products has been conducted at this station. The sub-committee on Bacteriological Methods for the Examination of Ice Cream rendered a report outlining the standard procedures for bacteriological analysis of this product. Some of the investigational work, including comparison of various methods of analysis, were made at this station.

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

The Influence of Homogenization on the Curd Tension of Milk.—There is growing interest in homogenized milk in the United States at the present time. Numerous statements have appeared in literature to the effect that homogenization of milk will effectively reduce its curd tension, but in no case has any experimental data been seen to substantiate such claims. This investigation was undertaken to determine experimentally to what extent and under what conditions the curd tension of whole milk may be altered by the process of homogenization.

Three lots of whole milk with distinct differences in curd tension were used. Portions from each lot of milk were processed at three different homogenization pressures and at three different temperatures. The average curd tensions for the three lots of milk used were 43.84, 59.25, and 87.90 grams, respectively. The homogenization pressures employed were 1,500, 2,500, and 3,500 pounds per square inch. The processing temperatures used were 120 degrees, 145 degrees, and 165 degrees F., respectively. In all cases six trials were conducted with each lot of milk at each of the three homogenization pressures and at each of the three processing temperatures.

The homogenization process, irrespective of the temperature or pressure used, was found to reduce the curd tension of the three lots of milk, 60.97 per cent, 61.13 per cent, and 49.2 per cent, respectively. The reduction in curd tension of the first two lots of milk was sufficient to place the milk definitely in the generally accepted soft-curd classification, which includes all milk with a curd tension of 30 grams or below. It is evident from the above results that the original curd tension of the milk has an important bearing on the reduction in curd tension affected by the homogenization process.

An increase in the homogenization pressure beyond 1,500 pounds per square inch was found to further reduce the curd tension. The reduction, however, was not in direct proportion to the increase in pressure. The average reduction in curd tension for all the milk samples was 53.3 per cent, 56.42 per cent, and 57.12 per cent when homogenized at 1,500, 2,500, and 3,500 pounds pressure per square inch, respectively. These data indicate that there is no practical advantage in using homogenization pressures in excess of 2,500 pounds per square inch for the purpose of reducing the curd tension of the milk.

The average reductions in the curd tension of all milk samples processed at 120 degrees, 145 degrees, and 165 degrees F. were 58.81 per cent, 51.39 per cent, and 56.77 per cent, respectively. In figuring the above data no account was taken of the fact that heating in itself, especially to a temperature of 165 degrees F., materially reduces the curd tension of the milk. The check samples in all cases were taken after the milk was heated to the desired temperature, and immediately before it was processed. If the combined effect of the heat treatment, together with the reduction in curd tension as a result of the homogenization process, are taken into consideration, the greatest total reduction in curd tension would be effected at 165 degrees F.

Duplicate pint samples of the homogenized milk were obtained immediately after homogenization in all cases. The curd tension of one set of samples was determined within five hours after processing, whereas the curd tension on the second set of samples was not determined until 48 hours later. All samples were packed in ice and held in a cooler at approximately 40 degrees F. until used. The differences in curd tension between the fresh and aged samples were slight. The aged samples showed a slightly higher curd tension on the average than the fresh samples. Passing the milk through the homogenizer a second time was found to be of no practical value in reducing the curd tension of the milk.

It was found that a rancid flavor developed in raw milk homogenized at 100 degrees and 120 degrees F. The flavor usually appeared within two hours after the milk was processed, and developed in intensity for several hours. The development of the flavor was always accompanied by a marked increase in the titratable acidity of the milk. No difficulty with this flavor was encountered when the milk was pasteurized prior to homogenization. A processing temperature of 120 degrees F. can be used successfully, provided the milk has been previously pasteurized or heated to a temperature sufficiently high to inactivate the enzyme lipase. When the milk was properly pasteurized prior to homogenization no objectionable flavors were encountered. A slight heated flavor was usually present in the milk samples heated to 165 degrees F.

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

Studies on the Curd Character of Milk.—This project was started in the fall of 1932. Its purpose was to study the normal variations in curd tension of milk produced in the Kansas State College dairy herd and some of the important factors influencing the curd tension of milk. The Hill test, with certain modifications as to technique recommended by Monier and Sommer, was followed in this work. Also the more practicable curd-o-meter has been used in making all tests.

During the past year and a half the following points have been studied more or less thoroughly:

1. The monthly variations in curd tension on all cows in the college dairy herd, or an average of approximately 60 cows each month. The herd is made up of representatives of the four leading dairy herds.

2. The daily variations in curd tension of the milk of representative soft-medium- and hard-curd cows in the college herd.

3. Changes in curd tension following freshening. This study was carried out in conjunction with another project, to determine when the milk reached normal in curd character and other respects following parturition.

4. Factors influencing the accuracy and uniformity of results obtained in the test itself, such as (1) variation between individual operators, (2) effect of temperature at which test is run, (3) effect of time of standing after coagulant is added and before curd test is made, (4) effect of amount of coagulant added—in one series of tests the dilution and salt balance were controlled, while in another series the dilution and amount of pepsin were controlled.

5. Correlation between the protein content of milk and the curd tension.

Some of the general conclusions which may be made as a result of these studies are as follows:

- a. Considerable daily variation was evident in the curd tension of individual cows and was more pronounced for some individuals than others. The variation between successive monthly tests on individual cows was even more marked, and indicated the desirability of running fairly frequent tests if a group of cows for the production of soft-curd milk (below 30 grams curd tension) were to be maintained within a herd.

- b. The milk of the recently fresh cows usually was characterized by an abnormally high curd tension, running in some cases five times the normal value. This usually applied to the first few milkings after freshening, following which the decline to normal set in. In some cases the high values were observed several days after freshening. These abnormal values for curd tension undoubtedly were correlated with variations in the protein and mineral constituents in the milk. In the majority of cases observed, the milk did not reach a normal curd-tension value until approximately three weeks after freshening.

- c. A high correlation (0.76 ± 0.037) was obtained between the total protein content of 58 samples of milk and their respective curd tensions. It seems logical to conclude that the protein, and more particularly the casein,

is the major factor involved in determining whether a milk is hard- or soft-curd in character. However, other important factors are concerned, a principal one being the salt composition of milk. Samples of milk have been observed which failed to set up a curd, due to the high chloride concentration of the milk.

d. Significant differences were obtained between different operators in running tests on representative samples of milk. Variation in the pressure with which the knife was applied to the surface of the curd was undoubtedly the principal reason for these differences.

e. All factors previously mentioned were found to influence significantly the accuracy and uniformity of results obtained in the curd test. If comparable results are to be obtained, close control must be exercised over the several factors studied.

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

A Study of the Formation, Isolation, and Properties of Milk Sugars.—Two phases of this project have been studied during the past biennium.

1. *The Structure of Methylated Sugars.*—The efforts in this phase were limited to finding a satisfactory method of controlling pH during methylation. Previously an amplifier and glass electrode had been built which controlled the use of alkali at a fairly constant rate during a methylating reaction that may be assumed to be uniform. The voltage of the electrode fluctuated frequently and rather regularly by amounts usually more than 50 millivolts. After a suggestion from Doctor West, of Washington University, St. Louis, it was discovered that these fluctuations could be greatly reduced by the addition of choloform to the methylating mixture.

Meanwhile an antimony electrode has been studied in methylating mixtures containing chloroform. It was shown that (a) the frequent fluctuations were satisfactorily eliminated, (b) the rate of alkali consumption was not constant for a given E. M. F., and (3) the calorimetric pH also varied while the E. M. F. was held constant. The antimony electrode is therefore considered incapable of giving satisfactory control for studying the effect of pH on the structure of methylated sugars.

The dropping mechanism built during 1933 has controlled the E. M. F. of a calomel-antimony cell in fermenting milk within about 1 M. V. for as long as 16 hours. Tests with a quinhydrone cell indicate that, in the fermenting milk, the calomel-antimony cell was a satisfactory measure of pH. A description of the dropping mechanism has been published in the *Journal of Industrial and Engineering Chemistry, Analytical Edition*, volume 5, page 352, 1933.

2. *Methods of Isolating Sugars in Whey by Partial Freezing or by Complete Freezing and Equilibrium Thawing.*—This study involved: (a) studies of methods of (1) freezing, (2) filtering or centrifuging, (3) estimation of sugars, and (4) extraction of rare sugars; (b) tests of the need of milk sugar for cerebroside formation.

The actual freezing was done by the Department of Dairy Husbandry. It was found that if the freezing were done in an ice-cream freezer or in a tank which was constantly stirred, an ice could be centrifuged off which was practically sugar-free. It was found impractical to freeze the unconcentrated whey in an ice-cream freezer, due to the formation of an ice crust on the inside of the freezer. The first concentration must therefore take place either in a tank stirred by hand or in a tank such as is used for freezing cakes of ice. The ice fraction, left after pouring off the center 30 to 60 per cent from the later type of freezing, contained large quantities of lactose, but apparently none of the rare sugars which could be isolated from the more concentrated whey. After the volume of the whey was decreased by about 30 per cent, the

residue could be readily frozen in an ice-cream freezer to contain something more than 50 per cent ice.

A Buchner suction filter, an Oliver rotary filter, and a basket centrifuge were tried for separating the ice from the liquid portion of the freezer-frozen product. The centrifuge was the only method that produced a satisfactory separation. After the liquid fraction was reduced to about one-tenth the original volume of the whey a good precipitate of fairly pure lactose formed on standing 12 hours at about 40 degrees F. Most of the liquor was syphoned off from this and the remainder decanted, after packing the sugar with a cup-type centrifuge. A second crop of lactose could be obtained by freezing another ice fraction out of the mother liquor. The residual liquor was then satisfactory material from which to extract rare sugars.

The availability of this method for the commercial production of lactose appears to depend largely on the possibility of finding a use for the ice produced during the freezing.

It was hoped that differences in the results of different methods of estimating sugars in the whey fractions would give an indication of partial separations of different sugars. Accordingly the sugar contents of ice fractions and liquor fractions were determined (1) with the polariscope, using either mercuric nitrate or ferric sulfate and barium carbonate as clarifier; (2) by the iodine titration of aldose, following Shafer and Acree, and using ferric sulfate as clarifier; (3) by the Lane-Eynon method; and (4) by the Shafer-Hartman method. In the last two methods, lead acetate or ferric sulfate was used as a clarifier. Before ferric sulfate and barium carbonate were used as a clarifier considerable differences were found in the results by different methods. These differences were largely eliminated by the use of this clarifier, and the remaining differences appeared to be related to the clarifying agent used. The early conclusion that the more concentrated liquor showed greatest variation and was therefore the most likely place to look for other sugars has been justified, but now appears more lucky than logical.

To isolate rare sugars, the concentrated mother liquor from production of lactose was evaporated before a fan to dryness at room temperature. The finely ground residue was then extracted with hot methyl alcohol, the extract mixed with an equal volume of absolute ethyl alcohol and cooled. Attempts were made to purify the solid product which separates out by recrystallizing from alcohol; by clarifying with either charcoal, mercuric nitrate, or trichloroacetic acid; by reprecipitating from acetone with benzene; and by recrystallizing from water. Products obtained by the different methods were not identical, and the exact nature of the product is still uncertain. Tests on the product purified with alcohol and charcoal indicate a molecular weight of 150, an iodine titration corresponding to an aldo pentose, a specific rotation of about + 20, and a reducing power for Benedict's new blood-sugar reagent which was about equal to glucose and was not greatly changed either by yeast or by hydrolysis. The largest yield so far obtained has been about 40 parts per million parts of whey.

A study of the need of lactose for cerebroside formation in rats has been possible. The coöperation of the Department of Psychology has also enabled a study to be made of the relation of cerebrosides and other brain lipoids to learning ability.

It was found that rats fed from 20 to 40 days of age formed much less cerebroside if fed a ration containing 20 per cent sucrose than if fed a ration identical except that lactose was substituted for the sucrose. The sucrose-fed rats developed brains nearly equal in weight and in per cent total solids, but, containing in some tests only about one-tenth as much unsaturated cerebroside as either the lactose-fed rats or controls on another ordinary ration. The body weight of the sucrose-fed rats also was far below normal. The ability of the lactose-fed rats to maintain normal weight appeared to depend on some "impurity" in the lactose. When the "best" grade of lactose was used, rats grew no better than on sucrose, but still did have more galactosides in their brains. The comparison of lipid analysis with learning ability indicates that there is

a significant correlation between learning ability and both unsaturated cerebrosides and unsaturated phosphatides.

Efforts are now under way and will be continued to push these relations to more conclusive tests, both by developing animals on synthetic feeds to satisfactory condition for learning tests and also by breeding for greater differences in learning ability to compare with differences in chemical analysis. Further studies also are needed to increase both the precision and the scope of the lipid analysis.

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

Protein Investigations.—Two lines of investigation were conducted under this heading; namely, (1) A study of the proteins of flour with reference to baking qualities, and (2) proteins of eggs with special reference to deterioration under cold-storage conditions.

During the past biennium no significant time was devoted to the proteins of flour, the work having been confined chiefly to studies of the protein of eggs. Some of the findings in this study are as follows:

All the sulphur in egg whites and yolks is organically bound. Cystine sulphur determinations show that it is only a fractional part of the total sulphur. Nitrogen determinations show conclusively some loss of total nitrogen during treatment with nitrite, which may or may not account for some of the loss in sulphur as determined calorimetrically by Sullivan's method. Fusion experiments were not a success, but need to be refined or changed until a quantitative method for estimating reduced sulphur is found. Further determinations of state of sulphur will have to be made that will definitely establish the amount present in a reduced or an oxidized form to agree with the total sulphur.

Studies of eggs under varying storage conditions showed that the average moisture content of egg white from strictly fresh eggs was 88.71 per cent for total egg white, 88.50 per cent for firm white, 89.08 per cent for soft white. The moisture content decreased as the time and temperature of storage increased. After 60 days' storage at ordinary temperatures (25 degrees C.), the percentages of moisture were for total white, 76.65, for firm white 76.76, for soft white 76.83. These two series of results represented the limits for the eggs investigated. Cold-storage eggs lost about 1 per cent moisture in 60 days. The moisture content was very uniform in the whites from different eggs and decreased at about the same rate under the same storage conditions. The average percentage of firm white in strictly fresh eggs was 52.64, that of soft white 47.36. The highest ratios of firm white to soft white in strictly fresh eggs was 73.80 to 26.20; the lowest, 31.28 to 68.72. This ratio varied within wide limits in the different eggs. The percentage of firm white decreased as the time and temperature of storage increased, while that of the soft white increased in about the same ratio. The average percentage of firm white in eggs stored at 25 degrees C. for 60 days was 18.83, that of soft white 81.17. These two series of results likewise represented the average limits for the eggs investigated. In some eggs the firm white disappeared entirely on storage. The average percentage of water-precipitable globulin in strictly fresh eggs was, for total white, 0.47; for firm white, 0.35; for soft white, 0.12. This percentage varied considerably in the different eggs. In eggs stored at ordinary temperatures for 60 days the averages were, in total white, 0.31 per cent; in firm white, 0.09; in soft white, 0.22. Thus the percentage of globulin decreased in the firm white as the time and temperature of storage increased, and at the same time increased in the soft white. The total globulin likewise decreased in storage. In all the above changes (in moisture content, in ratio of firm white to soft white and in globulin content); an increase in the temperatures of storage had a much greater effect than an increase in the time of storage.

[Project 192; Department of Chemistry. Leader. H. H. King; Purnell fund.]

The Inheritance of Standard Characteristics of Poultry.—Three phases of this project were studied during the biennium as follows:

1. *Inheritance of Crookedness of the Keel Bone.*—The work on this phase of the project for the past two years consisted of repetition of the earlier crosses between the crooked and straight keel strains under more carefully controlled roosting conditions. It was found that although the crooked breast-bone condition was inherited, its expression was materially influenced by the sharpness of the roost used by the bird during growth. The crooked-keel strain could be made to develop a high percentage of birds with crooked breast bones when the chicks were allowed to use sharp edged roosts while practically no crookedness would develop in the same stock when no roosts were used.

2. *Inheritance of Plumage and Eye-color Inheritance in Rhode Island Reds.*—Detailed records of plumage and eye-color variations have been kept for several years on the experiment station flock of Single Comb Rhode Island Reds. The matings were made for other studies, so that the color combinations utilized were largely chance. The numbers (over 3,000 birds) were large enough, however, to include most of the variations occurring.

Evidence was found for the heritability of variations in general plumage surface color, in under color, and the amount of black in the flight feathers. In most cases the genetic basis seemed to be a multiple-factor one. Sexual dimorphism was observed in all of these plumage color variations, the males averaging darker than the females. In no case was there any evidence for sex-linkage of the genetic factors involved. Although the eye color was found to be variable, the results were not definite enough to prove that, they were inherited. No evidence was secured which might indicate that the variations in eye color were due to environmental factors.

3. *Autosomal Linkage.*—The search for new linkage groups in the fowl constituted a major project during the past two years. Thirty-four new factor combinations were tested for linkage, and in most cases the number of offspring was large enough to demonstrate the existence or lack of linkage.

In three factor combinations evidence for linkage was found, indicating that the involved factors were carried on the same chromosome. The factors showing linkage were silky and flightless and dominant white and crest.

A new genetic character, frayed, was investigated. This character is expressed most conspicuously in the larger wing and tail feathers. The major causative factor seems to be a defective condition of the barbules. This results in a poorly formed web which has a slitted appearance, each barb being free from the contiguous ones. The smaller body feathers also have a somewhat ropy appearance. A mating of frayed birds to normal produced nothing but individuals with normal plumage, but these normals, when mated among themselves, produced frayed feathering in both males and females. These results indicate that frayed is a recessive autosomal character, although there is some shortage in the frayed class.

[Project 77-3 and 4; Department of Poultry Husbandry. Leader, D. C. Warren; state fund.]

Physiology of Reproduction in Poultry.—A study was made of the time factor in the passage of the egg down the oviduct of the hen as well as the accumulation of the egg parts in the regions of the oviduct. Forty-five hens were killed at various known intervals following expulsion of the previous egg, and records made of both the position of the egg and accumulation of egg parts. Accurate weights were taken of the parts accumulated and these values are to be compared with weights taken on parts of eggs previously laid by the same hen.

In addition to the autopsies, observations were made of the act of ovulation and progress of the egg through the oviduct of living hens while under the influence of an anesthetic. The positions of the egg were marked in the oviduct at 15-minute intervals. Ovulation was seen in 11 hens and complete time records obtained on five individuals. Observations would indicate that the infundibulum plays no part as a causative agent in ovulation, and that it is able to pick up ova released in the cavity about the ovary. Passage of the egg through the infundibulum was rapid, and time spent in the isthmus was much shorter than recorded by most workers. Time spent in the uterus and vagina was probably longer than that usually recorded. In high-intensity birds ovulation usually occurred within a few minutes after the previous laying.

[Project 77-6; Department of Poultry Husbandry. Leaders, D. C. Warren and H. M. Scott; state fund.]

Turkey Production.—Several phases of this project were studied during the biennium. Some of the results are presented below:

The Effect of Age of Breeding Turkeys on Hatchability, Percentage Production, Egg Weight, and on the Rate of Growth and Mortality of the Offspring.—

The 1932 breeding flock was divided into one lot of 16 pullets and a second lot of 20 hens. They were from the same blood lines and were given the same care. Both the male and female progeny of the hens were larger than were the pullet offspring at hatching. At each of the four-week intervals thereafter the pullet offspring were larger than the hen offspring. These differences were found to be statistically significant at each interval. The percentage hatchability for the pullet eggs was found to be 80.7 ± 1.30 per cent as compared with 55.0 ± 1.76 for the hen eggs. This is a difference of 25.7 ± 2.18 per cent. The percentage egg production for the pullets from March 28 to June 24 was 50.59 ± 0.89 per cent as compared with 43.18 ± 0.81 per cent for the hens. This difference of 7.41 ± 1.20 is considered significant. The mean weight of 705 pullet eggs produced during the breeding season was 89.6 grams as compared with 93.4 grams for the hen eggs. The mortality was 17.29 ± 1.56 per cent for the pullet progeny and 20.39 ± 1.89 per cent for the hen progeny. The difference 3.10 ± 2.45 per cent is not significant.

A Comparison of the Post Embryonic Growth of the Narragansett and Bronze Turkey.—A group of 130 Narragansett and 79 Bronze poults were grown together under identical conditions. Individual weights up to and including the twenty-sixth week were recorded weekly. At 26 weeks the Bronze males average 19.64 and the females 12.41 pounds, whereas the Narragansett males and females averaged 16.0 and 9.89 pounds, respectively. The shape of the cumulative-growth curve was the same for both breeds. The greatest difference was observed between sexes within the breed. The female growth curved tended to fall sharply after the eighteenth week, while that of the male rose steadily up to and including the twenty-sixth week. This difference was reflected in the increment curve. In the female the greatest increment of growth occurred between the eleventh and twelfth week. This velocity was never reached again, the increments growing less as time decreased. The weekly increments for the male were constant from the eleventh to the twenty-sixth week. These data support the conclusion that the female turkey reaches maturity (marketable age) in advance of the male.

The Effect of Gonadectomy on the Secondary Sexual Characteristics of the Bronze Turkey.—Of 69 Turkeys hatched April 14, 10 males and 10 females were gonadectomized on June 7, the remainder serving as controls. It has been stated in the literature that plumage pattern is nondimorphic in the turkey, and that following castration no changes occur in the plumage of either sex. The plumage pattern of the adult Bronze turkey is dimorphic. The male type of plumage was found to be independent of the male sex hormone. In the female, the male type is suppressed by the ovarian hormone, since following early ovariectomy the subsequent adult feathers are of the male type. The

head furnishings of the male were found to be dependent sex characters. The ovariectomized individuals develop head furnishings of marked masculinity. Beard development is an independent sex character of the male. The experiment has not progressed far enough to determine the relationship of the testis hormone to spur growth. There is some evidence that "strutting" is not necessarily a secondary sexual character of behavior.

The Response of Breeding Turkeys to Artificial Illumination.—Approximately 30 Narragansett pullets hatched May 6 were divided into three groups on December 1. The first group was confined in a house and received artificial light daily from 4:30 a. m. to daylight from December 1 to February 1. Thereafter the light ration was decreased 15 minutes each week and permanently discontinued after April 1. The second group (inside control) was placed in an adjoining pen of equal size but without lights. The third lot (outside control) was kept in a small pen out of doors without additional light or shelter. Otherwise the management given all lots was uniform.

The first egg was laid on January 3 by the pullets receiving lights, as compared with March 9 for the inside controls and March 10 for the outside controls. It was apparent that light alone stimulated early egg production. The average numbers of eggs produced per female up to May 25 were 68.8, 36.4, and 40.1 for the lighted birds, the inside controls, and the outside controls, respectively.

The effect on hatchability of having stimulated early egg production and of having confined the birds was studied. The only significant difference was found between the lighted group and the inside controls. It appeared that confining breeding turkeys did not reduce the viability of the eggs produced, but that stimulating early egg production in the manner described appreciably decreased the viability of the germ.

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

Growth of Leghorn Embryos as Influenced by a Ration Deficient in Vitamin A.—Two lots of Leghorn hens were fed an adequate ration for a period of 11 days, during which time eggs were saved for incubation. At the end of this time one lot was given a ration deficient in vitamin A. The adequate ration contained: White corn, 65 per cent; wheat bran, 15 per cent; meat scraps, 10 per cent, and alfalfa leaf meal, 10 per cent. The vitamin-A-deficient ration was secured by replacing the alfalfa-leaf meal by a mixture containing the same percentage of protein, mineral, and fiber, but having no vitamin A potency. The mixture consisted of dried sweet-clover stems, meat scraps, and mineral mixture. Each lot of birds was irradiated with a mercury arc lamp to furnish vitamin D.

Eggs from the two lots were incubated and the embryos extracted for weighing at intervals of 28, 56, 84, and 112 days from date of experiment. The lack of vitamin A did not seem to affect the rate of growth of the embryos extracted at the 28-day interval. In the case of the second extraction (56 days) the embryos removed from the vitamin-A-deficient eggs seemed to have a slower rate of growth. In the last two extractions (84 and 112 days) no apparent difference was observed in the rate of growth of the embryos from the two lots. At the time these eggs were secured there were only a few hens left in the lot, receiving the vitamin-A-deficient feed. These hens seemed to continue to produce eggs that permitted embryos to develop at a normal rate in spite of the vitamin-A-deficient feed. In previous experiments where hens received a vitamin-A-deficient feed it has been found that usually a few hens in a lot would survive in an apparently normal manner on a vitamin-A-deficient feed long after the majority of the individuals had died.

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

Improvement and Conservation of Farm Poultry.—Two phases of this project were studied during the biennium.

1. *Management of Leghorn Hens and Pullets With and Without Artificial Lights.*—The value of the market eggs produced by 200 White Leghorn hens in their second year of production was compared by four-week periods with the production of 200 pullets of the same variety in their first year of production. The pullets occupied lots 1 and 3 while the hens were in lots 2 and 4 of a long laying house. The pullets and hens in lots 3 and 4 received artificial lights from 4 a.m. until daylight from October 1 to April 1. In addition to this the hens had received lights since August 15. Dry mash, wheat, and shelled yellow corn were supplied to all lots continuously in open hoppers. The eggs from each lot were cased separately and sold locally on the graded basis twice a week. The number, size, shell texture, and interior quality were considered in arriving at the market value of eggs from the different lots. The same skilled grader examined the eggs each week and divided them into six grades. Forty-six per cent of the eggs from the two lots of hens graded firsts, 24 per cent seconds, and 11 per cent thirds, while 25 per cent of the eggs from both lots of pullets graded firsts, 22 per cent seconds, and 31 per cent thirds. The difference between the sum of the above figures and 100 per cent went into the three lower grades.

The average number of eggs produced per bird in each lot during the 52 weeks was 192, 167, 189, and 151 for lots 1, 2, 3, and 4, respectively. The birds receiving light excelled in egg production during the fall and winter, while those without lights gave a greater production during the summer.

2. *Management of Leghorn Hens and Pullets With and Without Artificial Heat, 1933-'34*—The value of market eggs produced by 200 White Leghorn hens in their second year of production was compared with the production of 200 pullets of the same variety for a period of 36 weeks beginning September 29, 1933, and ending June 8, 1934. The pullets occupied lots 1 and 3 and the hens were in lots 2 and 4 of a long laying house. The pullets and hens in lots 3 and 4 received artificial heat. Commercial heating units with natural gas as fuel, regulated by thermostatic control, were installed in each of lots 3 and 4. Heat was supplied from December 1 to March 16. Water was evaporated continuously over the heaters to make the humidity more comparable with that in the unheated rooms. Terminals of a birecord recording thermometer were placed in lots 2 and 3 and the day and night temperatures were determined by averaging hourly recordings. Humidity was taken daily with a sling psychrometer. Dry mash, wheat, and cracked yellow corn were supplied in open hoppers to all birds continuously. The eggs were candled and graded weekly and sold on a graded basis.

The income from eggs from the pullets in the heated lot was slightly less than from the pullets kept in unheated pens, while the hens with heat showed a greater value of eggs produced than the hens without heat, the difference being just enough to pay for the gas consumed. The results did not indicate any benefit from using heat in the laying house in this latitude during the winter of 1933-'34. The average temperature for November to April, inclusive, was 4.85 degrees F. higher than the average for the last 72 years, according to the weather records of the Department of Physics.

[Project 77-20; Department of Poultry Husbandry. Leader, L. F. Payne; state fund.]

Influence of Hybridization Upon Vigor in Poultry. Two phases of this project were studied during the biennium. They are described briefly below.

1. *The Effect of Mating Hybrids from the Combination of Two Breeds*

to a Third Breed.—This phase of the project was outlined to test the effect of a three-way cross in the fowl. The three breeds used were the Single Comb Rhode Island Red, Barred Plymouth Rock, and the Single Comb White Leghorn. The first-mentioned two breeds were originally crossed and the hybrid males thus produced were outmated to White Leghorn females. The three-way hybrids were compared with purebred White Leghorns as to evidences of vigor. The pure White Leghorn stock used for comparison was produced by mating two strains of White Leghorns, one of which was used in the three-way cross. The use of cross-strain Leghorns made it possible to avoid any deleterious effects of inbreeding within the breed.

Vigor was measured by the following criteria: Hatchability of eggs, viability of the chicks, rate of growth, and egg production of the mature females. Results on a complete year's egg production are not yet available. The available measures of vigor indicate no evident superiority of the three-way hybrids over the strain-cross Leghorn. The only evidence of any superiority of the hybrids was on rate of growth, and this difference was not great.

2. *A Comparison of the Vigor of Hybrids from Crossing of Various Breeds.*—The stocks studied were pure White Leghorn, pure Australorp, Australorp male X White Leghorn female, White Leghorn male X Australorp female, Ancona male X White Leghorn female, Light Brahma male X White Leghorn female, Light Brahma male X Rhode Island Red female, and White Plymouth Rock male X Rhode Island Red female. This group of matings includes combinations of breeds that have special utilitarian qualities regarding egg color, body size, egg production, and sex recognition.

As in previous studies vigor was measured by several criteria, but to date data are available only on hatchability and chick viability. The hatchability percentage of the pure White Leghorn stock was 71.8, while the four crosses utilizing the White Leghorn on one side gave the following percentages: 78.9, 81.4, 86.1, and 90.4. The most critical test of the effect of hybridization was secured when comparing the pure stocks of White Leghorns and Australorps with the reciprocal crosses between them. The percentage of hatchability for the White Leghorn was 71.8. Australorps 73.4, White Leghorn male X Australorp female 90.4, and Australorp male X White Leghorn female, 81.4.

The chick mortality (to three weeks of age) was relatively low in the pure White Leghorns but high in the Australorps, being 4.9 per cent in the former and 26.9 per cent in the latter. The reciprocal crosses between the two gave 4.8 and 2.9 per cent mortality to three weeks of age. The chick mortality resulting from crosses of the Light Brahma male and the White Plymouth Rock male to Rhode Island Red females gave relatively high mortality for hybrids, being 8.1 and 8.4 per cent. In all other crosses the chick mortality was less than 3 per cent.

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

Studies in Animal Reproduction and Inheritance.—Two phases of this project have been active during the past biennium. Brief descriptions of the work done are given below.

Inheritance and Physiology of Reproduction in Guinea Pigs.—For a number of years matings have been made for the purpose of producing animals that can be used in linkage studies. One individual of this type is salmon-eyed (*sm*), and at the same time is homozygous for the dominant allelomorph of pink-eye (*p*), but is also recessive for five different genes. Other animals of a similar nature are being produced, so that eventually it will be found possible to test the linkage relations of 13 different genes. The time is involved in producing the recessive individuals. The dominants require less care in their production.

It has been found that the pink eye-gene (*p*) makes possible the expression of other genes. For example, there are pink-eyed chocolates, some of

which have the pigment uniformly distributed, while others have spots that are more dilute than the remainder of the coat. Such differences have not as yet been found in dark-eyed animals. Pink-eyed yellows have been found which are white at the base of the hairs, while other pink-eyed yellows are pigmented at the base of the hairs. A third variation brought out by the pink-eye gene consists in the gradual fading of a pink-eyed yellow into a white. The exact mode of inheritance for all of the above variations is not completely known as yet.

One apparently somatic variation occurred some years back. A male was born that in every respect resembled a typical waltzer (*wa wa*). When mated to genetic waltzers, nothing but normals were produced, and when mated back to his daughters the offspring in that case also were normals. The offspring of this male are now being mated together to determine whether there is any possibility of the character reappearing.

Some of the environmental factors affecting birth-weight in guinea pigs were studied. Data collected between July 1, 1926, and June 30, 1933, were utilized. All litters of one in which the animals were born alive and lived at least 30 days were included, and also litters of two or more containing individuals of both sexes, which were born alive and lived at least 30 days. The total number of animals included was 7,611. A comparison of the two sexes showed that at birth the females weighed approximately 98 per cent as much as the males. One unsuspected relationship brought out was the extreme effect produced by high temperatures. Animals born in the summer averaged much less in birth weight than those born in the winter and the larger the litter the greater the effect produced. The high temperature seemed to decrease the appetite of the pregnant animal, thereby decreasing the nutriment supplied the fetus.

Inheritance in Cattle.—A number of new facts have been brought out in connection with inheritance in cattle. An Ayrshire bull, borrowed by the Department of Dairy Husbandry and used on the Ayrshire herd, shows evidence of carrying a dominant gene which inhibits the expression of the black-spotting gene (*Bs*). This animal is a good red-and-white, and, when mated to typical Ayrshires which show black, a large proportion of calves are born which remain red-and-white like the bull. Some of these red-and-white offspring are being retained in the herd and will be mated back to the Ayrshire bull belonging to the college. The latter carries typical black-spotting, and, by means of his offspring, it will be possible to determine more or less accurately the mode of inheritance of the postulated dominant inhibitor.

A careful study has been made of color in Guernsey cattle, particularly those that are in the college herd. It has been fairly well established that a dominant modifier of recessive white-spotting (*s*) causes small pigmented areas to occur on the legs directly above the hoofs. These have been described as distal leg-spots, and differ both genetically and physically from the pigmented-leg condition (*Pl*) found in Ayrshires and Shorthorns.

Evidence has been accumulated to show that susceptibility to acute mastitis is due to one or more dominant genes. It has also been shown that, although Galloways as a rule are entirely pigmented, they carry the gene for pigmented-leg (*Pl*) and also a new gene (*Wr*) which increases the amount of pigmentation in white-spotted (*s*) animals. These facts in regard to color have been brought out by the means of F_2 animals in crosses of Holsteins and Galloways.

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

Studies in the Inheritance of the Grouse Locust.—The specimens of the grouse locusts (*Tetriginoe*) used in this experiment for purposes of genetic analyses were also used in Adams project 104, "The Effects of Climate on Inheritance in the Grouse Locusts." Through a grant of \$400 from the National Research Council, in 1933, a considerable number of new live specimens were collected

in southern Texas and tropical Mexico. These included not only the color patterns already in use, but eight to ten others, three or four of which are extremely brilliant and distinctive. An additional 5,000, or more, specimens of several species of these grouse locusts were collected and preserved for use in a subproject in cooperation with Dr. R. A. Fisher of the Galton Laboratory, London. A joint paper with Professor Fisher on "The Evolution of Dominance" is in preparation.

A factor for lethal was studied quite thoroughly. It was ascertained that the individuals homozygous for it die uniformly at a stage four or five days before time for hatching. It also was ascertained that the lethal in heterozygous, or single, dose aids in viability and probably vigor. It is most extraordinary, though logical, to expect that the substance (probably an enzyme) induced by a single dose of a gene might be useful to the life of the individuals, yet a double dose of it is deadly poisonous. So far as can be ascertained, this is the first report of this kind. It is thought that the discovery may have rather important and wide application in animal life and man, and some of the implications will undoubtedly be of interest in connection with studies of evolution.

A study of the inheritance of the color patterns of a Kansas grouse locust, *Acrydium arenosum*, was discontinued, temporarily at least, and a paper published. These locusts are too slow breeding, giving only one, or at best, two, generations a year, in comparison with four succeeding generations a year of the southern species.

The study of abnormalities of the pronota and wings which has been under way for 14 to 16 years was continued. Certain features, such as upturned pronota and stubbiness are distinctly inherited. In fact, a new true breeding form, quite unique with respect to pronota, has been developed.

The dimorphism of the lengths of pronota and wings, whether short, incapable of flight, or long, capable of flying, has long been considered, probably correctly, as determined by the environment in most species. The inheritance of the capacity for either was a noted feature. However, it has been determined (1933-'34) that in one species, *Tettigidea lateralis*, long and short wings and pronota form a Mendelian pair of characters, with short dominant. This discovery (unpublished) will be of much interest to students of morphological questions.

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

Effects of Climate on Inheritance in the Grouse Locusts.—

Studies of the influence of X-raying, violet light, ultra-violet light, and the seasons on the inheritance of characteristics in the grouse locusts were in progress during the biennium. Further studies were made of the stock of the first X-rayed individual.

Dr. W. R. B. Robertson, of the University of Iowa, collaborator, has studied the chromosomes and found a complete cytological correlation with the genetic results. Another translocation of a factor for color pattern (W) resulted from the X-raying in the spring of 1933. The genetic evidence is complete, and material for the cytological study is being prepared for Doctor Robertson. Further X-raying was done in the spring of 1934, and the stock bred out.

The use of mercury lamps was almost abandoned for the time being. A paper has been published in which it is shown that an extra winter generation of the northern, slow-breeding grouse locusts may be produced by the exposure of the parents to mercury lamp rays. The offspring also grow much faster under the mercury light rays.

The effect of the seasons on long and short pronota-wingedness is being further studied, and comparison with heredity of these characteristics made.



Definite results have accrued showing that in one species (*Tettigidea lateralis*) the difference is due to a pair of Mendelian factors, short being dominant; whereas, in *A. eurycephalus* and *P. texanus*, the environments, conditioned by the seasons, compose the determining factors.

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

Bee Investigations.—The study of the relation of nectar secretion in plants and meteorological conditions which affect this phenomena was continued.

The season of 1932 was rather favorable for honey production. The hot, dry weather did not come until the middle of July. June was more favorable than it has been for several years. There was sufficient soil moisture and rains came at desirable intervals to provide immediate soil moisture requirements and to prevent the temperature from becoming excessively hot. The honey flow under these conditions began earlier than for the past several years. In the past, June weather has been unfavorable until the latter part of the month and, in this way, bee activity in the field has been held back. Plants made good growth, but due to the lack of solar radiation did not secrete nectar abundantly. The major nectar-secretion period, because of more favorable weather conditions in 1932, was about a month and one-half in length as compared with two weeks for each of a few previous years. The storage of honey beyond the needs of the 20 colonies was about 1,500 pounds, which is considered about a normal crop for this locality. A slight smartweed honeyflow provided a small amount of poor-grade winter stores.

The season of 1933 was not favorable to nectar secretion. Excessively hot, dry weather with temperatures reaching maximums of more than 100 degrees F. for much of June and July reduced the nectar secretion of plants and inhibited the flight of bees. For a time it appeared that there would be no honey stored by the colonies. At the time plans were made to reduce the number of colonies in the experimental apiary to one-half on account of the problem of providing food for them until the nest honeyflow should arrive in June, 1934. There was, however, enough soil moisture present to produce a little nectar secretion from white sweet clover during June. This nectar secretion continued after the sweet-clover plants had all set seed. The farmers decided not to cut the second cutting of alfalfa due to the drought and the prevalence of daily high temperatures. The remainder of the crop was thus obtained from alfalfa. The storage of honey beyond the needs of the 20 colonies was 580 pounds. The drought and daily high temperatures continued into July and thus there was no heartsease or smartweed honey flow.

Studies of races of bees were continued with the Italian and Caucasian races. The Carniolan race which is obtainable in the United States does not seem to compare favorably in honey production with the other two races of bees. Two hybrid Caucasian-Italian colonies each produced more honey than any other of the colonies.

Studies of substitutes for pollen in the diet of bees were continued. Before an actual test of a substitute could be started, it was necessary that the colonies being tested have their protein reserve removed. This was brought about by placing colonies in wire screen cages until they could no longer rear brood. After this stage was reached the experimental work was begun.

When whole milk and sucrose, mixed at the rate of 1 pound of sucrose to 1 quart of milk, were used, brood was reared in the sealed-brood stage. Experimental colonies fed milk and sugar reared only a little brood to the capped stage which emerged, in comparison to a normal colony which had access to pollen. The addition of the sucrose to the milk prevented the souring of the milk. Experimental colonies, given a mixture of two kinds of casein and powdered dried yeast, did not rear any larvae. After about one and one-half months the queens stopped laying eggs. Caucasian and Italian queens were used. Pure and technical casein each mixed with dried yeast, were used in

the experiments. Honey was also given to these experimental colonies as a food.

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

DISEASES, INSECTS, AND OTHER PESTS INJURIOUS TO PLANTS

Studies of diseases, insects and other pests injurious to plants were continued during the biennium. Some of the more important results of this work are given on the following pages.

Cereal and Forage Crop Disease Investigations.—The phases of this project dealing with wheat flag smut, wheat foot rot, and the root, crown, and shoot rot of milo were conducted in cooperation with the Division of Cereal Crops and Diseases, Bureau of Plant Industry, United States Department of Agriculture. The wheat flag smut studies were formerly under the supervision of J. A. Faris. The wheat foot rot, investigations herein reported are by Hurley Fellows and C. H. Ficke. Miss Charlotte Elliott has been cooperating in the studies of root, crown, and shoot rot of milo.

Out Smut Investigations.—Oat smut collections from many parts of Kansas were grown and increased so as to provide a composite inoculum for testing the resistance of all oat selections, varieties, and hybrids grown in the agronomy nursery. The object is to learn the reaction of all oats to smut, before the variety is distributed to farmers in Kansas.

Numerous hybrids and selections are showing high resistance to smut infection; especially is this true of some of the Burt and Early Red Texas selections. Also, strains found within the crosses, Fulghum X Markton, Richland X Fulghum, and Kanota X Markton seem to be extremely resistant to smut. The more promising strains and selections will be tested further, with emphasis on securing a desirable smut-resistant oat for Kansas. Smutted panicle characteristics of some 18 varieties of oats are being studied to see whether certain varieties are capable of separating the two common species of oat smut.

Oat Leaf Blotch.—A comparatively new disease of oats in certain years was extremely prevalent on the leaves of many of the Australian oat varieties grown in the agronomy nursery. Since many of the Australian oats are being used in crosses by numerous investigators, the nature and biology of this disease is being investigated.

Bunt of Wheat.—Bunt collections from many counties in Kansas were grown and increased on susceptible varieties to provide inoculum for testing the reaction of wheat varieties, selections and hybrids grown in the agronomy nursery. Data on the reaction of hundreds of varieties, selections, and hybrids have been obtained for the last few years. Also the inheritance of resistance to bunt was studied in the wheat cross, Oro X Tenmarq. It was found in the Oro X Tenmarq cross that the relation of bunt infection of F_4 lines inoculated with physiologic form 1 and with a composite of Kansas bunt collections showed that there is a high correlation between the two sets of bunt percentages. This indicates that there is probably only one important physiologic form of bunt in Kansas as far as the cross Oro X Tenmarq is concerned. Also, the presence of several factors in the inheritance of resistance to bunt in the cross Oro X Tenmarq is evident. The number of zero and near-zero lines observed in F_3 and F_4 progenies indicates that high susceptibility to bunt is recessive in this cross. Thirty lines show zero bunt infection to both physiologic form 1 and the Kansas composite bunt. No association between bunt and leaf-rust reaction and agronomic characters such as earliness, grain yield, or kernel plumpness was observed in this cross.

Certain Turkey selections and hybrids of Oro X Tenmarq are promising for bunt resistance. Many crosses are being tested, but the studies are not far enough advanced to draw conclusions. The studies on physiologic forms of bunt have been concluded and a publication is being prepared. Studies will be continued, with emphasis on the production of a bunt-resistant wheat for Kansas.

The work done on seed treatment for the control of bunt indicates that besides the copper carbonate dust now in common use, a new compound, called New Improved Ceresan, is also very effective.

Wheat Flag Smut.—This disease occurs in northeastern Kansas, where it has caused damage in some fields of Harvest Queen wheat. Approximately 300 varieties, hybrids and selections of wheat were grown in infested soil. Heavy infection was obtained in susceptible varieties, but many showed marked resistance. The work so far has demonstrated that resistant selections of Harvest Queen, Shepherd, Fulcaster, and other desirable varieties should be available in the near future. Most of the hard or semi-hard winter wheat varieties, such as Kanred, Turkey, Kawvale, Tenmarq, and Blackhull, are highly resistant, and because of this there seems little danger of flag smut becoming a problem in the hard-wheat area of Kansas.

Wheat Take-All.—Commercial fertilizers commonly used in Kansas showed but little tendency to control take-all which is due to the fungus *Ophiobolus graminis*. However, if phosphorus is deficient in the soil, superphosphate will help to reduce losses. Tests extending over six years have demonstrated that chicken manure always gives perfect control of take-all. This is due to the effect it has on the causal organism rather than on the wheat plant.

The history of take-all spots in the field has been studied for the last five years. Ordinarily a spot will appear one year; the second year it will increase in size and virulence; the third year it will decrease in size and virulence; and the fourth year it may not appear at all. If soil is removed from a place where the disease has disappeared, taken into the greenhouse, and planted to wheat, the plants become diseased, provided moisture conditions are satisfactory.

All of the eight possible combinations of the three factors, compactness, moisture, and temperature, when applied over a period of time to naturally infested soil had little effect on the retention of the causal organism in the soil. The amount of infestation was reduced slightly in soil stored in a loose condition. In only one out of four years' tests, was it shown that it was possible for take-all to be carried by water leachings. However, infested soil diluted with sterilized soil may produce a diseased condition of wheat.

It was formerly believed that infection of the wheat plant with *Ophiobolus graminis* occurs only in the spring. Three years' tests have given evidence that considerable infection also occurs in the fall. The evidence further shows that fall infection is extensive enough to cause considerable damage. Several years' tests have shown that high soil moisture favors the take-all disease. When the soil moisture content was low, temperature did not materially affect the amount of disease produced. When the moisture content of the soil was high, low temperatures were more favorable to disease. Two years' experiments have not shown that the length of day has much effect on the amount of take-all found on wheat plants grown in diseased soil.

It has been definitely established that the stems and roots of infested plants can introduce take-all into noninfested soil. There are several strains of bacteria which, when introduced into infested soil, reduce materially the amount of take-all this soil is able to produce. Soil removed from 18, 19 and 20 inches below the surface of a diseased spot has in several instances been found to be infested with take-all. In previous tests it had been found from the surface to a depth of 15 inches. Sterilized soil, when diluted with small amounts of infested soil, may not be able to produce the disease soon, but after several years *Ophiobolus graminis* may become well established.

Physiological experiments conducted with *Ophiobolus graminis* showed that it can utilize nitrogen as food only in the form of certain proteins. All inor-

ganic forms of nitrogen tried were not available as food. Tests for varietal resistance to take-all, although conducted over a wide range in Kansas, give no definite Proof of resistance.

Dry Land Foot Rot.—Data obtained from field-and greenhouse-plantings of winter wheat indicated that foot rot, such as occurs in the semiarid regions, produces variable symptoms, and may be due to one or several heterogeneous groups of fungous organisms. An important discovery with respect to control of the dry-land foot rot is that more foot rot and a greater severity of the disease appeared in the earlier fall plantings of winter wheat in infested fields. Soil moisture did not appear as an independent major factor in the development of foot rot in plantings artificially inoculated with *Helminthosporium* spp. Soil moisture was distinctly a major factor in the development of foot rot when winter-wheat plants were grown in naturally infested-soil in the greenhouse. Low moisture content of the soil (30 per cent water-holding capacity) checked the development of foot rot.

Sorghum Disease.—The diseases of sorghum which have been investigated consist of the following:

1. A date-of-planting test was made in which seed of Blackhull kafir was inoculated with *Sphacelotheca sorghi* and sown for 18 consecutive weeks, beginning March 28 and ending July 24. Soil and air temperatures and soil moisture records were correlated with the per cent of kernel smut obtained. It was found that the smut parasite has a wide range of temperature at which it grows and infects. It is more sensitive to low soil moisture. Sorghum kernel smut cannot be escaped or avoided by early or late planting of sorghum. In as far as temperature is concerned, kernel-smut infection will occur at any time that the seed of sorghum will germinate.

2. Five physiologic forms of *Sphacelotheca sorghi* and two of *S. cruenta* are being maintained on differential varieties of sorghum for a study of sorghum varietal resistance and for sorghum breeding work.

3. A group of sorghum varieties, selections and hybrids were studied with reference to the effect of *Sphacelotheca sorghi* and *S. cruenta* infection on height of plant, diameter of stalk and width of leaf. Similar measurements were made on uninfected plants. Several years' data are available and a paper will be published.

4. Studies on the inheritance of resistance to sorghum kernel smut (*S. sorghi*) were made in cooperation with the Department of Agronomy. It is believed that eventually this work will yield a good grain sorghum that is resistant to smut.

5. The relation of temperature to the growth of *Sphacelotheca sorghi* on artificial media was investigated. The minimum, optimum, and maximum temperatures were about 6 degrees, 26 degrees, and 48 degrees C., respectively. The exact maximum temperature has not been definitely determined, but it is less than 50 degrees and more than 45 degrees, being close to 48 degrees C. This makes the maximum temperature higher than for most parasitic fungi. Blackhull kafir seed will not germinate at 3 degrees or 48 degrees C. This indicates a greater temperature range at which growth occurs for *S. sorghi* than for the host plant.

6. Studies are in progress to determine whether infection occurs in inoculated sorghum seed at the lower and higher temperatures. The fact that *Sphacelotheca sorghi* grows on artificial media at low or high temperatures does not mean that infection will occur in the sorghum seedlings.

7. Investigations on the root, crown, and shoot disease of milo and other susceptible sorghums were continued. Varietal selections and hybrids were grown in infested soil at Garden City and their reaction studied. Most sorghums are resistant but milo and those varieties or hybrids having milo parentage are susceptible. The causal organism has not been definitely determined, although several species of *Fusarium* and *Pythium* are constantly found associated with infected roots. The disease is readily spread by soil water carrying the infecting principle. This disease can not be controlled by short rotations or by methods of cultivation, and it cannot be avoided by changing

the date of planting. The control of this disease will unquestionably be by means of resistant varieties.

A method of testing the reaction of selections or hybrids in the greenhouse in the seedling stage was found to be reliable. The inheritance of resistance to this disease was studied in the field and greenhouse. It was discovered that the seedling stage in greenhouse lends itself for a genetic study. At the Garden City Branch Experiment Station selections of milo, Beaver, and Wheatland have been made which are resistant. It is planned to have seed available for planting on infested soil in Kansas in the near future.

Alfalfa Diseases.—Studies on the reaction of numerous alfalfa varieties to the bacterial wilt organism were made both in the greenhouse and field. The susceptibility of various Lespedezas, clovers, and many of the native species of legumes of Kansas was studied to determine which of these plants may harbor the organism, and also aid in the spread of the wilt bacteria.

Notes were taken on the several leaf spots and a stem disease of alfalfa, with the hope of finding a hybrid, selection, or variety that will show some resistance to these diseases. This work has not progressed far enough to make any definite statements about the results.

[Project 76: Department of Botany. Leaders, L. E. Melchers and C. L. Lefebvre; state fund.]

Fruit and Vegetable Disease Investigations.—Investigations on the diseases of the Irish potato and sweet potato, and studies concerning the inhibition of normal growth of the Irish potato by a volatile substance from apple fruits, were continued during the biennium. Tests were made to learn more concerning the control of the cherry leaf-spot disease and of the leaf-spot diseases of the apple. Investigations were started for more effective control of raspberry diseases under Kansas conditions and attention was given to the testing of wilt-resistant varieties of watermelons and to the development of mosaic-resistant varieties of cucumbers.

Potato Disease Investigations.—Studies of diseases of Irish potatoes were conducted as described below.

1. *Rhizoctonia* control. The value of various seed-treatment fungicides was measured by comparative performance of the plants and by comparisons with plants grown from *Rhizoctonia*-free and *Rhizoctonia*-infected controls. Emergence, stand, prevalence of lesions, and yield were the criteria on which results were based. Corrosive-sublimate treatments gave earliest and most uniform emergence, best *Rhizoctonia* control, and highest yields. The acidified corrosive-sublimate 10-minute treatment was just as satisfactory as was the 90-minute treatment without the acid.

2. The importance of soil-borne *Rhizoctonia*. Plantings of *Rhizoctonia* sclerotia-free seed were made in 20 commercial potato fields, both in 1932 and in 1933, to learn more concerning the importance of soil-borne *Rhizoctonia* as a source of infection of the potato crop in Kansas. *Rhizoctonia*-infected untreated seed was planted in adjoining rows in all of these fields for a comparison where greatest possible chances for infection were present. *Rhizoctonia* infection occurred on 32.18 per cent of the plants from *Rhizoctonia*-free seed in 1932 and on 12.50 per cent of the plants in 1933. The yield from the plants of the *Rhizoctonia*-infected plots for 1932 was 44.9 per cent lower than was the yield from the plants of the *Rhizoctonia*-free plots. The season of 1933 was extremely hot and dry and the crop was a near failure.

The data obtained indicate that environmental conditions have a marked effect on the persistence of the *Rhizoctonia* organism in the soil. The summer of 1932 was hot and dry compared to the previous summer, and as a conse-

quence, much less soil-borne *Rhizoctonia* infection resulted in the spring of 1933.

3. *Rhizoctonia* strains and their effect on the potato. The studies of *Rhizoctonia* strains was continued and the results that were obtained gave further evidence that within the group generally recognized as the species *Rhizoctonia solani* there are variants that differ greatly in pathogenicity and in other biological aspects. The cultures studied vary markedly in their effect on the potato, both as to type and severity of infection. The pathogenic characteristics of certain strains have been compared for several years both under greenhouse and under field conditions. The strains have consistently produced similar reactions in all tests, whether grown in sterilized soil in the greenhouse or in unsterilized soil in the field.

Sweet Potato Disease Investigation.—Studies of diseases of sweet potato included the following:

1. Sprout treatments for stem-rot control. Stem-rot control of sweet potatoes by dipping the basal ends of the sprouts in the fungicidal mixtures Bordeaux, Oxo Bordeaux, and mercury hydroxide before planting were continued. The results obtained have been at variance to those secured in previous years. The harmful effect of the Bordeaux treatment to the plant was greater than was the benefit derived from the reduction of stem-rot infection by this treatment. The Oxo Bordeaux and mercuric hydroxide treatments did not produce significant yield increases and did not control stem-rot effectively.

2. Test of seedling stem-rot resistant varieties of sweet potatoes. Seedling varieties of sweet potatoes developed by the United States Department of Agriculture have been tested in the field for two years. Of the varieties tested, three or four are of good quality and are highly resistant, to the stem-rot disease. Among these the variety No. 47442 is probably of sufficiently high quality to be valuable, especially on soils that are infested with the stem-rot organism. Another variety, Mameyita, is susceptible to the stem-rot disease, but because of its desirable quality may be of value on soils that are not infested with the stem-rot organism.

Cherry Leaf-spot Control.—Spraying tests for the control of the cherry leaf-spot disease were continued in 1932. The fungicides Bordeaux, Oxo Bordeaux, lime sulphur, and wettable sulphur were used. The best control was obtained with Bordeaux. Oxo Bordeaux gave considerably better control than did either lime sulphur or wettable sulphur. Many yellow leaves developed on the lime sulphur and wettable sulphur sprayed trees, while such leaves were practically absent on the trees sprayed with Bordeaux and with Oxo Bordeaux.

Apple Leaf-spot Investigations.—Observations on the severe defoliation of apple trees in the northeastern portion of the state and at Manhattan in 1932 and previously, indicated the presence of a frog-eye-like leaf-spot. The regular spray schedule did not control this disease satisfactorily. The applied spray materials partially controlled the disease, as was evident by comparisons between sprayed and unsprayed orchards, and also by comparisons between the lower sprayed portions of tall trees and the tops of the same trees where coverage was poor. The unsatisfactory control, however, even on well-sprayed trees, indicated the need for more effective control methods.

The season of 1933 was hot and dry and not favorable for the development of leaf-infecting fungi. It was frequently noted, however, that frog-eye-like lesions were prevalent on well-sprayed trees. Unsprayed trees, on the other hand, did not have these frog-eye-like spots. It has been concluded from observations on trees sprayed with different spray materials that these frog-eye-like areas were due to arsenate burning. This observation indicates the necessity of guarding against mistaking arsenate injury for lesions produced by pathogenic fungi.

Growth Inhibition of Potato by Volatile Gas from Apple Fruits.—The problem concerning growth inhibition of potato plants and sprouting potatoes by a volatile substance from apple fruits was continued. Physiological studies of the affected potatoes were made and it was found that these potatoes respire

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approximately twice as fast, and that the catalase enzyme is approximately twice as active, as in the case of normally growing potatoes.

Efforts were made to isolate and identify the chemical substance which arises from apples and causes the abnormal growth reaction in the potato. It was found that this inhibitory substance was destroyed by passing the gases from the apple fruits through a red-hot furnace. The growth inhibitory substance from apples was also removed from the air by contact with chloro-sulphonic acid and with fuming sulphuric acid. Analyses of fuming sulphuric acid, through which a stream of air charged with the gases from apple fruits had been drawn, gave faint tests for the presence of a primary alcohol. This suggests the possibility that ethylene is present among the gases given off by apples.

Sprouting potatoes were treated with low concentrations of ethylene, and there resulted an abnormal and inhibited sprout growth similar to the abnormal growth produced when the potatoes were subjected to the gases from apple fruits. This problem will be investigated further because of the possibility of discovering a chemical which will prevent early sprouting of seed potatoes in storage houses.

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

Resistance of Winter Wheat to Leaf Rust.—The testing of varieties, introductions, selections, and hybrid lines for their reactions to leaf rust under both greenhouse and field conditions was continued.

In the nursery plots, natural infection, plus a limited amount of artificial inoculation, has been relied upon to produce epiphytotic leaf rust which would give a reliable measure of the relative susceptibility of the wheat under study. Fairly satisfactory readings were obtained in the rust nursery in 1932, but none were obtained in 1933, due to the elimination of leaf rust by extreme heat and drought.

The program of breeding for resistance to leaf rust is being vigorously pursued. A leaf-rust nursery of 1,741 rows of winter wheat and 439 rows of spring wheat was grown in 1932, while one consisting of 1,242 rows of winter wheat and 351 rows of spring wheat was grown in 1933. The 1932 winter-wheat nursery contained 998 hybrid lines, while that of 1933 contained 725 such lines. Resistance is still being sought in standard varieties and selections from various parts of the United States and in foreign introductions.

Many hybrid lines have shown resistance to leaf rust, and several of the best selections of the most promising crosses have been sent to the agronomy nursery for yield and other agronomic tests. Several selections of Kanred X Kawvale, Kawvale X Blackhull, Kawvale X Tenmarq, and Hard Federation X Kawvale appear to have considerable agronomic promise, as well as resistance to leaf rust. Compound crosses such as (Kanred X Fulcaster) X (Kanred X Hard Federation), (Kanred X Fulcaster) X Tenmarq, and (Kanred X Fulcaster) X Iobred continue to exhibit greater resistance than most of the simple crosses. Among the varieties of winter wheat, the highest field resistance continues to be found among the soft wheats. Kawvale, Fultz selections, Mediterranean selections, and Fulcaster selections have continued to exhibit high resistance in the field. The hard-seeded varieties have in general continued to show high field susceptibility to leaf rust. Efforts are being concentrated on the following phases of the work at the present time:

1. Increasing the softness of the seed of Kawvale by crossing with good standard soft-seeded varieties.
2. Increasing the hardness of the seed of some of the most promising leaf-rust-resistant hybrids and varieties by back crossing or compound crossing.
3. Increasing the leaf-rust resistance of certain promising hybrid lines through compound crossing.

4. Increasing the cold resistance of desirable rust-resistant hybrid lines through crossing with varieties of known hardiness.

5. Increasing the strength of straw of certain hybrid lines through further selection and hybridization.

6. Continued breeding for resistance to other diseases such as bunt, mildew, stem rust, and leaf blotch in the most promising hybrid lines.

These phases have necessitated much crossing. A total of 282 new crosses were made in the past biennium and the F_1 plants were grown in the greenhouse. Most of these will be grown in bulk in the leaf-rust nursery for several years, after which selections will be made from a few of the most promising combinations. Studies on the distribution of physiologic forms, overwintering, oversummering, and epidemiology of leaf rust of wheat are also in progress. Physiologic form 9 continues to be the most abundant and widely distributed form in the western Mississippi Valley and Great Plains area. Leaf rust survives the winter in small amounts over much of this region, but most of the spring infection seems to be due to inoculum carried northward on spring winds.

Controlled experiments in the greenhouse have proved that heavy leaf rust infection greatly increases the water requirement of a susceptible variety of wheat. It also retards heading and lengthens the fruiting period. The increase or retardation depends on the length of the rust period. In a resistant variety, the effect of leaf rust infection in the form of flecking was slight and often negligible.

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

Climate and Injurious Insect Investigations.—During the past biennium studies were conducted along four lines.

1. *Annual Insect Surveys.*—These annual surveys of the population of the more important insects of Kansas were prepared from questionnaires from entomologists residing in the state, county agricultural agents, vocational agriculture teachers, and farmers, together with personal observations made during the year. A summary report has been published each year beginning with 1931.

2. *Insect Light Traps.*—Two insect light traps were made to determine the relation between nocturnal activity of certain insects and weather conditions; to obtain specimens to add to the department insect collection; and to provide information on insect population, earliest and latest dates and generations of the more important insects for use in the population studies. These trap lights were operated at various intervals from April 1 to October 16, 1932, and from April 8 to July 1, 1933. The catches were sorted and analyzed with reference to weather data and other variables. These data permit conclusions as follows:

a. Few moths were caught on evenings when the temperature was 60 degrees F. or lower and the relative humidity was 59 per cent or lower.

b. At temperatures above 90 degrees F. the catches were reduced in size. Comparatively large catches were made when the humidity was 90 to 100 per cent. The catches tended to decrease as either humidity or temperature deviated above or below the optimum.

c. Warm, humid, calm, and cloudy evenings following unfavorable evenings characterized by cool, dry, and windy weather were favorable for large catches.

d. Wind was the most important climatic factor studied. The catches were always larger on calm evenings when other factors were at or near their respective optima.

e. The catches were smaller on bright moonlight nights than on dark nights.

f. The electric light trap caught more insects than did the gasoline light trap, apparently because of the greater intensity of the light.

g. The box trap was more efficient than the funnel trap in retaining the insects which were caught.

h. The light trap near the ground and close to dense vegetation caught by far the smallest number of insects.

i. The light traps provided a good method of catching the first and the last emerging moths during a season and of determining the number of broods any species of moth may have in a season.

3. *Insect Reactions to Soil and Plant Temperatures.*—Studies on the effects of soil and plant temperatures to determine lethal conditions in hot weather, optimum conditions, and the relation of temperature and humidity to distribution of insects on plants, particularly alfalfa, were continued during the biennium. The following conclusions appear to be indicated from the data.

a. Small and short-legged insects died more quickly than larger ones of the same kind when exposed on the bare ground to the hot sun. Alfalfa caterpillars were more resistant than the green clover worms.

b. There was a difference among the different species as to their abilities to withstand high temperatures. Green-clover worms, *Cænurgias*, and *Arctiids* died in a few minutes, while alfalfa caterpillars and garden webworms withstood 120 to 150 degrees F. for a slightly longer period.

c. If larvae climbed up a stubble or plants they survived lethal soil temperatures for hours in hot weather, although they were only a few inches above the surface of the soil. When placed on the bare ground they succumbed to the heat in from 30 seconds to five minutes. Insects in alfalfa fields apparently survived in part by climbing up plants when the alfalfa was cut. They always sought the shady side of the stem.

d. The surface of the soil was warmer on a hot day than the air immediately above and the air temperature decreased as the distance from the soil increased.

4. *Bacterial and Fungus Diseases.*—Studies on bacterial and fungous diseases of grasshoppers, chinch bugs, and termites were continued to determine the weather conditions and other requirements for their development. Grasshoppers killed by the fungus (*Empusa grylli*) were found in northeastern Kansas during June, 1932. In fields located near Manhattan fungus-killed grasshoppers were found in September of 1930, 1931, and 1932. All the known epidemic diseases of grasshoppers are dependent on weather conditions, chiefly temperature and humidity, for their development. This places them beyond the control of man for large-scale operations.

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

Hessian Fly and Other Wheat Insects.—This project was started in the fall of 1907 and has been continued regularly to the present time. The first 10 years were devoted entirely to a study of the Hessian fly and the results of these studies have been published in Bulletin 188 and Technical Bulletin 11 of the station. In 1918 this project was enlarged to include other wheat insects. Following are brief discussions of nine phases of this project conducted during the biennium.

1. *Distribution of Hessian Fly in Kansas.*—No surveys for study of field distribution of Hessian fly were undertaken during the biennium. No time-of-planting material was received from localities outside of Manhattan. The regular time-of-planting series at the agronomy farm received light infestation in both years. The counts made agree with past observations but were scarcely heavy enough to be significant.

2. *Life History of Hessian Fly in the Field Near Manhattan.*—In the spring of 1932 there was a medium-sized early and a large late spring brood of Hessian fly, which carried over in abundance in the stubble. There was little summer emergence. On September 7 only one flaxseed was found after examination of a number of clumbs of volunteer wheat. Most of the flies in

the flaxseed had not pupated. About September 19 there was a heavy emergency of fly, and about October 3 a much smaller emergence; hence, wheat sown even a few days before the normal fly-free-date escaped with light infestation. In the spring of 1933 some emergence and oviposition took place during the first week in April. The infestation did not appear heavy, perhaps because of an abundance of parasites in the fall generation. The fall brood in 1933 was light; most of the eggs were laid during the first part of September. Eggs were laid for the spring brood during the first week of April. Separate supplementary broods could not be distinguished because of low infestation.

3. *Survey of Insects in the Wheat Field.*—These studies were continued along the lines indicated in the preceding report. A number of insects were reared and will be submitted for identification by specialists at later dates.

4. *Wheat Straw Worm.*—In the spring of 1932 information on the life history of the wheat-straw worm was gathered. The data on the life history as observed in the field and insectary are given in the following table.

Stage	Field appearance		Insectary observations on length of stage in days
	First	Last	
Adults, first generation	Feb. 26	Mar. 30	10
Eggs	Mar. 19	April 8	10 - 11
First instar larva	Mar. 28	April 14	6 - 10
Second instar larva	April 4	April 18	4 - 6
Third instar larva	April 6	May 6	17 - 22
Pupa	April 21	May 21	14 - 16
Adult second generation	May 6	June ..	.....

The percentage of infestation by the second generation was taken on a combination date-of-planting and variety test. The varieties Quivira, Turkey, and Minturki showed little if any difference in intensity of infestation when the four dates were averaged.

A planting of a number of winter-wheat varieties made in 1931 for a study of resistance, showed little infestation due to the early date of planting. A late planting made in October, 1932, gave poor germination and heavy winter-killing. It was infested by the spring generation and gave some information. The early spring generation emerged poorly and gave only a light infestation. Because of dry weather the insect appeared to be at a low ebb in 1933-'34, and data probably will not be secured on this planting, which was planted late and escaped winter injury. Plantings of spring wheats in 1932 and 1933 gave a satisfactory count of infestation by the spring generation. In 1932 the percentage of culms infested ranged from 0 to 199, and in 1933 from 0 to 82. In general, the correspondence in results of the two years was good. The varieties of macaroni wheats (*Triticum durum*) in general were more heavily infested than the common bread wheats (*T. vulgare*). Three other species of *Triticum* included in the test were also infested. Einkorn was not infested. The larvae most frequently found were in the top nodes.

5. *Wheat Stem Maggot.*—Detailed life history observations of the wheat stem maggot were made. Some of these are entirely new. A number of species of parasites were reared, some for the first time. The results will be reported in detail later.

6. *Chinch Bugs on Wheat.*—Both in the summer of 1933 and 1934 the infestation by chinch bugs was heavy, and some wheat was killed before the filling of the heads. In 1933 young bugs were controlled in experimental plantings used for other purposes by an application of Derrisol. In 1933 an infestation in the Hessian fly nursery was controlled by dusting with Cyanogas. Neither treatment injured the wheat. Tests were made of various substances which may be used in the construction of barriers in place of creosote or tar and which may be superior in one or more respects.

7. *The Green Bug in Kansas.*—In the spring of 1934 the green bug reappeared in abundance in wheat in Kansas. It was reported or observed in

28 counties as doing appreciable damage. Two surveys were made to study the insect. In an area near Silver Lake there was severe damage to wheat and oats. Many wheat fields in Cloud, Clay, Ottawa, Dickinson, and Saline counties were partially destroyed by the insect.

An infestation in a field just east of Manhattan offered an opportunity for use of control measures. Spots infested by green bugs were covered by straw and burned. Wheat which had not been killed by the bugs, but had had the tops burned, recovered. The control was successful. The outbreak was finally controlled by ladybird beetles and parasites.

8. *Calendra sp. in Wheat*.—In the spring of 1933 a species of *Calendra* was found damaging wheat near the insectary. Eggs had been laid near the base of the culms. The larvae fed on the pith and internodes, finally emerging at the bottom of the culm to pupate in the ground. Preliminary observation indicated that infestation reduced both the number and weight of the grains. In 1934 the infestation was much lighter. Infestation of varieties varied from 0 to 72 per cent of the culms of winter wheat. Infestation was higher on later planted wheat.

9. *Underground Insects Affecting Wheat*.—During the past two years considerable progress was made toward the classification of the Tenebrionidae in the Kansas State College collection. Species ordinarily encountered in experimental work have been arranged into a workable collection.

There was an outbreak of the army cutworm, *Chorizagrotis auxillararis* Grote, which caused considerable injury to wheat in south central Kansas in the spring of 1934. Its presence in large numbers offered an opportunity to check up its habits and life history at Manhattan. An attempt to determine where and how the larvae spend the summer was of no avail.

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

The Corn Earworm and Other Insects Injurious to Corn.—

The work on this project during the past biennium may be divided into six phases:

1. *Corn Earworm Infestation in Corn of Varying Rates, Dates, and Methods of Planting*.—These data were taken chiefly from corn-breeding plots of the Department of Agronomy. Inasmuch as 99 per cent of the ears observed showed evidence of earworm infestation, data on the amount of infested ears alone are of little value. The extent of injury to the infested ears, however, varied from no commercial damage to complete commercial damage. Therefore, a scale for rating the damaged ears was adopted. This scale values an ear, infested at the tip but undamaged, as 1, and an ear rendered worthless as 5. Values 2, 3, and 4 represented damage approximately one-fourth, one-half, and three-fourths of the ear. A photograph of representative ears of the various values served as a standard and visual guide.

No significant differences in corn earworm infestation were observed in the two varieties examined nor in the method of planting plots. While the early May plantings showed nearly complete infestation, they were least damaged. In the rate-of-planting plots there was a decrease in the extent of injury in the more widely spaced plants.

2. *The Testing of Various Sprays and Dusts as Insecticides or Repellents Against the Corn Earworm on Corn*.—This work was conducted during the summer of 1932. The tests were conducted on both sweet corn and field corn. Sweet-corn plantings of four locally common varieties were made every two weeks, beginning April 15 and continuing until June 24. It was found that the insecticide-treated plots showed a definite and regular lag in infestation behind the checks, indicating that the time of planting has no particular effect on the use of insecticides.

In the sweet-corn plots, the first application of insecticides was made shortly after a number of the ears in the plot showed silks. Every ear treated was

tagged and the stage of development recorded to determine the effects of the stage of the ear at time of application of the insecticides. A new ear shoot before the formation of the cob was considered shoot-(minus). The stage during the development of the cob before the appearance of silks was shoot, + (plus). The third stage was silks.

Results of use of all insecticides on different stages of development of the ear were as follows:

Stage of ear	Per cent of Infestation
Shoot —	18.3
Shoot +	32.1
Silks	43.1
Controls	67.5

Five insecticides were used on the various plantings of sweet corn. The first application was made as indicated above and repeated at intervals of two days until the roasting-ear stage, when the ears were harvested.

Insecticide	Number ears	Ears infested	Per cent infestation
Lead arsenate, 100%	168	32	19.1
Lead arsenate, 50%	130	47	36.1
Calcium arsenate 50%	129	34	26.4
Commercial sodium fluosilicate	106	41	38.6
Pyrethrum dust	151	69	45.8
Check	175	118	67.5

Full-strength lead arsenate proved the most satisfactory insecticide tested. Commercial sodium fluosilicate severely burned the husks and silks, rendering the ears unsalable. Pyrethrum dust gave practically no control in the silk stage, but a 60 per cent control, when applied before the silks were out. This suggested a repellent effect on the moth.

In another series of plots, dusts and sprays with oil of wintergreen of various strengths and combinations were used to test its properties as a repellent for the moths. In none of the combinations used, however, did the material prove successful.

In the field-corn plots a series of 17 different insecticides was used. A summary of the more successful ones includes:

Insecticide	Number of applications	Number of ears	Per cent infestation
Barium fluosilicate	3	66	69.6
Lead arsenate, 100%	1	79	75.9
Lead arsenate, 100%	3	68	70.6
Lead arsenate, 75%	1	69	73.9
Lead arsenate, 75%	3	60	75.0
Sodium fluosilicate fluffy	3	53	62.2
Checks	—	217	98.6

In the test plots one application of lead arsenate was as satisfactory as three, though further studies should be made on sweet corn. Because of the labor and expense involved, the insecticide treatment could not be used on field corn.

3. *Biological Studies of the Corn-leaf Aphid, (Aphis maidis Fitch).*—Biological investigations conducted during the past biennium were confined wholly to the activities of the aphids throughout the growing season, summarization of the data, and to the preparation of a manuscript for publication. The studies revealed the following facts when young sorghum and corn plants were adjacent to each other in plantings made at 7 to 10-day intervals throughout the growing season:

- a. The summer behavior of *Aphis maidis* Fitch indicated that the insect is primarily a pest of sorghum.
- b. The aphids remained on sorghum plants throughout the summer when immature plants were present in the fields.
- c. Aphids were found on the corn for only a brief period prior to the appearance of the tassels.

d. The shift in the population of the aphids from sorghum to adjoining corn and then back to sorghum in the fall, followed the production of large numbers of winged forms. The peak in the population of these forms occurred July 1 and August 1 in the investigations conducted in 1932.

e. The aphids showed a preference for dent corn over sweet corn and for sorghum over corn when the entire season was considered.

4. *Corn Root Worm Investigations.*—Studies on the life history, ecology, and hibernation of the southern corn root worm (*Diabrotica duodecimpunctata*) were continued but no new facts were added to the contributions of other investigators. Again efforts to find the insect overwintering at Manhattan were of no avail.

The sudden appearance of the beetles May 18 in 1933, and May 14 in 1934, after other hibernating insects were out in the spring, together with their sudden disappearance in the fall, apparently confirms the opinion of some workers that this insect migrates from the south in the early part of the season and does not remain over the winter in the latitude of Kansas.

5. *Influence of Cultural Measures on Subterranean Insect Injury to Corn.*—Investigations were continued in an effort to determine the field practices which influence the activities of root worms, wireworms, ants, and other subterranean insect pests of corn. A detailed study of the type of injury to the young corn plants, caused by the feeding activities of wireworms was conducted during the summers of 1932 and 1933. The most significant observations made were, that although young corn plants make an attempt to recover from injuries caused by wireworms feeding on the underground parts of the plant, few, if any, stalks overcome the attack.

6. *Chinch Bug Investigations.*—An outbreak of chinch bugs at the field insectary and the agronomy farm offered an opportunity to study the effectiveness of an application of hot water to kill the bugs which were infesting the corn and sorghum plants. The results, which are of a preliminary nature, indicate that hot water from 130 to 165 degrees F. killed all of the bugs when not more than one-half pint of water was poured into the curl of the corn plant. The slight injury to the corn and sorghum plants proved to be only temporary, because the plants recovered within a short time.

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

Fruit and Vegetable Insects.—This project included a part of the apple-curculio and codling-moth studies in northeastern Kansas, and canker-worm emergence.

1. *Apple Curculio Parasites.*—Previous to 1932 there were only four hymenopterous parasites known to attack the apple curculio. During 1932 and 1933 two more hymenopterous larval parasites were found.

In carrying out the life-history study of the western apple curculio, larval parasites were anticipated, encountered, and identified. Three hymenopterous species, namely, *Eurytoma tyloclermatis* Ashm., *Microbracon variabilis* (Prov.), and *Microbracon tachypteri* Mues, were found. This is the first record of *E. tyloclermatis* and *M. variabilis* attacking *Tachypterellus quadrigibbus* magnus List. These parasites in 1932 caused 33 per cent parasitism of the apple curculio in one orchard where the commercial damage by the pest was 100 per cent. The same three parasites were found in 1933, but no others.

2. *Cankerworms.*—Banding tree trunks with tree "tanglefoot" over a period of years has proved an effective method of control for cankerworms if the bands are properly maintained over the period of moth emergence. Evidence of damage to trees was secured which showed the effect of bands that were and where not properly maintained over periods of four and six years. The contrast in protection showed that bands properly maintained over a period of years did protect susceptible trees.

3. *Codling Moth*.—The insecticide which has given the best control for this apple pest is arsenate of lead. A problem of lowered tolerance of spray residue for lead and arsenic, established by the Food and Drugs Administration of the United States Department of Agriculture, made it desirable to test the efficiency of certain arsenical compounds as substitutes for lead arsenate. The substitutes tested were calcium arsenate, zinc arsenate, and manganese arsenate ("Manganar No. 12"). These were compared with lead arsenate, which is the best control standard that is available, as an insecticide for the control of codling moth. There was only a 2 per cent difference at harvest time between the zinc arsenate and the lead arsenate blocks in sound fruit produced, and the earlier heavy drop of fruit in the block sprayed with zinc arsenate undoubtedly resulted in the lowered yield. The results of these experiments with substitutes for arsenate of lead show that there was only a 7 per cent advantage for the lead arsenate over that of the best of the tested substitutes.

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

Insects Attacking the Roots of Staple Crops.—This project was started in the spring of 1915 for the purpose of studying the life economy of various subterranean insects such as white grubs, wireworms, false wireworms, corn-root worms, etc., which attack the roots of staple crops. This group includes more than 200 species, and it is planned eventually to make a complete study of such species as is possible.

Life-history studies of wireworms during the past biennium consisted largely of attempts to rear collected larvæ, as well as larvæ from the egg to the adult. Additional information was gained regarding the advantage in rearing larvæ in the tile cages under approximately natural conditions. Since the larvæ are cannibalistic in the early instars, this method reduced the mortality usually resulting from cannibalism.

Larvæ which were hatched from the egg in 1930 were approximately full grown early in 1934. These larvæ belong to the genus *Melanotus*, which contains the most injurious species of wireworms attacking corn in Kansas. Some investigators are of the opinion that members of this genus require three to six years in which to complete their life cycles. The data obtained in these studies indicate that although the larvæ can live for eight or more years when soil or food conditions are unfavorable the period from egg to adult requires three years or less.

If these larvæ reach maturity in three years or less, the problem of devising cultural practices and rotation for their successful control shall be much simpler than if six or more years were required in which to complete their development.

Studies of wireworm injury in relation to cultural practices during the past two years confirm the observations of previous years. Counts were again made to determine the percentage of infestations on seed-bed preparation plots, rotations, and general fields. Observations show that land cropped to alfalfa for four or five years may be infested with wireworms when it again is planted to corn or sorghums. The evidence so far obtained indicates that it is not the kind of crop included in the rotation, but, the sequence of the crops within the rotation system, that determines the wireworm infestation of the area. Corn planted from April 10 to May 1 at Manhattan apparently suffered more from the attacks of the wireworms than corn planted after May 1. The larvæ become active in the upper few inches of soil before the temperature of the soil has increased sufficiently to insure rapid germination of the seed. Plants are most severely attacked after attaining a height of 4 to 5 inches.

The series of plots laid out in 1931 for the study of the ecological factors

which influence the population of white grubs and wireworms were maintained throughout the biennium. Diggings were made in these plots to determine the population of these insects, to obtain a comparison of the influence of different treatments upon the percentage of infestation. As many as 25 grubs to the square foot were found on one plot sown to white clover. This is a significant fact when one considers that some investigators have suggested that lawns containing both white clover and bluegrass are freer from grub injury than are the lawns containing bluegrass alone. No other plots contained more than five grubs to the square foot. Robins interfered with this study by digging the grubs out of the plots so that accurate infestation counts could not be continued.

A special study has been undertaken regarding the feeding habits of wireworms, with special reference to the genus *Melanotus*. The following observations have resulted from these investigations:

a. Experiments conducted to determine the ability of *Melanotus* larvae to select different food plants in a plot consisting of 64 plots, each one square foot in area, indicated that these larvae showed little preference for one food plant over another. They fed on the plants near where they were introduced into the plot.

b. Young larvae placed in moist soil, and those fed upon raw carrot, manure, honey, and insect larvae failed to live; while those fed cottonseed, yeast, and crushed beetles showed an increasing average total growth in the order named. Larvae placed in drain tile cages and supplied with germinating grain made slow growth at the beginning but the rate of growth was steady and continuous.

c. The studies indicate that the larvae cannot develop upon the humus in the soil, but do best in natural surroundings where considerable organic matter is available.

A study was begun on the vertical movement of wireworms in the soil throughout the season. Diggings were begun in September, 1932, on five locations representing different types of soil. The areas selected for the studies were as follows: Native prairie, backyard garden, cultivated field, sandy truck patch, and alfalfa field. Diggings were made on these areas at monthly intervals when the weather and soil conditions permitted. Four holes 1 foot square and 1 foot deep were made monthly on each area. The wireworms taken in each excavation were given a number, recorded, and saved for future studies. It was found that wireworms remained close to the surface throughout the winter, became active when the temperature of the soil was slightly above freezing, and could withstand freezing temperatures without injury. They went down as the soil cooled off and returned to the surface as the temperature of the soil increased.

The soil insecticide studies conducted on the 54 one-thousandth acre plots were continued in an effort to determine the residual effects of the insecticides in the soil. These plots were treated with materials recommended for the control of various species of soil insects in 1927 and retreated with the same materials in 1930. Crops of peas, beans, radishes, onions, and corn were grown on the plots the past year. Since beans are susceptible to the effects of arsenicals, the most noticeable residual effect was in evidence with this crop.

Taxonomic studies during the past year consisted in the compilation of a list of the Elateridae taken from the literature on Kansas insects. This list is only approximate, since no doubt many of the species need revision. It includes almost 100 species. There is reason to believe that when specimens now in the collections in the state are determined properly, the list will include almost twice as many as are now listed in the literature.

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

Insects Injurious to Alfalfa, Grasses, and Allied Plants.—

This project has included studies along two lines, each of which is discussed briefly below.

1. *Alfalfa, Vetch, and Clover Insects.*—The pea aphid occurred in outbreak proportions in alfalfa fields in the eastern half of Kansas during the springs of both 1933 and 1934, the latter outbreak being the most extensive since the pea aphid became an alfalfa pest in 1921. Various control measures, particularly harrowing and chain dragging, were further tested against this pest during both outbreaks. While the results were fairly satisfactory during 1933, they were unsatisfactory during 1934, largely because of the dry weather. An exceptionally large population of the convergent ladybird beetles brought the aphid outbreak to a sudden close on May 7. This was one of the most spectacular examples of biological control of any insect pest in Kansas in recent years.

The army cutworm occurred in outbreak proportions in central Kansas during the spring of 1933, but was almost absent during 1934 except in certain western localities. It was again demonstrated that fall-sown alfalfa in which there is considerable volunteer wheat or oats is most likely to have large populations of this insect during the following spring. Excellent control results were obtained with poisoned bran mash sowed in the evenings.

Moths of the alfalfa webworm (*Loxostege commixtalis*) were plentiful during the spring of 1933, but scarce in eastern Kansas during 1934. The larvae fed on certain weeds, especially Russian thistle and pig weed, and have been to date only a secondary pest of alfalfa in Kansas. This species was reared during both years, the stages photographed, and the over-wintering larvae discovered in their silken tubes for the first time.

Grasshoppers were somewhat less numerous and destructive than usual during the autumns of both 1932 and 1933. The parasitic flies (*Sarcophaga kelleyi*) were unusually plentiful during August and September, 1932. Some grasshoppers were killed during July by the fungous disease *Empusa grylli*, but it was not an important control factor. Experimental poisoned bran-mash sowings and the use of a modified grasshopper catcher gave usual results.

Two cutworms, *Feltia annexa* and *F. ducens*, became sufficiently plentiful for the first time in recent years to do perceptible damage to alfalfa during the fall of 1933. The larvae were largely destroyed by cold weather. The clover cutworm (*Scotogramma trifolii*) appeared for the first time in numbers in Kansas in clover and alfalfa fields during the summer of 1933. The moths were particularly plentiful in south central Kansas. An outbreak of the false chinch bug, *Nysius ericae*, centering especially on shepherd's purse and other weeds in alfalfa fields, occurred during the summer of 1933.

2. *Insects Affecting Grass and Allied Plants.*—Investigations on this phase of the project have proceeded along the following lines during the past biennium:

- a. Biweekly collections throughout the growing season.
- b. Study of insects affecting the culms of grasses.
- c. Study of insects affecting the inflorescence of grasses.

Biweekly collections throughout the growing season during the past year on three different grass stations have furnished a fairly accurate cross section of the insect population of those areas. Partially complete summaries of the collections of 1933 and previous years are available for Orthoptera, Cicadellidae, Chloropidae, most Hemiptera and a few Coleoptera. Some new and several rare insect species have been brought to light.

During the summer of 1933 rearings were attempted with 341 insects from 13 important grass species. The most important insects found in grass culms were of the Hymenopterous genus *Harmolita*, the Dipterous families Chloropidae and Cecidomyiidae, and the Coleopterous genus *Geraeus*. In the counts made of culm infestation by insects, the percentage of infestation varied from 19 to 100 per cent, depending upon the grass species and the insects involved. Approximately 3,709 insects, chiefly Chalcedoid, emerged from grass culms collected during the winter months. The bulk were *Harmolita* and their parasites.

Injury to the inflorescence of grasses, caused by grasshoppers, was found on several important native grasses during the late summer of 1932. During the summer of 1933 this type of injury was seldom observed. The injury caused by the grasshoppers was of three types:

- a. Tearing off the protective leaf blades or sheaths and consuming the tender developing heads or exposing them to the desiccating power of the air. This injury was especially prevalent in the bluestems.
- b. Biting through the protective glumes or lemmas and consuming the kernels in the milk stage. This injury was characteristic on grasses of the genus *Elymus* and numerous others.
- c. Biting through the protective covering and consuming the tender portion of the culm found just below the head or just above the upper node on many grasses. Injury of this type has been found in abundance on wheat, oats, side oats grass, and others.

[Project. 115; Department of Entomology. Leaders, R. C. Smith and D. A. Wilbur; Hatch and state funds.]

Biology and Control of the Western Apple Curculio.—The damage caused by the western apple curculio (*Tachypeterellus quadrigibbus magnus* List.) has been increasing in northeastern Kansas. During the past biennium studies were made of this insect along the following lines: Injury, life history, hibernation habits, feeding habits and methods of control.

Twigs and apples are injured by feeding and oviposition of the adults. New-generation adults produced the "pepper box" type of injury, which provided a place for codling moth, and under favorable weather conditions, disease entrance. The most serious damage was caused by the overwintering beetles. They systematically punctured the fruit, in egg laying and feeding, until all the apples were punctured on the limb.

Oviposition takes place in apples one-fourth to one inch in diameter, and the egg is laid near the carpels. The larva develops in the core region of the apple. It may develop in an apple which remains on the tree or drops to the soil. Many apples may have more than one small larva per apple, but only one matures. Pupation, which takes place within the apple, is rapid. The adult eats its way out of the drying, small, green apple. Average length of the stages in days is as follows: Incubation of egg, eight; larva, twenty; pupa, six; adult within apple (hardening), three. The complete life cycle takes twenty-eight to thirty-nine days. There is one generation a year.

This native insect hibernates as an adult and suddenly reappears, causing damage to the twigs and newly set fruit of the apple and pear. It does not hibernate in fence rows or similar places, but beneath fruit trees, congregated on slight elevations of soil, in accumulated leaves. The break-up of hibernation, which appears to be synchronized with the blooming of the host, is rapid.

Three larval hymenopterous parasites of the western apple curculio were reared and identified. Picking up of "June drops" and the use of running fire have been shown to be futile. Controlled burning by means of covered pressure burners which utilize distillate as the fuel gave the best control. Pressure burners were developed by the Bureau of Agricultural Engineering, United States Department of Agriculture, and the Department of Agricultural Engineering, Kansas Agricultural Experiment Station. The burner developed by the Department of Agricultural Engineering, Kansas Agricultural Experiment Station, which utilizes a combination fuel and pressure tank, was the more economical. The cost of fuel and labor to burn one acre was about \$5. This machine develops 1,900 degrees F. at the surface of the soil. When burning was properly done there were no beetles in the controlled burned area. Migration from unburned areas into burned areas was slow. For this reason it would be necessary to burn an area only once in five to 10 years. Poison baits were used, but as yet have not proved satisfactory, due to the fact that large doses of poison were necessary to kill this curculio. "Tanglefoot" bands were used

around the trunks of trees, since during cold weather the beetles crawl up the trunks, but this proved unsatisfactory .

[Project 187; Department of Entomology. Leader, R. L. Parker; Hatch and Purnell funds.]

The Resistance of Crop Plants to Insect Attack.—Studies have been made of the reaction of sorghums to chinch bugs; of wheat to Hessian fly, straw worm, and stem maggot; of corn to the corn-ear worm; of alfalfa to the pea aphid; and of corn and sorghums to the leaf aphid.

A sorghum chinch-bug nursery is grown at the United States Field Station at Lawton, Oklahoma, in coöperation with officials of that station. Observations made at Manhattan and Lawton show that Atlas, Kansas Orange, and Sunrise sorgos, and Blackhull, Reed, Pink, Dawn and Sharon kafirs are relatively resistant to chinch bugs, while Dwarf Yellow milo, Sooner milo, Wheatland, Beaver, and Kalo are very susceptible.

Most F₁ sorghum hybrids which showed marked heterosis or hybrid vigor were resistant to chinch bugs.

In a study of Hessian-fly infestation of species and varieties of spring wheat grown at Manhattan in the spring of 1932, it was found that Einkorn and Double Einkorn (14 chromosomes) were highly resistant. In the 28 chromosome group, a selection of Vernal emmer and Yaroslav emmer were highly resistant, while another selection of Vernal emmer and Khapli emmer had 32 to 34 per cent fly. Among the durum wheats, which also have 28 chromosomes, Iumillo and Kubanka, C. I. 2094, were highly resistant, showing zero and 1 per cent fly, respectively. Pentad was moderately susceptible and had 15 per cent fly, while Arnautka was very susceptible and had 56 per cent fly. In the 42 chromosome or common bread-wheat group, Marquis and Ceres were very susceptible, showing 60 per cent and 84 per cent fly, while Pusa No. 4, an early spring wheat from India, had only 21 per cent fly. Marquillo and Hope are two varieties of spring wheat recently developed from crossing *T. vulgare* with *T. durum* and *T. dicoccum*, respectively. Marquillo is fly resistant, having only 6.7 per cent infestation, while Hope is very susceptible, with 76.7 per cent fly. Spring-planted Tenmarq, a susceptible winter wheat used as the check in the same test, had 91 per cent fly.

The studies of Hessian-fly resistance in winter wheats include tests of varieties, pedigree selections and crosses. More emphasis is now put on selections and crosses than on varieties. The Hessian-fly nursery planted in the fall of 1932 included about 50 varieties, 175 purple straw selections and 425 hybrids, of which the selections of Tenmarq X Kawvale are perhaps the most promising as to fly resistance and agronomic characters. Some of the purple-straw selections are fly resistant but many of them are not, typical of the variety from which selected and may be the result of natural crossing.

A severe outbreak of pea aphid on alfalfa in the spring of 1934 afforded an excellent opportunity for studies of resistance, which were made in coöperation with Mr. C. O. Grandfield. Estimates of the numbers of aphids on 36 strains of alfalfa were made by taking 20 sweeps of an insect net in each plot and measuring in c. c. the aphids obtained.

Data on a few strains of special interest are included in this report:

F. C. No. and variety	C. c. of aphids
15988, Ladak	22
86696, Turkstan	40
19301, Turkstan	48
19302, Turkstan	48
Ks 307, Grimm	72
Ks 306, Kansas Common	79
15995, Utah	80
15939, Baltic	87
Ks 308, Kansas	108
19316, Turkstan	127



Observations made on alfalfa variety tests in four other localities in the state also indicated that Kansas Common and Grimm were much more severely injured than Ladak. About 300 plants of alfalfa which showed resistance to the pea aphid in the spring of 1934 have been transplanted to nursery rows for further study.

[Project 164; Departments of Entomology and Agronomy. Leaders, R. H. Painter and J. H. Parker; Purnell fund.]

Investigations of Injurious Mammals.—The reproductive cycles of the pocket gopher and mole were studied during the past biennium.

Measurements were recorded for the sizes of the reproductive organs of 205 pocket gophers, and the organs of 74 gophers were fixed and studied histologically. The endocrine organs of about one-fourth of these have been sectioned and studied. The results show a marked sexual development from November to May and a striking atrophy in the summer and early fall.

The reproductive organs of moles have been fixed for future study, and observations of their development are being recorded.

[Project 84; Department of Zoölogy. Leader, G. E. Johnson; state fund.]

Physiology of Reproduction and of Hibernation in Mammals.—The studies conducted during the biennium have been concerned with the relation of some of the ductless glands to reproduction and hibernation in certain rodents. These studies have included: (1) The laboratory sexual cycle of the ground squirrel; (2) the relation of the pineal and thymus to growth and reproduction in young rats; (3) the effect of ovarian residue extract on the reproductive organs of rats; (4) the effect of light on reproduction and hibernation in the ground squirrel; (5) the relation of the pituitary and gonads to hibernation in the ground squirrel; (6) the relation of the pituitary to the male reproductive system; (7) the effect of castration on the excess growth produced by injections of pituitary extracts in young male mice; and (8) the effect of Antuitrin S on sexually inactive ground squirrels.

The chief results may be stated briefly as follows:

a. In the laboratory ground squirrels showed sexual atrophy from about July to December, and genital enlargement from January to June, whereas in the field genital development was chiefly limited to April, May, and June.

b. Neither pineal nor thymus implants made daily into young rats had any effect on growth. The pineal implants indicated a slight inhibition of sexual maturity in males.

c. A purified extract, made from sow ovaries from which the corpora lutea and the fluid in the follicles had been removed, injected into 21- to 23-day old rats caused a premature enlargement of the uterus and vagina and the opening of the vagina in about 10 days, apparently because of its theelin content.

d. Neither unfiltered white light, light passing through a red, a green, or a blue glass filter, nor violet light produced any marked stimulating effect on reproduction and no inhibiting effect on hibernation in the ground squirrel.

e. Ground squirrels given pituitary implants showed less tendency to hibernate than brain-implanted controls.

f. Pituitary implants stimulated development of the testes, seminal vesicles, prostates and Cowper's glands.

g. The presence of the testes appeared to aid rather than hinder growth in pituitary-injected animals. The uncastrated injected males were heaviest, then

followed the castrated injected, and then the castrated uninjected group. The uncastrated uninjected males were perhaps slightly lighter than the castrated uninjected males but probably not significantly so.

h. Antuitrin S generally produced hypertrophy of the gonads and accessory reproductive organs, but apparently not wholly in a normal manner.

[Project 191; Department of Zoölogy. Leader, G. E. Johnson; Purnell fund.]

DISEASES OF FARM ANIMALS

During the past biennium the studies conducted by the Agricultural Experiment Station of animal diseases and parasites were continued. Some results are discussed briefly below.

Miscellaneous Animal Disease Investigations.—During the past biennium the work on this project has consisted of post-mortem and laboratory examinations of diseased animals and tissues. Investigational trips were also made to determine the cause of mysterious animal diseases as they made their appearance. Work on infectious enteritis of cats occupied considerable attention during the past year. Also work on equine encephalomyelitis was started again as a result of the small outbreak that occurred in the state in the fall of 1933. During the biennium 24,340 laboratory examinations were made.

As a result of a field investigational trip, equine encephalomyelitis was recognized. Specimens were brought back to the laboratory, sectioned, cultured, and studied. The characteristic lesions of encephalomyelitis were demonstrated in the brain, and the virus was obtained and successfully passed through guinea pigs. This study resulted in a positive identification of equine encephalomyelitis in Kansas.

A study of the use and importance of ovarian extract as a therapeutic measure to employ in treating cases of functional sterility was prompted by the failure to obtain results from the usual recommended lines of treatment, also by the success reported from the use of ovarian transplants. The extract was made from ovarian tissue after the removal of the corpora lutea. The remainder of the ovary was then ground up fine in a meat grinder and for each gram of ovarian tissue 1 c.c. of physiological salt solution was added as a menstruum. Formalin was used as a preservative, 10 c.c. being added to each 1,000 c.c. of the saline solution used. The container was shaken, to mix the contents thoroughly, and placed in the ice box for a week to allow complete maceration of the ovarian tissue to occur. A meat press was then used to remove all the fluid possible from the macerated ovarian tissues. The extract which was obtained was placed in a container for 24 hours and the supernatant fluid removed. This was the finished ovarian extract.

The method of administration which produced the best results was to inject 10 c.c. doses subcutaneously or intramuscularly twice a week for four weeks.

Ovarian extract is of value in treating those functionally sterile cows that have ovaries normal in size with mature follicles and normal corpora lutea and with heat periods which may or may not be regular. In other individuals the ovaries may be small and firm, with complete absence of oestrus or irregular heat periods. Some ovaries may be developing apparently normal follicles and corpora lutea but there is an absence of oestral symptoms. By further investigation it is hoped to reduce the number of treatments necessary for the individual cow. If this is accomplished the treatment of the average cow will be economical and practical.

[Project 102; Department of Veterinary Medicine. Leaders, R. R. Dykstra, H. F. Lienhardt, E. R. Frank, and E. E. Leasure; state fund.]

Abortion Disease Investigations.—Experiments have been conducted to determine a practical means of combating Bang's disease in the field as follows:

1. *Raising a Clean Heifer Herd from Bang-injected Cattle.*—A herd of 18 infected Jersey cows gave birth to enough heifer calves during a three-year period to enable the owner to isolate the infected cows, and after thoroughly cleaning up the barn and lots, to replace them with Bang negative heifers. The calves were removed from their dams shortly after birth and raised on milk from Bang-free cows on clean premises. Five months after these heifers freshened and were placed in the dairy barn they were still Bang-free. The heifer herd was tested annually.

2. *Dual Maternity Stable System.*—Two herds have been operating on this plan for 30 and 18 months, respectively. Herd I had 43 per cent Bang infection at the beginning of the experiment, and at the end of the biennium 22.8 per cent, a lowering of 20.2 points. Herd II had 34 per cent Bang infection at the start, and at the end of the biennium 15 per cent, a lowering of 19 points. Herd I has been completely isolated from the infected cattle on the dual-herd plan and should speedily obtain a Bang-free herd.

3. *Method of Control Based Upon Sale or Segregation of All Bang Reactors.*—All herds Bang-free for one full year are accredited and a certificate issued to the owner for one year.

- 5 herds have been accredited for four years.
- 5 herds have been accredited for three years.
- 5 herds have been accredited for two years.
- 9 herds have been accredited for one year.
- 21 herds have passed two or more Bang-free tests but have not been clean for the full year.

In addition to the above herds, many herds have passed clean tests by the local veterinarian, and these records will be accepted, provided the samples at the end of a year of clean tests can pass a test in the pathology laboratories. Such herds will be certified Bang-free.

Experimental use of Azamine in Bang-infected cattle was made. Seven doses of 300 c. c. at three-day intervals failed to influence the blood reaction of either a positive bull or a positive cow after a nine-month period. Azamine was injected through the teat canal in a cow having Bang-infected milk with no satisfactory results.

In an attempt to produce Bang agglutinins by the injection of hemorrhagic septicemia bacterin in two dairy cows, negative results were obtained during a 12-month period. These cows were sold for slaughter. This work refutes an impression advanced by various interests and tends to strengthen belief in the efficiency of the abortion agglutination test.

Two hundred and three milk samples were tested, together with the blood samples of cows, to determine the correlation of the milk and blood agglutination test and the bacterial findings. No cultures of Bang germs were secured from either blood or whey negative animals to the agglutination test, and no milk samples were agglutinin positive without the blood being at least positive in dilution of 1-200.

The research work done during the past two years has resulted in the perfection of a stable, sensitive antigen, and one that is considered superior to many on the market. Bang rapid-method antigens stored in an electric refrigerator over periods of one month to two and one-half years have been studied particularly in reference to the efficiency factor in relation to age. These antigens were diluted with physiological saline and preserved with

phenol, and in many cases parallel antigens diluted with 12 per cent saline were compared under the identical storage conditions. Practically all of the antigens showed a lowering of 10 to 20 per cent in sensitivity, which ordinarily occurred during the first two months. The antigen then stabilized and no further decrease in efficiency up to two and one-half years was noted.

Experiments were conducted to determine the breeding efficiency of a blood positive bull in service upon Bang-free heifers. Five heifers were bred by the infected bull. Three heifers did not conceive, but later did calve, following subsequent breeding to a Bang-free bull. Two heifers calved normally. To date (two years later) all five cows are Bang-free and have no history of Bang's disease. A microscopical and bacteriological examination was made upon this bull's semen before the above experiment was started. The presence of *Brucella abortus* could not be demonstrated in the semen of the bull, although the animal had been a high-blood reactor for two years.

[Project 135; Department of Veterinary Medicine. Leaders: H. F. Lienhardt and C. H. Kitselman; state fund.]

Blackleg Investigations.—The work on this project has consisted in the production and distribution of blackleg filtrate and anti-blackleg serum and of the following experimental work:

1. A laboratory study of so-called vaccination shock following the use of blackleg filtrates and bacterins.
2. A study of the potency of an old sample of blackleg filtrate which had been kept under poor conditions for 10 years.
3. A study of the use of certain preservatives in the production of blackleg filtrate and bacterin.
4. A bacteriological study of some atypical blackleg organisms isolated from cases of blackleg.
5. A bacteriological study of some anærobic organisms isolated from cases of blackleg.
6. A study of three outbreaks of blackleg occurring after the use of certain commercial products.
7. A study of anærobic organisms isolated from black-leg diseases of swine.

[Department of Veterinary Medicine. Leader, J. P. Scott; state fund.]

Shipping Fever Investigations.—The work on this project during the past biennium is briefly described below.

Field Investigations.—Investigations of eight outbreaks of shipping fever were made during the fall and winter of 1932-'33.

Bacteriological Examination of Material Obtained from Cases of Shipping Fever.—Material from four of the eight outbreaks of shipping fever was examined and in all cases only cultures of *Pasteurella bovisseptica* were obtained from the affected lungs or from the heart blood. In one of these cases a pathogenic and a nonpathogenic culture were obtained from the lung tissue. From material sent in for examination colon-type organisms were obtained from four specimens of lung tissue. No other organisms were found in these lungs. In a fifth case both a colon-type organism and *Pasteurella bovisseptica* were isolated. Four samples of blood were obtained from cattle affected with shipping fever. It was not possible to demonstrate *Pasteurella bovisseptica* in any of these samples; one proved sterile and the other three yielded colon-type organisms.

Bacteriological Studies of Cultures of Pasteurella Boviseptica—Five characteristics were considered sufficient to make an identification of *Pasteurella* cultures.

- a. Smears from tissues showed bipolar organisms when stained with methylene blue.
- b. The colonies growing on agar were small "dew drop" and were seldom more than 1 mm. in diameter.
- c. The organisms examined from agar slants and broth cultures were short nonmotile gram negative rods.
- d. The cultures proved pathogenic for rabbits and guinea pigs.
- e. The cultures produced acid but no gas in glucose and sucrose, but did not attack lactose and maltose.

Bacteriological Studies of Strains of Pasteurella Boviseptica.—A cultural examination of 36 cultures of *Pasteurella bovisseptica* isolated from cases of shipping fever and obtained from other laboratories in this country and in India showed that all the organisms were identical culturally and morphologically. The pathogenicity of these strains varied considerably. Some organisms were highly pathogenic when first isolated and lost this character rapidly; others maintained their virulence for moderate periods, and a few strains were nonpathogenic on isolation. It was possible to increase the pathogenicity of most of the cultures by repeated transfer in broth containing iron salts. It was found possible to keep cultures of *Pasteurella bovisseptica* viable for three months or longer when grown in a semisolid salt medium. When grown on ordinary nutrient agar viability was only maintained for three or four weeks. Agglutination titre and the survival of animals following inoculation with *Pasteurella bovisseptica* was apparently of no significance, as rabbits with a titre of 1:1600 died just as readily following inoculations as those rabbits showing a titre of 1:80. Immunological studies of different concentrations of *Pasteurella* antigens preserved by heat 60 degrees F. for one hour, formaldehyde 1 per cent, acetaldehyde 1 per cent, or merthiolate 1:1000 were made. Agglutination and complement fixation studies were made of all sera. It was noted that agglutination titres of 1:1600 were attained in a number of cases. Acetaldehyde was apparently the better preservative for the production of *Pasteurella* antigens used in this study. Similar results were obtained by complement fixation. Merthiolate was apparently the more efficient preservative for antigens 1,000 x tube 1 of McFarland's nephelometer. Complement fixation was complete in dilutions of 1: 40.

[Project 176; Department of Veterinary Medicine. Leaders, R. R. Dykstra, J. P. Scott, and Herman Farley; state fund.]

Anaplasmosis Investigations.—The work during the biennium on this project, which is in coöperation with the Bureau of Animal Industry, United States Department of Agriculture, included the following:

1. A study of vectors by exposure to flies (*Tabanidæ*) of susceptible cattle closely associated with an animal sick with anaplasmosis.
2. The use of composite carrier serum to protect susceptible cattle against inoculations of virulent blood.
3. The use of phenolized defibrinated blood from an acute case, the blood held in refrigeration for six weeks, to protect susceptible cattle against inoculations of fresh virulent blood.
4. The use of thymus extract (heated and unheated) at intervals subsequent to inoculation of cows with fresh virulent blood, to determine its effect on the course of the disease.
5. The development of strains in other species of animals (sheep, goats, and swine) for subsequent transfer back into susceptible cattle.
6. The study of native sheep grazing on pastures where cattle sick with anaplasmosis have been kept, to determine if such sheep harbor *A. marginale*.
7. The trial of several tests for the identification of carriers.
3. An attempt to attenuate the virulence of carrier blood by use of intravenous injections of solutions of chemicals on the carriers.

9. A study of immunity of calves out of immune dams.
10. An attempt at culturing the *A. marginale*.
11. Continued studies of immune cattle as carriers.

[Project 180; Department of Veterinary Medicine. Leaders, R. R. Dykstra, C. A. Pyle, and H. F. Lienhardt; state fund.]

Poultry Disease Investigations.—The general study of poultry diseases as they occur in Kansas was continued during the biennium. Certain diseases previously considered and reported upon have been given further study. During the biennium general observations and investigations of poultry diseases, and specific studies of pullorum disease, coccidiosis, fowl pox, infectious laryngotracheitis, tuberculosis, and neurolymphomatosis were conducted.

[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 Chicks.—The results of previous work on this project indicated that the tendency for the development of malformed bones was greater when corn was used as the base of the ration than when other grains were used. An experiment, to test the effect of the grains—corn, wheat, oats, and barley—on the development of malformed bones has been repeated. To eliminate the influence of the varying amounts of calcium and phosphorus in the various grains, sufficient mineral was added to each ration so that each would contain about 0.75 of 1 per cent phosphorus and about 1.5 per cent of calcium.

Six lots of 25 chicks each were used in this trial. Two lots receiving the standard Kansas State College chick mash served as controls, while one was used to test each of the four grains.

Another group of four lots of 25 chicks each was used to test the influence of various amounts and sources of fiber on the development of malformed bones.

The first experiment confirmed previous results by showing that an excess of corn produced a much greater percentage of slipped tendons than an equal amount of other grains tested.

Crude fiber from different sources was used at a fairly high level in four lots of 26 Rhode Island Red chicks. The difference in the number of slipped tendons produced in the high- and low-fiber lots is probably not great enough to be significant. These results indicate that oat hulls have an inhibiting tendency, as has been pointed out by other workers. However, the factor or factors in oat hulls is probably something other than fiber. This inhibiting factor was not sufficient to prevent the malformed leg trouble developing with the high mineral level used in this ration. The chicks did not make normal growth, due, no doubt, to the high summer temperature and the large number with deformed legs being unable to take nourishment and exercise normally. While corn and oats represent contrasting grains with respect to aggravating and preventing slipped tendons in growing chicks, their effects seem to be either exaggerated or nullified, depending upon the amount of phosphorus in the ration.

[Project 127; Departments of Poultry Husbandry and Chemistry. Leaders, L. F. Payne and J. S. Hughes; Adams and Purnell funds.]

Histopathology of Poultry Diseases.—A study of two outbreaks of infectious laryngotracheitis was made. One outbreak

occurred during mild weather in December, 1932; losses were only 2 per cent, although 90 per cent of the flock became affected. A second outbreak occurred in 1933 during zero weather; losses were more than 50 per cent. Twenty-three birds which had passed through the 1932 outbreak developed laryngotracheitis during the 1933 outbreak. Sixty-five per cent of these birds died, suggesting that exposure to a mild outbreak of the disease does not always produce immunity.

The 1933 flock was divided into four pens for the production of hatching eggs. During March these birds were subjected to a tracheal swab, and susceptible chicks were inoculated with washings of these swabs. From this examination it was found that two of the pens contained carrier birds while the other two pens remained free. The records on hatchability of the four pens showed that pens having carrier birds produced eggs with hatchabilities of 67 per cent and 69 per cent, respectively, while the two pens which had no carriers produced eggs with hatchabilities of 87 per cent and 85 per cent.

[Project 168; Department of Veterinary Medicine. Leaders, H. F. Lienhardt and J. P. Scott; state fund.]

Parasitological Investigations.—Carbon tetrachloride administered to growing chickens at a dose rate of 4 c. c. per kilo of body weight proved to be an effective and relatively nontoxic anthelmintic for the intestinal nematode, *Ascaridia lineata* (Schneider). When administered at this dosage rate to mature pullets sufficient toxicity resulted to markedly reduce the egg production for a period of 7 to 10 days.

Greatly increased resistance to the viability and growth of the fowl nematode, *Ascaridia lineata* (Schneider), resulted after White Leghorn chickens increased in age week after week. The rate of increase was more rapid in Single Comb White Leghorns than in such heavier breeds as Rhode Island Reds and Barred Plymouth Rocks.

Other new findings include tetra- and polyradiate tapeworms from a dog; the red squirrel as a new intermediate host of the cat tapeworm, *Taenia taenioformis*; a new species of nematode, *Rictularia scalopsis*, from the mole; and experimentally determined life cycles of cockroach nematodes.

[Project 79; Department of Zoölogy. Leader, J. E. Ackert; Adams fund.]

Resistance of Chickens to Parasitism.—By varying certain dietary supplements it was found that chickens that received skimmed milk (*ad libitum*) and meat meal in addition to a cereal basal ration were constantly more resistant to the nematode *A. lineata* than were chickens of the same age whose diet lacked the skimmed milk or whose ration lacked skimmed milk and had peanut meal substituted for meat meal. This last group, fed on a plant ration, was the least resistant to the parasites and had the narrowest range of amino-acids.

From numerous previous studies the degree of resistance of White Leghorn chickens to the parasite *A. lineata* has been determined. Whether or not the broody or heavier breeds of chickens reacted similarly to the presence of these worms was unknown. The results of five experiments, involving 1,351 chickens, indicate that the heavier breeds, Single Comb Rhode Island Red, Barred Plymouth Rock, and White Plymouth Rock chickens, were more resistant to

the viability and growth of these parasites than the nonbroody or lighter breeds, the Single Comb White Leghorns and White Minorcas. These two latter breeds use up much more nervous energy than do the other breeds.

The comparative resistance of bronze turkeys and Single Comb White Leghorn chickens was studied. The turkeys proved to be constantly more resistant to this large intestinal roundworm than did chickens. However, the infestations in the turkeys were such as to make them definite factors in the spread of this fowl nematode.

[Project 169; Department of Zoölogy. Leader, J. E. Ackert; Purnell fund.]

STUDIES IN HOME ECONOMICS

Studies which have as their purpose the development and improvement of the rural home have been conducted by the Agricultural Experiment Station during the past biennium. Brief statements of the work done are given below.

Vitamin Content of Foods in Relation to Human Nutrition.—Three phases of this project were studied during the biennium. Brief descriptions of the work done are given below.

The Vitamin A Content of Foods., Including Butter, Eggs, Cherries, and Green Leafy Vegetables.—The vitamin A content of the yolk of hens' eggs was studied, as influenced by rate of production and by rations so widely different as to bring about distinct changes in the color of the yolk. The studies of vitamin A content also have included leaves of plants sometimes used in this section as leafy vegetables or "greens"; namely, dandelion, dock, and lamb's quarters. Previous work on the vitamin A content of varieties of cherries important in this region was rechecked. The rat-growth method of Sherman and Munsell was used for all vitamin A assay work.

For the vitamin A content of egg yolk the findings are (a) young pullets, both high and low producers, nearing the end of the first four months of production, laid eggs with yolks of similar vitamin A content containing at least 25 units per gram. This period of production was apparently too short to bring about marked differences between the vitamin A content of the yolk of eggs of the two groups. (b) Pullets of high- and low-production records laid eggs with dissimilar vitamin A content near the close of the first year of egg production. At that time, eggs from low producers showed 33 units of vitamin A per gram of yolk, compared with 20 units in the high producing group, high producers having decreased and low producers increased the vitamin A content, compared to the content of similar eggs produced at the end of only four months of laying. (c) The pale eggs produced on a ration devoid of carotene and xanthophyll, but supplying vitamin A in the form of cod-liver oil, contained 25 units of vitamin A per gram.

The green leaves of dandelion (*Taraxacum officinale*) contained at least 200 Sherman units of vitamin A per gram. The leaves of lamb's quarters (*Chenopodium album*) were a good source of vitamin A and were more than half as rich as the dandelion. The leaves of curled dock (*Rumex crispus*) were also an excellent source of vitamin A, and apparently were equal to the dandelion.

Cherries of Early Richmond and Montmorency varieties, canned by the cold-pack method, were similar in vitamin A content, containing approximately three Sherman units per gram, calculated on the basis of the fresh fruit. The same cherries, frozen when fresh and held frozen until used, also were similar in vitamin A content, containing four or five Sherman units per gram.

The Vitamin B (B₁) Content of Cereal Products.—The study of the vitamin B (B₁) content of wheat and its milling products was continued, using a definite lot of Kansas winter wheat. The vitamin B (B₁) content of yeast breads made of these milling products was also investigated. The method of Chase

and Sherman for vitamin B (B_1) determinations was used. The bread was baked especially for the experiment by the Department of Milling Industry and a coöperating commercial bakery.

Results of the experiments with milling products of wheat and with yeast breads made from these products showed that in equal weights of wheat milling products in the form of yeast breads, vitamin B (B_1) was contained as follows:

<i>Kind of Bread</i>	<i>Vitamin B (B_1)</i>
White	At least twice as much as in the patent flour used in making the white bread
Whole wheat (50-50)	Twice as much as from white bread
Germ stock	Twice as much as from white bread
Whole wheat (100%)	Four to five times as much as from the white bread.

The Vitamin A Content of the Colostrum of the Dairy Cow.—The first work on this phase has been to study the vitamin A content of the colostrum as compared with the normal milk of individual cows in the college dairy herd, all receiving the regular Kansas State College Dairy ration. The rat-growth method of Sherman and Munsell is being used for the assay of vitamin A. This experiment has been under way only a few months. Data now available indicate that colostrum is much richer in vitamin A than is normal milk.

[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.—Three phases of this project were conducted during the biennium. Brief descriptions of the work done are given below.

Utilization by Adults of Calcium and Phosphorus from Fresh, Dried, and Canned Milk.—A balance experiment has been conducted with two adult human female subjects of similar age and weight, one pregnant and the other nonpregnant. No results are available for the human metabolism experiments, as collection of samples only has been completed.

Three diets which have been the subject of investigation with human subjects have been checked by means of an animal experiment, involving a major portion of the life span of the rat, the animal used. Favorable results with human subjects were secured with the three diets, only one of which contained milk. In the animal experiment, it was evident that the rats which received the diet containing milk were superior in many ways, particularly as regards the calcium stored in the body. These animals also grew better than the others and reproduced successfully.

A Study of the Calcium and Phosphorus of Cheese Made in Various Ways.—Analyses were completed of cheese made under controlled conditions through the coöperation of the Department of Dairy Husbandry. Fifty-four samples of cheese, 50 being laboratory products made under known conditions, were analyzed for calcium, phosphorus and nitrogen. These included rennet and acid types of cottage cheese, cream, Neufchatel, cheddar, and processed cheese. Results included the following points:

- a. Caloric values varied from 4.81 calories per gram for cheddar cheese and 3.53 calories per gram for cream cheese to less than 1 calorie per gram for various types of cottage cheese.
- b. Cheddar and processed cheese made under known conditions were by weight about one-third protein, commercial-processed cheese one-fourth protein, cottage and Neufchatel one-sixth to one-tenth protein, and cream cheese about one-fourteenth protein.
- c. The difference in the percentage of calcium in rennet and acid types of cottage cheese was not significant, but cheddar cheese contained approximately 10 times as much calcium as the soft cheeses. About 20 per cent of the calcium of the milk was retained in the soft cheeses, while 80 per cent was retained in cheddar cheese.

d. The amount of phosphorus seemed to vary according to the amount of protein in the cheese. About 37 per cent of the phosphorus of the milk was retained in the soft cheeses and 38 per cent in cheddar cheese.

The Relation of the Consumption of Milk and Milk Products to the Intake of Protein, Calcium, and Phosphorus, as Indicated by Output.—Young women college students served as subjects, saving complete samples of feces and urine for periods of four days. The subjects ate the quantity and quality of food desired, with the following stipulations for periods:

1. The customary diet was followed.

2. All high-protein foods of animal origin (meat, fish, poultry, eggs, milk, cheese) were avoided, but other foods high in calcium and phosphorus were urged. This subproject was planned to follow up preliminary work already finished, the subjects eating the customary diet, as in (a).

Findings from the preliminary work may be summarized as follows: Figures for protein used by the 25 subjects give averages distinctly below accepted standards, suggesting that the majority of the subjects were consuming less protein than is often advised, while averages for calcium and phosphorus were above the accepted standards, figures for some subjects were below accepted standards, in one else the calcium figure falling below the calcium requirement.

[Project 159; Department of Home Economics. Leader, Martha M. Kramer; Purnell fund.]

An Investigation of the Effect Upon the Animal Body of Varying the Amount of Vitamin in the Diet.—The work on this project consisted of a study of the effects of vitamin C deficiency upon female guinea pigs. Investigation is under way to determine certain effects of vitamin C deficiency upon female guinea pigs, particularly as related to reproduction and to changes in the ovary and in uterine tissues. Rats were used for one phase of the work to study the adequacy of the vitamin-C-free diet used.

The Sherman, LaMer, and Campbell vitamin-C-free diet, used for experiments in this laboratory was fed to rats to determine whether or not it was adequate in all respects other than vitamin C. The rats appeared healthy, grew normally and reared normal young. This diet appeared to be adequate for the growth and reproduction of the rat.

Guinea pigs receiving 1 c. c. of orange juice or tomato juice, an amount less than the minimum protective dose, did not maintain their body weights. Those receiving 3 c. c., a quantity greater than the minimum protective dose according to Sherman, LaMer, and Campbell, grew at a slightly subnormal rate, but those receiving 5 c.c., an amount fully protective according to the above authors and Höjer, made good growth. All female guinea pigs receiving the standard diet, together with supplements of 1, 3, or 5 c.c. of orange juice or tomato juice, failed to give birth to living young. There were less than the normal number of pregnancies and no pregnancy occurred when less than 3 c.c. of orange juice or tomato juice was fed. Abortions or resorptions of embryos occurred in all pregnant animals. This was true whether pregnancy had taken place before the animals were placed on the experiment, or whether they became pregnant during the experiment. The ovaries of those animals varied from the normal in that there was a degeneration of the Graafian follicles and a lack of normal development of new Graafian follicles.

[Project 188; Department of Home Economics. Leader, Martha M. Kramer; Purnell fund.]

A Study of Factors Affecting the Service Qualities of Certain Textile Fabrics.—Six phases of this project, were studied during the biennium, as follows:

1. *Comparison of Blanket Materials.*—The first part of this study included the determination of thread count, breaking strength, weight, protective ratio, total thickness, and percentage of enmeshed air of certain all-wool blanket materials. Four in the finished and unfinished state and two finished blankets were studied. The results showed that finishing reduced greatly the strength of filling yarns. A blanket 72x84 inches that weighs less than 3½ pounds would probably be lacking in protective value or durability or both.

In the second study four all-wool and five all-cotton blankets in the finished material were tested. In the group of all-wool fabrics, the heaviest one had an extremely weak filling yarn, and 1 per cent of the nap was lost in one laundering. One blanket that met the minimum breaking strength requirements weighed approximately 4 1/5 pounds. One blanket that weighed 3 1/6 pounds was slightly below the minimum breaking strength. One blanket that weighed 3 pounds lacked sufficient breaking strength. These lighter-weight blankets were low in protective value also. These findings agreed with those resulting from the tests run on the first group of all-wool blankets.

In the group of cotton blankets the heavier fabrics did not prove to be the stronger ones. There was a higher percentage of enmeshed air in this group, but for the same weight of fabric a lower protective value than in the wool blankets. However, higher protective value accompanied increase in weight.

2. *The Effect of Dry and Moist Atmosphere and of Human and Synthetic Perspiration Upon Unweighted and Weighted Silk Fabrics.*—Unweighted silk crepe, and portions of the same crepe weighted to 25 per cent and 40 per cent above par by the tin-phosphate-silicate method, were selected for this study. Unsaturated specimens of each silk, and specimens saturated with either human, acid or basic synthetic perspiration, were allowed to remain under the following conditions for five weeks: (1) In a room with a humidity of approximately 60 per cent at 80 degrees F; (2) in a dry oven at 80 degrees F; (3) in a moist oven at 80 degrees F. Moisture was supplied in the oven by the evaporation of a gallon of water each 24 hours. At the close of the five-week period all of the specimens were conditioned and broken.

A comparison of the tensile strengths of unsaturated and saturated specimens kept under the same conditions of humidity and temperature indicated that weighting increased the rapidity of deterioration. Perspiration caused tendering, especially of the weighted silks; silks saturated with synthetic perspiration showed a greater loss in strength than those saturated with human perspiration; the acid portion of synthetic perspiration was more severe in its effect than was the basic. Heat in combination with weighting and/or perspiration caused the greatest loss in breaking strength and a decided yellowing of the silks. Heat and moisture were more destructive than dry heat.

3. *The Effect of Different Wave Lengths of Light Upon the Deterioration of Certain Unweighted and Weighted Silks.*—The work of this project consisted of exposure of pure dye silk, 50 per cent lead-weighted and 25 and 50 per cent tin-weighted silks, to the rays of an S-1 sun lamp under controlled conditions of temperature and humidity. Samples were exposed to the entire spectrum given by this light source and to different regions of the spectrum to determine which rays had the greatest deteriorating effect upon the fiber. Corning glass filters were used for filtering out the undesired rays. As a measure of the deterioration due to the light, tensile strength of the samples after exposure was compared with the tensile strength of control samples not exposed to the light. X-ray pictures will be used to determine what changes fibers have undergone during exposure to certain of the light rays.

The results of the work thus far indicate that the lead-weighted silk undergoes greatest deterioration as measured by its decrease in tensile strength. Pure-dye and 25 per cent tin-weighted samples appeared to increase slightly in strength under exposure to wave lengths above 3,400 Å. The 50 per cent tin-weighted silk showed little or no change under these rays. All samples showed the greatest deterioration when exposed to wave lengths between 2,600 and 3,400 Å, or to the entire spectrum which includes these shorter wave lengths.

4. *Qualities of Percale Obtained on the Market Compared with Government Specifications.*—The purpose of this study was to compare the qualities of percales available to average consumers with the standard set for that fabric by the government. The results of the study indicate that width, thread count and amount of finish of the market percales meet the standard set by the government. Considerable variation in breaking strength was apparent. Only one of the 13 specimens tested equaled or exceeded the government standard. Color fastness was not sufficient to withstand Kansas sunlight; only one faded in the standard fade-ometer test. Fabrics purchased from the retailer who stated that they would meet government specifications were no better in quality than cheaper ones which were not guaranteed. Price was not a criterion of quality, for the most durable percales were the least expensive. Results of this study were published in the *Journal of Home Economics*, vol. 26, No. 5, May, 1934, pages 286-287.

5. *A Comparison of the Absorptive Qualities of Certain Fabrics.*—A study was made of three selected knitted fabrics commonly used in the manufacture of underwear, to determine the rate of absorption and amount, of absorption per unit area and per unit weight. One silk, one rayon and one cotton fabric, similar in construction and size of yarn, were used. A study was made of the absorptive quality of the fabric, yarn in the fabric, and fibers in the yarn to determine the effect on this quality of the differences in fiber, yarn, and construction of the fabric.

Data obtained from the limited number of fabrics used indicate that with these filling-knitted fabrics—

- a. Rayon had the greatest hygroscopic property, silk next, and cotton least.
- b. The ranking of the yarns and fibers in percentage of moisture content and regain was the same as that of the fabric. The absorption increased as the result of manufacturing processes, with the exception of cotton yarn, which seemed to absorb less moisture than the fibers in loose form.
- c. The rate and amount of absorption of synthetic perspiration per unit area was higher for silk than for either rayon or cotton.
- d. The unit of area in contact with the surface was more important in the rate of absorption than the unit of weight, and the total amount absorbed was in proportion to the weight.

6. *A Study of the Service Qualities of Fabrics as Affected by Laundering.*—A study was made of the effect on certain cotton textiles of variations in methods of power and home laundries. The percentage loss in strength and the loss and change of color were chosen as the means of comparison. Spectrophometric analyses were used to determine color changes. A loss of less than 10 per cent in tensile strength for 20 launderings was made the standard for efficient laundering. Tan and green chambray; blue, green, tan, and white broadcloth (all in plain color) were used.

A local laundry affiliated with the National Laundry Owners Association was selected as representative to efficient power laundry methods. The two home-management houses, acting as a unit, were chosen as representative of home laundry methods. Two one-yard lengths of each fabric were used for testing. One marked section of each fabric was removed for test purposes, after the first, second, third, fourth, fifth, tenth, fifteenth, and twentieth launderings. A summary of results indicates:

- a. In three-fourths of the cases, counting both warp and filling, the loss in strength was greater in portions laundered by the home-management houses than in those laundered by the power laundry.
- b. In 10 specimens loss in strength was more than 10 per cent for 20 launderings. Six of these were laundered by home methods and four by power methods.
- c. All fabrics showed some change in color for both laundry methods. White broadcloth, tan and green chambray became grayer and darker. Dark colored fabrics varied in type and extent of color change. Home methods caused a greater change in color than power methods.

[Project 161; Department of Home Economics. Leaders, Katharine Hess and Esther Bruner; Purnell fund.]

A Comparison of Cooking Equipment of the Farm Home.—

Studies on the use of the top burners of a kerosene stove were continued. The study consisted of an investigation of flame temperatures of different wick heights, securing information concerning the characteristics of the burner with relation to sizes of kettles, masses of water in the kettles, fuel consumption for the tests, and the time to bring water to a boil. The results are given below.

a. A study of the flame temperatures showed that the highest temperatures occurred within the chimney. As would be expected, the higher the flame was turned without smoking, the higher the temperature.

b. Kerosene did not burn as uniformly as gas, and repeating the rates at which kerosene was used was difficult.

c. The burner efficiency was greater when the 9-inch diameter kettle was used than when the 7-inch or 5.5-inch kettle was used.

d. The burner efficiencies with the flame at the low position tested was less than the burner efficiencies with the flame at the high position tested, and the time for heating the water was longer.

e. The burner efficiencies were greater when larger masses of water were used.

Studies were made on top burners of gas ranges to study the efficiencies and the time required to use them under various conditions. Star-shaped giant, regular, and simmering burners were used as well as one ring-type burner.

The results given below are from data obtained by using gas at approximately 11 cubic feet per hour per burner.

a. On the two gas ranges equipped with regular and giant burners, the regular burners were found to be more efficient, required less time for heating a given volume of water, and consumed less gas than the giant burners.

b. In general, with the regular-size burner a greater efficiency was obtained less gas consumed, and less time required to heat a given mass of water in a 9-inch kettle than in a kettle of smaller diameter. The efficiency decreased and the gas consumption and time required for heating increased with a decrease in the diameter of the kettle.

c. The burner efficiencies increased up to a certain point with an increase in the mass of water, when heated in 9-inch kettles. Beyond this point variable results were obtained, depending, apparently, upon the rate of gas consumption and the rate of evaporation. With kettles of smaller diameter the burner efficiencies increased with an increase in the mass of water, no maximum point being reached in these experiments.

d. Tests made with four slanting-sided kettles of practically the same top and bottom diameters showed the burner efficiencies to be practically the same regardless of thickness of the kettle.

e. Burner efficiencies were greater when using curved-sided kettles than straight-sided or slanting-sided kettles in which the bottom diameters were the same. Less time for heating was required when using the curved-sided kettles.

A study was made to determine some of the factors affecting oven operation, such as opening the oven door when loading, time required to heat various masses, final temperature of those masses, the relationship between those times and temperatures, and the efficiencies of the masses studied. Square cake tins and rectangular bread pans filled with different masses of Ottawa sand were used to obtain the oven outputs. Ottawa sand was a medium by which change of temperature only was made, and eliminated variables due to physical and chemical changes. The following are some of the results:

a. Comparatively large drops in oven temperature occurred the first minute

after the oven door was opened. The temperature was restored in 10 to 15 minutes when unloaded and within 60 minutes when loaded.

b. As the size of load was increased, the output, input, and efficiency increased.

c. With larger loads, the final constant temperature became slightly larger, and the time to reach the final constant temperature became longer.

d. A point of maximum efficiency was not found with the range of loads studied.

e. For the same mass of sand, that in the square pans came to a higher final temperature and reached this final temperature in less time than did that in the rectangular pans.

[Project 174; Department of Home Economics. Leader, Mary F. Taylor; Purnell fund.]

BRANCH EXPERIMENT STATIONS

The work at the central station is supplemented by work at four branch stations located at Hays, Garden City, Colby, and Tribune in the western part of the state. At each of these stations experimental work is conducted with particular reference to local conditions. The Division of Dry Land Agriculture, Bureau of Plant Industry, United States Department of Agriculture, coöperated in the investigation of tillage and rotation problems at the Fort Hays, Garden City, and Colby branch stations. The Division of Cereal Crops and Diseases coöperated in the investigations with cereal crops at the Fort Hays and Colby stations. Other agencies of the United States Department of Agriculture coöperating in the work at the Fort Hays station are: The Forest Service in the production and distribution of trees; the Division of Forage Crops and Diseases, Bureau of Plant Industry, in investigations of forage-crops problems; and the Bureaus of Agricultural Engineering and Chemistry and Soils in moisture conservation and soil-erosion problems.

The experimental work at these branch stations has been maintained on a high plane during the past biennium. Each station has presented the results of its work to the public through meetings, field days, press reports, and bulletins. A brief description of the work conducted and of the results secured is given in the following pages:

FORT HAYS BRANCH EXPERIMENT STATION

The Fort Hays station, which utilizes an area of 3,440 acres, was established on the old Fort Hays military reservation by legislative enactment in 1901. Approximately 2,000 acres are under cultivation, the remainder being pasture, roads, building sites, and feed lots. 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 tillage and rotation work was conducted coöperatively with the Division of Dry Land Agriculture, Bureau of Plant Industry, United States Department of Agriculture. The work on this project was conducted on 566 one-tenth-acre plots which, with roads and waste areas, utilized approximately 80 acres. Investigations under way included (1) seedbed preparation for most of the staple crops adapted to this area; (2) rota-

tion experiments, using the same crops with the addition of alfalfa and brome grass, and including the use of green manure, barnyard manure, and commercial fertilizer; and (3) the use of numerous tillage implements in the preparation of land for wheat. Special study was made of the proper time to begin tillage for fallow, methods to pursue, and the value of fallow in the cropping system. The effects of regular- and wide-row spacing of corn and sorghum crops on the subsequent wheat, barley, and oats crops also were determined.

On continuously cropped wheat land, studies were made of the effect of working all the straw into the soil by different methods of tillage; and of the effect of burning off the straw on (1) physical condition of the top soil; (2) the storage of moisture and the development of nitrates in the soil; (3) the resulting yield of winter wheat; and (4) the protein content and quality of the wheat. Studies also were made on the effect of seed-bed preparation, the previous crop, the use of fallow, green-manure crops, and barnyard manure on the protein content of wheat. To study the influence of various methods of seed-bed preparation on the nitrate content of the soil at seeding time, nitrate determinations were made on a number of plots. All studies continue to show that tillage work done well and at the proper time is the most important factor in crop production. It remained for the season of 1934, with a total precipitation of only 3.82 inches from January to May, inclusive, following a dry fall, to prove that the best of tillage practice will fail to produce a crop unless sufficient moisture is received.

Cereal Investigations.—These investigations were conducted in cooperation with the Division of Cereal Crops and Diseases, Bureau of Plant Industry, United States Department of Agriculture, and consisted of the varietal testing of sorghum, wheat, barley, oats, corn, flax, and broomcorn; plant breeding and selection with sorghum and to some extent with spring barley; and cultural experiments with sorghum and wheat. The mid-early varieties of winter wheat are best adapted to central Kansas. Blackhull and Tenmarq yielded 29.9 and 29.8 bushels per acre, respectively, for the six-year period 1928 to 1933. Tenmarq has the advantage of a stiffer straw. Kanred, in comparison with the above varieties, yielded 27.9 bushels, and Turkey 27 bushels. The optimum date for seeding wheat in the Hays territory is from September 25 to October 5. The data secured indicated that well-established winter wheat may be moderately pastured with little or no material loss in grain yield.

Barley is the best spring small grain for the western half of Kansas. Flynn compares favorably with the Kansas common six-rowed (Stavropol) barley, and has the advantage of smooth awns. Flynn is favorably considered for distribution to farmers as soon as seed can be made available. Kanota or other Fulghum types of oats are the best adapted to the region. The average yield of Linota flax was 9.3 bushels for the nine-year period 1925 to 1933.

The purification and distribution of Wheatland to farmers of Kansas have demonstrated that a grain sorghum can be grown and harvested successfully by modern power machinery. In the western half of the state dwarf grain sorghum can be grown in the same manner as wheat at a reduced cost over the row method of planting, but special effort must be made to reduce the drill rate of seeding to not more than 4 pounds per acre. In 1934 approximately 450 hybrids and selections were under observation for securing improved strains of sorghum better suited to combine methods of harvesting. Some of the objectives sought are improvement in seed color, earliness, and resistance to insects and soil diseases. Experiments have shown that the field germination of sorghum seed is relatively much lower than corn. Sorghum seed which germinated 95 per cent in the laboratory averaged about 60 per cent when planted under the most optimum conditions in the field. The variation in germination depends somewhat on varieties.

Forage Crops Investigations.—These studies, which were conducted cooperatively with the Division of Forage Crops and Diseases, Bureau of Plant Industry, United States Department of Agriculture, consisted of a comprehensive and detailed study of all forage crops of possible or proved value in this region, with the major attention devoted to sweet clover, grasses, alfalfa,

and forage sorghum. The work included the agronomic phases of forage-crop production, field technique, and methods of reestablishing native pastures and lawns.

Results obtained indicated that sweet clover may be successfully grown in this vicinity, providing a substantial amount of high-quality protein pasturage from early spring until July 1, a period when other crops provide little grazing. The most practical method of growing sweet clover in the Hays area consists of drilling scarified seed without a nurse crop at the rate of 15 pounds per acre between April 15 and May 15, on disked and surface-packed Sudan grass, kafir, sorgo, or corn-stubble land, and packing again after seeding. When late winter or early spring precipitations are above normal, sweet clover may be seeded to best advantage by stubbling in about March 15 with no preparation in advance.

A three-year rotation, including one year of Sudan grass and two years of sweet clover, represents a practical and productive pasture sequence for this locality, the two crops providing continuous pasturage from early spring until killing frost in the fall. A number of new and exceedingly promising strains of sweet clover have been tested and seed increased for trial elsewhere in the state. These strains are definitely superior to the common white or yellow varieties, but seed is not yet available for general distribution.

Successful and practical methods of reestablishing buffalo grass by transplanting pieces of the sod on cultivated land have been developed. Pieces of the sod 4 to 6 inches square and 2 to 4 inches deep, when spaced 3 to 4 feet apart, have spread to cover all intervening spaces in three years. An effective method of transplanting large areas, the cost of which has not yet been determined, is to slide thin pieces of the sod in sheet-iron chutes from a wagon to the surface of deeply cultivated land and press them into the ground with a heavily weighted surface packer. This eliminates the tedious labor involved in digging holes or plowing furrows and setting the sods by hand.

Much effort is being made to select and test many native and imported grasses for the purpose of securing a drought-resistant perennial pasture grass suitable for reseeding in western Kansas. *Agropyron pungens*, an importation from Siberia, is one of the few of these which has given any promise in this area. This grass usually dries up during drought periods in midsummer but renews growth in the fall. Seed of this variety is not yet available for distribution.

The indications are that alfalfa may be successfully reestablished on bottom land by replenishing the subsoil moisture so that the alfalfa roots may penetrate to the underground water table. This was accomplished by fallowing in advance and seeding in August at the rate of 12 to 15 pounds per acre on a well-prepared and firmly-packed seed bed. Spring seedings on similarly prepared land are handicapped by weed growth at the outset, which often exhausts the moisture below the depth of the seedling alfalfa roots, thus preventing them from coming in contact with underground water. Ladak, a new and drought-resistant strain of alfalfa, has been decidedly superior to any other variety in first-cutting yield and is therefore especially promising for upland production where normally only one crop is expected per year.

Results of date-of-planting tests proved conclusively that consistent and substantial increases in the seed and forage yields of corn and most varieties of sorghum may be obtained by planting later in the season than is commonly practiced in western Kansas. Generally, the later these crops are planted, so long as they mature before frost, the greater will be the resultant yields. No advantage may be expected from deferred seedings unless the land is well prepared and the weeds fully controlled in advance. All of the many varieties tested yielded more forage, and all but two produced more seed, when planted on or after June 1 than when planted on or before May 15. Conserving moisture by keeping the land clean until planting time and seeding late enough to avoid excessive hot winds during the flowering period promote the rapid growth of late plantings, which is considered responsible for the large increases obtained from delayed seeding.

Several new and quite promising early strains of forage sorghum having nonbitter seeds have been developed for possible use in the western and northwestern sections of the sorghum belt. These will require further testing before being recommended for general distribution.

Soil Erosion and Moisture Conservation Investigations.—Approximately 200 acres of the station are devoted to experimental work in soil erosion and moisture conservation investigations. This project was inaugurated in July, 1929, under a cooperative agreement with the Bureau of Chemistry and Soils and Agricultural Engineering. Observations are now being made on a number of separate subprojects in which soil and water losses are measured. These areas are cropped under the most approved tillage and cropping practices to determine the value of surface cover as affecting soil and water losses.

The effect of wind erosion and overgrazing of pastures is being given special attention by the Bureau of Chemistry and Soils. Results from pasturing experiments in 1933 show that 6 times as much water and 11 times as much soil are lost from heavily grazed buffalo-grass sod as from the moderately grazed area of the same kind of grass.

In the control plots, results for the four-year period 1930 to 1933 showed that more than 1½ times as much rainfall and 6 times as much soil were lost by surface runoff on fallow as by surface runoff on the same kind of land in wheat. Seventeen and one-half times the amount of water and 28 times the amount of soil were lost from wheat land as were lost on closely-clipped buffalo grass sod. It was also found that 3 times as much water and 3 times as much soil were lost from fallow land cultivated with the duck-foot weeder when run with the slope as was lost from the same land cultivated with the duck-foot weeder run on the contour. A comprehensive series of soil moisture samples was taken over the areas under investigation to secure information as to the rate and depth of moisture penetration under different conditions.

The Bureau of Agricultural Engineering constructed approximately 18 miles of terraces of varying widths, heights, and lengths, and with the rate per 100 feet and vertical spacing on slopes ranging from 0.2 to 9 per cent. Various tillage methods running on the contour and up and down the slopes were used to provide information on the amounts of silt and water losses. Automatic silt- and water-measuring devices were installed at the outlets of many terraced and unterraced areas. Measured water losses from terraced cultivated cropped areas were from 10 to 30 per cent of the annual rainfall. Losses of from 60 to 90 per cent frequently occur from a single rain of 1.5 to 2 inches, depending upon the intensity of the rain. The experiments indicate that cultivated land can best be protected from water losses and from losses of soil by wind and water erosion, by the combined use of crops, methods of tillage, and terracing.

The Bureau of Agricultural Engineering is also carrying on investigations looking toward the improvement of farm machinery for use on hillsides and terraced land.

State Forest Nursery Investigations.—The work in the forest nursery was a continuation of the work of previous years in the experimental planting of new untried varieties of shrubs, ornamentals, and forest and fruit trees; and in the propagation and distribution of hardy types adapted to western Kansas.

The number of ornamental trees and shrubs sold in the spring of 1933 was 10,113 units, going to 47 counties. In the spring of 1934, 10,458 units were distributed in 51 counties. In the forest tree seeding service 29,028 units were distributed in 56 counties in 1933. In 1934 58,222 forest tree seedlings were distributed in 64 counties. The distribution of forest tree seedlings is carried on in cooperation with the Forest Service of the United States Department of Agriculture.

The vineyard, demonstration cherry and plum orchard, and the testing blocks of trees and shrubs were maintained as in previous years. A total of 357 kinds of trees and shrubs were under observation in the testing blocks. Plant materials that proved valuable were added to the distribution list. A

small demonstration apple orchard of eight of the hardiest varieties was started on a bottom-land site.

In the summer of 1933 an effort was made to find a method of control of chlorosis in trees and shrubs. The most promising results were secured from spraying certain varieties with a weak solution of ferrous sulphate. Spraying the leaves apparently did not have a lasting effect. Injection of compounds in the trunks of trees did not prove effective. Additional attempts will be made to find a more permanent control of chlorosis by treating the soil with various compounds.

In the fall of 1932 an irrigation plant was installed in the nursery so that small trees, seedlings, and other nursery stock might receive irrigation in years of insufficient rainfall. Were it not for this irrigation plant, thousands of units would have been lost during the spring and summer of 1934 because of the serious drought.

Pure Seed Distribution.—Much more than the usual amount of pure seed was distributed during the past biennium. The distribution for the 1932-'33 season reached the record amount of 619,181 pounds, going into 92 counties of Kansas, 17 states, and three foreign countries, embracing 1,374 orders. Sorghum comprised 425,580 pounds of this seed; the remainder was Kanred and Tenmarq wheat, barley, and Hays Golden seed corn. This distribution of Tenmarq marked the first release of this important variety for Kansas.

In 1933-34 the total seed sales amounted to 573,482 pounds, which went, to 77 counties in Kansas, 22 states, and one foreign country, and embraced a total of 1,272 orders. Sorghum again comprised the bulk of the seed distributed. Much of this sorghum seed was carried over from the 1932 crop. The distribution by crop was as follows: Sorghum, 352,456 pounds; Kanred wheat, 113,120 pounds; Tenmarq wheat, 103,265 pounds; barley, 268 pounds; Hays Golden corn, 3,893 pounds; and Turkey wheat, 480 pounds.

The sale and distribution of pure certified seed is one of the most valuable functions performed by the station. The sorghum seed distributed, if planted at the normal rate of 5 pounds per acre, would have planted more than 85,000 acres in 1933, and 70,000 acres in 1934, thus providing foundation sources of supply for good reliable seed for a large percentage of the farming area of western Kansas. Wheatland, the new combine grain sorghum, and Atlas sorgo, the new forage sorghum, both of which have been released within the last few years, constituted the largest portion of the sorghum seed sold.

Dairy Cattle Pasture Investigations.—Grazing investigations with dairy cattle continued as in the past. From June 17 to September 25, 1932, 101 days, an average of 25.45 cows per day were grazed on 15 acres of Sudan grass. The cows produced 708.52 pounds of milk daily, or an average of 27.84 pounds of milk and 0.986 of a pound of butter fat per cow per day. In addition to supplying pasturage for the 25.5 cows for 101 days, the summer fallow Sudan pasture made 25.92 tons of Sudan hay, or an average of 1.73 tons per acre.

In 1933 an average of 25.9 cows pastured for 122 days, June 15 to October 14, on 13.1 acres of Sudan pasture. The cows produced 102,965 pounds of milk or an average dally production of 32.58 pounds per cow. Butterfat readings were not taken. The larger number of cows per acre and the greatly reduced fall precipitation considerably reduced the amount of hay cut from this land in 1933, as only 4.32 tons were obtained from the 13.1 acres.

Beef Cattle Feeding Investigations.—Beef cattle feeding investigations were concerned largely with the utilization of western Kansas feeds for the maintenance of beef cattle. The 1932-'33 and 1933-'34 feeding trials were planned to study (1) the possibility and practicability of substituting ground kafir, ground milo, ground barley, and ground wheat for cottonseed cake as a supplement to silage in winter rations for stock cattle; (2) the comparative value of Atlas sorgo silage and Pink kafir hay as the basis of winter rations for stock cattle when each is supplemented with ground wheat; and (3) the value of adding monocalcium phosphate to stock cattle rations that contain cottonseed cake as a protein supplement. In 1933-34 the following problems

were studied: (1) The comparative value of whole kafir fodder, ground kafir fodder, and kafir silage as basal winter rations for stock cattle; (2) the addition of phosphorus to improve silage as a basal winter ration for stock cattle; and (3) the amount of cottonseed cake which should be fed when silage is used as the basal winter ration for stock cattle.

The first comparison in 1933-34 was a repetition of an experiment conducted in 1932-'33 with the same cattle, the only difference being that the cattle were one year older. The cattle made satisfactory gains. The value of the grains, ranked in the same order as the previous winter, the order being, ground wheat, ground barley, ground kafir, and ground milo. When price levels justify, 2 pounds of ground wheat, barley, kafir, or milo may be substituted for 1 pound of cottonseed cake as a supplement to silage for winter rations for stock cattle. An acre of Atlas sorgo silage produced 68 per cent more gain than an acre of kafir hay. No benefit was derived from feeding monocalcium phosphate to stock calves.

Results of the 1933-'34 feeding season emphasized the greatly increased gains per acre secured from grinding or ensiling kafir roughage that is to be used as the basal winter ration for stock cattle. The decided increase in gains where cottonseed cake was added to silage as compared to the absence of a significant increase in gain where phosphorus in the form of monocalcium phosphate was added to silage, indicated that the protein, rather than the phosphorus content of the cottonseed cake, was responsible for its excellent supplemental value when fed with silage or other nonleguminous roughage. Everything considered, ½ pound of cottonseed cake per head daily for the entire wintering period proved to be the most satisfactory amount and method of adding cottonseed cake to silage when fed as a wintering ration to calves. These calves will be grazed together during the summer of 1934 and the effect of winter gains upon summer gains noted and reported later.

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 consists of dry-land agriculture and irrigation agriculture.

Dry Land Agriculture.—In cooperation with the Division of Dry Land Agriculture, Bureau of Plant Industry, United States Department, of Agriculture, the station has conducted experiments under dry-land conditions since 1907. The dry-land project utilizes approximately 35 acres of land, which is divided into one-tenth-acre plots. The experiments during the biennium included crop rotation and crop sequence of adapted varieties; tillage methods for conservation of soil moisture; seed-bed preparation methods; soil studies with green manures and barnyard manure; methods and frequency of fallow for winter wheat and grain sorghum; soil moisture studies on tillage practices for winter wheat production; and continuous cropping versus crop rotation for grain production.

Some of the later experiments were outlined with the thought of adapting them to the use of modern machinery in crop production. The one-way plow proved to be one of the most valuable of the newer implements introduced for seed-bed preparation for winter wheat. This is valuable for weed destruction on trashy ground and, when properly used, compares favorably with the plow or lister for the first operation in preparation of wheat stubble land for wheat. Continued use of the one-way, however, may prove hazardous from the standpoint of soil blowing in the drier sections of the wheat belt. In many instances the blowing of fields can be traced directly to this practice, as continued one-waying destroyed the straw mulch and pulverized the soil.

The lister is an implement which seems to be unsurpassed for seed-bed preparation for winter wheat. The one-way works well with the lister under

present-day methods of wheat harvest. The use of the combine harvester has increased the volunteer hazard, since more wheat is scattered over the field. A light one-waying immediately after harvest covers this seed, thus hastening germination and at the same time destroying existing weeds. Following this operation with the lister at the proper time destroys the volunteer wheat crop and weeds and puts the seedbed in better condition for wheat. This method does not leave the soil in such hazardous condition for soil blowing and is a cheap operation.

Control of weeds and volunteer wheat in the conservation of soil moisture and preparation of the soil to resist blowing are two prime factors favoring successful production of wheat in the drier sections of the Great Plains. Results show conclusively that thorough and timely operations are more important than the kind of implement used for seed-bed preparation.

Irrigation Agriculture.—A material reduction in funds for operation and maintenance due to reduced appropriations and lower income from sale of seed and livestock during the past two years has made it necessary to reduce the experimental work. Certain rotations and rate- and season-of-watering experiments under irrigation were discontinued and some of the variety testing of corn and sorghum was dropped temporarily to bring the work more nearly within range of the funds available.

New work in corn and sorghum variety testing was started. The new plan provides for combination date-of-planting and variety tests on fallow following winter wheat. Plantings were made on three dates and on a single seed-bed method instead of planting on three different seedbeds on a single date as was formerly done. In past years corn and sorghum were grown on continuously cropped sorghum land, on fallow following sorghum, and on winter-irrigated sorghum land. Winter-irrigated, continuously cropped land proved to be fully equal to alternate fallow for corn and sorghum production. Either method is capable of producing approximately double the yield that can normally be expected from continuously cropped nonirrigated sorghum land.

Medium-early varieties of corn, such as Cassel White, Freed White, Colby Bloody Butcher, and Hays Golden, averaged better in yield than the later-maturing sorts. Dwarf yellow milo is still the highest-yielding grain sorghum but it is losing in popularity because of the greater difficulty of harvesting as compared with the combine sorts. Wheatland and Beaver milos are the leading combine sorghums for this area, although several new varieties that are still in the experimental stage appear promising.

Thirteen varieties of alfalfa that have shown varying degrees of resistance to the bacterial wilt disease of alfalfa, which has caused the loss of stands on fields over all of Kansas and in some adjoining states during the past several years, were grown for further tests of their value on infested soil. Two of the varieties that appeared most promising have been planted in larger areas for seed increase purposes and it is expected that seed will soon be available for still larger plantings. This work is being done in cooperation with the United States Department of Agriculture.

A limited amount of work was done with red clover for seed production. Seven and one-third bushels per acre is the maximum yield thus far obtained.

The soil-borne disease that is so highly fatal to all milos and most milo crosses is one of the major problems. This station has conducted intensive experimental work in rotation and cultural methods, as well as in testing of varieties for resistance to the disease. It has been found that one year of fallow, followed by two years of winter wheat, and then an additional year of fallow is not sufficient to eliminate the disease-producing organisms from the soil. Apparently the disease cannot be controlled through ordinary rotation methods.

The best known method of control is through the use of varieties that are resistant to the disease. All varieties of kafir, feterita, and sweet sorghums are immune to the disease. A resistant strain of Dwarf Yellow milo has been developed at this station that can be satisfactorily used on infested soil. Several lines of resistant Wheatlands are being developed and seed of a resist-

ant Beaver milo will be available soon. The new and resistant types can be grown on infected soil as readily as can the naturally immune sorts that have been previously mentioned.

Crested Wheat grass and Slender Wheat grass were planted on two plots of unirrigated land in 1930 to obtain information as to their value for use in reseeding cultivated areas of dry land to a permanent grass. The years of 1930 to 1934 were severe for unirrigated grasses because of long periods of drought and high temperatures. Slender Wheat grass was the first to show injury and reduction in stand. The stand of Slender Wheat was reduced slightly before the end of the growing season in 1930, with further losses occurring in 1931 and 1932. The stand remaining in the spring of 1933 was so light that the weeds soon covered the ground and the loss of the stand became completed. Crested Wheat grass showed more ability to withstand drought than Slender Wheat grass. No loss of stand occurred in that variety in 1930 or 1931 and little in 1932. About 40 per cent loss of stand occurred in 1933. It made a vigorous early growth in the spring of 1934, but continued dry weather after February resulted in further damage.

Two small irrigated plots were set in the spring of 1932 to plants of Big Bluestem and Little Bluestem grasses for the purpose of determining whether seed of good germination could be produced under irrigation. Under natural conditions on unirrigated land seed of Bluestem is low in vitality, often showing a germination as low as 3 or 4 per cent. Seed produced on the irrigated plots in 1933 gave a germination of approximately 65 per cent. The yield also was considerably above the average, and the indications are that seed of these grasses can be satisfactorily grown under irrigation. Increased plots for further study were started in 1934.

Shelter belts for windbreak purposes around buildings, corrals, and stock yards were started. Western Yellow, Austrian, and Scotch pines, Red cedar, hackberry, and Chinese elm were used. A small area of irrigated land was set aside for use as a specimen planting block for shade and ornamental trees. Some thirty varieties of trees were set and the list includes some of the oaks, pines, spruces, firs, maples, and other trees that are valuable where rainfall is sufficient for their needs but which are generally considered unadapted to this region. Practically all varieties have done well.

One field of approximately 20 acres was terraced in the spring of 1934. The slope on this field ranged from 3 to 4 per cent to as much as 12 per cent. Graded terraces were used and it is hoped that through their use soil erosion can be controlled.

The dairy herd was reduced from 35 to 12 head during the biennium. All remaining animals are purebred Holsteins of high quality.

A carload of choice cross-bred western lambs was fed experimentally during the winter of 1933-34. The lambs were divided into five lots of 56 lambs each. One lamb died on the day of arrival at the station and two more were lost during the feeding period. The total death loss during the 90 days that the lambs were on feed was approximately two-thirds of 1 per cent. The experiment was planned to include three major comparisons: (1) Alfalfa hay versus cane stover as the main roughage portion of the fattening ration; (2) a basal ration of ground milo heads, cottonseed meal, ground cane stover, and ground limestone with and without beet molasses; and (3) hand feeding versus self-feeding. The following results were secured.

a. The lambs fed alfalfa made slightly larger but more expensive gains than those receiving ground cane stover as roughage.

b. Ground alfalfa and ground cane stover half and half also produced slightly larger but more expensive gains than ground cane stover fed as the only roughage.

c. Ground cane stover fed as the only roughage produced satisfactory gains on fattening lambs when ground limestone was fed with it and is a much cheaper roughage feed than alfalfa in most of western Kansas.

d. Beet molasses added to a ration of ground milo heads, cottonseed meal, ground cane stover, and ground limestone materially increased the gains and reduced the feed cost of gains on fattening lambs in this test.

e. Self-fed lambs receiving ground milo heads, cottonseed meal, ground cane stover, and ground limestone made slightly larger but slightly more expensive gains than hand-fed lambs receiving the same ration. This result, is in agreement with observed practices of feeders.

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, crop adaptation, and dairy herd improvement. Minor projects consist of variety tests of fruits, shrubs, and trees.

Dry Land Agriculture.—The experimental work in crop adaption and cultural methods in cooperation with the Division of Dry Land Agriculture, Bureau of Plant Industry, United States Department of Agriculture, was continued without change or addition during the biennium, two years in many respects among the most unfavorable for crop production since the work was started in 1914. Moisture conditions were so unfavorable for winter wheat and spring small grains in 1933 that these crops were a total failure under all methods of tillage. The long-time average at this station shows that winter wheat will yield about twice as much on fallow as on land cropped the preceding year. The 1934 season demonstrated the value of fallow as at least a partial insurance against crop failure. A fair crop was produced on fallow, whereas all other methods resulted in practically a total failure, due to the unprecedented drought during the spring months. The importance of timely preparation of the ground for fallow also was brought out. Delaying the plowing for fallow until the middle of June resulted in practically a failure, whereas fair yields were produced on the fallow plots where the plowing or listing was done by the middle of May.

Crop Adaptation.—The work in crop adaptation consisted of both variety testing and nursery studies. The following listed numbers of varieties were tested in triplicated plots: Winter wheat, 19; spring wheat, 6; oats, 5; barley, 10; grain sorghum, 19; forage sorghum, 8; corn, 12; popcorn, 5; sweet clover, 17; beans, 2; and flax, 1. These tests were a continuation of those previously reported, with some new varieties replacing those that had been found to be unadapted.

An increased number of grain sorghums was tested because of the interest of farmers in this section in securing a grain sorghum that can be harvested with wheat machinery. The combine types of sorghum, such as Wheatland, that are adapted to portions of the state farther east and south, are too late in maturing to be of much value in this section. Some progress has been made toward finding an early-maturing combine grain sorghum.

Because of a demand for more pasture crops, sweet clover was studied more intensively than before. The work has not progressed far enough to warrant a statement, as as its value as a pasture crop for this area.

Reduced appropriations made it necessary to reduce the size of the nurseries during the second year of the biennium. The nursery work with winter wheat was conducted in cooperation with the United States Department of Agriculture. It consisted of winter-hardiness and disease-resistance studies, as well as the study of the behavior of new strains. The barley nursery was made up largely of new strains secured through selection.

Date-of-planting tests with corn and winter wheat were conducted during both years of the biennium. These tests indicate that both of these crops are being planted too early in the season on many farms of this section.

A pasture project consisting of six 2-acre blocks was started in 1933. The plan of this project is to study the value of sweet clover and Sudan grass as pasture crops for this area, and if possible to perfect a pasture rotation that will provide feed throughout the growing season of the year.

Dairy Herd Improvement.—The dairy herd now consists of 18 grade and 14 registered Ayrshire cattle. During 1932 the average production of 13.71 cows was 9,092 pounds of milk, containing 343.22 pounds of butterfat, and in 1933 the average production of 13.46 cows was 9,553 pounds of milk and 367.5 pounds of butterfat. The grade cows in the herd-improvement project produced more, on an average, than did the purebreds. This is, no doubt, because more rigid selection has been practiced in the grade herd than in the purebred herd.

The outstanding grade cow in the herd is No. 29. She is a second-generation cow from the original stock purchased in 1916. She was sired by a registered Ayrshire bull and is out of a dam of unknown ancestry. During her last four lactation periods her average production was 13,341 pounds of milk, containing 514.15 pounds of butterfat. She is now milking in her ninth lactation period and will, no doubt, pass the 100,000-pound mark in milk production during this period.

TRIBUNE BRANCH EXPERIMENT STATION

The Tribune station, consisting of 110 acres, is located 16 miles from the Colorado line and approximately midway between the north and south boundaries of Kansas. It represents the high-plains area between the Smoky Hill and the Arkansas rivers.

This area has heretofore been used largely for grazing, but a considerable part is now used for crop production. In Greeley county during the four-year period 1929 to 1932, there was an average of 46,545 acres of wheat planted per year, compared to 6,813 acres for a like period 10 years earlier. The work of this station has consisted of securing information on the adaptation of varieties and methods of soil management for both cash and feed crops. The production of home vegetables, flowers, lawns, and trees has also been given attention.

While the annual precipitation for both 1932 and 1933 was approximately normal, the peculiar distribution, consisting of torrential rains and protracted dry spells, prevented the production of normal crops.

Winter wheat failed to produce a crop both years of the biennium. Kanred outyielded Turkey and Blackhull, as an average for the last nine years, but Oro, Early Blackhull, and Tenmarq have given high yields during the time they have been tested. Wheat seeded September 1 made a higher average yield over a six-year period than that seeded earlier or later. Results secured over an eight-year period showed that practically the same yield can be expected from wheat sown with the common as with the furrow drill. Spring wheat has given an average yield of about half as many bushels per acre as barley or Dwarf yellow milo and one-third as many as Kanota oats or Cassel White corn.

Kunota and Brunner oats have given the same yield over a 10-year period. Oats sown with the furrow drill outyielded those sown with the common drill approximately 3 bushels per acre.

Stavropol, Flynn, and Trebi barley have made nearly equal yields over a four-year period. Stavropol barley sown with the furrow drill made a 3-bushel higher yield than that sown with the common drill.

Greeley, a grain sorghum produced and distributed by this station, has outyielded any other grain sorghum 52 bushels per acre over a seven-year period. Leoti Red, a high-quality sweet sorghum, has averaged 321 tons of dry forage per acre over a 12-year period. This is a slightly lower yield than Kansas Orange but the quality is better because of the inability of Kansas Orange to mature. A source of pure Leoti Red seed has been established.

Sudan grass is the surest and best source of hay or annual pasture for this section. Sudan grass following Sumac sorgo produced 1,593 pounds of cured hay per acre or 100 cow days of pasture per acre in 1933. Sudan grass planted on summer-fallowed land averaged 3,437 pounds of cured hay per acre, compared to 1,718 pounds when planted following Sudan grass. The yield of

Sudan grass planted with the common drill was practically equal to that sown with the furrow drill.

Cassel, a white dent corn that, was developed at this station, made a higher average yield than any other variety. During the eight years 1926 to 1933, Hays Golden made the second highest yield. Manure, at the rate of 10 tons per acre, did not increase the average yield of corn, but when applied at the rate of 5 tons per acre it increased the yield 4.3 bushels per acre. The method of planting two rows of corn and shipping one slightly outyielded 42- or 84-inch rows.

Irish Cobbler potatoes made a higher yield than the Early Ohios in 1932, in 1933, and over a 13-year period.

Plans were made and work started on a study of varieties of pasture grasses and legumes and methods of resodding with buffalo grass.

STATION PUBLICATIONS

The results of investigations by the Agricultural Experiment Station are reported in four series of publications: Biennial reports, technical bulletins, bulletins, and circulars.

Biennial Reports.—At the close of each biennium a report is made giving a brief survey of all the work of the station. It consists primarily of progress reports on the various projects 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. Five 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. Twelve bulletins were printed during the biennium.

Circulars.—Brief popular reports of experimental results and popular discussions on various agricultural problems are published as circulars. Nine circulars were published during the biennium.

The following are the regular station publications issued during the biennium listed by series and showing the title, size of edition and the number of pages:

BIENNIAL REPORT				
No.	Title	Edition	Pages	Total pages
	Sixth Biennial Report of the Director.....	1,750	139	243,250
TECHNICAL BULLETINS				
33	The Quality of Wheat as Affected by Farm Storage.....	2,500	70	175,000
34	The Effect of Inadquate Rations on the Production and Hatchability of Eggs.....	2,500	64	160,000
32	Resistance of Varieties of Winter Wheat and Rye to Low Temperature in Relation to Winter Hardiness and Adaptation.....	1,750	66	115,500
36	The Relation of Phosphorus Deficiency to the Utilization of Feed in Dairy Cattle.....	2,000	54	108,000
37	The Influence of Some Factors on the Hatchability of the Hen's Egg.....	3,000	42	126,000
GENERAL BULLETINS				
257	The Poultry Enterprise on Kansas Farms.....	7,500	22	165,000
253	Factors Influencing the Time of Buying Feeder steers and of Selling Them as Choice Summer-fed Steers.....	10,000	35	350,000
259	The Organization and Operation of Cooperative Creameries in Kansas.....	7,500	43	322,500
260	Soil Fertility.....	30,000	60	1,800,000
261	Wheat as a Fattening Feed for Cattle.....	15,000	20	300,000
262	Tillage Practices for Southwestern Kansas.....	10,000	17	170,000
263	The Codling Moth in Southern Kansas, and Recommendations for Its Control.....	7,500	29	217,500
264	Lamb Feeding Experiments with Atlas Sorgo.....	10,000	33	330,000

No.	Title	Edition	Pages	Total pages
265	Sorghum Production in Kansas.....	25,000	47	1,175,000
266	Varieties of Sorghum in Kansas.....	15,000	51	765,000
267	Lawns in Kansas	25,000	32	800,000
268	The Comparative Nutritive Value of Sorghum Grain, Corn, and Wheat as Poultry Feeds	15,000	32	490,000

CIRCULARS

165	Information Regarding Recent Publications.....	15,000	4	60,000
166	Twenty Years of Experience with Dairy Sires.....	10,000	42	420,000
167	Judging Dairy Cattle	20,000	47	940,000
168	The Progeny Test in Poultry Breeding.....	10,000	24	240,000
169	Spraying Fruit Plants	15,000	34	510,000
170	Growing Combine Grain Sorghums.....	7,500	18	135,000
171	Information Regarding Recent Publications.....	14,000	3	42,000
172	Growing Tomatoes in Kansas.....	10,000	15	150,000
173	Flax Production in Kansas	40,000	16	640,000

SOME INFORMATION REGARDING EACH PUBLICATION ISSUED
BIENNIAL REPORT

SIXTH BIENNIAL REPORT OF THE DIRECTOR: For the Biennium July 1, 1930, to June 30, 1932.—This biennial report outlines the scope of the work of the Agricultural Experiment Station for the period. Brief summaries of the results on some projects are given and brief progress reports made on the others. The annual financial statements and a list of the publications of the station and of contributions to other scientific publications by members of the station staff are included. (By L. E. Call, Director, Agricultural Experiment Station. 139 pages; 3 figures; 14 tables.)

TECHNICAL BULLETINS

TECHNICAL BULLETIN 33: The Quality of Wheat as Affected by Farm Storage.—This bulletin reports studies made during eight years on factors that affect the quality of wheat under various conditions of storage. Data were obtained from observations on wheat stored on farms and in bins specially constructed at the Fort Hays Branch Experiment Station. These were supplemented by studies on small samples of wheat stored under laboratory conditions. The effects of storage conditions were measured by commercial grading, viability, milling, baking, and chemical tests.

The results show that type of bin is of less importance than the ventilation in preventing damage due to heating. Ventilators which admit air but do not cause air movement do more harm than good. Bins in which the air enters through the floor or sides of the bin and then passes through the wheat and out at the top of the bin are most effective. Forcing air into the wheat is more effective than drawing air from the wheat, and forcing air in at night is more effective in cooling than forcing air in during the day. (By C. O. Swanson, Department of Milling Industry, and F. C. Fenton, Department of Agricultural Engineering. 70 pages; 27 figures; 25 tables.)

TECHNICAL BULLETIN 34: The Effect of Inadequate Rations on the Production and Hatchability of Eggs.—This bulletin reports the results of a series of experiments conducted during the period from 1918 to 1929. Eighty-five lots of chickens were used to determine the effect of the lack of the various vitamins on the production and hatchability of eggs. The results show that rations deficient in vitamins A, B, or D will reduce egg production and hatchability, but that vitamin C is not essential in a poultry ration. (By L. F. Payne, Department of Poultry Husbandry, and J. S. Hughes, Department of Chemistry. 64 pages; 19 figures; 46 tables.)

TECHNICAL BULLETIN 35: Resistance of Varieties of Winter Wheat and Rye to Low Temperature in Relation to Winter Hardiness and Adaptation.—This bulletin presents a critical discussion of research work in winter hardiness of wheat and rye. The relative cold resistance of varieties in the hardened condition is reported in comparison with the survival in winter-hardiness nurseries located in the northern United States and Canada. Consideration is given various features of technic employed in the artificial

refrigeration of cereals. The possible use of artificial freezing in breeding hardy varieties and the relation of cold resistance to the adaptation of crop plants are discussed. (By S. C. Salmon, Department of Agronomy. 66 pages; 5 figures; 24 tables.)

TECHNICAL BULLETIN 36: The Relation of Phosphorus Deficiency to the Utilization of Feed in Dairy Cattle.—This bulletin reports a three-year investigation of the lowered efficiency of feed utilization in phosphorus-deficient dairy cattle. The effect of phosphorus deficiency on digestion and energy metabolism was studied in particular. Data also are presented on the balance of nitrogen, calcium, and phosphorus in deficient animals. The results show that a shortage of phosphorus in the ration is a limiting factor in the economical utilization of feeds. (By W. H. Riddell and J. B. Fitch, Department of Dairy Husbandry, and J. P. Hughes, Department of Chemistry. 54 pages; 7 figures; 16 tables.)

TECHNICAL BULLETIN 37: The Influence of Some Factors on the Hatchability of the Hen's Egg.—The material in this bulletin consists largely of a statistical treatment of hatchability data accumulated on the Kansas Agricultural Experiment Station poultry flock for the years 1921 to 1929. Hatchability of eggs in relation to age of breeding stock, egg production tendencies, consanguinity, egg size, period of holding eggs, age of sperm, and temperatures was considered. In addition to presenting new data on each of these phases an attempt has been made to summarize briefly the more critical previously published evidence on the subject. (By D. C. Warren. Department of Poultry Husbandry. 42 pages; 20 tables; 3 figures.)

BULLETINS

BULLETIN 257: The Poultry Enterprise on Kansas Farms.—This study of the poultry enterprise on Kansas farms shows the sections of high, medium and low poultry population and the variation in production from one part of the state to another. Factors influencing costs are discussed, based upon data secured from records of farm flocks. Size of flock, feed, labor, housing, receipts, and factors influencing the price of eggs and poultry are also discussed. (By Morris Evans, Department of Agricultural Economics. 22 pages; 5 figures; 12 tables.)

BULLETIN 258: Factors Influencing the Time of Buying Feeder Steers and of Selling Them as Choice Summer-fed Steers.—This bulletin gives the results of studies based upon the experiences of farmers in purchasing steers and in feeding them out as choice summer-fed steers. The factors affecting the trend of prices for feeder steers to be fed and of fat steers when sold vary from year to year. How these conditions can be forecast on the basis of economic conditions existing prior to and at the time of buying the feeders and prior to marketing these feeders as choice summer-fed steers is discussed. (By Homer J. Henney, Department of Agricultural Economics. 35 pages; 14 figures; 14 tables.)

BULLETIN 259: The Organization and Operation of Cooperative Creameries in Kansas.—Bulletin 259 discusses both the organization and the operation of cooperative creameries in Kansas. During the five-year period 1928 to 1932, nine cooperative local creameries were organized in Kansas. These have been operated with varying degrees of success. A few have made a profit, while others have sustained heavy losses. The fact that some have not been successful only emphasizes the importance of sound organization, careful management, and efficient operation. The purpose of the bulletin is to point out the causes of wide differences in the success of Kansas cooperative creameries and to make suggestions relative to proper methods of organizing and operating a cooperative creamery. (By George Montgomery, Department of Agricultural Economics, and W. J. Caulfield. Department of Dairy Husbandry. 43 pages; 7 figures; 7 tables.)

BULLETIN 260: Soil Fertility.—This bulletin is intended to be a hand-

book on soil fertility. A general soils map of Kansas shows the more important soils areas of the state. Each of these areas is described. The chemical and physical composition of the soil is discussed and the effect of cropping on the composition is shown. Soil losses due to erosion, leaching, and soil blowing are discussed, and methods of control are given. The practical use of rotations as well as the use of manures, green manures, commercial fertilizers, and lime are considered; also methods of building up run-down land and treating alkali soils. (By R. I. Throckmorton and F. L. Duley, Department of Agronomy. 59 pages; 21 figures; 19 tables.)

BULLETIN 261: Wheat as a Fattening Feed for Cattle.—This bulletin reports the results of an experiment in which ground wheat, ground shelled corn, and different mixtures of ground wheat and ground shelled corn were compared as fattening feeds for yearling steers. Results of previous investigations with wheat as a fattening feed for cattle are summarized. (By A. D. Weber and W. E. Connell, Department of Animal Husbandry. 20 pages; 11 tables.)

BULLETIN 262: Tillage Practices for Southwestern Kansas.—Five important tillage practices related to crop production for southwestern Kansas are discussed in this bulletin. The importance of fallow and its influence on crop yield are emphasized. The control of weeds, insects, and diseases and the distribution of labor as it affects the cost of production are explained. The best tillage practices suitable for crop production on the various soils of southwestern Kansas are discussed. (By R. L. von Trebra, agent, Office of Dry-land Agriculture, United States Department of Agriculture, and F. A. Wagner, superintendent, Garden City Branch Experiment Station. 17 pages; 2 figures; 5 tables.)

BULLETIN 263: The Codling Moth in Southern Kansas and Recommendations for Its Control.—This bulletin summarizes the results of six years investigations of the codling moth in the Arkansas river valley of southern Kansas. In this region the codling moth is the limiting factor in the production of apples of commercial quality. Descriptions and life-history data of this insect are given for the region. Methods of control, such as spraying, banding, packing-house sanitation, the use of natural enemies, cultivation, and pruning are given. Spray technic is discussed in detail. A spray schedule is given for the Arkansas valley in Kansas and orchard income as affected by spraying practices is discussed briefly. (By Paul M. Gilmer and Ralph L. Parker, Department of Entomology. 29 pages; 6 figures; 3 tables.)

BULLETIN 264: Lamb Feeding Experiments with Atlas Sorgo.—The general trend in new lamb-feeding developments in Kansas is discussed briefly in this bulletin. Most of the space, however, is devoted to the explanation of feeding methods and discussion of results of feeding experiments with fattening lambs. Comparisons are made of the results obtained from feeding varying proportions of grain and roughage in rations composed largely of ground atlas sorgo fodder. Tests are also reported showing the value of ground limestone fed with low calcium roughages to fattening lambs; comparing ground atlas fodder with and without alfalfa hay as the roughage portion of lamb-fattening rations; and comparing ground atlas fodder with atlas silage as the sole roughage in lamb-fattening rations. (By R. F. Cox and W. E. Connell, Department of Animal Husbandry. 33 pages; 12 figures; 14 tables.)

BULLETIN 265: Sorghum Production in Kansas.—This bulletin gives methods for growing and handling sorghum for grain, silage, fodder, and hay. Sections dealing with the production of pure sorghum seed, Sudan grass for pasture and hay, the effect of sorghum on the land, prussic acid poisoning, insects and diseases injurious to sorghum are included. (By H. H. Laude, and A. F. Swanson, Department of Agronomy. 47 pages; 18 figures; 11 tables.)

BULLETIN 266: Varieties of Sorghum in Kansas.—This bulletin gives the origin and description of the varieties of sorghum grown in Kansas and includes the historical development of the crop from the early introduction

of the original types. Variety experiments are reported for Manhattan; the branch experiment stations at Hays, Garden City, Tribune, and Colby; the experiment fields in southeastern Kansas; and cooperative experiments on farms in all parts of the state. Considering adaptation, quality, and yield, the best varieties for the several purposes for which the crop is grown are given for the different localities and conditions in the state. (By A. F. Swanson and H. H. Laude, Department of Agronomy. 50 pages; 17 figures; 5 tables.)

BULLETIN 267: Lawns in Kansas.—Essential practices in establishing and maintaining lawns in Kansas are discussed in this bulletin. The kinds of grass best suited for lawns under different conditions; preparation of the seed bed; time and method of planting; height of mowing; use of fertilizers; rejuvenation of old lawns; and control of weeds, insects, animal pests, and diseases are among the topics treated.

A portion of the bulletin is devoted to a discussion of the methods employed in establishing and maintaining bentgrass putting greens for golf courses. (By J. W. Zahnley, Department of Agronomy, and L. R. Quinlan, Department of Horticulture. 32 pages; 14 figures; 2 tables.)

BULLETIN 268: The Comparative Nutritive Value of Sorghum Grain, Corn, and Wheat as Poultry Feeds.—Data are presented in this publication which indicate the feeding value of these grains. Results of experiments over 3 seven-year periods are reported, concluding with grain sorghum rations for laying hens, growing chicks, and fattening poultry. Results show that good-quality kafir or milo can replace either white or yellow corn in a ration when adequately supplemented with other nutrients. (By Loyal F. Payne, Department of Poultry Husbandry. 32 pages; 4 figures; 21 tables.)

CIRCULARS

CIRCULAR 165: Information Regarding Recent Publications.—This circular gives brief statements regarding the content of the following popular publications of the station: Bulletins 251 to 256 and Circulars 158 to 164. (Office of Director. 4 pages.)

CIRCULAR 166: Twenty Years of Experience with Dairy Sires.—This circular presents a summary of the results obtained by herd sires used in the dairy herd at the Kansas Agricultural Experiment Station during the last twenty years. The picture and pedigree are shown for every sire used. Each sire's ability to transmit the factors for milk and butter-fat, production is measured by the production of his daughters as compared with their dams. The circular is divided into four sections, each dealing with one breed of dairy cattle. (By J. B. Fitch and H. J. Brooks, Department of Dairy Husbandry. 42 pages; 30 figures; 19 tables.)

CIRCULAR 167: Judging Dairy Cattle.—An effort is made in this circular to give specific reasons for certain requirements of dairy animals as stated in the different score cards. Pictures of the true-type animals for each dairy breed, as well as representative cows, heifers, and bulls, are given for the five dairy breeds. Breed score cards are included, as well as a new score card that considers type, production, and the pedigree of dairy animals. The circular is adapted for class-room work as well as a valuable source of information to breeders. (By J. B. Fitch and H. J. Brooks, Department of Dairy Husbandry. 46 pages; 21 figures.)

CIRCULAR 168: The Progeny Test in Poultry Breeding.—The value and application of the progeny test to problems of poultry breeding are discussed in this publication. Various methods of application of the progeny test are outlined. Special attention is given to the use of the test for production characteristics expressed early in the life of the pullet. Examples are given of the use of the progeny test for measuring the breeding qualities of individuals both for production and standard characteristics. (By D. C. Warren, Department of Poultry Husbandry. 24 pages; 9 figures.)

CIRCULAR 169: Spraying Fruit Plants.—Circular 169, a revision of Cir-

cular 145, treats of spraying the common fruit plants grown in Kansas. The more common fruit pests and the preparation and use of important fungicides and insecticides are discussed. Spray schedules for proper timing of spray applications are given. (By W. F. Pickett and G. A. Filinger, Department of Horticulture. 34 pages; 21 figures; 1 table.)

CIRCULAR 170: Growing Combine Grain Sorghums—This circular discusses grain sorghums which can be grown and harvested with wheat machinery. Methods of preparing the seed bed and of planting the crop are treated along with rate and date of seeding, cultivation, and harvesting. Illustrations showing many of the operations in the handling of this new crop are presented. (By L. C. Aicher, superintendent, Fort Hays Agricultural Experiment Station. 18 pages; 14 figures; 2 tables.)

CIRCULAR 171: Information Regarding Recent Publications—This circular gives brief statements regarding the content of the following popular publications of the station: Bulletins 257 to 264 and Circulars 166 to 170. (Office of Director. 3 pages.)

CIRCULAR 172: Growing Tomatoes in Kansas—The purpose of Circular 172 is to discuss and illustrate the best methods of producing the tomato in Kansas. Directions are presented for both home gardeners and commercial growers. Recommendations regarding varieties and methods of culture are based on 11 years of experimental work carried on in the station gardens and in coöperation with Kansas tomato growers. United States Bureau of Markets grades for tomatoes are given and important insect and disease pests of the tomato are discussed briefly. (By W. B. Balch, Department of Horticulture. 14 pages; 4 figures; 2 tables.)

CIRCULAR 173: Flax Production in Kansas—This circular gives the essentials for success in growing, harvesting, and marketing flax in eastern Kansas. Climatic requirements, the value of flax compared with other crops, the importance of legumes in the rotation with flax, and adapted varieties are also discussed. (By I. K. Landon, Department of Agronomy. 16 pages; 3 figures; 11 tables.)

PUBLICATIONS BY DEPARTMENTS

The following table contains a list, classified by departments, of the regular publications of the Agricultural Experiment Station, and also the technical articles contributed to scientific journals by members of the station staff:

LIST OF PUBLICATIONS BY DEPARTMENTS
Department of Agricultural Economics

Serial No.	Year of issue.	Title, author, and publication.
69	1932	The Poultry Enterprise on Kansas Farms. Morris Evans. Kan. Agr. Expt. Sta. Bul. 257:1-22.
74	1932	The Organization and Operation of Coöperative Creameries in Kansas. George Montgomery and W. J. Caulfield. Kan. Agr. Expt. Sta. Bul. 259:1-43.
78	1932	Factors Influencing the Time of Buying Feeder Steers and of Selling Them as Choice Summer-fed Steers. Homer J. Henney. Kan. Agr. Expt. Sta. Bul. 258:1-34.
79	1933	Tenure Significance of Innovations in Farm Organization. W. E. Grimes. Scope and Method of Research in Agricultural Land Tenure. Social Sci. Res. Council. Bul. 20:67-68.
80	1931	The Grain Marketing Program of the Federal Farm Board. W. E. Grimes. Amer. Inst. of Coop. Proc.
82	1933	Meeting Conditions Through the Reorganization of the Farm Business. J. A. Hodges. Kan. State Bd. of Agr. Quarterly Report, 52: 88-98.
83	1933	Programs of Adult Study of Taxation. Harold Howe. Jour. Farm Econ. 15:126-133.
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147	1933	An S-mY Induced Chromosomal Translocation in <i>Apotettix eurycephalus</i> Hancock (Grouse Locusts). R. K. Nabours and W. R. B. Robertson. <i>Nat. Acad. Sci. Proc.</i> 19:234-239.
148	1933	Resistance of Chickens to the Nematode, <i>Ascaridia lineata</i> . Affected by Dietary Supplements. J. E. Ackert and T. D. Beach. <i>Amer. Microscop. Soc. Trans.</i> 52:51-58.
150	1933	Two Pigs Within a Single Chorion with Some Considerations Concerning Monochorionic Twins. Mary T. Harman. <i>Kan. Acad. Sci. Trans.</i> 36:220-223.
152	The Operations of a Lethal Factor in <i>Apotettix eurycephalus</i> (Grouse Locust). R. K. Nabours and Laurel L. Kingsley. <i>Genetics</i> 19:322-328.
153	1933	Experiments with Light Upon Reproduction, Growth, and Diapause in Grouse Locusts (Acrididae, Tetriginæ). C. W. Sabrosky Iva Larson, and R. K. Nabours. <i>Kan. Acad. Sci. Trans.</i> 36:298-300.

<i>Serial No.</i>	<i>Year of issue.</i>	<i>Title, author, and publication.</i>
154	1933	The Sexual Cycle of the Thirteen-Lined Ground Squirrel in the Laboratory, G. E. Johnson, Mark A. Foster, and R. M. Coco. Kan. Acad. Sci. Trans. 36:250-269.
158	1934	The Effect of Daily Hetero-Pituitary Implants into Adult but Sexually Inactive Male Ground Squirrels, G. E. Johnson, E. L. Gann, M. A. Foster, and R. M. Coco. Endocrinology 18: 86-96.
...	1934	<i>Cysticercus fasciolaris</i> from the Red Squirrel, C. G. Dobrovlny and M. J. Harbaugh. Amer. Microscop. Soc. Trans. 53: 67.
Director's Office		
47	1932	Tillage Practices for Southwestern Kansas R. L. von Trebra and P. A. Wagner. Kan. Agr. Expt. Sta. Bul. 262:1-17.
48	1932	Sixth Biennial Report of the Director of the Kansas Agricultural Experiment Station. 1930-1932. L. E. Call, pp. 139.
49	1932	Information Regarding Recent Publications. Kan. Agr. Expt. Sta. Circ. 165:1-4.
50	1933	Information Regarding Recent Publications. Kan. Agr. Expt. Sta. Circ. 171:1-3.
51	1934	Regional Coordination of Agronomic Research from the Standpoint of the Station Director. L. E. Call. Jour. Amer. Soc. Agron. 26:81-88.
Fort Hays Branch Experiment Station		
11	1933	Growing Combine Grain Sorghums. L. C. Aicher. Kan. Agr. Expt. Sta. Circ. 170:1-18.
12	1933	Sorghum Production in Kansas. H. H. Laude and A. F. Swanson. Kan. Agr. Expt. Sta. Bul. 265:1-47.
13	1934	Varieties of Sorghum, in Kansas. A. F. Swanson and H. H. Laude. Kan. Agr. Expt. Sta. Bul. 266:1-50.

FINANCIAL STATEMENT, 1932-'33

(The Kansas Agricultural Experiment Station in account with federal and state appropriations.)

	<i>Federal appropriations</i>	<i>State appropriations and receipts</i>	<i>Totals</i>
Main station	\$90,000.00	(a) \$ 75,161.47	\$165,161.47
Branch stations, appropriations		(b) 104,194.41	104,194.41
Branch stations, sales		41,804.76	41,804.76
Totals	\$90,000.00	\$221,160.64	\$311,160.64
Personal services	\$81,503.64	\$ 89,993.71	\$171,497.35
Supplies and materials	3,684.58	16,205.72	19,890.30
Communication service	59.17	2,212.79	2,271.96
Travel expenses	1,058.26	4,629.87	5,688.13
Transportation of things	38.75	1,374.40	1,413.15
Publications	241.15	1,011.79	1,252.94
Heat, light, water, and power	1.25	6,404.62	6,405.87
Contingent expenses	249.25	1,331.22	1,580.47
Equipment	3,000.53	10,381.12	13,381.65
Buildings and land	163.42	19,926.16	20,089.58
Balance		21,776.65	21,776.65
Funds withheld from expenditure by Senate Order No. 28		45,912.59	45,912.59
Totals	\$90,000.00	\$221,160.64	\$311,160.64

(a) Includes a balance on hand June 30, 1932, of \$19,724.47.
(b) Includes a balance on hand June 30, 1932, of \$23,694.41.

FINANCIAL STATEMENT, 1933-'34

(The Kansas Agricultural Experiment Station in account with federal and state appropriations.)

	<i>Federal appropriations</i>	<i>State appropriations and receipts</i>	<i>Totals</i>
Main station	\$90,000.00	(a) \$ 59,296.74	\$149,296.74
Branch stations, appropriations		(b) 57,346.56	57,346.56
Branch stations, sales		55,506.61	55,506.61
Totals	\$90,000.00	\$172,149.91	\$262,149.91
Personal services	\$84,236.46	\$ 84,353.59	\$168,590.05
Supplies and materials	2,882.98	21,149.38	24,032.36
Communication service .....	.11	1,826.01	1,826.12
Travel expenses	601.83	4,325.09	4,926.92
Transportation of things	13.02	1,079.88	1,092.90
Publications	60.24	2,393.38	2,453.62
Heat, light, water, and power	7.63	5,079.31	5,086.94
Contingent expenses	24.53	548.48	573.01
Equipment	1,988.76	13,353.12	15,341.88
Buildings and land	184.44	5,508.42	5,692.86
Balance		32,533.25	32,533.25
Totals	\$90,000.00	\$172,149.91	\$262,149.91

(a) Includes a balance on hand June 30, 1933, of \$9,681.20.
(b) Includes a balance on hand June 30, 1933, of \$6,296.56.