

AGRICULTURAL EXPERIMENT STATION

KANSAS STATE AGRICULTURAL COLLEGE
MANHATTAN, KANSAS

DIRECTOR'S REPORT

1922-1924



FOR THE BIENNIUM
July 1, 1922, to June 30, 1924

PRINTED BY KANSAS STATE PRINTING PLANT
B. P. WALKER, STATE PRINTER
TOPEKA 1924
10-3933

AGRICULTURAL EXPERIMENT STATION

KANSAS STATE AGRICULTURAL COLLEGE
MANHATTAN, KANSAS

DIRECTOR'S REPORT

1922-1924



KANSAS AGRICULTURAL EXPERIMENT STATION

BOARD OF ADMINISTRATION

GOVERNOR JONATHAN M. DAVIS, *Chairman*Bronson, Bourbon County
 A. B. CARNEYManhattan, Riley County
 ROGER WILLIAMSLawrence, Douglas County
 W. P. LAMBERTSONFairview, Brown County
 T. J. O'NEIL, *Business Manager*Osage City, Osage County

STATION STAFF

W. M. JARDINE, *President*.

F. D. FARRELL, *Director*.

AGRICULTURAL ECONOMICS.

W. E. GRIMES, *in Charge*.
 ERIC ENGLUND, *Land Economics*.
 R. M. GREEN, *Marketing*.
 R. D. NICHOLS, *Cost of Production*.
 J. H. MOYER, *Cost of Production*.
 HOMER J. HENNEY, *Cost of Production*.
 MORRIS EVANS, *Farm Organization*.

AGRONOMY.

L. E. CALL, *in Charge*.
 S. C. SALMON, *Crops*.
 R. I. THROCKMORTON, *Soils*.
 JOHN H. PARKER, *Plant Breeding*.
 H. H. LAUDE, *Cooperative Experiments*.
 M. C. SEWELL, *Soils*.
 J. W. ZAHNLEY, *Crops*.
 R. J. SILKETT, *Cooperative Experiments*.

ANIMAL HUSBANDRY.

C. W. McCAMPBELL, *in Charge*.
 H. L. IBSEN, *Genetics*.
 D. L. MACKINTOSH, *Horses*.
 A. D. WEBER, *Hogs*.
 H. E. REED, *Sheep*.
 B. M. ANDERSON, *Cattle*.
 H. W. MARSTON, *Animal Nutrition*.
 C. E. AUBEL, *Pasturing Experiments*.

BACTERIOLOGY.

L. D. BUSHNELL, *in Charge*.
 A. C. FAY, *Dairy Bacteriology*.
 P. L. GAINES, *Soil Bacteriology*.
 W. R. HINSHAW, *Poultry Disease Investigations*.

BOTANY.

L. E. MELCHERS, *Plant Pathologist, in Charge*.
 E. C. MILLER, *Plant Physiology*.
 R. P. WHITE, *Plant Pathology*.

ENTOMOLOGY.

G. A. DEAN, *in Charge*.
 J. W. MCCOLLOCH, *Staple Crop Insects*.
 J. H. MERRILL, *Apiculture, Fruit Insects*.
 R. C. SMITH, *Staple Crop Insects*.
 W. P. HAYES, *Staple Crop Insects*.

BRANCH EXPERIMENT STATIONS

FORT HAYS.

L. C. AICHER, *Superintendent*.
 *A. L. HALLSTED, *Dry-land Agriculture*.
 *R. E. GETTY, *Forage Crops*.
 *A. F. SWANSON, *Cereal Crops*.
 D. D. WILSON, *Nurseryman*.

TRIBUNE.

T. B. STINSON, *Superintendent*.

HORTICULTURE.

ALBERT DICKNS, *in Charge*.
 R. J. BARNETT, *Pomology*.
 W. F. PICKETT, *Orchard Investigations*.

CHEMISTRY.

H. H. KING, *Chemist, in Charge*.
 J. T. WILLARD, *Consulting Chemist*.
 J. S. HUGHES, *Animal Nutrition*.
 E. L. TAGUE, *Protein Investigations*.
 W. L. LATSHAW, *in Charge Analytical Laboratory*.
 R. W. TITUS, *Feedingstuffs Analysis*.
 J. F. MERRILL, *Fertilizer Analysis*.

DAIRY HUSBANDRY.

J. B. FITCH, *in Charge*.
 H. W. CAVE, *Dairy Production*.
 N. E. OLSON, *Dairy Manufactures*.
 P. C. MCGILLIARD, *in Charge of Official Tests*.
 H. M. JONES, *State Dairy Commissioner*.

MILLING INDUSTRY.

C. O. SWANSON, *in Charge*.
 EARL B. WORKING, *Wheat and Flour Investigations*.
 C. W. OAKES, *Milling*.

POULTRY HUSBANDRY.

L. F. PAYNE, *in Charge*.
 D. C. WARREN, *Genetics*.

VETERINARY MEDICINE.

R. R. DYKSTRA, *in Charge*.
 C. W. HOBBS, *in Charge Vaccine Laboratories*.
 H. F. LIENHARDT, *Pathology*.
 J. P. SCOTT, *Blackleg Investigations*.
 N. D. HARWOOD, *Vaccine Production*.
 C. H. KITSELMAN, *Abortion Disease Investigations*.

ZOOLOGY.

R. K. NABOURS, *in Charge*.
 J. E. ACKERT, *Parasitology*.
 CAROLINE PERKINS, *Genetics*.
 F. L. HISAW, *Injurious Mammals*.

GARDEN CITY.

F. A. WAGNER, *Superintendent*.
 *E. H. COLES, *Dry-land Agriculture*.

COLBY.

*B. F. BARNES, *Superintendent*.

* In cooperation with United States Department of Agriculture.

LETTER OF TRANSMITTAL

OFFICE OF THE DIRECTOR,
June 30, 1924.

To His Excellency, Jonathan M. Davis, Governor of Kansas:

Pursuant to the act of congress approved March 2, 1887, establishing agricultural experiment stations, I transmit herewith the report of the Agricultural Experiment Station of Kansas State Agricultural College for the biennium ending June 30, 1924. It includes a brief account of the work completed or in progress, a list of the station publications and of the scientific contributions of the station staff published during the biennium under review, and statements of receipts and expenditures for the two fiscal years.

F. D. FARRELL, *Director.*

(3)

TABLE OF CONTENTS

	PAGE
LETTER OF TRANSMITTAL	3
INTRODUCTION	5
COOPERATION WITH THE UNITED STATES DEPARTMENT OF AGRICULTURE. . .	5
STATION RELIEVED OF POLICE WORK	6
INTEREST IN THE COTTON INDUSTRY	6
ESTABLISHMENT OF OUTLYING EXPERIMENTAL FIELDS	7
PERSONNEL	8
SCOPE OF THE STATION WORK, JULY 1, 1922, To JUNE 30, 1924	12
STUDIES IN THE ECONOMICS OF AGRICULTURE	16
CONSERVATION OF THE SOIL	24
INVESTIGATIONS IN THE PLANT INDUSTRIES	30
DISEASES OF PLANTS	69
INJURIOUS INSECTS AND OTHER PESTS	76
INVESTIGATIONS IN THE ANIMAL INDUSTRIES	89
DISEASES OF FARM ANIMALS	120
BRANCH EXPERIMENT STATIONS	128
Fort Hays Branch Experiment Station	129
Garden City Branch Experiment Station	136
Colby Branch Experiment Station	137
Tribune Branch Experiment Station	138
PUBLICATIONS	138
Stations Publications	138
Publications by Departments	139
Publication Difficulties	144
FINANCIAL STATEMENT, 1922-'23	145
FINANCIAL STATEMENT, 1923-'24	145

DIRECTOR'S REPORT¹

INTRODUCTION

During the biennium ending June 30, 1924, the principal work of the Kansas Agricultural Experiment Station and its four branches comprised about 150 projects of investigation. These investigations included certain of the economic features of agriculture, studies in soil conservation, problems directly connected with the maintenance of plant industries and animal industries of the state, and a number of miscellaneous agricultural problems. The present report makes brief mention of a few outstanding developments affecting the work of the experiment station during the biennium and gives brief summaries of the more important results secured in the conduct of research and experimental work.

COOPERATION WITH THE UNITED STATES DEPARTMENT OF AGRICULTURE

One of the most effective features of the work of the Kansas Agricultural Experiment Station is its extensive cooperation with the United States Department of Agriculture. During the past two years the quantity of cooperative work has increased and cooperative relationships have been entirely cordial. During the period covered by this report the cooperative work included research and experimental work in cereal production, cereal breeding, and the control of cereal diseases, in cooperation with the Office of Cereal Investigations of the Bureau of Plant Industry; an experiment on sex type as related to functional development and performance in Short-horn cows in cooperation with the Division of Animal Husbandry of the Bureau of Animal Industry; investigations in dry-land agriculture in cooperation with the Office of Dry Land Agriculture of the Bureau of Plant Industry; forage-crop experiments in cooperation with the Office of Forage Crop Investigations; and investigations in farm organization, cost of production, land utilization, wheat marketing, and hay grading, in cooperation with the Bureau of Agricultural Economics.

1. Contribution No. 30 from the director's office.

STATION RELIEVED OF POLICE WORK

During the past biennium the Agricultural Experiment Station has been relieved of practically all police work, The legislature of 1923 enacted laws transferring to the State Board of Agriculture the administration of the feeding-stuffs, live-stock remedy and fertilizer laws. An arrangement has been made, however, for the station to continue to do the technical analytical work which the laws require and to be paid for that work by the State Board of Agriculture. On March 20, 1924, the Board of Administration relieved the Agricultural Experiment Station of responsibility for the supervision of the work of the state dairy commissioner, a responsibility which the station had carried since July, 1910, as a result of action taken at that time by the board of trustees. The station in the future will have only an advisory relation to the dairy inspection work. These fortunate changes are in harmony with recommendations made several years ago by the Association of Land-grant Colleges and with proposals frequently made by the Agricultural Experiment Station during the past five years. They relieve the director and several members of the staff of duties which are in no sense scientific or educational, and thus provide increased opportunity for devotion to scientific and educational work.

INTEREST IN THE COTTON INDUSTRY

On June 15, 1924, the average farm price of wheat in the United States was about 10 per cent above the average June 15 price for the five prewar years, 1910 to 1914. On the same date the farm price of cotton was 120 per cent above the June 15 average of the five prewar years. This comparison represents approximately the disparity in the prices of wheat and cotton during the past two or three years. The disparity in price has had a marked effect on the thinking of farmers in those districts where the wheat belt and the cotton belt overlap. It has increased interest in cotton production and tended to depress interest in the wheat industry in those districts. This has encouraged a northern expansion of the cotton belt.

Ordinarily American cotton has been produced in districts where the growing season is as long as 200 days or longer. The northern limit of a 200-day growing season does not quite reach southern Kansas. Nevertheless a few attempts are being made to grow cotton on a small scale in two or three of the southern counties, notably Labette and Montgomery. In 1923 a few small commercial plant-

ings were tried in these two counties and one rather extensive experimental planting was made in Labette county by the Agricultural Experiment Station. The results gave considerable promise, but the season probably was unusually favorable, especially with reference to the date of the first killing frost in the autumn. A few commercial plantings were made in these counties in 1924. In the spring of that year the Agricultural Experiment Station began a series of varietal tests and some cultural tests. These experimental plantings were made in Cherokee, Labette and Montgomery counties chiefly, but small varietal trials were started in Wilson, Sumner, Shawnee, Kingman, Reno, Morton and Finney counties. A total of thirty-four varieties are on trial in the three counties first named, and small numbers are being tested in the remaining counties. One of the most important objectives of these experiments is to find whether any of the standard American varieties will be sufficiently early in maturity to produce profitable yields under average southern Kansas conditions.

If the forces which have produced the recent high prices for cotton continue to operate, it may become desirable for the Agricultural Experiment Station to launch a comprehensive program of research and plant breeding for the purpose of developing cultural methods and strains of cotton which can be relied upon to produce profitable crops year after year. One of the principal factors in the situation is the Mexican cotton-boll weevil. Whether this insect will be brought under control in the near future is by no means certain. Meantime the Agricultural Experiment Station purposes to exert every possible effort to secure facts which will be helpful in dealing with the cotton situation in the state.

ESTABLISHMENT OF OUTLYING EXPERIMENTAL FIELDS

At the request of the Agricultural Experiment Station, the legislature of 1923 made an appropriation of \$6,000 per annum to support outlying experimental fields in southeastern Kansas. The soils of that section of the state vary widely in character and the problems of soil productivity have become dominant in agricultural production. Soil conditions at the main station and at the four western Kansas branch stations are not representative of those in the southeastern corner of the state, and climatic factors in the latter section also are peculiar. It had been found that the soil and crop experiments conducted in cooperation with farmers, while very useful in certain respects, were not adequate for the conduct of fundamental

research work with soils and crops. The establishment of definite soil and crop experimental fields, to be controlled and financed entirely by the station, was therefore suggested. Accordingly, since the appropriation became available on July 1, 1923, five outlying fields have been established. The locations of these fields are shown in figure 1. The fields have been located on the five principal soil types of southeastern Kansas, as is indicated further along in this report, in the chapter on "Conservation of the Soil."

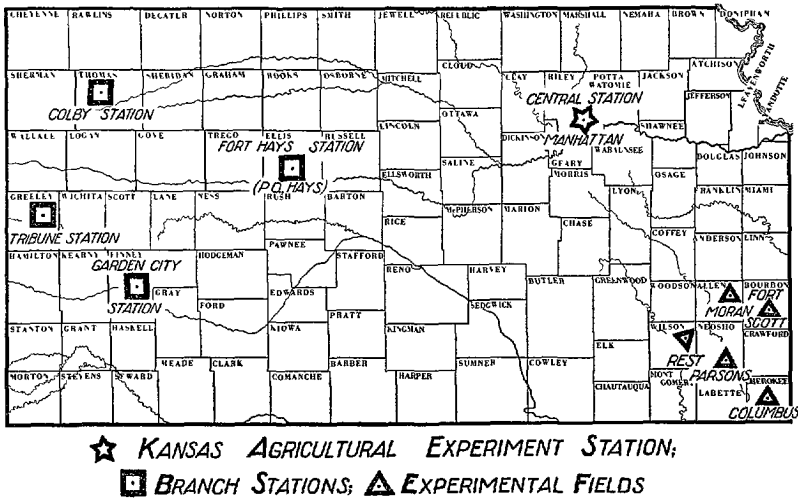


FIG. 1.—Map showing the location of Kansas Agricultural Experiment Station, the four branch stations, and the five outlying experimental fields.

PERSONNEL

Appointments. The average number of persons regularly employed on the scientific staff during the biennium was 80. A total of 14 new appointments were made, the number of appointments equaling 17.5 per cent of the average personnel. The appointments made during the biennium are listed below:

- F. E. Emery, assistant in zoology.
- Charles R. Enlow, assistant in cooperative experiments.
- Arthur H. Helder, in charge of landscape gardening.
- W. R. Hinshaw, assistant in poultry disease investigations.
- Pearl Insley, research assistant in poultry husbandry.
- George E. Johnson, in charge of injurious mammal investigations.
- I. K. Landon, in charge of southeastern Kansas experimental fields.
- H. E. Reed, in charge of sheep investigations.
- H. I. Richards, assistant in marketing.

R. J. Silkett, assistant in coöperative experiments.

Thomas B. Stinson, superintendent of Tribune Branch Experiment Station.

R. W. Titus, assistant chemist.

Don. C. Warren, in charge of poultry genetics

Earl B. Working, assistant in wheat and flour investigations.

Resignations. A total of 15 members of the staff resigned during the biennium, the number of resignations being 18.75 per cent of the average personnel. The persons who resigned from the staff during the two years under review are named below:

F. R. Beaudette, assistant in poultry disease investigations.

R. B. Becker, in charge of official tests of dairy cows.

N. E. Dale, assistant in cooperative experiments.

L. A. Fitz, in charge of milling industry.

R. L. Hensel, in charge of pasture investigations.

C. A. Herrick, research assistant in zoology.

W. A. Lippincott, in charge of poultry husbandry.

R. N. Loomis, assistant in feedingstuffs analysis.

G. E. Lowrey, superintendent of Tribune Branch Experiment Station.

Paul L. Mann, assistant in wheat and flour investigations.

A. M. Paterson, in charge of sheep investigations.

Luella Schaumberg, research assistant in poultry husbandry.

R. J. Silkett, assistant in cooperative experiments.

W. S. Wiedorn, in charge of landscape gardening.

H. B. Winchester, assistant in animal nutrition.

Advanced Study by Members of Staff. During the past two years a special effort has been made to encourage members of the staff to improve their scientific and professional status by pursuing graduate study either at Kansas State Agricultural College or at other institutions. A total of 43 members of the staff, or 54 per cent, took some graduate work during at least one year of the biennium, while 15 of the members, or 19 per cent, pursued advanced study during both of the two years. Four of the members who did graduate work received doctors' degrees at other institutions. The beneficial effects produced by the practice of pursuing advanced study have been noteworthy. The practice is strengthening the staff and helping to improve the quality of the research work of the station.

Distribution of Time. There is so much demand for the services of members of the scientific staff in addition to their regular station work that undue distraction must constantly be guarded against. In general, the station follows the principle that each staff member should do some teaching and a small quantity of extension work each year so as to avoid the development of an undue feeling of

detachment from the public by which the station is supported. The extent to which a member of the staff engages in teaching or extension activities depends chiefly upon his own temperament and abilities and upon the demand for his services, the latter especially in extension work. While the research work of the station probably suffers somewhat from delays, and occasionally even from neglect, because of the demand for service in nonresearch activities, it is believed that, on the whole, distractions are kept within reasonable bounds. During the fiscal year ending June 30, 1924, the working time of the 80 members of the station staff was distributed, on the average, as follows:

Strictly station work	53 per cent.
Teaching	43 per cent.
Extension work	4 per cent.
Total	100 per cent.

Salaries. On June 30, 1924, the salaries of members of the scientific staff ranged from \$1,500 per annum, in two instances, to \$5,000 per annum, in three. On that date 12 members of the staff were receiving salaries in excess of \$4,000; 24 were receiving from \$3,000 to \$4,000; 17 were receiving from \$2,500 to \$3,000; and the remainder less than \$2,500 each. The average salary on June 30, 1924, was \$2,943 per annum. A few salary increases were authorized to become effective on July 1, 1924. It is believed that salaries at this station are somewhat below those at most other institutions of the same class, and several moderate increases are clearly desirable.

SCOPE OF THE STATION WORK, JULY 1, 1922, TO JUNE 30, 1924

A list of the principal active projects carried on during the biennium ending June 30, 1924, is given below, together with a statement of the source of financial support in each instance and references to the discussions included in the present report:

NAME.	Project No.	Departments	Funds.	Discussed on page
Studies of Farm Organization and Cost of Production.....	95	Agricultural Economics.....	State.....	16
Investigations in Land Tenure and Other Land Problems. . . .	132	Agricultural Economics.....	State.....	17
The Marketing of Kansas Wheat.....	143	Agricultural Economics.....	State.....	19
The Economics of the Poultry Industry on Kansas Farms....	144	Agricultural Economics.....	State.....	24
Investigations in Soil Fertility.....	17	Agronomy.....	Hatch and State....	25
Tillage Investigations.....	18	Agronomy.....	Hatch and State....	26
The Relation of the Absolute Reaction of the Soil Solution Upon the Quantity of Nitrogen Fixed by Azotobacter. . . .	128	Bacteriology.....	Adams.....	28
Soil and Crop Experimental Fields.....	. . . .	Agronomy.....	State.....	29
Work on the Flora of Kansas.....	137	Botany.....	State.....	30
Drought Resistance in Crop Plants.....	74	Botany.....	State.....	30
Small Grain and Sorghum Improvement.....	67	Agronomy.....	Hatch.....	32
A genetic Study of Aberrant and False Wild Types in Kanota Oats.....	146	Agronomy.....	Adams.....	38
Sorghum Varietal Tests.....	129	Agronomy.....	Hatch.....	41
Small Grain Tests.....	129	Agronomy.....	Hatch.....	41
Corn Production and Improvement.....	129	Agronomy.....	Hatch.....	43
Coöperative Experiments with Soils and Crops.....	. . . .	Agronomy.....	State.....	44
Alfalfa Production Experiments.....	129	Agronomy.....	Hatch.....	50
The Production of Soybeans and Cowpeas.....	129	Agronomy.....	Hatch.....	51
Chemical Factors Influencing Quality of Wheat and Flour....	60A	Milling Industry.....	State.....	51
Cropping Systems and Fertilizer Treatments as Influencing the Quality of Wheat.....	60B	Milling Industry.....	State.....	52

Seed-bed Preparation and Tillage Methods as Factors Influencing the Quality of Wheat	60C	Milling Industry.....	State.....	55
Variety as a Factor Influencing the Quality of Wheat.....	60D	Milling Industry.....	State.....	56
Milling Work on Wheat Shrinkage, Loss, and Damage in Farm Storage.....	143	Milling Industry	State	57
Flour Chemistry Investigations.....	60	Chemistry and Milling Industry.....	State	58
O rchard Investigations.....	25	Horticulture.....	State.....	58
Small Fruit Investigations.....	26	Horticulture.....	State.....	66
Experiments with Vegetables.....	27	Horticulture.....	State.....	67
Tree Investigations.....	82	Horticulture.....	State.....	68
Cereal and Forage Crop Disease Investigations.....	76	Botany.....	State.....	69
Fruit and Vegetable Disease Investigations.....	130	Botany.....	State.....	73
Climate and Injurious Insect Investigations.....	6	Entomology.....	Hatch.....	76
Hessian Fly and Other Wheat Insects.....	8	Entomology.....	Hatch.....	77
Corn Earworm and Other Insects Injurious to Corn.....	9	Entomology.....	Hatch.....	79
The Control of Fruit Insects.....	13	Entomology.....	Hatch.....	81
Control of Insects Attacking the Sorghums.....	92	Entomology.....	State.....	82
Insects Attacking the Roots of Staple Crops.....	100	Entomology.....	State.....	83
Insects Injurious to Alfalfa.....	115	Entomology.....	State.....	84
Shade Tree Insects.....	116	Entomology.....	State.....	86
Investigations for the Control of Injurious Rodents.....	84	Zoölogy.....	State.....	87
Parasitological Investigations.....	79	Zoology.....	Adams.....	88
Embryology of Parasitic Worms.....	119	Zoölogy.....	State.....	88
The Nutritive Requirements of Swine.....	38	Chemistry and Animal Husbandry.....	State and Adams.....	89
The Efficiency of Varying Amounts of Cottonseed Meal When Fed as a Supplement to a Full Feed of Corn, Alfalfa and Silage, and Incidentally the Relative Value of Cottonseed Meal and Linseed Oil Meal.....	78	Animal Husbandry.....	State.....	91
Full Feeding of Calves on Grass versus Full Feeding in a Dry Lot During Summer Months After Having Been Carried Through the Winter on Virtually a Maintenance Ration, the Basis of Which Was Silage.....	78	Animal Husbandry.....	State.....	92

SCOPE OF THE STATION WORK—CONCLUDED.

NAME.	Project No.	Departments.	Funds.	Discussed on page
Sex Type as Related to Functional Development and Performance in Shorthorn Cattle.	97	Animal Husbandry.	State.	92
Hogging Down Corn.	110	Animal Husbandry.	State.	93
Mineral Supplements in Swine Feeding.	110	Animal Husbandry.	State.	94
Feeding Western Lambs.	111	Animal Husbandry.	State.	94
A Study of Pasture Values and Pasture Methods for Horses, Cattle, Sheep and Swine.	142	Animal Husbandry.	State.	95
Farm Flock Management.	142	Animal Husbandry.	State.	95
The Influence of Exercise on Reproduction in Hogs.	142	Animal Husbandry.	State.	96
Growing Stocker Pigs.	142	Animal Husbandry.	State.	97
Factors Influencing Mineral Metabolism of Dairy Cows.	147	Dairy Husbandry, Chemistry and Veterinary Medicine.	State.	97
Sunlight in Relation to the Growth of Calves.	148	Dairy Husbandry and Chemistry.	State.	98
Dairy Cattle Feeding Investigations.	34	Dairy Husbandry.	State.	99
The Palatability of Ground Wheat in Grain Mixtures for Dairy Cows.	100	Dairy Husbandry.	State.	100
Normal Growth of Dairy Cattle.	101	Dairy Husbandry.	State.	101
Ice Cream Investigations.	124	Dairy Husbandry.	State.	101
Bacteriological Study of Ice Cream.	124	Bacteriology.	State.	103
Improving Mongrel Flocks Through Selected Standardbred Cockerels.	77—1	Poultry Husbandry.	State.	103
The Feeding Value of Milo, Cane, Kafir and Mixed Feed for Pullets.	77—2	Poultry Husbandry.	State.	104
The Inheritance of Eye Color in Chickens.	77—3	Poultry Husbandry.	State.	106
A Study of the Inheritance of the Characteristics in Which the Single Comb White Leghorns and the Jersey Black Giants Differ.	77—4	Poultry Husbandry.	State.	106



The Inheritance of Egg Production in the Single Comb White Leghorn.....	77—5	Poultry Husbandry.....	State.....	107
Poultry Flock Management.....	77—6	Poultry Husbandry.....	State.....	107
Incubation Studies.....	77—7	Poultry Husbandry.....	State.....	108
The Effect of Inadequate Rations on the Production and Hatchability of Eggs.....	127	Poultry Husbandry and Chemistry.....	Adams.....	112
Relation of Vitamin Content of Feed and of the Use of Light to Immunity to Roup and the Production and Hatchability of Eggs.....	131	Chemistry, Bacteriology, and Poultry Husbandry.....	State.....	113
Studies in Animal Reproduction and Inheritance.....	93	Animal Husbandry.....	State.....	116
Studies of Inheritance in the Grouse Locusts (<i>Tettigidae</i>).....	72	Zoölogy.....	Adams.....	118
Influence of Climate on Inheritance and Parthenogenesis in the Grouse Locusts (<i>Tettigidae</i>).....	104	Zoölogy.....	Adams.....	119
Bee Investigations.....	126	Entomology.....	State.....	119
Miscellaneous Animal Disease Investigations.....	102	Veterinary Medicine.....	State.....	120
Abortion Disease Investigations.....	135	Veterinary Medicine.....	State.....	120
Blackleg Investigations.....	...	Veterinary Medicine.....	State.....	121
Poultry Disease Investigations.....	85	Bacteriology.....	State.....	122
A Study of the Relation of Adequacy of Diet to Disease.....	131	Bacteriology and Chemistry..	State.....	127
Fort Hays Branch Experiment Station:				
Dry Land Agriculture.....	.....	.....	State and Federal....	129
Cereal Investigations.....	.....	.....	State and Federal....	131
Forage Crop Investigations.....	.....	.....	State and Federal....	132
Bindweed Eradication.....	.....	.....	State and Federal....	133
Dairy Cattle Feeding Investigations.....	.....	.....	State.....	134
Beef Cattle Feeding Investigations.....	.....	.....	State.....	134
The State Forest Nursery.....	.....	.....	State.....	135
Vegetable Garden.....	.....	.....	State.....	135
Garden City Branch Experiment Station.....	.....	.....	State and Federal....	136
Colby Branch Experiment Station.....	.....	.....	State and Federal....	137
Tribune Branch Experiment Station.....	.....	.....	State.....	138

STUDIES IN THE ECONOMICS OF AGRICULTURE

Since its organization in 1918, the Department of Agricultural Economics has made rapid and substantial growth. Already the work of the department has produced noteworthy effects upon the thinking of the people of the state through its work in ascertaining facts regarding some of the economic problems which confront the farmer. Something of the scope and character of the work done during the past two years is briefly indicated in the following pages.

Studies of Farm Organization and Cost of Production. The detailed cost routes located in Jackson and McPherson counties were continued. The McPherson county route included 21 farms and the Jackson county route included 18 farms. Three years' results in the McPherson study are being summarized and manuscripts on various phases of this study will be prepared within a short time. The studies of the cost of producing beef in the Flint Hills region were carried on, records for 9,628 steers being secured. This study has been terminated and the results for the three-year period are being summarized and prepared for publication. A survey of western Kansas farms was conducted in 1923 in cooperation with the United States Bureau of Agricultural Economics. The results of the survey are being summarized.

The data available from the complete cost records in McPherson county for the years 1920, 1921, 1922, and 1923 were summarized during the past year and are now nearly ready for publication. These data show the labor and material requirements of the various crops and kinds of live stock. These requirements are shown in terms of yearly averages and the items for individual farms are given for 1922 to show the variations in the individual farms. The amounts of labor recorded are shown, and the distribution of this labor is also given. Such data are of great value in planning the reorganization of farms. Table I shows the average yearly requirements for some of the crops grown on the farms included in the study.

These averages do not tell the entire story. The variations from farm to farm are very significant. For example, in the seed-bed preparation and seeding of wheat the time required varied from 1.72 hours to 3.93 hours of man labor per acre in 1922. Similar variations are to be found in the labor and material requirements for the other crops. These variations are due to differences in methods used, in types of machines, and in the efficiency of the

TABLE I.—Average labor and material requirements for crop production in McPherson county for the three years, 1921 to 1923.

CROP AND YEAR.	Hours of man labor per acre.			Hours of horse work per acre.		
	Prior to harvest	Harvesting.	Total.	Prior to harvest.	Harvesting.	Total.
Wheat:						
1921.	3 52	3.08	6.60	15.20	4 91	20.11
1922	2.70	4.06	6.76	12.94	6.03	18.97
1923	3.25	3 06	6.31	14.75	4.85	19.60
Oats:						
1920	2 62	3.85	6.47	11 99	5.99	17.98
1921.	2 48	2.90	5 38	10 44	4.95	15.39
1922.	3 06	3.69	6.75	13 81	6.37	20.18
Corn for Silage:						
1920	5.88	12 80	18 60	19 09	15.48	34.57
1921	4.95	6 76	11.71	16.60	9.27	25.87
1922	4 21	9.87	14 08	14 95	11.03	25 98

men. Similar data for live-stock enterprises are being summarized. [Project 95; Department of Agricultural Economics; state fund.]

Investigation in Land Tenure and other Land Problems. At the beginning of the fiscal year 1923-'24 work was begun on this project in cooperation with the Division of Land Economics of the United States Bureau of Agricultural Economics. Records were obtained from individual farmers by the survey method. This cooperative work was divided into two parts: (1) Land utilization and settlers' progress. This is a part of the Great Plains study conducted by the Department of Agriculture in cooperation with the various states in the Great Plains region. In this study 142 records were obtained. These records called for data on two principal subjects—(a) the utilization of land in these areas as shown by types of farm organization, and (b) settlers' progress, which embodied a history of the progress of land-owning farmers from the time they settled in those areas, and in fact from the time they began farming, up to the year of this survey. (2) The second phase of last year's field work pertained to land tenure. Three hundred and fifty records were obtained in Jackson, Atchison, Brown and Jewell counties. These questionnaires emphasized the manner in which each individual farmer acquired ownership of his land, type of contract between landlords and tenants, progress made by tenants toward ownership, and other phases of tenancy. It was thought that this num-

ber of records would be a fair representation of the land tenure situation in the corn-belt section of the state. Plans have been laid to conduct similar investigations in various parts of the state. However, it was deemed inadvisable to continue this study until an analysis shall have been made of the data obtained last summer. These results may suggest important improvements in the questionnaires and in the general methods of doing this work.

Through the courtesy of the Kansas State Tax Commission, it was possible to obtain data on the following points relating to taxation:

1. The transfer of farm land and city real estate in *bona fide* sales by counties for the past 15 years. These data have been copied and are now on file. Record of these sales is available by townships and by cities for 10 of the 15 years.

2. Assessed value of each item of real estate sold. This has made it possible to make extensive tabulations of the relation of assessed value to sale value of both farm and city real estate. The principal work on this project has been made on the basis of this information.

3. Data on land utilization. From the records of the Tax Commission it was possible to obtain the number of acres in cultivation by years, as reported by the tax assessors for the past 15 years. These data are given as for cultivated and uncultivated land, the sum of the two being the total area of taxable land in each county. Data on land utilization were obtained in much greater detail for the year 1912.

4. Information on tax levies, and data on assessment of personal property and property of public-service corporations between towns and cities, on the one hand, and rural districts on the other, were obtained, all of which will be a foundation for other studies in taxation.

The preparation of a manuscript for an Agricultural Experiment Station bulletin entitled "Tax Reform in Kansas" has been nearly completed. This is divided into two parts: (1) Why tax reform is needed in Kansas, and (2) a tax program for Kansas. Data pertaining to these have been used by the project leader in thirty talks on taxation in various parts of the state, and in newspaper articles, mimeographed papers and radio talks. An analysis of the tax dollar is under way and will be carried on into the next year. Analysis has been completed for 1923 and for nearly all of 1922. This is a detailed analysis showing precisely how much each class of property contributes to each public purpose in cities and outside of cities in

each of six sections of the state. One purpose of this is to determine to what extent each public purpose is responsible for the increase in the general tax burden, and particularly the burden on farm land and city real estate. The following tabulation shows the average tax per acre of all taxable land and improvements in 1923:

Section of the state.	Average tax per acre of taxable land with improvements, 1923. <i>Cents.</i>
Corn belt	91.0
General farming	75.6
Flint Hills	49.0
Eastern half of wheat belt	52.5
Western half of wheat belt	28.1
Grazing region (southwest)	18.7
Average for the state	50.7

Another purpose of this study is to show the relation of the tax burden on land to the land income, wherever data on net income from land can be obtained. [Project 132; Department of Agricultural Economics; state fund.]

The Marketing of Kansas Wheat. The work on this project was devoted to six phases of the general subject. Each phase is briefly discussed below.

I. *The Extent and Effect on the Marketing of Kansas Wheat, of Any Shortage in the Supply of Farm Storage Space.* Work on this phase of the project has been devoted to summarizing data from 46.5 farms for the year 1923, and making comparisons between these data and those of previous years. Station data for the three years 1920, 1922 and 1923 have also been compared with data secured by county assessors. The latter data were obtained through cooperation with the State Board of Agriculture. It is believed that this part of the project has been pursued far enough to answer definitely questions with regard to (1) adequacy of the supply of farm storage space in Kansas and (2) the extent to which shortage of farm storage space is a factor in forcing an early marketing or "dumping" of the Kansas wheat crop. A bulletin, giving the results of this study combined with certain findings to date under Phase II of this project, is being prepared under the title, "Shortage of Farm Storage Space and Inability to Get Local Bank Credit as Factors Forcing an Early Marketing of Wheat." The supply of farm storage space in the state as a whole is indicated by Table II.

TABLE II.—Supply of farm storage space in the state as a whole.

	1923.	1922	1920.	Data of St. Bd. of Agr.
Ratio of total bushels of bin room to bushels of crop .	1 91	1 46	1 44	1.49
Ratio of bin room to part of crop actually stored	2.93	1 84	1.77	. .
Per cent of crop sold direct from threshing machine .	34 80	20.50	17 20	. .
Per cent of crop first going into farm storage	65.20	79 50	82 80	. .
Per cent of farmers short of storage space .	14.70	19 70	19.90	. .
Per cent of farmers having no storage space	1.00	2 00	4 80	... .
Size of Kansas wheat crop (millions of bushels)	76	117	141	(a) 108
Number of farms from which data were secured	325	152	743	

NOTE—Total farm storage space for wheat in the state, 161,163,053 bushels.
(a) Average crop for eight years, 1915 to 1922, inclusive.

The effect of storage shortage as measured by excess of crop per county over bin room per county in per cent of total crop of the state for the years 1915 to 1923, inclusive, is indicated below:

	Total state crop. <i>Bushels.</i>	Total of counties excess crop over bin room. <i>Bushels.</i>	Per cent of total crop.
1915.	95,768,176	1,129,029	1.2
1916.	99,384,760	4,280,823	4.3
1917.	41,563,387	152,401	0.3
1918.	93,195,332	4,172,949	4.5
1919.	146,109,192	12,908,208	8.8
1920.	140,842,516	18,022,190	12.1
1921.	18,220,148	7,790,864	6.1
1922.	116,864,983	5,480,781	4.7
1923.	76,172,274	239,101	0.3
	938,120,768	54,176,346	5.8

The effect of shortage of storage space in 1923 as measured by farmers replies to the question, "How many bushels of wheat did you sell before you otherwise would have sold, because of shortage of storage space?" is indicated in Table III.

TABLE III.—Effect of shortage of storage space in 1923 on forcing sale of wheat.

	Number of farmers reporting.	Per cent	Total crop	Crop short of storage space.	Per cent of crop short of storage space.
Stated definitely, not short of storage space	353	75 9	<i>Bus.</i> 391,183	<i>Bus.</i> 0	0
Short of storage space	17	3 7	25,170	12,040	47.9
Not reporting any shortage of storage space.	95	20.4	46,504	(a) 0	0
	465	100.0	462,857	12,040	2.6

(a) Because of small crops and no definite report of shortage of storage space, it was assumed there was no shortage.

Because of the simultaneous influence of the credit factor and other impelling motives, it is impossible, as in the case of much economic data, to segregate exactly the amount of wheat marketed because of shortage of storage space alone. The cross-question method of approach from three different angles, however, settles the question with enough accuracy to serve any practical purpose. This is all that can be expected of any commercial analysis. It may safely be concluded that:

1. The wheat industry of Kansas is now carrying approximately a 50 per cent surplus of farm storage space to take care of fluctuating crop yields.
2. Much of the shortage apparent in recent years has been due to the heavy shifting of other crop land into wheat in the eastern and western thirds of the state and will diminish as the wheat acreage recedes in these sections.
3. In most years no more than 3 to 5 per cent of the wheat crop of the state is forced on the market before it would otherwise go, because of shortage of farm storage space.

II. *The Extent of Farmers' Inability to Obtain Short-time Bank Credit and Its Effect on the Marketing of Kansas Wheat.* A further classification of the credit data collected for 1922 and 1923 has been made. Because of shortage of funds, fewer data were collected for the year 1923 than was intended. The effect of shortage of bank credit as measured by wheat sold direct from the machine where the farmer believes it pays to store and has more bin room than crop is shown below:

Y _{FAR.}	Total number of farmers reporting.	Number farmers selling direct from machine but believing it pays to store and having plenty of storage room.	Per cent.	Per cent of crop involved.
1922	152	10	6.6	5.1
1923	325	70	21.5	12.1
	477	80	16.7	9.6

The effect of shortage of bank credit as measured by farmers' replies to the question, "How many bushels of wheat did you sell be-

fore you otherwise would have sold, because you were unable to get local bank credit?" is shown in Table IV.

TABLE IV.—Effect of inability to secure local credit in 1922 and 1923 on forcing sale of wheat.

	Number farmers reporting.	Per cent	Total crop	Crop sold because of credit needs.	
				Bushels.	Per cent.
1922.					
Stated definitely, none sold because of credit shortage	216	86.0	298,272	0	0
Sold because of inability to get credit,	35	11.0	63,141	37,342	59.1
	251	100.0	361,413	37,342	10.3
1923.					
Stated definitely, none sold because of credit shortage	372	83.9	401,272	0	0
Sold because of inability to get credit,	71	16.1	109,591	63,977	58.4
	443	100.0	510,863	63,977	12.5

While the data secured on this phase of the project are too limited in volume to permit the drawing of very definite conclusions, they are suggestive. It seems that, on the whole, with normal crops and ordinary, stable banking conditions, not more than 10 to 15 per cent of the wheat crop is forced onto the market before it otherwise would go there, because of credit difficulties. This factor probably contributes to the forced marketing of two to three times as much wheat in this state as does shortage of farm storage space. In the years of poor crops, the part of the total crop forced on the market by this bank credit factor may equal 20 to 25 per cent in the central and western thirds of the state.

III. *Local Elevator Costs in Handling Wheat.* Work the past year has been devoted to tabulating cost data from 62 elevators in the state. This now gives cost data collected by mailed schedules for the three years 1920, 1921 and 1922. More detailed data for about 60 elevators have been obtained for the year 1921 through cooperation with the United States Department of Agriculture. A bulletin entitled "Problems in Buying and Handling Wheat at Local Elevators in Kansas" is in preparation. Data summarized to date indicate local elevator costs, including interest on investment, range around 5 to 6 cents a bushel. Extreme ranges in costs are from 2 cents up to 8 cents a bushel. Very few elevators with over a 100,000 bushel business have a per-bushel cost exceeding 5 cents.

IV. *Study of the Extent of Variations in Determining Test Weight*

per Bushel of Wheat at Local Elevators, and Some of the Other Factors that Influence the Price Paid for Wheat Locally. No work was done on this phase of the project in 1923. A part of the data already collected will be incorporated in a bulletin, "Problems in Buying and Handling Wheat at Local Elevators in Kansas," which is now in preparation.

V. A Study of High and Low Protein Wheat Areas in the State as Depicted by Mill Laboratory Records and Other Data. The work on this phase of the project consisted in summarizing data incidentally collected from a number of mills in the state while pursuing work on Phases III and IV of this project. This extra work was made possible largely through the one-year cooperative arrangement with the Food Research Institute of Stanford University, California. A summary was made of 14,066 protein tests, covering 103 counties and extending over the seven crop years 1917-'18 to 1923-'24, inclusive. The variation in protein content of wheat in an extensive area in central Kansas has been studied. It has been found that the average range in protein content from county to county any one year is about as great as the range from one crop year to another. This means that one is likely to find as much difference in quality of wheat in this territory any one year in going from county to county as will be found in any single county from season to season. This makes it possible for those interested in supplying mill demands to furnish a fairly uniform raw product from year to year, if they will only draw wheat from the right sections. This makes the geography of quality wheat important to any marketing organization handling wheat in quantity for mill trade.

There are no invariably low- or high-protein areas in the principal wheat belt of Kansas. There is a certain variation, dependent upon the season, that keeps any county or group of counties from always ranking at the top or bottom. In spite of this shifting, however, there is a certain consistency on the part of some counties to rank above or below average. For instance, the average protein content for all tests in a group of 17 counties is 12.5 per cent, but not once in seven years did the tests made on Stafford county wheat average as good as 12.5 per cent. At the same time only once in seven years did Comanche county fall below the average of 12.5 per cent, and three years out of the seven the county average was the highest of the 17 counties represented in this group. Apparently a section be-

ginning with Comanche county and extending westward to Seward, thence north to Trego and east to and including Russell county, thence southwest to and including Ford county, contains a considerable area where soil and climatic conditions are frequently favorable to the production of high-quality wheat, especially if good methods of production are used.

VI. *Wheat Shrinkage, Loss and Damage in Farm Storage.* The work during the past year consisted of getting shrinkage data on 69 samples of wheat of about 7,000 grams each, placed in 27 different bins on 8 farms in the vicinity of Stafford, Kan., observing temperature changes in these 27 bins, and obtaining data on changes in moisture content in these samples. The one year's work was done with very dry wheat. Weather conditions were ideal for the use of the combine harvester in this locality. No apparent heat damage occurred. Wheat placed in storage with less than 12 per cent moisture almost invariably showed an increase in weight four or five months later. The average gain in weight was 0.6 of 1 per cent. Wheat stored with more than 12 per cent moisture almost always showed a loss in weight four or five months later. The average loss in weight was 0.4 of 1 per cent. Wheat cut in midday and three or four degrees warmer than wheat above or below it took nearly a month to reach an even temperature with the other wheat. It is purposed to repeat this work during the summer of 1924. [Project 143; Department of Agricultural Economics; state fund.]

The Economics of the Poultry Industry on Kansas Farms. The work on this project has consisted chiefly of tabulating and summarizing the monthly reports mailed in by cooperators. The data obtained during 1923-'24 have not yet been summarized. The things proposed during 1924 are to make a study of the complete records and what partial records are available from the entire period of the project, and to combine these records with the complete cost records secured in project 95 that deal with poultry on farms. [Project 144; Department of Agricultural Economics; state fund.]

CONSERVATION OF THE SOIL

Because of the exploitative character of Kansas agriculture during the past 50 or 60 years, there has been a pronounced decline in the productivity of Kansas soil. No agricultural problem is of more fundamental importance than the problem of soil conservation. The Agricultural Experiment Station devotes much attention to this feature of Kansas agriculture. A few of the results of investigations

in soil conservation during the past two years are briefly discussed below.

Investigations in Soil Fertility. The investigations in soil fertility have been continued without any essential change. During the past year records of yields were secured and special attention was given to the influence of rotations, manure and fertilizers on the quality of wheat. Composite samples of soil were taken from all plots of the project and filed for future use. The samples are to be used later in making a study of the balance of nutrients in the soil. Corn yields for 1923 were much higher than the average for the project. The cropping system continues to have a marked influence on the yield, as is shown below:

CROPPING SYSTEM.	YIELDS OF CORN IN BUSHELS PER ACRE	
	1923.	Av. for 13 yrs., 1911 to 1923.
Alfalfa, four years; corn, one year; wheat, two years	49.4	29.5
Corn, cowpeas, wheat	50.9	29.5
Corn, two years; wheat one year.	29.9	26.4
Continuous corn	26.5	19.9

Apparently cowpeas grown for hay are just as valuable in influencing the yield of corn as is alfalfa. The only fertilizer treatments influencing the yields of corn in rotation with alfalfa were rock phosphate with green manure, stable manure with acid phosphate, and a complete fertilizer. Where cowpeas were grown in the rotation, the potassium, the complete fertilizer, and the stable manure produced slight increases in yields. In continuous corn production all fertilizers increased the yields of grain, but the increase from the use of manure was far greater than that from any other treatment.

The 1923 wheat yields were above the average for the 13-year period. The cropping systems showed some marked influences on yields, as shown below:

CROPPING SYSTEM.	YIELDS OF WHEAT IN BUSHELS PER ACRE	
	1923.	Av. for 13 yrs., 1911 to 1923.
Alfalfa, four years; corn, one year; wheat, two years	23.7	17.4
Corn, cowpeas, wheat	25.6	17.7
Corn, two years; wheat, one year.	18.4	15.6
Wheat continuously	21.4	15.6

In the rotation with alfalfa, acid phosphate increased the yield 10 bushels per acre in 1923 and has increased the average yield 3 bushels per acre. The complete fertilizer increased the yields 11.2 bushels per acre in 1923 and the average increase has been 4.3 bushels. Manure and acid phosphate produced practically the same yield as the complete fertilizer, while manure alone increased

the yield but 2.8 bushels per acre. In the rotation with cowpeas, the only treatments showing a significant increase in yield of wheat were complete fertilizer and manure. The former increased the yield 14.8 bushels per acre in 1923 and has increased the average yield 7.5 bushels. The manure treatment increased the yield 10.5 bushels in 1923 and has increased the average yield 4.5 bushels.

Alfalfa grown in rotation produced very satisfactory yields in 1923, but the yields were very low from the continuous alfalfa plots. Because of the poor stand, the continuous alfalfa was broken up after the first cutting and was reseeded in the fall. Acid phosphate alone caused a slight increase in yield of alfalfa, but the acid phosphate and manure plot showed an increase of 1,302 pounds of hay per acre. Rock phosphate and green manure showed an increased yield of 973 pounds of hay. A complete fertilizer increased the yield 897 pounds per acre. All of these treatments have shown marked average increases. In continuous alfalfa production, manure and fertilizer treatment continue to have a marked influence on yields, as is shown by the following figures:

TREATMENT.	YIELDS OF ALFALFA HAY, LBS. PER ACRE	
	1923.	Av. for 13 yrs., 1911 to 1923.
None	519	3,002
Phosphorus	1,217	3,575
Potassium	546	3,085
Phosphorus, Potassium, and nitrogen.	1,509	4,160
Manure, 2.5 tons per acre.	1,606	4,924
Manure, 5 tons per acre	2,002	6,101

The sulphur plots laid out in 1919 are still in use. The results show a decrease in the yield of alfalfa hay from the application of sulphur. During the year 1924 more intensive studies will be made on the influence of alfalfa on the quality of wheat. Either during 1924 or 1925 it is purposed to expand the project to include some additional work on the use of different green-manure crops, especially sweet clover, and methods of handling the soil when wheat is to follow alfalfa. [Project 17; Department of Agronomy; Hatch and state funds.]

Tillage Investigations. This project has consisted of a continuation of the tillage investigations established in 1909 as the wheat seed-bed project and of the tillage project as outlined in 1919. The tillage treatments of the wheat seed-bed project, average yields, and moisture and nitrate data are given in Table V.

TABLE V.—Tillage treatments, yields, and moisture and nitrate data for wheat seedbed project.

TILLAGE TREATMENTS.	Bushels per acre.				Average moisture and nitrate determinations at seeding time, 1910 to 1922 (a).	
	1921.	1922.	1923	Average, 1911 to 1920	Per cent moisture.	P. p. m. nitrates.
Disked at seeding	4.1	9.3	6.4	7.7	19.0	6.1
Plowed Sept. 15, 3 inches deep	6.9	12.2	10.5	13.1	19.1	9.0
D. D. July, plowed Sept. 15, 7 inches deep (b)	7.1	26.0	28.4	17.4	19.8	20.9
D. D. July, plowed Aug. 15, 7 inches deep	10.1	24.3	(c) 17.6	17.8	20.0	29.6
Plowed Sept. 15, 3 inches deep	6.1	12.1	7.0	11.3	18.7	7.1
Listed July, ridges worked down	10.7	25.6	19.0	18.0	19.3	23.0
Listed July, ridges split Aug. 15	12.6	25.0	(c) 10.8	10.3	19.3	26.1
Plowed Sept. 15, 3 inches deep	6.3	14.3	10.6	14.6	18.2	9.0
Plowed July 15, 7 inches deep	15.6	22.1	(c) 13.7	20.7	19.4	26.0
Plowed Aug. 15, 7 inches deep	12.5	20.4	5.3	19.1	19.3	18.1
Plowed Sept. 15, 3 inches deep	5.1	9.7	5.3	12.0	18.4	6.2
Plowed Aug. 15, 7 inches deep, not worked till September.	11.1	17.4	(c) 6.5	16.8	19.4	13.0
Plowed Sept. 15, 7 inches deep	7.8	12.6	8.1	11.7	18.8	6.0
Plowed Sept. 15, 3 inches deep	5.6	8.9	5.6	10.3	18.0	5.5
Plowed July 15, 3 inches deep	12.1	23.5	16.5	15.0	18.8	17.4
THREE-YEAR ROTATIONS (d).						
Plowed July 15, 12 inches deep	27.6	29.0	27.3	(e) 25.7	21.2	23.0
Plowed July 15, 7 inches deep	30.3	30.9	31.9	(e) 26.7	20.7	20.2
Plowed July 15, 3 inches deep	27.5	29.3	29.1	(e) 26.7	21.0	19.6
Plowed Aug. 15, 7 inches deep	23.3	21.1	18.6	(e) 23.1	21.8	14.0
Plowed Sept. 15, 3 inches deep	10.6	11.6	11.9	(e) 17.0	18.5	7.8

- (a) Average of foot-section samples to a depth of 6 feet and 3 feet, respectively.
 (b) "D. D." means doubled disked.
 (c) Plots badly infected with footrot.
 (d) Corn, oats, wheat, each one year.
 (e) Average of 11 years, 1913 to 1923.

Foot rot of wheat put in its appearance on certain plots in 1921, and the infection increased progressively in 1922 and 1923. The plots receiving early and deep tillage were so badly damaged in 1923 that it was decided to institute a rotation for a period of three years before again sowing wheat. Because of the foot rot, the yields since 1920 are not true criteria of the effects of time and depth of tillage upon production of wheat. Accordingly the yields shown above have been arranged only for the years 1911 to 1920 and are given separately for the years 1921, 1922 and 1923. There was no indication of foot rot in the wheat plots that are rotated with corn and oats. The yields of these rotation plots again show the greater economy in tillage that is made possible by practicing a rotation. As heretofore, the moisture and nitrate data show that early summer tillage is accompanied by a greater amount of available nitrogen and moisture than is later summer tillage.

The tillage project, distinct from the wheat seed-bed project, was begun in 1919 and has been continued. The treatments with yearly and average yields of grain are presented in Table VI. The yields given are the averages from triplicate treatments.

The yields on the tillage project for the four years 1920 to 1923 demonstrate that shallow early plowing has been as effective as deep early plowing for these four years. The results from the disked and scraped-surface treatments indicate that some plowing in addition to the prevention of weed growth is essential for maximum yields of wheat. Plowing under straw or disking it in the plowed ground has produced better yields of grain than applying it as a top dressing during the late fall. [Project 18; Department of Agronomy; Hatch and state funds.]

The Relation of the Absolute Reaction of the Soil Solution Upon the Quantity of Nitrogen Fixed by *Azotobacter*. Studies on two series of plots that were begun in 1919 and 1920, together with laboratory studies, have been continued and the data accumulated has confirmed the former findings. A series of 32 cylinders, three feet deep and 2.5 feet in diameter, have been installed in what is believed to be a very desirable location. These were carefully sampled for total nitrogen and variously treated and inoculated in 1923. Examination has shown that the inoculations were successful. The cylinders are now planted to oats. A careful record of the presence or absence of *Azotobacter* in the soil in these cylinders will be kept, as will also the addition and removal of nitrogen.

TABLE VI.—Data on tillage project, 1920 to 1923.

TILLAGE TREATMENTS.	Bushels per acre.				
	1920.	1921.	1922.	1923.	Average.
Plowed July, shallow	29.5	25.2	33.7	20.4	27.2
Plowed July, deep.	26.5	27.7	33.6	22.8	27.6
Plowed deep, 1919; shallow, 1920; etc (alternating)	28.7	26.1	36.7	22.9	28.7
Plowed deep, July, 1919, and every third year thereafter	24.3	25.7	35.2	22.5	26.9
Plowed deep, July, 1919, and every sixth year thereafter	25.4	24.8	33.8	18.2	25.5
Disked during summer, not plowed	23.8	18.2	26.0	13.5	20.4
Disked during summer, plowed shallow, Sept	24.7	18.3	23.5	17.1	20.9
Disked during summer, plowed deep, Sept	21.6	16.6	21.4	16.9	19.1
Weeds growing, disked at seeding	12.1	4.3	4.7	3.8	6.2
Scraped, disked at seeding	28.6	15.6	21.9	13.6	18.4
Plowed Sept, shallow	19.0	9.1	11.5	10.1	12.4
Plowed Sept, deep	17.3	11.8	12.8	10.4	13.1
Plowed Aug, shallow	24.3	25.0	28.9	13.8	21.9
Stubble burned, plowed July, deep	27.3	23.7	31.6	18.3	25.2
Stubble burned, plowed July, shallow	29.3	23.9	31.3	19.6	26.0
Straw before plowing, plowed July, deep	29.5	29.7	34.5	21.6	28.8
Straw before plowing, plowed July, shallow	32.1	27.1	33.2	19.4	28.0
Straw after plowing, plowed July, deep	29.0	30.7	35.9	19.8	28.8
Straw during winter, plowed July, deep.	26.1	28.8	29.1	19.0	25.7

By this means it is believed the influence of *Azotobacter* upon the nitrogen balance of the soil, and incidentally upon plant growth, can be determined. Experiments are under way and will be continued during 1924-'25 by which it is believed a biological method, making use of *Azotobacter*, can be worked out for determining the lime requirements of soils. One manuscript based on the work of this project was published in 1924. [Project 128; Department of Bacteriology; Adams fund.]

Soil and Crop Experimental Fields. Five crop and soil experimental fields were located in southeastern Kansas. Work has been begun on four of the fields and operations will be started on the fifth field about the beginning of the next fiscal year. The fields are located at the following points:

Columbus field, Cherokee silt loam; 20 acres on the farm of W. H. Shaffer (Cherokee county).

Fort Scott field, Summit silt loam; 15 acres on the farm of Harper Fulton (Bourbon county).

Moran field, Oswego silt loam; 27 acres on the farm of R. O. Furneaux (Allen county).

Parsons field, Bates silt loam; 17.3 acres on the farm of E. A. Volmer (Neosho county).

Rest field, Crawford silt loam; 20.2 acres on the farm of R. W. Wing (Wilson county).

The soil work on these fields will consist of crop rotations, commercial fertilizer applications, and applications of barnyard manure and green manure. The crop work will consist of a study of methods of seeding alfalfa and clover, and variety studies of wheat, oats, soybeans, cowpeas, cotton, corn, sorghums and flax. In addition there will be a limited amount of tillage work with winter wheat and rate-of-application of fertilizers on winter wheat. [Department of Agronomy; state fund.]

INVESTIGATIONS IN THE PLANT INDUSTRIES

The importance of the plant industries in Kansas agriculture is suggested by the fact that in 1922, a year of very low prices, the value of the crops produced in the state was reported by the State Board of Agriculture as more than \$246,000,000. During the past 20 years the annual value of crops has averaged \$363,000,000, the wheat crop alone representing more than \$100,000,000 of the annual average. Some of the work which the Agricultural Experiment Station is doing on problems relating directly to the plant industries of the state is briefly discussed in the following pages.

Work on the Flora of Kansas. During the past year the herbarium was maintained in good working order and about 900 sheets were added to it. By exchange, 337 sheets were received from North Dakota and 350 from the University of Michigan. About 50 miscellaneous specimens were received from Kansas. The manuscript for a publication on the poisonous plants of Kansas has been completed. The actual preparation of the illustrations and the finishing touches on the manuscript are now in order, whereupon it will be ready to submit for publication. [Project 137; Department of Botany; state fund.]

Drought Resistance in Crop Plants. The work on this project recently has been confined to two lines of study: (1) The effect of the amount of water in the soil on the rate of water loss from plants; and (2) preliminary work on the effect of sprays on the temperature of leaves. The data obtained in the above-mentioned experiments are not yet ready for presentation, since all the available time outside the experimental season has been employed in writing up the

results obtained in earlier experiments. During the past year three papers have been submitted for publication to the *Journal of Agricultural Research* and will appear in print in the near future. One of these papers, entitled, "Daily Variation of the Carbohydrates in the Leaves of Corn and Sorghums," may be summarized briefly as follows: In order to determine the changes of the carbohydrates in the leaves of corn and the sorghums during the day, analyses were made of material collected at two-hour intervals from the leaves of Pride of Saline corn, Dwarf Yellow milo, and Red Amber sorgo, grown under identical or similar field conditions during three growing seasons. Ten sets of plants were under observation and the more important data obtained were as follows:

1. *The Total Sugars.* The total sugars in the leaves of the plants began to increase between 4 and 6 a. m., reached a maximum, which varied from 12 m. to 5 p. m., and decreased gradually from that time until daylight the following morning. In the 10 observations, the maximum amount of sugar in the leaves occurred in five cases at the same time as the maximum amount of dry matter, while in the other five cases the maximum sugar content was reached at periods varying from one to six hours earlier than the maximum amount of dry matter.

2. *The Nonreducing and Reducing Sugars.* The nonreducing sugars in the leaves studied were, with but one exception, always in excess of the reducing sugars. The nonreducing sugars increased markedly during the day and decreased during the night, while the reducing sugars, as a rule, showed very little increase and the amount present at the different periods of the day was very irregular. No significant differences were observed between corn and the sorghums in regard to the relationship between the reducing and non-reducing sugars in their leaves.

Another paper, prepared in coöperation with the Department of Chemistry, is entitled, "Elemental Composition of the Corn Plant." An elemental analysis was made of five Pride of Saline corn plants grown in the field at Manhattan. Determinations were made for carbon, oxygen, hydrogen, nitrogen, phosphorus, potassium, calcium, magnesium, sulphur, iron, silicon, aluminum, chlorine, and manganese. From the data obtained the number of pounds of each of these elements removed per acre from the soil and air by a crop of corn was calculated. The results are published in detail in the paper referred to. The third paper is entitled, "Some Observations on the Number of Stomata of the Leaves of Crop Plants." The number of stomata of the leaves was determined for 50 crop plants growing under the conditions of the field during the years 1914 to 1923. The results of the work are reported in detail in the paper last mentioned. [Project 74; Department of Botany; state fund.]

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

The winter wheat nursery harvested in 1923 contained about 350 strains grown in replicated rod rows. The wet season caused a very rank growth with consequent serious lodging. Most varieties were completely lodged as early as May 31, after a severe storm. The average yield of the 37 Kanred checks was 32.5 bushels per acre. There were 120 selections from the Kanred X Marquis and other winter X spring wheat crosses which yielded more than this check average. Many of these appear promising as to grain quality, a few are slightly earlier than Kanred, and many are as resistant to leaf rust as Kanred, some being more resistant. The greatest lack of information on these strains is with respect to their winter hardiness, since there has been no severe winterkilling in the nursery at Manhattan since the winter of 1916-'17. Through cooperation with the United States Department of Agriculture some of the more promising of these crosses were planted at Colby, Kan., Akron, Colo., Lincoln, Neb., Ames, Iowa, and St. Paul, Minn., in the fall of 1923 for the purpose of securing data on winter hardiness. Two of these crosses (Tenmarq and Kanmarq) were included in the uniform winter-hardiness nurseries at 17 northern stations. Data on winter survival collected in the spring of 1924 indicate that these strains are not as hardy as Kanred, as indicated in the following table:

	Average per cent survival of winter wheat at 17 northern station, 1923 to 1924.
Odessa	69.1
Minhardi	68.4
Minturki	66.1
Padui	65.9
Buffum No. 17	64.9
Turkey (Minn. 1488)	64.9
Kanred	62.0
Blackhull	57.7
Nebraska No. 28	55.0
Kanmarq	54.0
Sherman	52.9
Tenmarq	51.4
Hussar	47.0

Twenty of the winter X spring wheat crosses were planted in plots at the Agronomy Farm in the fall of 1923. All of these strains survived the mild winter of 1923-'24. One of the bearded selections headed several days earlier than Kanred and appears

promising, while most of the awnless selections do not appear to have the yielding capacity of Kanred. A number of these same crosses were also planted at Hays and Mankato, Kan., Denton, Tex., La Fayette, Ind., Arlington Farm, Va., and Knoxville, Tenn. The plantings at the last three stations were primarily for leaf-rust observations by Dr. E. B. Mains, of Purdue University, and Dr. C. E. Leighty, of the United States Department of Agriculture.

Preliminary milling and baking tests were made on some of the more promising of these crosses, and protein determinations were made on a larger number. Samples from the nursery crop of 1923 were also graded by federal grain supervision officials at Kansas City, Minneapolis and Washington. Some of the selections will grade as hard red spring, some as hard red winter, and others as mixed wheat. Any selections which appear promising but which are not pure for kernel type will be subjected to further pedigree selection.

In addition to the replicated rod rows of winter wheat, about 425 strains were grown in single rod rows. This section of the nursery included new introductions, first increases from head rows of selections and crosses, and the U. S. D. A. winter wheat classification nursery. Most of the Kanred × Eureka crosses and nearly all of the Kharkov × Ghirka crosses were discarded as being of no further interest or promise. About 50 varieties and selections and about 100 crosses were grown in the Hessian-fly nursery in coöperation with the Department of Entomology. Several of the Illini Chief × Marquis and Illini Chief × Kanred crosses are resistant to fly and appear promising in other respects.

In addition to the replicated and single rod row series above mentioned, the 1923 winter wheat nursery included more than 4,000 short rows (plant and head rows). Selections from two crosses, Kanred × Kota and Kanred × Hard Federation made up the greater portion of this number, there being about 1,000 of the former and about 1,600 of the latter. Very few of the Kanred × Kota selections appeared promising, most of these hybrid progenies being late, badly lodged, susceptible to leaf rust or otherwise undesirable. The Kanred × Hard Federation material contained strains of much greater promise, many of the hybrid families being early, very resistant to lodging and desirable in other respects. The head-row nursery also contained about 100 pedigree selections of Blackhull, about 125 progenies of a Prelude × Kanred cross made to secure

an early variety of hard red winter wheat, and about 700 selections from the Marquis X Kanred and other winter X spring wheat crosses.

The nursery yields of some of the more important winter wheat varieties for the five-year period 1919 to 1923 are arranged in order of average yield in Table VII.

TABLE VII.--Nursery yields of winter wheat varieties, 1919 to 1923.

Kan. No.	VARIETY.	Bushels per acre.					Five-year averages.
		1919.	1920.	1921.	1922.	1923.	
343	Blackhull.....	33.84	44.50	26.47	46.17	39.11	38.02
2414	P1068.....	25.39	39.31	31.07	40.83	32.33	33.78
2401	Kanred.....	25.82	32.92	24.50	37.10	32.53	30.76
317	Fulcaster (a).....	31.23	31.71	19.07	37.93	33.69	30.72
382	Kharkov.....	22.63	35.78	18.43	41.87	31.35	30.01
19	Harvest Queen (a).....	26.83	36.63	14.97	39.93	25.20	28.71
570	Turkey.....	22.03	35.04	13.67	38.70	29.32	27.67

(a) Soft red winter wheats.

During this five-year period in which no hard winters have occurred, Blackhull has yielded significantly more than the other varieties.

Nursery yields of the winter rye varieties which have been grown during the same five-year period are given in Table VIII.

TABLE VIII.—Nursery yields of winter rye varieties, 1919 to 1923.

Kan. No.	VARIETY.	Bushels per acre.					Five-year averages.
		1919.	1920.	1921.	1922.	1923.	
9075	Kansas.....	51.72	44.83	28.47	55.47	51.53	46.32
9074	Rozen.....	48.11	38.85	31.87	53.10	46.73	43.73
9073	Abruzzes.....	42.70	43.21	31.90	52.40	44.97	43.03

It is interesting to note that common Kansas winter rye, obtained by the station from a local seedsman in 1903, has outyielded the two introduced varieties by a significant quantity.

About 75 strains of oats were grown in the replicated rod-row series of the 1923 nursery. The yields of some of the better known varieties are as follows:

Kansas No.	Variety.	Bushels per acre.
5331	Cornellian	63.86
5244	Fulghum	62.55
5311	Alabama Hybrid	60.06
5005	Red Texas Sel	59.80
6110	Idamine	59.50
5209	Richland	58.44
5220	Burt	58.04
5212	Kherson (Neb. No. 21)	57.20
5179	Kanota	55.46
5218	Iowar.	55.13
5213	Red Texas (Neb.)	54.75
6106	Burt (Neb. White Kernel Sel.)	52.40
5208	Albion	52.35
6111	Iogren.	50.51
6112	Cole	49.17
5333	Empire	47.50
5334	Standwell	47.40
5315	Burt X Sixty Day	46.73
5332	Comewell	45.04

Late varieties such as Cornellian and Idamine made better yields than can ordinarily be expected under Kansas conditions, probably due to the unusually wet season. In Table IX are recorded the nursery yields of some of the more important oat varieties which have been grown during the six-year period 1918 to 1923, arranged in order of average yields.

TABLE IX.—Nursery yields of oat varieties, 1918 to 1923.

Kan. No.	VARIETY.	Bushels per acre.						Six-year averages.
		1918.	1919.	1920.	1921.	1922	1923.	
5005	Red Texas ..	59 60	60 10	29 15	44 53	38 22	59 80	48 57
5208	Albion	55 88	70 76	29 57	39 20	43 40	52.35	48 53
6094	Burt (Iowa) ..	58 80	58 20	24 00	50 93	43.00	55 00	48.32
6090	Burt (Iowa) ...	56 00	58 16	26 86	44 40	39.94	47 60	45.49
5020	Burt (Iowa) .	60 60	55 20	25 00	40 87	35 86	55 33	45.44
5213	Red Texas (Neb)	52 68	47 66	26 78	47 33	40 46	54 75	44.94
5181	Fulghum	59 80	66 88	28 84	41 33	14 46	58 28	44 93
5220	Burt.	60 00	54 28	20 02	41.93	34 12	58 04	44.73
5209	Richland .	56 73	57.72	25 68	38 20	30.40	58.44	44.53
5179	Kanota ..	62 44	59 60	28 22	34 07	21.80	55 46	43 60
5148	Kherson . .	51.84	59 28	30 84	37.00	27 74	53.95	43 57
5212	Kherson (Neb. No. 21) ..	48 28	54 76	27 42	37 40	34 60	57 20	43 28
5211	Burt (Neb.)	51 34	62 04	20.86	38 47	35.26	50.25	43.04
6004	Burt.	55 28	50.98	22.11	40.73	38.20	48 60	42.65
6052	Burt.	55.88	48 58	24.15	43.87	30.60	50 60	42.28
6076	Burt	50 20	44 78	21 53	35 87	32 94	38 71	37 34

According to these nursery results, a strain of Red Texas (No. 5005) has made the highest yield, followed by Albion, a selection from Kherson made at the Iowa Agricultural Experiment Station. The average yields of Fulghum and Kanota are reduced, due to low yields produced in seasons such as 1922, when the nursery was planted late, these varieties not yielding well under these conditions. The variety Burt contains types which vary considerably in yielding capacity, the two strains (Nos. 6090 and 6094) from the Iowa station being the highest-yielding lines of Burt included in these tests.

The experiment on smut infection in relation to yield of oat varieties was continued in 1923, the per cent of smut for the varieties grown from inoculated seed being as follows:

Kansas No.	Variety.	Per cent smut.
5219	Burt	0.03
5179	Kanota . . . . .	.24
5209	Richland . . . . .	.36
6090	Burt (Iowa) . . . . .	.61
5211	Burt (Neb.) . . . . .	.66
6004	Burt	1.40
5200	Aurora	5.16
5208	Albion	17.30
5201	Hull-less	48.28

Twenty-eight strains of barley were grown in replicated rod rows in the 1923 nursery. The yields of some of the more commonly recognized sorts are as follows:

Kansas No.	Variety.	Bushels per acre.
8067	Minsturdi	34.96
7125	Mansuri	33.40
7107	Gatami	28.80
7133½	Black Barbless (Mich.)	28.34
7135	Coast	27.95
8019	Manchuria	27.13
7137	Trebi	25.20
7143	Flynn (smooth awn)	23.74
7136	Stavropol (Hays)	18.52
7131	Club Mariout	12.64
7132	California Mariout	10.78

The variety Minsturdi, a selection from the cross South African X Manchuria made at the Minnesota station, appeared promising in the field and made the highest yield. Club Mariout made a lower yield than usual, due in part to poor stand. Three-year average yields for only four varieties are available. They are as follows:

Kansas No.	Variety.	BUSHELS PER ACRE			Three-year average.
		1921.	1922.	1923.	
7131	Club Mariout	19.90	30.16	12.64	20.90
7125	Mansuri	14.17	13.60	33.40	20.39
8019	Manchuria	13.17	16.46	27.13	18.92
7132	California Mariout	14.67	29.27	10.78	18.24

In addition to the strains grown in the replication rod-row series, 20 additional sorts were given preliminary trial in duplicate rod rows.

The barley nurseries at the Hays and Colby Branch Stations were much larger than the one at Manhattan, and included 724 strains at each station grown from seed furnished by the Office of Cereal Investigations. The nursery at Hays was destroyed by hail just before harvest in 1923 and no yield data are available. These strains were grown in single eight-foot rows; hence the yields are not reliable, but the following group comparisons from the Colby station may be of interest:

	Bushels per acre.
Two-row types (180 strains)	22.25
Six-row types (164 strains).	14.41
Hooded types (46 strains)	19.38
Bearded types (606 strains)	21.36
Hulled types (581 strains).	21.40
Hull-less types (92 strains)	18.70

The differences in number of strains included in each of the above groups are so great as to introduce a serious error, but the data given suggest the need of trials of comparable numbers of strains of the several groups in replicated rod rows over a period of years in order to gain an understanding of barley adaptation in western Kansas, an important barley-producing section.

Of the 724 strains grown at Hays and Colby in 1923, 322 were discarded because of late maturity or other obviously undesirable characters, as determined in the field and after threshing. Ninety strains were selected for trial in triplicate rod rows at each station in 1924, ninety-eight for planting in single rod rows, and 314 for further trial in single eight-foot rows.

The miscellaneous sorghum varietal nursery grown at the Agronomy Farm in 1923 included 185 rows of new introductions, selections from standard varieties and crosses, some of which were used in obtaining further data on heterosis or hybrid vigor in sorghums, as expressed in terms of height of plant and weight of heads.

About 100 selections of F₆ generation material of the Red Amber X Feterita cross were grown in 66-foot rows at the Agronomy Farm. All of these selections are white seeded, most of them are resistant to kernel smut and have juicy stalks. Many of them lodged rather badly, and although grown on heavy bottom land, this may possibly be one of their weak points. Selections of the erect, higher-yielding types were made for planting in 1924. Data on forage and grain yields were secured on all rows.

About 130 selections representing F4 material of the Kansas Orange sorgo X Dwarf Yellow milo cross were grown in short rows adjacent to the winter-wheat nursery, where chinch bugs were present in large numbers. Observations on degree of injury by the bugs to the two parental varieties, Kansas Orange (resistant) and Dwarf Yellow milo (susceptible) and to the hybrid plants were made during the season in coöperation with the Department of Entomology. Plants in many of the hybrid rows as well as in the rows of milo were severely injured, while those of Kansas Orange sorgo and of certain hybrid selections were much less severely injured, under the same environmental conditions.

Preliminary studies were made of the cause of these differences in susceptibility to chinch-bug attack, and it is believed that variations in the amount of lignified tissue in the stem may be one of the determining factors. The selections from this cross are nearly all late, and offer little promise so far as economic value is concerned, but certain selections will be continued and tested further in relation to chinch-bug attack and injury.

Thirty-one pedigree selections of Kansas Orange sorgo were grown in triplicate rows at the new agronomy nursery, and yields of forage and seed determined. Strains with red glumes have been isolated from this variety, which is ordinarily described as having black glumes. Data on these 31 strains for a three-year period are now available, and the head-row work will be discontinued and a few of the more promising lines tested in field plots at the Agronomy Farm and in cooperative experiments in various parts of the state.

A head row of dwarf yellow milo was observed in which a certain proportion of the seedlings were albinos. Counts were made and it was found that there were 727 green to 234 white seedlings, or an approximate ratio of 3 green to 1 white. Self-fertilized seed was obtained from plants in this row and further studies were made during the winter of 1923-'24 in the greenhouse, with similar results. This is one of the first reports of the occurrence of chlorophyll-deficient types in sorghum, similar to those which have received considerable attention from geneticists in corn and the small grains. [Project 67; Department of Agronomy; Hatch funds.]

A Genetic Study of Aberrant and False Wild Types in Kanota Oats. This project was suggested in March, 1923, and approved on April 13, 1923. During the year considerable preliminary work has been accomplished in assembling and reviewing the foreign and American literature on false wild oats. Photographs of sev-

eral of the aberrant and false wild types in Kanota have been obtained and material gathered for the continuation of the project. A survey has been made of the occurrence of false wild oats in nursery rows, variety test plots and fields on the Agronomy Farm, and in farmers' fields of Kanota oats inspected for seed by the Kansas Crop Improvement Association. Strong-awned, dark-glumed, false wild and other aberrant types are not at all uncommon in the material above mentioned. These off-type plants were also observed in Fulghum oats (the variety of which Kanota is a strain) at the Missouri Agricultural Experiment Station, June, 1923.

The plants in every row of oats grown in the 1923 nursery were carefully examined in the field and the occurrence of false wild and other variant types noted. These were found to occur not infrequently in the Kanota and Fulghum varieties, one or more plants being present in nearly every check row. False wild types were also observed in the following varieties grown in replicated rod rows: Albion, Richland, Nebraska No. 21, Idamine, Comewell, and Alabama Hybrid No. 640. They were found in the following strains of Fulghum: Kansas Nos. 5181, 5221, 5244 and 5310. It is of interest to note that no false wild types were observed in the Red Texas variety. In the 318 single rod rows of Kanota oats grown from seed of 1922 head rows, described as typical of the variety, *i. e.*, normal in kernel characters, there were 17 rows which were found to contain one or more plants of homozygous false wild type, 25 rows in which both homozygous and heterozygous false wild types were observed, 78 rows in which only the heterozygous false wild types were observed, and 198 rows which were designated as pure, *i. e.*, of normal type, and containing neither heterozygous nor homozygous false wild forms. These results seem to indicate that the false wild types in Kanota are produced in rather large numbers even in material only one year removed from individual panicle selections grown in head rows. The fact that a much larger number of rows was observed in which heterozygous, but no homozygous, false wild types occurred, strengthens the hypothesis that the first mutative change is from the normal to the heterozygous false wild type, the homozygous types appearing in later generations and in smaller numbers as products of segregation. In the 40 single rod rows of Kanota and Fulghum planted from 1922 single rod rows, *i. e.*, more than one year removed from head rows, there were 4 rows containing one or more homozygous false wild types, 4 rows containing both homozygous and heterozygous false

wild types, 14 rows containing one or more heterozygous false wild plants but no homozygous false wild, and only 18 rows described as pure, *i. e.*, of normal type. This material contained a higher per cent of false wild types than that discussed immediately above, as might be expected.

About 225 head rows were planted from seed of the extreme, *i. e.*, homozygous false wild type which occurred in Kanota oats grown in 1922 in the crop-improvement nursery, on the Agronomy Farm or in fields in various parts of the state which were inspected for seed. It was expected on theoretical grounds and from published accounts of other students of false wild oats that all of these rows would breed true, *i. e.*, would produce nothing but extreme homozygous false wild types. A large majority of the rows did breed true, but enough exceptions occurred to be of considerable interest. There were 20 rows which contained one or more plants each (usually only one) which were described as heterozygous false wild or as intermediate, *i. e.*, neither normal Kanota nor extreme false wild. It is not believed that these plants are the result of mechanical mixture. They may be natural crosses, but it seems more likely that they may represent reverse mutations from the false wild condition back toward the normal. The fact that no normal but only individual heterozygous false wild Kanota plants were observed in these supposedly homozygous false wild rows would seem to lend support to the idea expressed above. The observation of these intermediate types in rows planted from extreme false wild types will make it necessary to qualify the statement that the extreme false wild types always breed true. Neither is it true that all the homozygous false wild types which occur in Kanota are alike in all their characters. The plants differ in height and at least three distinct forms have been recognized.

One of the most interesting deviations from the usual homozygous false wild type is one which has been designated as the non-articulating type, as found in 1923, rows Nos. 3829, 3883, 3876 and 3888. The spikelets of the plants in these rows resembled the usual type of homozygous false wild in Kanota with one very important exception. One of the most characteristic features of wild and false wild oats is their tendency to shatter from the glumes before fully ripe. This brittleness of the rachis and spikelet joints is in fact a feature of primitive types of all small grains. The types known as nonarticulating often had three fairly well-developed kernels per spikelet, a condition common in normal Kanota.

Whether two or three kernels were present, the spikelet remained intact even after machine threshing. One sample, row No. 3888, was put through the small head-row thresher five times with the spikelets still unbroken. This type is of peculiar interest, for it is "false wild" with respect to awns, basal scar, basal hairs, and rachilla hairs; but in its nonarticulate character it is not only far removed from the false wild type, but the spikelets are even more tenacious than in normal Kanota oats, where a considerable number of the primary and secondary kernels are separated in threshing.

About 575 plants of oats for use in these studies were grown to maturity in the greenhouse during the winter of 1923-'24. These included normal Kanota, homozygous false wild, heterozygous false wild and plants of the wild *Avena fatua* and *Avena sterilis* for comparative study and for crossing. Quite a large number of crosses were attempted, but for some reason very few of the crossed seeds developed. Data were obtained on dates of heading and ripening, height of plant, number of culms, and on kernel characters. The homozygous false wild plants are in general shorter than those of the heterozygous false wild or normal Kanota, and they ripen a little earlier and stool more. [Project 146; Department of Agronomy; Adams fund.]

Sorghum Varietal Tests. Contrary to the usual result, the highest yields of grain were secured in 1923 from some of the sorghos, a selection of Kansas Orange producing the unusually high yield of 105.3 bushels per acre. A new kafir X feterita hybrid produced 97 bushels, the highest yield of any grain sorghum. Among the standard grain sorghums, Darso, Red Kafir and Blackhull gave the best yields. As an average of five years, Darso leads with an average of 65.9 bushels, but Blackhull, with an average of 59.1 bushels, is probably to be preferred because of better grain quality. Dwarf Hegari has produced an average yield of 59.9 bushels, but is somewhat objectionable because of rather erratic yields and a decided tendency to sucker. A new sorgo variety, white Africa, secured through the United States Department of Agriculture, proved rather promising, especially from the standpoint of securing a variety which lodges less than Kansas Orange. [Project 129; Department of Agronomy; Hatch fund.]

Small-Grain Tests. The varietal tests, which make up a considerable portion of the small-grain project and were begun in the early days of the experiment station, are continued indefinitely in

order (1) to learn more of the factors that determine the superiority or lack of it which characterizes different varieties, and (2) to determine the value of new varieties secured from farmers, other stations, and the crop-improvement nursery. Other experiments are often continued for the same reason, but are more likely to be discontinued or modified according to circumstances. The season of 1923, like several recent years, has been characterized by better than average conditions, especially with respect to winter temperatures. Since it is known that the superiority of any given variety is determined very largely by its ability to survive unfavorable conditions, the varietal experiments for the past year have furnished no information of outstanding value. Kanred was outyielded by a number of varieties known from previous work to be distinctly inferior in several respects. Among these may be mentioned Hard Winter Defiance, Improved Turkey, Turkey, and Blackhull. As an average for 13 years Kanred has exceeded Hard Winter Defiance and Improved Turkey by one and one-half bushels per acre and Turkey (570) by 2.6 bushels per acre. For the five years in which Blackhull has been grown it has outyielded Kanred by 2.2 bushels per acre. Were it not known as a result of experiments outside this state that Blackhull is materially less winter hardy than demanded by the average Kansas winter, it would be necessary to class it among the most promising varieties. A heavy frost on the night of May 8, 1923, materially injured some of the varieties, especially the earliest, which at this time were in the boot stage of development. Thirty-eight per cent of the culms of Nebraska 28, for example, were found to have been injured as compared with 5.6 per cent for Turkey and 10.4 per cent for Kanred.

In the method-of-seeding test, seeding in furrows produced materially better yields of grain than the usual method when sown east and west, but practically the same when sown north and south. There was no winterkilling and the result cannot be explained at this time.

In the rate- and date-of-seeding test, seeding September 29 at the rate of 6 pecks per acre, gave the best yield. Late seedings produced very low yields. It appears that as a general rule wheat should be in the ground in the vicinity of Manhattan previous to October 1, except when Hessian fly threatens serious damage.

Timely rains favored the later-maturing varieties of oats, such as Red Texas, which in normal seasons are injured by early summer heat and drought. The best Red Texas (5085) produced 46.5

bushels per acre as compared with 41.2 bushels for Kanota, 39 for Burt (5211), and 37.7 for Albion, which is one of the best strains of the Kherson type. As an average of all years in which Kanota has been grown it has produced 47.5 bushels per acre as compared with 38.6 for Red Texas.

The experiment relating to methods of seeding wheat was discontinued at the end of the season; no other changes of importance are contemplated. Technical Bulletin 13, "Seeding Small Grains in Furrows," was issued in January, 1924. [Project 129; Department of Agronomy; Hatch fund.]

Corn Production and Improvement. In the date- and method-of-planting test with corn, listing gave much better yields in 1923 than surface planting or planting with disc furrow openers for the two earliest dates of planting. This was due in the main to the differential effect of a late spring freeze which greatly injured all early plantings except that planted in lister furrows. The extent of injury is indicated in Table X.

TABLE X.—Per cent of injury due to a late spring freeze in date- and method-of-seeding test, 1923.

Date planted.	April 10.			April 19.		
	Listed.	Surface planted.	Planted in open furrows.	Listed.	Surface planted.	Planted in open furrows.
Per cent uninjured . . .	65 9	1 0	3 6	89 2	1.3	7.2
Per cent partly injured . . .	22.1	9 8	10.6	6.4	8 9	9.4
Per cent killed . . .	12 0	89 2	85 8	4 4	89 8	83 4

Corn planted after April 19 was uninjured and there were no marked differences in yield depending upon method of planting. This experiment indicates that, in general, listed corn planted early germinates less and requires a longer period for germination than corn planted on the surface or with disc furrow openers. With a uniform stand such as has been secured in these experiments by thick planting and subsequent thinning, yields are generally in favor of listing in seasons characterized by midsummer or late summer drought and in favor of one of the two other methods in seasons of heavy spring and summer rainfall. The differences in average yield of the three methods at Manhattan are probably within the limits of experimental error, disregarding the one season in which early planted corn has been injured by late spring freezes.

In the variety test, Hildreth led with a yield of 64.9 bushels per acre, thereby exceeding Pride of Saline by 10.3 bushels. The season was such as to favor late-maturing varieties.

In the rate-of-planting test, 12-inch spacing produced the highest yield of grain, whereas the 8-inch spacing produced the highest yield of stover. As an average for nine years, 20-inch spacing has produced the highest yields of grain and 32-inch spacing the least.

Ordinary methods of cultivation gave slightly higher yields than summer cultivation with a one-horse harrow-tooth cultivator or scraping with a hoe, but the extreme difference was only 1.5 bushels per acre, which probably is no greater than the experimental error. The average yields of 13 tests in nine years are practically the same, no differences being materially greater than the probable error.

The principal new lines of investigation taken up in the corn project have to do with the application of methods of controlled pollination to corn breeding. The main emphasis during the past year has been placed on collecting and starting to inbreed a wide range of locally adapted and exotic varieties to serve as foundation material for future experiments. Contemplated phases of this work for the future include:

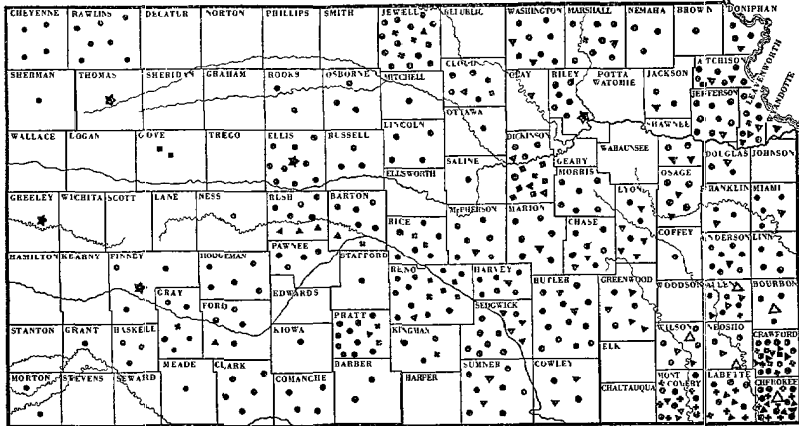
1. Comparison of various F₁ combinations between selfed lines of locally adapted varieties with the parent variety in hopes of finding crosses which are outstandingly superior.
2. Crosses between selfed lines from varieties of widely different origin.
3. A study of the possibility of recombining a large number of purified selfed lines to distribute as an improved variety.
4. A study of the relation to yield of various weak recessive abnormalities when in a heterozygous condition.
5. A study of the relation between yellow endosperm color and yield.
6. A study of the possibility of producing a superior silage variety.

Besides these phases, coöperative work with two departments is under way to study the reasons for immunity from or resistance to insect and plant parasites, respectively, together with their mode of inheritance and the practicability of establishing immune or resistant strains. [Project 129; Department of Agronomy; Hatch Fund.]

Coöperative Experiments with Soils and Crops. The agronomic experiments conducted in coöperation with farmers in various parts of the state were continued. The work done during the crop season of 1923, as indicated in the following table, illustrates the character and distribution of these experiments:

KIND OF TEST.	Number of tests.	Number of counties.
Wheat variety	110	65
Oat variety	38	35
Barley variety	10	9
Corn variety	57	38
Sorghum variety	69	41
Sorghum-corn comparison	7	7
Soybean variety	33	23
Wheat Fertility	50	32
Oat fertility	4	4
Alfalfa fertility	23	19
Kafir fertility	3	3
Potato fertility	3	3
Wheat-bed preparation	3	3
Rotation studies	12	4
Corn disease	2	2
Grass seeding	2	2
Crop adaptation	23	3
Miscellaneous	12	10
Totals	461	75

The geographical distribution, as well as the nature of the work in each community, may be seen by referring to the accompanying map. (Fig. 2.) Farmers in 75 counties cooperated in conducting 461 experiments.



● VARIETY TESTS ▲ FERTILITY TESTS ■ ROTATION AND TILLAGE TESTS + OTHER TESTS
 ★ AGRICULTURAL EXPERIMENT STATIONS ▲ EXPERIMENTAL FIELDS

FIG. 2.—Map of Kansas, showing distribution and nature of cooperative experiments with soils and crops in 1923.

Kanota oats maintained its lead and further demonstrated its superiority over Red Texas. The average yields of these two varieties in 1923, as well as in the previous four years, are given in Table XI.

TABLE XI.—Yields of Kanota and Red Texas oats, 1919 to 1923.

YEAR.	1919.	1920.	1921.	1922.	1923.	Five-year average.
Number of tests	7	27	22	25	35	116
Kanota	46 9	42 8	37 .5	32 4	39 9	39.9
Red Texas	32 4	37 2	26 5	19 8	33.5	29.9
Difference	14 5	5 6	11 0	12.6	6 4	10.0

In the 116 tests Kanota outyielded Red Texas 103 times, *i. e.*, in 89 per cent of the tests. The higher test weight of Kanota is an outstanding factor in favor of this variety over Red Texas. The results in both 1922 and 1923 evidence this fact as shown in Table XII.

TABLE XII.—Average test weights of Kanota and Red Texas oats, 1922 and 1923.

Year	Average weight per bushel.		
	1922.	1923.	Two-year average. 49
Number of tests	15	34	
Kanota	Pounds. 27 81	Pounds. 28 52	Pounds. 28.16
Red Texas	25.08	26 26	25.67
Difference in favor of Kanota	2 73	2 26	2 50

In the corn variety tests in 1923, Pride of Saline showed the usual wide range of adaptation and superiority over the varieties commonly grown in the localities where the tests were made. The following figures give the comparison of Pride of Saline in tests in 1923 with Boone County White, which is the base of more white corn than any other variety, and with Reid Yellow Dent, which is the leading basic variety of yellow corn in Kansas:

VARIETY.	Yield per acre—average of 24 tests
Pride of Saline	Bus. 44.70
Boone County White	39.48
Difference	5.22

	Yield per acre average of 29 tests. <i>Bus.</i>
Pride of Saline	40.10
Reid Yellow Dent	33.16
Difference	6.94

Varieties of sorghum were tested in 1923 to study the relative value for grain as well as forage. In the following table several of the leading grain varieties are compared:

	Percent grain in head	Average yield of grain per ^a acre. <i>Pounds.</i>
Number of tests	9	8
Dawn Kafir	72	1,322
Pink Kafir	76	1,468
Sunrise Kafir	75	1,415
Feterita	76	1,202

The comparative yields of silage for the chief forage varieties are as follows:

VARIETY.	Average yield per acre for nine tests. <i>Tons of silage.</i>
Kansas Orange sorgo	11.17
Dawn Kafir	5.41
Sunrise Kafir	6.35

Last season (1922-'23), 110 cooperative variety tests with winter wheat were placed with farmers in 65 counties. Eighty of the tests were successfully completed and harvested. On account of abnormal climatic conditions, soft wheat was not at a disadvantage last year except perhaps in the extreme west and northwestern parts of the state. This is shown by the fact that in the main wheat section—typically a hard red wheat region—the Fulcaster, a variety of soft red wheat, averaged, in 57 tests, more than a bushel per acre above Kharkof and Kanred, and yielded the same as Turkey. Such results do not often occur and cannot be expected except occasionally in seasons that are especially favorable for soft wheat. The average yields of the wheat varieties used in these tests are as follows:

VARIETY.	Average yield per acre. <i>Bus.</i>
Blackhull	17.93
Turkey	17.90
Fulcaster	17.86
Kharkof	16.70
Kanred	16.58

As will be seen, the yields of the first three varieties are identical. The difference between these and the yields of the last two varieties given in the table may be significant considering the number of

tests included to secure these averages. Blackhull has been grown in coöperative tests for five years and has yielded, on the average, approximately the same as Kanred. In 1923 Blackhull outyielded Kanred in the central and western parts of the state an average of 1.3 bushels per acre, which is probably a significant difference. Since 1919 Blackhull has been a good variety to grow, but since that time there has been no severe winterkilling in Kansas. The evidence indicates that when Kansas has a "hard winter" the varieties of soft wheat, and probably Blackhull also, will suffer much more than the hard wheats of the Turkey, Kharkof and Kanred varieties. In eastern Kansas, where conditions are normally more favorable for soft wheat than in the area farther west, varieties of soft wheat lead in yield by a larger difference than in the hard wheat belt in 1923, as shown below:

VARIETY.	Average yield per acre. <i>Bus.</i>
Fulcaster	21.47
Blackhull	20.92
Currell	19.24
Turkey	19.47
Fultz	19.01
Poole	18.93
Harvest Queen	18.74
Kanred	18.06
Red Sea	17.01

While the difference in yield between any two adjacent varieties in the preceding table is probably not significant, it is safe to say that the varieties named toward the top of the list were superior to those named toward the bottom of the list. These results are closely in line with the average results secured in southeastern Kansas, namely, that soft wheats outyield hard wheats and that Fulcaster and Currell are among the best varieties. Blackhull has been tested for a shorter period, but for four years has averaged approximately the same as Fulcaster. In northeastern Kansas the average results for a period of years show Kanred, Harvest Queen, Blackhull and Fulcaster to be the best-yielding varieties. The facts that last year Kanred lodged considerably and Harvest Queen seemed to be especially damaged by the late freeze probably account for these varieties ranking lower in yield than usual.

Most of the coöperative wheat-fertility tests conducted in 1922-'23 were located in southeastern Kansas, though some tests were distributed throughout the eastern half of the state. The eastern section, which is the fertilizer-using section, includes the three tiers of counties along the east end of the state, in which area nineteen

fertility tests were successfully completed. In every test, treated plots outyielded the check plots. The following tabulation gives the relative yields of wheat for the different treatments in the east section:

TREATMENT.	Yield of wheat per acre. <i>Bus.</i>
No treatment	13.80
2-12-2 (Nitrogen, phosphorus, and potash).....	19.80
2-12-0 (Nitrogen and phosphorus).....	19.58
0-16-0 (Acid phosphate)	19.01
1¼-30-0 (Bone meal)	19.62

These results show a decided increase in yields where fertilizers were applied. There was but little difference between the different treatments, all of them producing between five and six bushels more than the untreated land. It is apparent from this table that the greatest benefit was received from phosphorus, though nitrogen and potash both produced slight increases which may be large enough to be significant. West of the east section and extending as far as the middle of the state, fifteen tests were completed. In this section the results were not as regular as in the east section and where increases occurred they were usually smaller.

A soybean inoculation study was conducted in connection with the variety tests. In addition to the soil-fertility value of inoculation, as reflected in succeeding crops, the results of one year indicate that an appreciable benefit is secured in the current crop of beans. The average yield of hay in 1923, without inoculation, was 1,283 pounds per acre, whereas the inoculated plots produced 1,478 pounds per acre. The average yield of grain was increased from 6.6 bushels per acre to 8.1 bushels by inoculation.

Work was begun with cotton in 1923 to study the adaptation of the crop and the relative value of varieties. A variety test was successfully completed in Labette county. Several of the best varieties produced at the rate of 1,000 pounds or more of seed cotton to the acre.

In the studies with tame pasture grasses in Cherokee county several points were clearly shown: (1) The high grazing capacity in comparison with common pastures; (2) the importance of heavy seeding; (3) the value of lime in securing stands of both grasses and legumes; (4) the value of manure and acid phosphate; (5) the importance of thorough preparation of the seed bed. [Department of Agronomy; State fund.]

Alfalfa Production Experiments. The project relating to the stage of cutting alfalfa, begun in 1914 in coöperation with the Departments of Chemistry and Animal Husbandry, was discontinued at the close of the 1922 crop season. However, a supplementary experiment was outlined and work begun in 1923 to clear up some of the points raised in the earlier work. The most important of these was to determine (1) more precisely and definitely the effect of very early cutting on stand and vigor, and (2) the possibility of taking the first crop off very early (bud stage or prebud stage) and by permitting the second and later crops to go to full bloom, prevent any damage that would otherwise occur. This latter is thought to be particularly important from the practical viewpoint, since the first crop secured during the season is not only of the poorest quality, but also is frequently the most difficult to handle because of unfavorable weather. If this crop could be cut earlier when weather conditions permitted, the quality could often be greatly improved. On the other hand, the second and later crops can be permitted to reach a later stage of growth without material injury to their feeding value. In other words, this system of management, if it can be accomplished without injury to the stand or reduction of yield, will be of material benefit in improving the quality of the total crop for the season, and perhaps be of material value from the standpoint of distribution of labor.

It was found in 1923 that cutting every 10 days was sufficient to destroy practically a stand of alfalfa in a single season, and cutting every 20 days noticeably reduced the stand and vigor. These results substantiate the earlier work in which it was shown that cutting in the bud stage greatly reduced the stand and vigor after the first year. No significant differences in stand and vigor were observed between plots which were cut first in bud stage and later in full bloom and those cut in tenth bloom and full bloom throughout the season. The former seemed to be somewhat better in point of yield and quality of hay, but a single year's work is not sufficient to justify any conclusions regarding this point.

A new experiment was begun in the fall of 1922 in coöperation with the United States Department of Agriculture to determine the value of a number of varieties and strains of alfalfa as compared with native varieties. Eighteen varieties and regional strains were sown in duplicate in one-twentieth-acre plots on the Agronomy Farm. Good stands were secured in most cases and no winter injury occurred. In 1923 Grimm produced 3.95 tons per acre, the highest

yield of any variety. Cossack produced 3.80 tons per acre, Italian 3.69, and Kansas common 3.27. The land was somewhat more variable than was anticipated, the mean of the probable errors of each pair of plots being approximately a half ton. Hence the differences observed should probably be given but little weight.

It is purposed to continue the stage-of-cutting experiment another year and to lay out some new plots which, unlike the present ones, may be left for a number of years. The variety and strain test will be continued indefinitely. No other changes are contemplated. A manuscript entitled "Experiments Relating to the Time of Cutting Alfalfa" has been submitted for publication as a station technical bulletin. [Project 129; Department of Agronomy; Hatch fund.]

The Production of Soybeans and Cowpeas. Twenty-nine varieties and strains of soybeans and three varieties of cowpeas were planted for comparison of yields of hay and seed in 1923. The yields for 1923 were over 30 per cent above those of the preceding season, five varieties and strains yielding not less than 23 bushels of seed per acre, and four varieties yielding more than two tons of hay. The average yield of hay of the five varieties of soybeans was approximately the same as of the best variety of cowpeas. The production of soybeans in corn was not very successful owing to failure to obtain good stands of soybeans and to the unusually rank growth of the corn. [Project 129; Department of Agronomy; Hatch fund.]

Chemical Factors Influencing Quality of Wheat and Flour. Some work was done on the influence of diastatic enzymes on the baking qualities of flour. When flour is suspended in water at 63.5° C. for one hour, about one-third of the starch is changed to reducing sugars. Some investigators claim such great importance for the diastatic activity of flour that this practically rules out the baking test. Some time has been spent on assembling and studying data obtained by other investigators on factors that influence the quality of flour. In spite of all the work that chemists have done on factors that determine quality, it cannot be said that the problem is anywhere near solved, but substantial progress is being made. The material collected will be useful both for guidance in experimental work and in future publications. The experiments on the influence of diastatic enzymes show that, while the reducing sugars produced by them are important, yet as yeast food they are much less efficient than cane sugar. The diastatic enzymes are most active during panary fermentation, and the investigation on enzymes is important because of the light it throws on the results of

the baking test. The work on lipoids shows that emulsifying agents, either naturally present in the flour or added artificially, have an influence on the baking quality of flour. It is purposed to continue the work on diastatic enzymes and also on emulsifying agents. It is also purposed to do some work on the relation of methods of tempering to the baking qualities of flour. The viscosity test is one of the latest introduced in cereal laboratories and it is purposed to use this not only in connection with testing the wheat and flour samples obtained in the cooperative experiments, but also in special investigations. One paper entitled "Lipoids as a Factor in Gluten Quality" has been submitted for publication in a technical journal. [Project 60A; Department of Milling Industry; state fund.]

Cropping Systems and Fertilizer Treatments as Influencing the Quality of Wheat. The baking tests on the 48 samples of the crop of 1922 were made during July and August, 1923. The chemical work on the samples of the crop of 1921 and 1922 was finished. Fifty-one samples from the crop of 1923 were submitted by the Department of Agronomy. The milling and baking tests on these samples have been completed and the chemical work is practically finished. The wet and dry gluten determinations have been omitted, as the results do not give information that is not obtained from the protein determination and the baking test. The acidity test has also been omitted, as the ash determination gives the same kind of information on flour from sound wheat. The phosphorus estimations are continued on a limited number of samples. The viscosity test has been used for the first time on flour samples from the 1923 crop. A dough mixer made in the college shops from plans submitted by the department has been of great value in improving the technique of the baking test. This machine has been used on all samples from the 1923 crop. A large amount of time has been spent on tabulating and summarizing the data obtained since 1912, when the work was started on this and allied projects. The tabulation of the results on the 1923 samples has not been finished. The wheat yields, protein percentages, and yields of protein calculated in pounds per acre are given in Tables XIII and XIV; Table XIII showing the averages of certain groups of results for eleven years, 1912 to 1922, and Table XIV showing certain groups of the results by years. The field experiment is a part of the work of the Department of Agronomy.

TABLE XIII.—Wheat yields, protein percentages, and protein yields associated with soil treatments.

(Averages of 11 years, 1912 to 1922.)

SOIL TREATMENT.	Continuous wheat.			3-year rotation (a).			16-year rotation (b).		
	Bushels per acre.	Per cent protein.	Pounds protein per acre.	Bushels per acre.	Per cent protein.	Pounds protein per acre.	Bushels per acre.	Per cent protein.	Pounds protein per acre.
Phosphorus	20 99	17 30	192 5	22 9	14 29	173 4	21 75	17 67	203 7
Check (no treatment)	17.60	17 76	165.7	20 9	14 78	163 7	19 11	17 59	178 2
Phosphorus and potassium	19 20	16 67	169 6	21 8	14 06	162 4	21 47	17 44	198 5
Potassium	15 50	18 83	154 8	18 5	14 95	146.6			
Check (no treatment)	14 10	18 65	139 4	16 3	15 23	131 6	18 56	17 60	173 1
Nitrogen, phosphorus, potassium	17 50	18 87	175 1	22 5	15 60	186 0	22 61	18 53	222 0
Manure	19 60	17 35	180 2	26 9	15 23	217 1	21 89	17 44	203 3
Average	17 78	17 92	168 2	21 4	14 88	168 7	20 90	17 71	196 3

(a) Corn, cowpeas, wheat

(b) Alfalfa 4 years; corn 1 year wheat 2 years, for 12 years.

TABLE XIV.—Wheat yields, protein percentages, and protein yields by years, 1912 to 1922.

YEAR.	1912.	1913.	1914.	1915.	1916.	1917.	1918.	1919.	1920.	1921.	1922.	Average.	
CONTINUOUS WHEAT.													
Bushels per acre	5 80	19 00	24 30	23 30	10 60	14 70	6 90	22 60	13 10	10 20	33 00	.	16.70
Per cent protein	19 67	18 37	17 82	18 47	14 83	16 80	21 81	16 79	19 12	18.11	13 88	.	17 79
Pounds protein per acre .	60 40	185 00	229 50	228 10	83.30	130.90	79 80	201 10	132 80	97 90	242 80	.	152 00
THREE-YEAR ROTATION.													
Bushels per acre	9 20	11 00	30 80	19 10	19 80	13.20	15 10	22.30	11 80	21.20	26 00	.	18 10
Per cent protein . . . .	.	12 94	16.58	19 74	14 50	16 66	15 90	13 19	16.39	14 95	13.08	.	15 39
Pounds protein per acre. . .	.	75.40	27 07	199 80	152 20	116.60	127 20	155 90	102 50	168 00	180 20	.	154.90
SIXTEEN-YEAR ROTATION.													
Bushels per acre	13 80	15 60	33 70	23 30	22.20	10 83	12 84	20 88	13 86	18 19	Series II. 36 60	Series IV. 26 50	20 69
Per cent protein	.	12 55	17.19	19.74	16.85	18.20	17.69	17 88	23 81	14 90	13 21	18 76	17.34
Pounds protein per acre. . .	.	103 80	307 00	243 80	198 30	104.50	120 40	197 90	174 90	143 60	256 20	263 50	192 20

The probable reason for the lower protein content of wheat in the three-year rotation is that wheat is grown after cowpeas and these grow to within about a week of wheat-seeding time, hence not enough of available nitrogen is present in the soil. In the 16-year rotation wheat is grown directly after corn. While the per cent of protein in the continuous wheat was higher than in the three-year rotation, the yield of protein per acre was not so high. In the 16-year rotation both the per cent of protein and the yield of protein per acre were the highest. The figures show that variations due to seasonal changes are greater both in yield and in per cent of protein than any due to different soil treatments. The following general statements appear to be borne out by these results:

1. The years of very highest wheat yield may have the lowest per cent of protein, but at the same time the highest yield of protein per acre.

2. The years of lowest yield may have the highest per cent of protein, but at the same time the lowest yield of protein per acre.

3. Years of medium yields are likely to have wheat of high protein and high yields of protein per acre.

4. The results from the rotations show that one particular system will influence the protein content to such an extent that it will give in a series of years a consistently higher per cent of protein than another system. Thus while weather conditions may be the strongest factor in influencing the protein content of wheat, the crop rotation is an important factor. [Project 60B; Department of Milling Industry; state fund.]

Seed-bed Preparation and Tillage Methods as Factors Influencing the Quality of Wheat. The baking tests as well as the chemical work on the 91 samples of the crop of 1922 were made during the summer of 1923. From the crop of 1923, 87 samples were submitted by the Department of Agronomy. On these the milling and baking tests have been completed and the chemical work will be finished in the near future. The results on the 1923 crop have not been summarized. In general it may be said that tillage methods which increase the yield will at the same time improve the milling quality of wheat and the baking quality of the flour. The averages of the results for 11 years, 1912 to 1922, obtained from samples submitted by the Department of Agronomy, from the wheat seed-bed preparation plots are summarized in Table XV.

TABLE XV.—Influence of various soil treatments on quality of wheat.

(Average results for 11 years, 1912 to 1922)

SOIL TREATMENT.	Bushels per acre.	Per cent protein.	Pounds protein per acre.	Loaf volume, cubic centi- meters.
Disked at seeding	7.72	13.84	56.6	1,801
Plowed in September	11.37	13.88	83.6	1,834
Plowed in August	16.83	16.19	135.5	1,882
Plowed in July.. . . .	16.44	15.85	138.1	1,874
Plowed in July.... . . .	16.52	15.97	139.8	1,870
Double disked in July, plowed in September.	16.33	15.97	138.2	1,859
Double disked in July, plowed in August	16.12	16.88	144.2	1,916

It has been shown in this project that changes in protein content as affected by seasonal conditions are greater than any induced by soil treatments. But it is also evident that soil treatments given in July and August produce larger yields, a higher per cent of protein, and consequently more protein per acre, than the treatments given in September. Loaf volume is one of the most significant factors in measuring quality. While the differences shown in Table XV are not large, yet since they are the average of 11 years' work they are very significant in showing that better tillage methods give a better quality of wheat. [Project 60C; Department of Milling Industry; state fund.]

Variety as a Factor Influencing the Quality of Wheat. The baking tests and the chemical determinations on 41 samples of the 1922 crop were made during the summer of 1923. From the crop of 1923, 45 samples were submitted by the Department of Agronomy for milling, baking, and chemical tests. Besides these, 194 samples were submitted for protein tests. The work on these samples is finished except some of the chemical tests on flour. The milling and baking qualities of some of the new varieties of wheat are very high and promising, but it cannot be said that they are superior to Kanred. Kharkof has probably the best average baking quality of all varieties tested, followed closely by Kanred. In a comparison of the quality of Kanred, Blackhull and Turkey wheat varieties grown in different parts of Kansas, the work on about half of the 117 samples of the 1922 crop was done in July and August, 1923. From the crop of 1923, 122 samples were submitted for baking and chemical tests. All the work is finished except some of the chemical tests on flour, and these will be completed in the near

future. From the data obtained it cannot be said that any one of the three varieties is superior to others in the state as a whole. In some counties Kanred gave the best test, in others Turkey, and in some Blackhull, and where there was more than one test from one county the results were not by any means uniform for that county. On the whole it appears that in conditions which favor a hard wheat, Kanred and Turkey made the better showing, but this was by no means uniform, probably due to variation in local rainfall. Blackhull appears to have some characteristics of both a soft wheat and a hard wheat, and would therefore be suited to a region which has normally a greater rainfall than a more dry region in which Kanred and Turkey succeed best; that is, so far as milling quality is concerned. In a study of the protein content of wheat varieties grown in Kansas, 828 samples of wheat grown in 53 different counties were submitted by the Department of Agronomy. These were analyzed for total protein. The remarkable uniformity in the average protein content of the different varieties is apparent from the following figures:

PROTEIN CONTENT OF LEADING WHEAT VARIETIES, 1923

VARIETY.	Number of samples.	Per cent protein.
Kanred	135	12.53
Blackhull	118	12.64
Turkey	110	12.10
Fulcaster	98	12.38
Kharkof	70	12.73
Harvest Queen	51	12.32
Currell	44	12.37
Poole	40	12.32
Fultz	38	12.16
Local varieties	30	12.90
Red Sea	21	12.22
Penn. No. 44	8	11.57
Miscellaneous, 15 varieties	20	12.16

The local varieties average the highest, followed in order by Kharkof, Blackhull and Kanred. But the differences are too small to be significant from the standpoint of protein alone. Yields have also to be considered. [Project 60D; Department of Milling Industry; state fund.]

Milling Work on Wheat Shrinkage, Loss, and Damage in Farm Storage. The Department of Agricultural Economics has submitted during the year 201 samples of wheat for moisture tests, and 22 samples for milling, baking and chemical tests. This work is finished except on a few samples lately received and some work on flour. All the samples of wheat this year were comparatively low

in moisture and hence suffered no damage in storage as far as could be detected by any of the tests used. Samples high in moisture at the start lost weight in storage and samples low in moisture gained. This means that for our atmospheric conditions there is a point of moisture equilibrium which the wheat will attain in storage. This point seemed to be near 12 per cent during the last year. The project will be continued on the same general lines as last year. Some minor changes in technique are contemplated, but these plans have not been completed. [Project 143; Department of Milling Industry; state fund.]

Flour Chemistry Investigations. The principal lines of investigation as outlined previously have been continued. The work for this past year includes: (1) A study of the chemical constants of flour, *i. e.*, hydrogen ion, iso-electric point, etc. (2) A study of the gluten proteins of flour and the factors influencing gluten quality. (3) Application of lactic acid to the baking of bread. (4) A study of the viscosity of flour solutions.

The following lines of work have been completed and the data are ready for publication: (1) Investigations on the hydrogen ion concentration of different flours and mill streams. (2) A new method for the determination of the iso-electric point of flours and mill streams. (3) A new method for the preparation of dry gluten from flour. (4) The behavior of gluten under different degrees of acidity and alkalinity. [Project 60; Departments of Chemistry and Milling Industry; state fund.]

Orchard Investigations. The spraying experiments which were carried on in the station orchard during the season of 1923 dealt with two problems which are of importance to Kansas apple growers. One was a comparison of dry lime sulphur and liquid lime sulphur as to their efficiency in controlling the early infections of apple scab on the leaves of Winesap trees. On account of the apple crop failure in 1923 it was necessary to omit a study of apple scab control on the fruits. No significance differences in results in scab control were observed in the plots which were sprayed. All sprayed plots were practically free from apple scab, although the check plot had an average of 59.5 lesions per leaf. There was no appreciable difference in the fungicidal efficiency of liquid lime sulphur when combined with acid lead arsenate or when combined with tricalcium arsenate. Apple scab was not a serious pest in 1923. This was probably due to the extremely dry winter of 1922-'23, from which the pathogen did not survive sufficiently in the fallen apple leaves to cause much damage.

Spraying with either dry lime sulphur, 4 pounds to 50 gallons, or with liquid lime sulphur, 1-35, at both the cluster bud and calyx cup applications, proved to be ineffective against cedar-apple rust infections. The following is a summary of the data collected August 13, 14, and 15, 1923, concerning cedar-apple rust control:

Row No.	Spray materials used.	Number of leaves examined.	Average number of lesions per leaf.
44. . . .	Dry lime sulphur, 4 pounds to 50 gallons water, plus 1 pound acid lead arsenate	550	7.9
48. . . .	Liquid lime sulphur 1-35, plus 1 pound acid lead arsenate powder to 50 gallons	1,000	6.3
49. . . .	Check—no spray	1,000	8.0

During the winter of 1923-'24 all the red cedar trees on the Horticulture Farm were carefully inspected for the overwintering cedar apples. These were removed, and after the spring rains started in April the cedar trees were again inspected. By this time the gelatinous horns had formed on the few cedar apples which were overlooked at the time of the winter pruning. Such treatment, although rather expensive, has materially reduced the cedar-apple rust infection on the apple trees. During the last week in March, 1924, a dormant spray of commercial lime sulphur solution diluted 1 to 15 was applied to the station peach orchard. This spray gave nearly perfect control of peach leaf curl. The application of Bordeaux mixture, 3-4-50, sprayed on the trees at two-week intervals after the petal fall stage, gave excellent control of cherry leaf spot in the station cherry orchard. In the check plot a marked susceptibility of the English Morello cherry to leaf spot was noted.

The young trees in the pruning test outlined last spring made a good growth, except two which died. Note was made of the condition, growth, and set of fruit buds on the rejuvenated peach trees, pruned heavily in March, 1923. None of these trees died because of the heavy pruning, but the past winter was a very hard one on peach trees. Not only were the fruit buds killed by the low temperatures of December and January, but about fifty per cent of the preceding summer's twig growth was destroyed. The peach orchard was given good care, spraying and cultivation during last summer, and an excellent twig growth was secured. On plots 2 and 3 a full set of fruit buds developed. Not much difference could be detected between these two plots as far as number of fruit buds was concerned, but the buds were in distinctly better locations on the tree in plot 3. They were both lower in the tree and better placed to avoid breaking the branches. The deheaded trees, plot 1, made an excellent growth and, contrary to usual results, produced a light set of fruit

buds. These trees were pruned heavily again this spring and have started into good growth. They are entirely free from leaf curl for the first time in four years. Pruning apple trees by the "open head" and the "modified leader" systems was continued in the apple orchard. During the coming year, it is purposed to continue work on these lines and to expand the work on disbudding one-year-old trees at planting time, as this seems to be an untested and promising line of experiment. State circular 102, "Pruning Fruit Plants," published in February, 1924, is in part based on this experimental work. The records were also of value in the preparation of a paper entitled "Apple Varieties of the Missouri Valley" and presented before the Missouri Horticultural Society in Kansas City, December 16, 1923.

The experimental work in orchard soil management has followed much the same lines as during the preceding two years. Since good seed was obtained in 1923, the cover crop work was much more nearly normal than in 1922. The year's work could be summarized under three general heads or phases: (1) Commercial fertilizers, (2) cover crops, and (3) barnyard manure alone. The commercial fertilizers were applied in the apple orchard and the records were taken as for the previous years. A brief summary of these data would be the statement that, by the measures used, no application of fertilizer or combination of fertilizers has proved beneficial. In fact, in two of the three experiments, Winesap variety, the check trees have averaged greater growth than have the trees on any of the treated plots, and the check trees occupy an intermediate position in the other experiment, with Jonathan. This leads to a similar conclusion to that reached in other years: Commercial fertilizers on this soil do not seem to benefit the trees. The regular applications of commercial fertilizers were made on the usual date during the spring of 1924. However, the rainfall was not sufficient to dissolve these chemicals prior to May 26, so the effect, especially in the case of the sodium nitrate, will be the same as though the application had been delayed until the above date.

Cover-crop work was somewhat expanded and successfully carried through during the past year. The spring of 1924 was the first dry spring since the cover-crop treatment was started in 1921, and valuable comparative data were thus obtained. Outstanding among these are those relating to the use of wheat and rye under drought conditions. Plots planted to these crops were in bad soil condition, both as to moisture content and total nitrates, before those planted

to a legume had suffered serious depletion in either respect. Because of the drought, some of the plots were plowed earlier than usual and the yield of dry material per acre was greatly reduced. Vetch appeared to be better able to withstand drought than are the cereals. Although its growth in late April and May was retarded, the dry weather did not permanently injure it, as was shown by its very rapid development following the rains of late May. So rapid was this growth that by the date on which samples were taken some of the largest yields yet secured in this project were obtained. Soil texture was much better under vetch than under wheat or rye. Yields from self-seeded plots were less than from adjoining planted plots, but the difference, 660 pounds per acre, is not of great significance. Rate-of-seeding tests with vetch gave results parallel with those of preceding years and confirm the conclusion that heavy planting is most profitable. The best soil conditions in the cover-crop portion of the orchard during the spring drought were found in plots 17 to 19, cowpeas, which were plowed under April 2. A slight shortage of moisture seems sufficient to mask the effect of any of the soil treatment methods. The straw-covered plots continued to show good results, and the trees make growth equal to that of the Delicious trees under any other methods of management.

Barnyard manure has been applied to the peach and cherry orchard for the past two years at the rate of about 10 tons per acre. The soil on which these trees are growing is thin and unproductive and would not produce a crop of corn worth harvesting. The effect of better management on these trees has been very marked. They are now making good growth and have set an abundance of fruit buds. The yield of cherries was good last year and promises to be even better this year. This in no doubt due in part to the control of leaf diseases on these trees by better spraying as well as increased fertility and improved water-holding capacity of the soil.

Several new varieties of apple were set in the station orchard during April, 1924. One of these, the Courtland, was originated by the New York state station and is highly recommended for that section. The mean summer temperature at Manhattan is likely to prove too high for it. Very poorly shaped two-year-old trees were obtained from a New York nursery at a very high price, \$1.50 per tree. Five were planted and all have started into growth. Mr. Herman Theden, of Bonner Springs, donated five Gray's Red apple trees for the test block. These were good one-year-old trees and have started off well. This is a new variety of fine quality and a

crisp, juicy, red flesh. Some unnamed Russian cherry trees were received in the same shipment from Mr. Theden and were planted in vacant places in the cherry orchard. Other new varieties under test, with the exception of Red Bird (all of which died), made good growth last summer, and the Golden Delicious and Henry Clay, both set April, 1921, produced a few blossoms this spring but have set no fruit.

During the winter of 1922-'23 it became necessary for the Department of Horticulture to remove a mature apple orchard, known as the Marlatt orchard, situated on the Dairy Farm belonging to the College. The trees in this orchard were about 30 years of age, averaged 12 inches in diameter and consisted wholly of Jonathan. They were on rather dry clay loam soil. Inclement weather somewhat increased the cost of the work. As the work was originally planned, part of the trees were to be taken out with a stump puller and part blown out by explosives. The latter method was abandoned, however, because the representative of the powder company could not come to supervise the blasting prior to the time limit set for the completion of the clearing. As a basis of keeping the record, the time rather than the cost was adopted, as the latter is so variable. These time records were made by the foreman in charge of the work. His time is included for only such periods as he was actively engaged in labor on the job. These trees were planted 35 to the acre. The cost of man labor was 35 cents per hour and of horse labor 20 cents per hour. The data secured shows that getting rid of an orchard is an expensive piece of work, the cost per tree being \$2.10, and per acre, \$73.43. The wood was sold for \$75.10, but out of that should be deducted the cost of delivery, of which no record was kept.

The Agricultural Experiment Station apple orchard comprises about 30 acres and the trees vary in age from 1 to 12 years. Fifty-seven varieties of apples and two varieties of pears appear in the orchard. The number of trees of each variety varies from 1 to as many as 300. It has appeared necessary to prune parts of this orchard rather heavily during the past two years in order to remove interfering framework branches. This, combined with soil improvement work and the exceptionally favorable June, 1923, weather, caused a rapid succulent twig growth, and on certain varieties numerous watersprouts during the early summer. Early in June, 1923, a few twig and spur blight infections could be observed in several parts of the orchard. These were at first overlooked, as they are

similar in appearance to broken twigs. But as soon as the real nature of the trouble was recognized a survey of the orchard was made. This showed the disease to be present in nearly all parts of the planting, to be much more prevalent on some varieties than on others, and, within the variety, to have made much greater progress on certain trees than on the average. Jonathan, for example, proved to be one of the most susceptible varieties and nearly all of the 235 trees of this variety showed some blight. However, four trees, and more especially two, were so severely attacked as to indicate serious injury and possible death. These were large, vigorous 10-year-old trees. Chenango also proved to be a highly susceptible variety, judging by the one tree in the orchard, as was also Maxwell, a comparatively unknown variety.

As soon as indications pointed to a serious epidemic of the blight, steps looking to its control were taken. The first of these was a survey of the orchard to determine the extent of the injury. Next two young men who understood the nature of bacterial infection and the methods of antisepsis were employed and set to work on the diseased trees. The method of combating the pest was to remove all infected twigs well below the lowest point at which the browning appeared. The pruning implement was swabbed off with disinfectant following each cut. Infections on spurs or which had gained entrance into large branches were much more difficult to handle. If, upon the removal of a spur, the ring of cambium appeared healthy, the wound was disinfected, dressed, and left. If, however, the bacteria had spread down into the cambium of the limb, a cut was made just through the bark and following the outline of the lesion. This plate of bark was then removed, the knife disinfected, and a second cut parallel with the first and three-fourths of an inch to one inch outside of it was made. This ring of healthy bark was then removed. The wound was next disinfected, and soon after painted over with water glass at the strength of one part of water to three parts of commercial water glass. The disinfectant used in the greater part of this work was that most recently recommended by F. C. Reimer of Talent, Ore. The formula is bichloride of mercury, one ounce; mercuric cyanide, one ounce; and water, four gallons. This was used for both the pruning implements and the wounds. It was applied by means of a swab made of rags tied around the end of a stick. No metal was allowed to come in contact with the supply of disinfectant, which was carried in a wide-mouthed glass bottle. The mercuric cyanide could not be obtained

in the local market when the control measures were started, so 25 per cent commercial formaldehyde was used as an implement disinfectant and 1 to 1,000 mercuric bichloride solution for the wounds. It is a real advantage to have one disinfectant which will serve for both purposes.

The cutting of blight was continued at frequent intervals until about the 6th of August, 1923, at which time the hot and dry weather had so slowed up the growth as to enable the trees to resist the bacterium. The greater part of the orchard was gone over six times during this campaign and a number of the more seriously infected trees received several additional visits. The results obtained through the treatment described were studied August 10. On this date all the blight cuts made on eight trees of the more susceptible varieties were observed. The results of this inspection are shown in Table XVI.

It will be noted that of the 573 treatment wounds studied, only 21, or less than 4 per cent, showed evidence of active cankers at the time of the inspection. The great majority of these secondary infections, 19, were on twig cuts, and in many cases a short shoot had grown before the cut end of the twig had died. In these cases it is fully as probable that the blight gained entrance through the new young shoot as that the cut was too high or the tissue was reinfected from the implement at the time the wound was made. One of the two limb wounds in which the bacterium seemed to be continuing growth was almost certainly due to careless work. The other may have enlarged through infection from a fruit spur just above it. This spur was killed at the time of the inspection and the canker reached the edge of the former wound. Neither the Douglas nor the other pear, unnamed, showed any blight throughout the epidemic. Several small orchards near Manhattan containing Jonathan, and which, though attacked by the blight, were given no treatment, were observed. The number of infections in these trees were, if any different, fewer than in the treated trees. However, the twig infections did greater damage because they penetrated to larger branches, and, given a favorable winter for the blight, the holdover cankers and subsequent damage will prove a serious menace. Protection from the fire blight involves, first of all, the elimination of holdover cankers. If these are allowed to become active in the spring insects will carry the bacteria to the naked parts of the other trees, as the nectaries of the blossoms, or to rapidly growing tips, and new infections occur. A knowledge of the method by which an early

TABLE XVI.—Results of treatment of fire blight.

VARIETY AND TREE NO.	Treatment of twigs.			Treatment of limb lesions.			Total per cent cured.	Remarks.
	Number treated.	Number not cured.	Per cent cured.	Number treated.	Number not cured.	Per cent cured.		
MAXWELL; R. 44, No. 14.....	87	9	89	45	0	100	93	Remaining twigs badly rosetted.
MAXWELL; R. 44, No. 15.....	54	4	92	14	0	100	94	Better condition.
JONATHAN; R. 47, No. 17.....	52	2	96	15	1	93	95	A watery growth stimulated.
JONATHAN; R. 47, No. 18.....	64	2	96	17	0	100	97	Tree in fair condition.
JONATHAN; R. 47, No. 20.....	8	0	100	0	0	.....	100	Very mild attack.
JONATHAN; R. 6, No. 4.....	96	2	98	6	0	100	98	Tree in fair condition.
JONATHAN; R. 5, No. 2.....	68	0	100	5	0	100	100	Tree in good condition.
CHENANGO R. 1, No. 1.....	32	0	100	10	1	90	97	Tree now in good condition.
Totals	461	19	95.9	112	2	98	96	

summer epidemic of blight is caused indicates clearly that united community effort is necessary if the disease is to be controlled. Holdover cankers on all the pear and apple trees of the entire neighborhood must be eradicated. The planting of resistant or immune varieties and the control of the rate of twig growth are important accessories to surgery in the control of this destructive orchard disease. Though definite data are lacking, it would appear that insect control, especially that of the aphis, would greatly lessen the spread of the bacterium. [Project 25; Department of Horticulture; state fund.]

Small-fruit Investigations. Frost has compelled the postponement for one year of a number of studies which were to be commenced in the vineyard this spring. Very little fruit will be produced and the young plants are no doubt considerably weakened due to the loss of the new shoots. So far as has yet developed, no plants were killed outright by the spring freeze, and the low winter temperatures caused but little damage even to the hybrid varieties, Brighton, Agawam and Diamond. During the past winter the east 13 rows of the vineyard were trellised. Three post materials were used—boiler tubes set in concrete, osage orange wood, and home-made reinforced concrete post. Wire from the old vineyard was used. Although much of it is more than 30 years old, it seemed much better than the wire now on the market. Although this trellis was expensive to construct, it is exceptionally well built and should need but little in the way of repairs for many years. It cost about \$367 an acre, in contrast with the common estimate of \$250 an acre for commercial vineyards. More than half of the cost was for labor. Three types of trellis were built, corresponding to four systems of training which it is purposed to test out in the vineyard. These are the three-wire “fence” trellis for the fan and the four-cane Kniffin systems, the two-wire “fence” trellis for the two-cane Kniffin system, and the cross-arm three-wire trellis for the Munson system of training. Vines of each of the commercial varieties will be trained according to each of these systems. A study of the yield and quality of fruit grown on vines under each system should make possible more definite recommendations as to their relative value. Row 15 in the vineyard was this year set to the variety Lucile, and it is purposed to extend the planting of this variety as land may become available. Early this spring such brambles in the old location by the cave as had shown no orange rust infection were transplanted to the new location east of the apple orchard. So many plants had

been lost through the rust and death from other causes that both the size of the patch and the number of varieties were greatly reduced. Recent research work on the orange rust disease makes it seem probable that the only possible method of combating it will be through the production of resistant or immune varieties. Certain strains of the wild blackberries of eastern Kansas probably possess this immunity. The department is now testing one such variety, tentatively named Jackson, from the wild. It is hoped that definite experimental use of both the bramble patch and the vineyard may be started next spring. Only the freezing of the shoots on the grapes then and for the third successive year can prevent it as far as the vineyard is concerned. [Project 26; Department of Horticulture; state fund.]

Experiments with Vegetables. A new project on steam soil sterilization, with the purpose of finding a method for the control of the *Fusarium* species and nematodes attacking cucurbits and solanaceous plants in greenhouses was started. The soil in the beds was changed. Since then the rotation followed has allowed for only one crop of cucumbers and one of tomatoes, there being a crop of lettuce grown between these two crops. There has been no opportunity to study the effect of the steam sterilization, as different species of *Fusarium* attack these two crops. The nematodes were apparently successfully controlled, though the infestation was mild and the tomato crop has not yet been harvested or the roots of the plants examined. With the cucumbers no other work was planned, but the value of Bordeaux mixture was demonstrated as a control for cucurbit anthracnose. The sprayed plants produced 25 per cent more marketable cucumbers than the unsprayed following a mid-season infestation. The average production of each sprayed plant was \$2, and of the unsprayed \$1.50. The total cost of the spray and its application was about \$2, or less than 1 cent per plant sprayed. With the tomatoes a varietal test is being made. Twelve varieties of tomatoes are being tested for production of desirable fruit. The crop is as yet but half harvested, so no figures or conclusions are available. Out of doors the variety and cultural work with tomatoes was continued. In every variety but one the plants which were mulched and pruned produced more marketable fruit than those given other treatment. The Louisiana Red again outyielded the other varieties under any of the four methods of treatment. It was followed by Marvel, Norduke, Bonnie Best, and White's Number 9, a new variety. From one year's results the latter gives great

promise as a heavy yielder. It is also desirable from a point of view of earliness, marketability, and shipping qualities. This work is being continued this year, though the area given to this project has been reduced. It is not planned to carry this particular piece of work after September, 1924. On account of the marked increase of the tomato crop due to mulching, many vegetable gardeners and truckers have adopted this method of culture for several of their crops. One of them has been experimenting with melons under direct instructions from the department. His figures taken from two half-acre tracts which were compared showed from one year's work that mulching increased the net profits per acre about \$40. This year a larger area will be under observation. [Project 27; Department of Horticulture; state fund.]

Tree Investigations. During the fall of 1923 and the spring of 1924 an increasing interest in pecan planting has been noted. The success of the species *Hickoria pecan* in the northern counties, Nemaha and Jefferson, has been observed; and in Republic county, on the farm of Mr. Ed. Haney, six miles north of Courtland, seedling trees planted in 1888 are giving evidence of the adaptability of this species when planted in favorable soil. These trees were planted in a belt, designed to prevent erosion, and the soil has been deposited to a depth of approximately two feet about the pecan trees. The trees show no indication of injury from drought and have made satisfactory growth for the species. A diameter of 13 inches at 4 feet, and a height of 25 feet has been attained. Several crops of nuts of fair size and quality have been borne. The pecan planting on the College campus was uninjured by a temperature of -21° F. in the winter of 1923-'24, but the blossoms were injured by the April frost. In many cities and towns of the state there is a gratifying interest in replacing the rapid-growing but short-lived species that were planted for shade in the early years of the community with more valuable and desirable species. The demand for nursery-grown oak and walnut has been in excess of the supply. Linden, *Tilia americana*; sycamore, *Platanus occidentalis*, and tulip tree, *Liriodendron tulipifera*, are being more fully appreciated in southern Kansas, and the hard maple, *Acer saccharum*, is being planted in the northeastern counties in considerable numbers. A very marked increase in the injury to the red cedar, *Juniperus virginiana*, by the fungus, *Gymnosporangium macropus*, has been given considerable attention. In trees of small size, satisfactory control has been secured by cutting off and destroying the excrescent mass before the

development of spore-bearing tissue. Older trees in many cases required heavy cutting. The success of the removal of infected tissue and also of fungicidal sprays is being carefully noted. [Project 82; Department of Horticulture; state fund.]

DISEASES OF PLANTS

Some of the more important features of the station's work on plant diseases during the past two years are discussed below.

Cereal and Forage Crop Disease Investigations. One of the phases of this project relates to leaf rust. In this work the F₂ generation of a number of crosses of Kanred × Fulcaster, Harvest Queen × Fulcaster, and Harvest Queen × Kanred was grown in the greenhouse and the plants were inoculated with leaf rust at three stages of growth. In the seedling stage, segregation for resistance to leaf rust was obtained in the ratio of one resistant plant to three susceptible plants. In the shooting and heading stages, part of the susceptible hybrids exhibited signs of resistance, indicating the presence of modifying factors. It was found that the old leaves near the base of wheat plants were often easily infected with rust, while the upper leaves remained rust free. As the plants approached the heading stage the change from susceptibility to resistance, in the hybrids exhibiting that phenomenon, became more marked. The resistant F₂ segregates remained resistant in all stages of growth, as did also the resistant Fulcaster parents. The susceptible hybrids, Kanred and Harvest Queen parents exhibited changes in the degree of susceptibility as the plants approached maturity. Resistance to leaf rust is apparently a recessive character dependent upon a single main factor difference for its expression.

About 400 varieties and strains of wheat were grown in a rust nursery in the spring of 1923. An artificial epidemic was induced. Kanred and all other varieties which normally exhibit resistance in the field or greenhouse were heavily rusted at the end of the season. Resistant varieties became heavily rusted at a much later date than susceptible varieties. Two strains of leaf rust were found to be present in the culture used. One of these evidently produced the late season epidemic. Further studies on varietal resistance, the inheritance of resistance, and strain studies of the leaf rust organism occurring in Kansas are to be made. The plans are to produce, if possible, a variety of wheat resistance to leaf rust which will be adapted to eastern Kansas.

In the stinking smut (bunt) phase of the project, over one hun-

dred varieties of wheat were heavily smutted with *Tilletia laevis* and a similar group with *Tilletia tritici*. This material was planted in a bunt nursery in the fall. A second planting was made 10 days later. None of the wheats commonly grown in Kansas were found to be immune from attack by either species of bunt. Red Hussar and a number of other strains of wheat which were developed in the Pacific coast states were highly resistant to both species. Varieties and strains of the Turkey type that have been grown in Kansas are somewhat more susceptible to *Tilletia laevis*, the species of bunt found in the state. Zimmerman, Harvest Queen and other soft winter wheat varieties were found to be much more susceptible to *Tilletia tritici* than to *T. laevis*. Weekly sowings of a susceptible variety indicated that little infection took place until the mean daily soil temperature had fallen to about 40° F. As the soil temperature fell below that point, smut infection increased until a minimum of about 27° F. was reached. At both high and low soil temperature the percentage of infection increased and decreased with the moisture content of the soil. A large number of seed treatment were carried out in which the smut control obtained by the use of commercial seed-treating compounds was compared with that obtained by the use of the standard formaldehyde treatments. Copper carbonate and a number of commercial dusting compounds gave excellent control. Of the soaking treatments none gave more satisfactory results than the formaldehyde treatment, although chlorophol seems to be very promising from the standpoint of smut control and freedom from seed injury.

The wheat foot rot disease is not spreading at an alarming rate in the state. *Ophiolobus cariceti* and *Helminthosporium sativum* are involved in the problem in Kansas. In wheat seed-bed and tillage plots where the disease has become severe, it appears evident that early and deep plowing favors the spread of the disease, while shallow working of the soil in September appears to prevent the foot rot from appearing. The environmental factors concerned in such soil management are undoubtedly very important. Artificial inoculating varieties of wheat in the spring, using pure cultures of *Ophiolobus cariceti*, will produce foot rot. Such inoculations have been made in a variety wheat series.

In the barley smut investigations it was found that soaking both hulled and hull-less barley seed in a 1-320 formaldehyde solution for two and three hours, did not materially affect the germination of the seed and gave excellent smut control. The addition of smut

spores to hulled barley seed failed to produce infection. When smut was added to hull-less barley seed, however, the smut percentage was materially increased. The hulls apparently protect barley seed to some extent from infection by the covered smut organism.

In the oat smut studies it was found that, for hulled varieties of oats, smut percentages above 50 per cent are very difficult to obtain even when the seed carries its maximum spore load when planted. Treatment of oat seed with copper carbonate dust does not seem to give as satisfactory smut control as chlorophol or the formaldehyde treatments. Smutted oat seed has been treated with a number of commercial seed-treating compounds, but none have given more satisfactory results than the standard formaldehyde treatments, with the possible exception of chlorophol, which seems promising. Strains of artificially contaminated Burt, Fulghum and Red Texas oats have been grown for six seasons, with the result that only a trace or zero per cent smut infection was obtained. Checks and susceptible strains have shown a high percentage of smut. It seems apparent that some strains of oats, especially Fulghum, can be selected which are resistant. Pure strains of Kanota oats are showing such resistance, and as a variety Kanota displays resistance. A study of the effect of smut on actual yield is being made. About 2,000 head and rod rows are being studied in the smut nursery. Further studies on what factors are involved in resistance are to be made, as well as a continuation of strain and variety tests. The most promising fungicides for smut control will receive some attention.

The sorghum smut studies have included Blackhull kafir, Pink kafir, Red Amber sorgo, and Kansas Orange sorgo, which have been used in a seed-treatment experiment in which all varieties were treated in several different ways in each of two years. A number of commercial seed-treating compounds were used in comparison with the standard formaldehyde treatments. Slight seed injury and satisfactory control of smut were obtained when the seed was soaked in copper sulphate or chlorophol solutions, or when the seed was dusted with copper carbonate or Corona 40 S dust. Very few of the commercial compounds were found, however, to be equal to the formaldehyde treatments in smut control. Plantings of Pink kafir made at intervals during the spring exhibited a gradual reduction in the amount of smut obtained from the early to the late plantings. Some sorghum hybrids (Feterita \times Red Amber) in the F₇ generation are being grown in cooperation with the Department of Agron-

omy in the hope that some will be found which have the desired qualities for forage purposes and resistance to kernel smut. Numerous resistant hybrids have been obtained, but apparently their value is somewhat less than the juicy-stalked parent, on account of the tendency to lodge.

In the corn smut and root rot investigation a large number of inbred lines of Commercial White and Pride of Saline corn were grown and studied from the standpoint of resistance to smut and root rot. A few lines of both varieties show high resistance to both diseases. Other lines exhibit resistance to one of the diseases, while still others apparently are susceptible to both diseases. These lines of corn have been inbred three generations and many of them are approaching homozygosity for vegetative characters and resistance to disease. About 100 crosses were made between desirable lines of Commercial White. The F₁ generation was grown in the greenhouse and the F₂ generation planted in the field in the spring of 1924. A number of inbred lines of Commercial White were grown in a cooperative test in five states. In general these lines seem to be promising from the standpoint of resistance. A number of inbred lines of Kansas Sunflower and Colby Bloody Butcher gave some lines which were very low in smut and others which were high. The amounts of smut obtained in 1923 were not as large as those obtained in previous years.

Studies on the occurrence of fungous organisms found in Kansas seed corn in 1923 have further confirmed the following conclusions: (1) Practically all Kansas corn has *Fusarium moniliforme*. This organism is not confined to good or bad ears, or to rough or smooth ears. No evidence is at hand that it is an important factor in reducing the yield of corn. (2) *Gibberella saubineti* is a negligible factor in Kansas seed corn and does not enter in the root, stalk or ear-rot problem of this state. (3) *Diplodia zeæ* varies in prevalence, having been more common in corn in Kansas in 1923 than ever before reported. It is a factor in injuring the germination qualities of seed corn. (4) A modification of a method of arranging the seed on the rag doll has merits. This consists of placing the kernels in a row which is at an angle of 75 degrees. By such means the individual seedlings do not come in contact with each other as much as when the checker method is used, thereby avoiding to some extent the transfer of organisms. Extensive studies on the corn smut organism are being made to discover whether it is the same in various regions of the United States. Pure cultures from 20 states

and localities are being used in inoculation studies. The effect of temperature on the growth of the corn smut organism is underway. Further studies along the following lines are to be made: Extensive studies of resistance and susceptibility of inbred strains of corn of several varieties adapted to Kansas will be continued; studies of the technique for testing resistance and susceptibility of corn seedlings in the greenhouse; studies of the possible existence of strains of the corn smut organisms from the physiologic standpoint, and further testing of resistant and susceptible inbred strains of corn in several states are to be made; and a genetic study of what constitutes resistance to smut in maize will be made. [Project 76; Department of Botany; state fund.]

Fruit and Vegetable Disease Investigations. Continued experiments on the comparative value of the hot formaldehyde method of treating seed potatoes for the control of *Rhizoctonia*, versus the corrosive sublimate method, have sustained the results of the previous year. Both laboratory and field data support the statement that the hot formaldehyde treatment is as efficient in controlling this disease as corrosive sublimate, even when the latter is used for an hour and a half. The four-minute hot formaldehyde treatment has proved superior to the two-minute dip. An average increase of 45 bushels per acre due to the two-minute hot formaldehyde treatment was obtained in 1923 in two extensive field experiments. In the same experiments the 90-minute corrosive sublimate treatment gave an average increase of 36 bushels per acre. Increased yields of over 100 per cent have been recorded in experimental fields due to the control of *Rhizoctonia* by the hot formaldehyde method of seed treatment. Further work is under way at the present time to determine the efficiency of stronger solutions, longer dips and higher temperatures in the control of *Rhizoctonia*. Analyses of solutions of both mercuric chloride and formaldehyde were made to determine the weakening of strength when used in treating seed potatoes. The weak solutions of formaldehyde that were used were found to retain their original strength indefinitely. Solutions of mercuric chloride were found to weaken rapidly, necessitating the addition from time to time of more mercuric chloride. This weakening was more rapid when cut potatoes were used, due to the greater absorbing surface exposed to the solution. After four successive dips the strength of the solution was 57.4 per cent of its original strength when whole seed was treated, and 12.5 per cent when cut seed was treated.

Five years' results in the potato-spraying experiments show that Bordeaux sprays do not produce an increase in yield in the absence of early blight or tip burn. From the results obtained it would seem that this practice must be looked upon as an insurance against possible loss through epidemics of foliage diseases. If sprays are applied, the 4-5-50 or the 4-8-50 Bordeaux sprays should be used rather than the weaker strengths. The use of copper dusts has not been tried over a sufficiently long period to warrant a definite statement regarding their value.

During the past year work on tomato wilt disease has consisted mainly of three lines: (1) Variety and hybrid testing in the field. (2) Studies of the pathogene in the laboratory. (3) Studies of the cause of wilting. Continued work with the five most resistant varieties, namely, Louisiana Red, Louisiana Pink, Norton, Norduke and Marvel, has shown these varieties to be highly resistant to the wilt disease and productive of a tomato adapted to commercial purposes in Kansas. Especially is this true of the Louisiana Red variety, which has been further improved for uniformity of type. Kansas hybrid No. 9B has continued to be highly resistant and very productive and to yield fruit of good quality. This hybrid is now in the fifth generation, and continues to breed true for resistance and productivity. It is being increased this year for distribution to the tomato growers of Kansas. Further work upon this phase should be confined to selections within the two varieties Louisiana Red and No. 9B, the two most promising field tomatoes for Kansas conditions. The greenhouse tomato wilt problem should be stressed from now on. The varieties developed for wilt resistance and field culture have not proved desirable for culture under glass. The tomato wilt disease is causing very heavy losses in the greenhouses over the state. Work upon the development of a desirable greenhouse tomato which will be resistant is already under way. Studies of the pathogene, *Fusarium lycopersici*, have shown that in all probability physiologic races exist within the species. This is based on a study of the temperature relations, hydrogen ion ranges, growth rates and cultural characters of 24 strains of the organism representing widely separated parts of the country. There is also evidence that there are two distinct species causing tomato wilt. These studies help to explain why resistant varieties of tomatoes in one state or locality are sometimes less resistant or even susceptible in other states or localities. This points to the necessity of each state or region developing its own resistant varieties, where tomato wilt is important. This study is completed and the results are being

prepared for publication. Investigations directed toward the solution of the problem as to the actual cause of wilting have demonstrated that the organism secretes an enzyme, which, when precipitated, dried, and redissolved in distilled water, will cause young plants to wilt rapidly when their cut stems are immersed in the solution. When the enzyme solution is boiled, thus coagulating the enzyme, no wilting of young plants results. Nutrient solutions upon which *Fusarium lycopersici* has grown, were subjected to dialysis, and both residue and dialysate tested as to their power to bring about wilting. Both were capable of producing rapid wilting of young plants when the cut stems were immersed in the solutions. This proves that there is both a colloidal and crystalloidal "specific" produced by the growth of the organism, both of which are capable of producing a wilted condition in plants. This study is completed and the results are in manuscript form.

Three years' results in the cabbage yellows investigations show that Wisconsin All Seasons and Brunswick, and selections of Kansas Copenhagen are resistant to yellows, if the seed is sown in the hotbed and the plants transplanted in the field. These varieties have been found susceptible in some cases if the seed is sown directly in infested soil in the field. It is a question whether this can be explained by environmental conditions entirely, or whether strains of the causal organism exist. Three varieties from Scotland have some resistance and the required early character. Studies do not indicate that the causal organism is distributed to any extent in or on the seed. The organism causing aster yellows failed to produce cabbage yellows.

In the sweet potato disease investigations field experiments show that stem rot can be greatly reduced by careful seed selection at digging time. The type of potato can also be improved at the same time. Black rot can be practically eradicated by careful seed treatment, seed selection, rotation, the use of new hotbeds and care in the storage cellars. By controlling stem rot and black rot, together with the improvement of seed by selection, increases in yield of 100 per cent have been obtained. [Project 130; Department of Botany; state fund.]

INJURIOUS INSECTS AND OTHER PESTS

Kansas has a large number of important insect pests and several other pests which menace her plant industries. There are given below brief summaries of the results of station work on these pests during the past two years.

Climate and Injurious Insect Investigations. Considerable life-history data on the pea aphid have been accumulated. These cover information on the optimum temperature and moisture conditions, length of life, number of young produced, and the number per day under different conditions and the relation to their food plants. It appears that at temperatures slightly below their optimum (55° to 65° F.) the pea aphids live longer, reproduce more rapidly and produce more young on alfalfa than on peas; while at temperatures slightly above the optimum (80° to 90° F.) the aphids are more successful on garden peas than on alfalfa. They could not be maintained on alfalfa at high temperatures. If this proves to be constantly true, the behavior of this important insect in alfalfa fields will be readily explained. The pea aphid most commonly overwinters on alfalfa at Manhattan in the form of wingless agamic females. In the spring they reproduce even at low temperatures, reaching damaging numbers somewhat before their predators become active. It is therefore during March to May that they are injurious to alfalfa. During May and June an ever-increasing number become winged and scatter. During July and August they may be entirely absent on alfalfa. They do occur on peas, however, during this time. During September they return to alfalfa again. The behavior of this insect is greatly influenced if not controlled by weather conditions. Hence these studies are of fundamental importance, and it is hoped to continue them.

The clover root miner (*Sitona linellus*), the clover leaf weevil (*Phytonomus punctatus*), the alfalfa plusia (*Plusia simplex*) and the alfalfa caterpillar (*Eurymus eurydice*) were reared under controlled conditions for one generation. Special effort was made during the autumn to learn the conditions under which the wilt disease appears and thrives. This disease is very important at Manhattan in controlling the alfalfa caterpillar, but is uncommon at other places. As previously experienced, this is an extremely difficult problem to study. The difficulty is in providing controls which will be free of the disease. Enough has been done to indicate that humidity is of greater importance than temperature. High tem-

peratures and low humidity are less favorable than high humidity and low temperatures. The disease is less prevalent in the drier parts of the country, but after a series of heavy rains in these regions the disease may appear suddenly and practically eliminate the species.

It is purposed to change the work of this project somewhat to a phase which may bring more immediate results, and may open up some new lines of work. This work has been already begun. It is purposed to study the station notes and all published accounts dealing with yearly insect abundance in the state. On the other hand, weather data will be accumulated and the two treated mathematically for evidence of correlation. The weather data have in part been brought together. Statistics on insect abundance are more difficult to obtain, but it is known that considerable information can be had. It is hoped by these studies to find the climatic conditions favorable to the development of the more important species of insects. This should be of special value to entomologists, county agricultural agents and others in predicting injuries and in anticipating them. The accumulation of rearing data under controlled conditions will be continued. [Project 6; Department of Entomology; Hatch fund.]

Hessian Fly and Other Wheat Insects. The observations on the life history of the Hessian fly under field conditions were continued. The fact that this insect is greatly influenced by climatic conditions necessitates following the life history over a long period of years. Three distinct broods were distinguished in 1923, namely, first spring brood, second spring brood, and main fall brood. There was also a midsummer brood in some parts of the state. The recent severe outbreak of the fly in northwestern Kansas presents many new problems in the life economy of this insect, and preliminary studies are now under way. Little is known of the behavior of the fly in semiarid regions, and very little help can be given the farmers until studies are made in the area. The data thus far accumulated indicate that in case of severe drought, as in the fall of 1922, the fly holds over for much longer periods in the flaxseed stage. Studies on the distribution of the fly in Kansas during the past year show that it is now present in 87 counties, the heaviest infestation being in the northwestern quarter of the state. Some counties in this area report an abandonment of 25 per cent of the wheat acreage last fall due to fly injury. The studies on the control of the Hessian fly have been along the lines of time of planting and seed-bed preparation. At

Manhattan it was found that wheat planted before October 1 was severely injured in the experimental plots. A study of the infestation in northwestern Kansas indicates that the fly-free date is earlier than that heretofore given. Rainfall has an important part in determining the data in that area. A heavy rain on September 17 was the dividing line between severe injury and light infestation in the fall of 1923. Considerable data were secured in the influence of seed-bed preparation in relation to fly infestation in the northwest. The severe outbreak of Hessian fly in northwestern Kansas following the prolonged drought of the fall of 1922 has made it desirable to study the causes or factors producing such outbreaks. This station is now cooperating with the Federal Bureau of Entomology in such a study. Data are now being collected on all factors which may have influenced the situation. Several causes, such as abnormal rainfall during the summer of 1923, wheat abandonment in the spring of 1923, and the methods of handling the crop, apparently have had an influence on the conditions now existing in that area.

Several lines of investigation on resistance of wheat to fly injury were conducted. A study was made of the varietal differences of 27 varieties of wheat which have been under observation for several years. Several varieties, notably Illini Chief, Dawson Golden Chaff, and Miracle, continued resistant to the fly, while practically all the hard winter wheats were heavily infested. Two strains of red winter wheat which have been under observation since 1916 are worthy of mention. One strain, No. 2101, has been very heavily infested in all plots, while another strain, No. 2132, has exhibited a marked degree of resistance. These two strains have been grown side by side in a number of plots during the past few years, and have shown this same relation. A study was made of 21 selections of Illini Chief, a resistant variety, which were grown in two series of plots, and, with the exception of three selections, all were free from infestation. Varieties of barley and rye have also been under observation and have remained practically free from injury. The absence of Hessian fly on these crops and on some of the soft wheats suggests the possibility that there are physiological strains of the fly. An attempt was made during the past year to find resistant strains of Kanred. About sixty head-row selections were under observation, but with the exception of one or two rows, all were heavily infested at harvest time. Studies were begun on the inheritance of fly resistance in wheat. A large series of crosses were under observation and the data indicate that resistance is inherited. The data are summarized briefly in Table XVII.

TABLE XVII.—Data on inheritance of fly resistance in wheat.

CROSSES AND CHECKS	Number crosses studied.			Number plants examined.		
	Total	Resistant	Susceptible	Total.	In-fested.	Per cent infested.
Illini Chief X Marquis...	55	14	41	764	118	15.4
Illini Chief X Kanred....	37	19	18	595	32	5.4
Kanred X Illini Chief....	19	10	9	317	18	5.6
Harvest Queen X Illini Chief .	3	1	2	30	3	10.0
Kanred check....	7	0	7	115	34	29.5
Illini Chief check	12	9	3	180	5	2.7

A review of the literature on all phases of the resistance of wheat to Hessian fly injury was begun last year. Particular attention is being paid to any reference of varieties observed to be resistant in any locality and to any factors which might be associated with resistance. The bibliography now contains about 75 references, many of which are to obscure publications.

Experiments were conducted for the first time during the spring and summer of 1923 to determine the value of calcium cyanide for the control of chinch bugs in wheat. Some promising results were secured.

The work on insects affecting grain and grain products was continued. Studies are being made on the effect of feeding stored-grain insects on various types of food, such as wheat, bran, graham flour, various grades of flour, breakfast foods, and other wheat products. Many interesting results are being obtained. The type of food has a marked influence on the development of the insect, some foods prolonging the life cycle from two to three years. Other foods accelerate growth, reducing the normal life cycle. Plans are now being made to investigate the factors which retard or accelerate growth. [Project 8; Department of Entomology; Hatch fund.]

Corn Earworm and Other Insects Injurious to Corn. The corn earworm investigations were begun during the spring of 1908. The first two years were devoted primarily to a study of the life history and habits. Since then the work has been centered on the development of the more promising control measures. In 1918 the project was enlarged to include a study of all insects concerned with the production of corn. Two time-of-planting experiments were under observation in 1923. In the first experiment five varieties of corn (Boone County White, Commercial White, Pride of Saline, Kansas Sunflower and Hildreth) were planted on April 23,

May 1, May 8, and May 15. The results show that from the standpoint of earworm injury, May 1 was the optimum date for all varieties except Commercial White, which had the least injury in the planting of April 23. When yields are considered, April 23 was the optimum date for Hildreth, May 1 for Kansas Sunflower, May 8 for Boone County White, and May 15 for Pride of Saline and Commercial White. The second experiment was conducted at the Agronomy Farm with one variety, Pride of Saline. Plantings were made every 10 days from April 10 to May 21, three methods of planting being used, namely, listing, surface planting, and open furrow. The results of this experiment also showed May 1 to be the optimum date to plant corn from the standpoint of injury. During 1923, 19 varieties of field corn were under observation. The plantings were in three series, and owing to wireworm damage it was necessary to replant quite a lot of the corn. This had a marked influence on the experiment and the data are rather confusing. No variety was outstanding in regard to corn earworm injury and no conclusions can be drawn from the results. A test of six different varieties of sweet corn was conducted during the past summer. Considerable variation was noted in the percentage of injury to the different varieties. Golden Bantam had 81.6 per cent of the ears injured, while Country Gentleman had only 41.8 per cent damaged.

The study of various plant characters of the corn plant which might influence corn earworm damage was continued. A large number of ear selections made in 1921 have been propagated and studied in 1922 and 1923. Such characteristics as smoothness, hairiness, prolonged husks, tight husks, freedom from injury, and habit of growth, were used as a basis for selection, and notes on these factors were taken each year. The results indicate that certain selections are maintaining their resistance to earworm injury and that there is a possibility of producing resistant strains of corn. During the past year 336 hybrids in the plots of the Department of Botany were studied as to corn earworm injury and plant characters. Particular attention was paid to the prolongation of the husk, since many of these hybrids are apparently homozygous for this character. In many cases the length of the husk over the tip of the ear had a marked influence on the amount of injury, and it is desirable to observe these hybrids further. One of the most interest features of the work during the past year was the marked resistance of ears bearing a few tassel spikes on the tip. Several hybrids in the botany

plots are homozygous for this character and all are remarkably free from earworm injury. This same character was observed in field-run corn and the freedom from injury was outstanding. Selections were made for this character last fall and it is hoped to secure further data during the coming summer. Since it has been shown that the moths of the corn earworm are attracted to the odor of corn silk, it seemed desirable to study the odors produced by different varieties of corn. An attempt was made, therefore, to take up this line of investigation, and preliminary observations were made. There is an apparent difference in the odor produced by the different varieties, but thus far no method has been found for making a careful analysis of the silks. A review of the literature on the subject of ethereal substances has been started in hope that some information will be revealed as to methods of technique. Preliminary studies were begun last year on the resistance of corn to chinch bugs. The work consisted primarily of general field observations in order that information could be obtained on points of attack for this problem. Observations made on a large series of varieties, selections and hybrids in the agronomy and botany fields brought out the fact that plants showing a deficiency of chlorophyll were much more attractive to chinch bugs and were the first to succumb to attack. Plants having a deep green color or red and purple pigment were much more resistant. A preliminary study of the amount and location of lignin in the stalks was made and the results indicate that the lignin content may be one factor influencing the activity of the bugs on the different varieties.

An experiment on the protection of seed corn in storage was begun because plant breeders experience great difficulty in preventing injury to seeds which they have kept for long periods. This experiment has now been under way for a year, and three chemicals have been used. Germination tests are made each month and the results are summarized in the following table:

CHEMICAL USED.	Number germination tests.	Number kernels used.	Per cent germinations.
None (check)	11	1,100	97.9
Naphthaline	11	1,100	99.4
Paradichlorobenzine	11	1,100	99.4
Calcium cyanide	11	1,100	99.4

These studies will be continued. [Project 9; Department of Entomology; Hatch fund.]

The Control of Fruit Insects. Cooperative experiments were conducted on truck farms belonging to J. J. Hennon, South Fourth

Street, Manhattan, and H. A. Horne, Hunters Island, near Manhattan. Plots of watermelons and cantaloupes were selected for purposes of this experiment. These plots received frequent dustings with F-2 nicotine sulphate dust prepared by a commercial insecticide company. Smaller plots were dusted with calcium cyanide under different weather conditions and under varying strength. The F-2 nicotine sulphate dust gave very satisfactory control of both aphids and cucumber beetles without injury to the plants. The calcium cyanide did not give as good insect control and caused so much injury to the plants that it does not seem safe to recommend it for use on melons. [Project 13; Department of Entomology; Hatch fund.]

Control of Insects Attacking the Sorghums. The work on sorghum insects has been along the following lines: (1) The importance of Sudan grass in relation to chinch bugs. (2) The resistance of sorghums to chinch bugs. (3) Insects infesting sorghum seed. (4) Survey of insects of the sorghum field. The principal investigation along the first line was a study of Sudan grass as a hibernating place for chinch bugs. During the winter of 1922-'23 it was found that an average of 11 bugs per clump of grass successfully passed the winter. The number of bugs per clump decreased rapidly throughout the winter, as shown by the following table:

MONTH.	Average number of bugs per clump.
September, 1922	505
October, 1922	81
November, 1922	58
January, 1923	38
February, 1923	25
March, 1923	11

During the winter of 1923-'24, an average of 20 bugs per clump were found to have survived the winter. The results show that chinch bugs can hibernate in Sudan grass stubble and that as the acreage of this crop increases it will become an important factor in chinch bug control. An infestation in a late-sown field of Sudan grass on the Agronomy Farm was also studied. Here the infestation was so severe as completely to destroy the crop.

The second phase of the project is being carried on in cooperation with the Department of Agronomy. During the past year studies were made of a large series of F₄ hybrid progenies of Kansas Orange sorgo X Dwarf Yellow milo, and also of the parental varieties. Previous experiments have shown that Kansas Orange sorgo is re-

sistant to chinch bug injury, while Dwarf Yellow milo is very susceptible. It was also shown in 1922 that the various hybrids exhibit different degrees of resistance, ranging from no apparent injury to very severe damage. The work of 1923 was to verify the results of previous years and to study certain factors associated with resistance or susceptibility to chinch bug injury. Four rows of each of the parents and 66 rows of the F_4 hybrids were included in the studies this year. The results were in accord with those of previous years. Dwarf Yellow milo was very susceptible and suffered severe injury, while Kansas Orange sorgho was fairly resistant. The various hybrids exhibited marked differences. Several rows were markedly more resistant than the resistant parent, while none were more susceptible than milo. Two rows were outstanding in their ability to withstand chinch bug attack. A number of factors which might be associated with resistance were studied. These factors included seedling color, number of suckers, degree of vigor, lignin content, pith content, midvein color, and maturity. This phase of the work was of a preliminary nature and in many cases it was necessary to develop the technique. The results are indicative, however, and should be continued. Lignin and pith were especially significant.

The study of insects infesting sorghum seed in the field and in storage was continued. The angoumois grain moth continues to be the outstanding pest. Attempts are now under way to rear various stored-grain insects, especially meal worms and dermestids, on sorghum seed. The experiments thus far conducted indicate that these insects thrive better in the seeds of some varieties than in others.

Frequent collections were made in sorghum fields throughout the summer, and a good series of insects were obtained. Studies of the kafir ant and the new species of *Pheidole* were continued. A preliminary survey was made to discover the sorghum midge in Kansas. [Project 92; Department of Entomology; state fund.]

Insects Attacking the Roots of Staple Crops. Studies on the life history of Kansas May beetles were continued. The loose ends of the life histories of 17 species were gathered and prepared for publication. Regular nightly collections were made throughout the season, and once a week all-night collections were made to study flight habits. Collections of beetles and grubs were made from various sources to study ecological relationships, and some attention was given to collecting the adults found in drift of the Kansas river. Studies in the morphology of white grubs were continued to find dis-

tinguishing characters, and some attention was given to the conditions under which the insects hibernate. Studies on *Bolbocerosoma*, an important scarabæid, were begun and descriptions of three new species were published. Notes on several other species of *Scarabæidæ* were made ready for publication. Other related scarabæids studied included several species of *Trox* and *Anomala*, and a description of a new species of *Anomala* was published. The life-history studies of wireworms were continued. Because of the long life cycle, progress is slow. Collections of adults were made and are now awaiting study. Owing to abundant rainfall during the latter part of the summer of 1923, false wireworms were scarce and it was difficult to secure sufficient material to carry on life-history studies. Studies were made on the relation of insects to the soil. One of the graduate students of the department has taken up this phase of the project and has gathered considerable data which will be presented as a master's thesis. His work has emphasized the interchange of soil due to insects. Their burrowing habits were noted and their influence on the porosity of the soil was observed. Project 100; Department of Entomology; state fund.]

Insects Injurious to Alfalfa. The studies on *Cænurgia erectea* (Cram) were brought to completion and a paper published on this insect. The common name "forage looper" was proposed in this publication for this insect. The name had been previously submitted to the committee on nomenclature of the American Association of Economic Entomologists, and was unanimously approved by them. It has been found that this insect is present annually in the alfalfa fields near Manhattan. It is always well represented, but at times it is the most numerous lepidopterous insect in alfalfa. There are three full broods, and a partial fourth which succumbs usually to the cold of November and December. There is evidence indicating that it may overwinter occasionally as a partly grown larvæ, but in these studies the usual method was in the pupal state. It is a pest of secondary importance, never having been seriously injurious. It is, however, a potential pest of importance and is one of the large group taking an annual toll of the crop. The natural enemies, chiefly insect predators, as *Nabis fuscous* and *Sinea diadema* Fabr.; certain birds, as grackles, robins and sparrows; larval parasites, as *Winthemia quadripustulata* Wied.; and an egg parasite, *Trichogramma minutum* Riley, are in evidence throughout the summer and assist in holding it in check. It was observed repeatedly that the usual cutting of alfalfa is the most important check on them.

Practically all of the larvae disappear during the cutting, and the next generation must be bred from eggs deposited on the new growth. The published paper contains biological data, description of stages, a list of the important published papers, and a plate of drawings.

Two sowings of grasshopper bait made with amyl acetate as a substitute for lemons were made in tests against baits made according to the usual Kansas formula, and the commercial brands. The first sowing was made at the Agronomy Farm, where the red-legged locust was fairly plentiful the latter part of June. The results were inconclusive because the hoppers scattered immediately following a rain, and there were really not enough hoppers in the first place. The next sowings were on the dairy fields of the College Farm and were inconclusive because of too few hoppers. There were many dead hoppers found in both cases. No objections to these changes in the formula were noted. In fact, the commercial bait and amyl acetate baits both had a stronger and more attractive odor, as far as the human is concerned, than the lemon bait. This work will be continued.

A severe outbreak of the garden webworm (*Loxostege similalis*) occurred during July and early August, 1923. This insect was studied intensively. The insect was reared for two generations and daily field trips were taken to watch its progress. This insect appears first on certain weeds (chiefly *Amaranthus* spp.). The best control tried was cutting the alfalfa as soon as it begins to show injury, leaving a strip around the field, then spraying it and the weeds along the fence row with a driving spray of arsenate of lead. Most larvae in the field perish from the heat, from the action of enemies and from starvation when the alfalfa is cut, while the poison gets those which migrate to the borders. Poison bran mash, which was recommended by some county agricultural agents, was found to be absolutely ineffective. The time of the previous cutting determined largely the degree of injury, it was observed. The third, or August, generation proved to be exceedingly light. Many photographs and some drawings were made during the outbreak.

The pea aphid was studied during the year. They returned to the field in September and October in fair numbers. In November intensive rearings were made at the insectary. A small outbreak was found south of the horse barn at the College, and control experiments were carried on. Practically 100 per cent control was effected with calcium cyanide flakes at the rate of 100 pounds to the acre. Serious burning of plants resulted, but the plants soon recovered.

The growth was practically the same as on the check plot at cutting time. Fair control was effected with nicotine dust, both 27 and 4 per cent dust applied at 50 and 30 pounds per acre, but poor results were obtained with calcium cyanide "B" dust, chiefly, it is believed, because of the weather conditions at the time of application. A machine for collecting pea aphids, and in fact all kinds of alfalfa insects, was made. Certain adjustments will be necessary, it was found at the first trial, but the machine is promising. This will be useful for collecting pea aphids, tarnished plant bugs, and all lepidopterous larvae. The work with this machine will be continued. The Departments of Agronomy and Shop Practice have been especially generous in connection with the building and trial of this machine.

The green clover worm (*Platypena scabra*), alfalfa caterpillar (*Eurymus eurydice*), clover sitones (*Sitones linellus*), (*Phisia simplex*), *Ptychopoda inductata* and a number of other insects were reared and studied in the field as time permitted. These observations are almost entirely biological.

It has been observed for several years that the chinch bug (*Blissus leucopterus*) was common in alfalfa at certain seasons. Last fall large numbers went into hibernation in alfalfa fields. These questions arose: How important are alfalfa fields in the overwintering of this species? and do the bugs feed on alfalfa? Preliminary tests appear to indicate that the bugs feed readily on young growth and that they overwinter both in alfalfa clumps and grass in the field. This work is being continued.

The census of alfalfa insects has been carried along, and Part I, listing over 200 species collected on alfalfa, was reported in a paper before the Kansas Academy of Science at McPherson, April, 1924. Most of these insects have been determined by specialists in all parts of the United States. Biological and field notes were included with all the species. The collection is now contained in 17 Schmitt boxes. [Project 115; Department of Entomology; state fund.]

Shade Tree Insects. Eleven trees were banded November 1, 1923. On November 15 the first fall cankerworm moth was taken from the band. The last fall cankerworm moth was taken December 7, 1923. The total number of male cankerworm moths taken was 17. The total number of female cankerworms taken was 3. The maximum emergence of fall cankerworm moths was on November 16 and 17. Four cankerworm moths were taken each day. On February 2, 1924, the first spring cankerworm moth (female) was

taken on the tree bands. The last spring cankerworm moth was taken on March 23, 1924. The total number of spring cankerworm moths (females) was 17. The total number of spring cankerworm moths (males), 15. The maximum emergence of spring cankerworm moths was on February 7, 1924, On this date 3 males and 4 females were taken. [Project 116; Department of Entomology; state fund.]

Investigations for the Control of Injurious Rodents. The work of this project recently has included: (1) A study of the life history of the pocket gopher, continued from the previous year. (2) The influence of the ovary on the resorption of the pubic bones of the female pocket gopher. (3) The value of the bull snake as a natural enemy of the pocket gopher and other injurious rodents. (4) The value of calcium cyanide in the control of pocket gophers. (5) Through the cooperation of the Division of College Extension and the United States Biological Survey, 32,771 quarts of poisoned oats and 1,488 pounds of calcium cyanide were prepared and distributed for the control of injurious rodents. Additional data bearing on the breeding habits of the pocket gopher have been obtained. It has been found that if the spring, and consequently the breeding season, is early, and the fall late, the young females may reach sexual maturity and breed during late summer, making two generations in one season. It has also been found that adult females may have more than one litter during a summer. Additional embryological material has been collected in connection with the life-history study, and it is thought that enough material is at hand to work out the complete embryological development. The experimental investigation of the influence of the ovary on the resorption of the pubic bones of the female pocket gopher is complete. It seems well established that the ovary plays an important rôle in the resorption of these bones. Bone resorption seems to be limited to the pubic bones, as analyses of the femurs seem to demonstrate that they are not affected. A complete record of food, molts, hibernation and growth of bull snakes has been kept for two years, and their economic value as a natural enemy of the pocket gopher and other injurious rodents has been well established. The value of calcium cyanide in the control of pocket gophers has been studied and has given some favorable results. During the spring months it was found to have over 90 per cent efficiency, but during the dry summer months it had only 50 per cent efficiency. This may be due to the moisture content of the soil, and more work must be done to find the cause of this variation. [Project 84; Department of Zoölogy; state fund.]

Parasitological Investigations. The work recently has been centered upon the large roundworm (*Ascaridia perspicillum*), parasitic in chickens. The following phases have been pursued: (1) Further studies on the occurrence and life history. (2) The effects of this parasite on chickens. (3) The viability of the eggs of this parasite when placed out of doors under conditions similar to those in a poultry yard. Examinations of 1,000 chickens from the vicinity of Manhattan show that 51 per cent were infested with *Ascaridia perspicillum*. The eggs of the parasite hatch in the small intestine of the chicken, and the larvæ burrow deeply among the intestinal villi, often making openings which cause loss of blood, and occasionally boring through the wall of the intestine, pursuing a migratory course through the liver, lungs, trachea, and back to the intestine again. The young worms mature in about two months in the intestine of the chicken. Experiments on several hundred chickens indicate that the parasites have very detrimental effects upon young chickens when large numbers of the eggs are swallowed. Extracts of the worms injected subcutaneously produced similar effects. Experiments on fertile eggs of this parasite placed out of doors at the surface and at various depths indicate that under unshaded conditions the heat of the sun in July and August in Kansas may constitute a lethal factor for eggs on the surface and buried to depths no greater than six inches. Eggs placed in shaded soil survived rather long exposures. [Project 79; Department of Zoölogy; Adams fund.]

Embryology of Parasitic Worms. The work of this project recently has been of three kinds: (1) A study of the behavior of newly hatched nematode parasites in the intestines of their hosts—a continuation of work done last year on this project. (2) The infectivity of some human hookworm larvae which had lived 18 months in the zoological laboratory was tested. (3) Feeding experiments were conducted to test the alleged identity of *Ascaris lunabricoides* L. of man and *Ascaris suum* Goeze of the pig. Studies on the behavior of newly hatched nematode larvæ indicate that in the family Ascaridæ the larvæ, after hatching in the intestine of their host, penetrate the wall of the intestine and migrate to the liver and lungs and pass up the trachea to the mouth, where they may be lost or swallowed with food and carried to the stomach and intestine again, where they may grow to maturity. Larvæ of nematodes belonging to the family Heterakidæ seldom migrate over the body before settling down in the intestine to grow to maturity. Larvæ of nematodes belonging to the family Oxyuridæ apparently do not

migrate at all before settling down in the intestine to grow to maturity. In the studies on the hookworm larvæ the following results were obtained: Sheathed hookworm larvæ (probably *Necator americanus*) lived 18 months in a culture of cistern water, equaling a world's record for age of hookworm larvæ. The temperatures to which they were exposed varied from 45° F. to 98° F., with fluctuations between 60° F. and 85° F. most of the time. Infectivity tests, made with an adaptation of the Goodey method, and with a live rat, showed that these 18-month-old larvæ responded to heat stimulation, but indicated that they were no longer infective, as none of the larvæ penetrated either the parchment or the skin. From the tests on the alleged identity of the human and pig *Ascaris*, it appears that the human *Ascaris* does not mature in the pig nor does the pig *Ascaris* mature in man. The two parasites are morphologically similar but physiologically distinct. The studies showed, however, that when young pigs swallowed large numbers of eggs of the human *Ascaris* serious lung affections ("thumps") occurred from the invasion of the migrating larvæ, demonstrating that there is danger from insanitary conditions even about a pig yard. On this project during 1924-'25 it is planned to continue the studies on the behavior of newly hatched nematode larvæ in the bodies of their hosts. It is obvious that the damage done by the parasite is in some way related to the extent to which the parasite migrates over the body of its host before settling down in the intestine to grow to maturity. [Project 119; Department of Zoölogy; state fund.]

INVESTIGATIONS IN THE ANIMAL INDUSTRIES

Although Kansas agriculture is known chiefly for its plant industries, its animal industries are extremely important. The state ranks twelfth among the states of the Union in the number of milk cows and fourth in the number of other cattle. And Kansas ranks high in the number of horses, pigs and chickens. The following brief discussions cover some of the important work of the station during the past two years on problems which are directly involved in these animal industries.

The Nutritive Requirements of Swine. The present phase of this project was started in July, 1922, with 18 head of Poland China gilts. Sows Nos. 110, 120 and 199 from lot 1, receiving white corn, tankage, and bone ash, were eliminated from the experiment January 1, 1924. Sows Nos. 110 and 120 failed to come in heat in the spring of 1923 and did not produce pigs in the fall of 1923. Sow No.

199 produced weak pigs, only one of which lived to weaning time and it is decidedly lacking in vitality. Sow No. 101, lot 2, receiving white corn, tankage, bone ash and butter fat, was eliminated from the experiment January 1, 1924. She had a litter of very weak pigs, all of which were blind and none of which lived more than a few hours. Since farrowing she has not settled to repeated services of a boar. Sow No. 133, receiving the same ration, has acted very much the same as sow No. 101, except that her pigs were not blind at birth. She also was eliminated January 1, 1924. The sows eliminated January 1, 1924, were placed on green winter pasture and fed corn, shorts, and tankage. The sows themselves failed to respond in any marked degree to this treatment, but sow No. 110 from lot 1 and No. 113 from lot 2 farrowed spring pigs that were much stronger and thriftier than pigs from the same sows farrowed while on experiment.

When nervous disorders began to appear certain sows were fed cod liver oil. Sow No. 96, lot 3, receiving white corn, tankage, bone ash, and sprouted oats, began to show symptoms of disorders on June 9, 1923. After July 9, 1923, she was fed cod liver oil at the rate of one-half ounce per day. She made some improvements while on this treatment, but never reached a normal condition. She was killed and posted on February 23, 1924. At that time she was in very bad condition, not having eaten for a week. The lungs were full of pus and the right lung had grown fast to the walls of the chest cavity. Sow No. 126, lot 1, receiving white corn, tankage, and bone ash, began to show signs of a breakdown about July 10, 1923. As she was not to be fed cod liver oil, she was separated from the other sows in this lot so that she could not get any cod liver oil from their excreta. She died November 13, 1923, and at that time was very emaciated and anemic. There was more inflammation of the intestinal tract than in any pig so far posted. There were several large abscesses on the intestines, and the quantity of hair in the stomach gave evidence of a depraved appetite.

Since January 1, 1924, three sows in the experiment have farrowed pigs. Sow No. 107, lot 4, receiving white corn, tankage, bone ash, alfalfa, sprouted oats, and cod liver oil, farrowed 10 live pigs on March 26, 1924. These were all big, strong pigs. The sow crushed one and two have died of broken blood vessels. The other seven pigs lived until weaning time and are all growing nicely. Sow No. 132, lot 3, receiving white corn, tankage, bone ash, sprouted oats and cod liver oil, farrowed on April 7, 1924, five live and two dead pigs. These pigs were all very small and weak, and as the sow gave

little milk they died in a few days. The sow died April 11, 1924, and upon post-mortem examination it was found that a rupture had occurred between the right and left ventricle of the heart, causing poor circulation. The lungs were full of blood, showing that hemorrhages had occurred. There were also a large number of pus pockets in the lungs. Sow No. 99, lot 3, receiving white corn, tankage, bone ash, sprouted oats, and cod liver oil, farrowed five live and one dead pig on May 3, 1924. These pigs, while small at birth, have grown nicely and are developing satisfactorily at the present time.

On January 1, 1924, the sows in lots 1 and 2 were discarded as previously indicated. One group of sow pigs farrowed in the fall of 1923 were used to replace lot 1. This group consisted of six head and were placed on the same ration—white corn, tankage, and bone ash. Since being placed on experiment this group have not grown rapidly, are rather rough coated, and are rather cramped and stiff in their movements. At times there is some discharge from the eyes, but so far this is not regular. Another group farrowed in the fall of 1923, consisting of four head, were placed on a ration composed of white corn, tankage, bone ash, alfalfa, sprouted oats, butter fat, and cod liver oil. Since January 1, 1924, these pigs have grown well. They are very active and always have keen appetites. Theoretically this ration contains everything necessary for normal growth and reproduction. It is assumed that if this ration does not permit normal growth and reproduction some other factor has been overlooked—probably exercise. The results secured from this lot will indicate the necessity of exercise studies. [Project 38; Departments of Chemistry and Animal Husbandry; state and Adams funds.]

The Efficiency of Varying Amounts of Cottonseed Meal When Fed as a Supplement to a Full Feed of Corn, Alfalfa, and Silage, and Incidentally the Relative Value of Cottonseed Meal and Linseed Oil Meal. This year's work was, in the main, a repetition of last year's, involving a study of the amount of cottonseed meal to feed with a full silage ration fed with alfalfa hay and corn to calves being fattened for market. A second phase of this year's work was a comparison of cottonseed meal with linseed oil meal as a protein supplement to a full feed of silage when fed with alfalfa hay and corn to calves being fattened for market. Four lots of calves were used. Lots 1, 2 and 3 were fed all the silage and corn they would consume, together with two pounds of alfalfa hay per head per day. In addition, lot 2 received one pound of cottonseed meal per head per day and lot three received two pounds of cotton-

seed meal per head per day. The results of two years of work indicate rather strongly that one pound of cottonseed cake is the correct amount to use to supplement a heavy feed of silage in a ration used to fatten calves for market. The use of linseed oil meal did not increase daily gains and increased slightly the cost of gains, but the increased bloom and finish commanded a price high enough to make the use of linseed oil meal slightly more profitable than the use of cottonseed meal. [Project 78; Department of Animal Husbandry; state fund.]

Full Feeding of Calves on Grass versus Full Feeding in a Dry Lot During Summer Months After Having Been Carried Through the Winter on Virtually a Maintenance Ration, the Basic of Which Was Silage. One lot of calves was wintered on a ration consisting of 22.83 pounds of cane silage and 3.5 pounds of alfalfa per head per day; another on 22.84 pounds of cane silage and one pound of cottonseed meal per head per day. The first lot gained 65.3 pounds per head during the winter and the second 84.6 pounds. On April 1, 1923, half of each lot was grouped together as lot 2a and the other half of each lot as 3a. Both these lots were started on full feed in a dry lot on that date. Lot 2a was continued on a full feed in a dry lot throughout the summer, Lot 3a was continued on a full feed throughout the summer, but was transferred to a blue-stem pasture on May 1, 1923. A comparison of full feeding during the winter with roughing through the winter and full feeding in a dry lot during the summer was made. The results of the test indicate that full feeding calves during the winter and marketing during the spring is more profitable than roughing calves through the winter and full feeding during the summer, either in a dry lot or on grass in spite of the fact that they command higher prices in the fall than in the spring. They also indicate that full feeding calves through the summer on grass is more profitable than full feeding calves through the summer in a dry lot. [Project 78; Department of Animal Husbandry; state fund.]

Sex Type as Related to Functional Development and Performance in Shorthorn Cattle. Very little could be done with the cows in this experiment during the past year other than maintain them in good condition and study the development of their offspring of recent years. This year's work started with ten cows officially in the experiment. During the year three have died, as follows: Cream Toast 87609 (probably old age), Gwendoline 79th 217427

(foreign body in thoracic cavity), and Lady Lavender 498760 (ruptured diaphragm). These deaths leave officially in the test on June 1, 1924, seven cows, as follows:

College Emma 106095, calved October 11, 1910.
Collynie Maid 647512, calved July 24, 1916.
Matchless Rose 648540, calved March 10, 1917.
Pride's Bessie 206445, calved June 6, 1912.
Type's Queen 925342, calved December 15, 1919.
Village Emily 489203, calved December 29, 1915.
Dale's Rose 790447, calved February 18, 1917.

Calves were dropped by cows officially in the test from July 1, 1923, to June 1, 1924, as follows:

College Emma 106095—September 25, 1923—Heifer.
Matchless Rose 648540—October 16, 1923—Bull, steered.
Dale's Rose 790447—November 22, 1923—Bull, steered.

Collynie Maid 2d 1020348, calved January 11, 1921, out of Collynie Maid 647512, that made the Advanced Registry with a record of 8,108.8 pounds of milk, calved February 21, 1924. She has been milked, and to June 1, 1924, a period of 92 days, produced 1,442.3 pounds of milk, an average of 15.67 pounds per day—not a satisfactory record for a cow of her age during the first three months of a lactation period. Because of lack of funds necessary to maintain this work on the large scale necessary to produce reliable results, the experiment is to be discontinued. [Project 97; Department of Animal Husbandry; state fund.]

Hogging Down Corn. There are two phases to the work done under this part of the project: (1) A study of the relative efficiency of corn and kafir for fattening feeder hogs when both are hogged down. (2) The relative efficiency of hogging down and feeding corn by hand in a dry lot in fattening feeder hogs. Since it had been suggested that the time of turning into fields of corn and of kafir might affect results, one group of hogs was turned into an acre of corn and another into an acre of kafir on September 13, 1923. Similar groups were turned into similar areas of corn and of kafir on October 13, 1923. It required 2.4 bushels more kafir than corn to produce 100 pounds of gain when the hogs were turned into the fields September 13, and 4 bushels more kafir when turned into the fields October 13, showing that kafir hogged down is less efficient than corn and becomes less efficient as it approaches maturity. This probably is because less grain is masticated and digested as the grain matures. The decrease in the efficiency of corn as it became more mature was insignificant compared to the decrease in the case of kafir. The increase in the amount of corn required to

make 100 pounds of gain was 21.32 pounds when turned in October 13 instead of September 13.

In comparing hogging down with hand feeding in a dry lot, a 40-day hogging-down period was compared to a 30- and a 60-day hand-feeding period. To produce 100 pounds of gain the 40-day hogging-down period required 8.7 bushels; a 60-day hand-fed period, 6.6 bushels; and a 30-day hand-fed period, 4.9 bushels. The hand-fed pigs gained 2.14 pounds per head compared to 1.53 pounds for the pig that hogged down corn. These figures indicate wastefulness in the practice of hogging down corn in this section of the country. During the period when hogging down is going on there frequently is considerable rain and very little or no freezing weather, whereas in the north the ground is frozen and little corn is lost. During the period the hogging-down work was in progress this year, 4.17 inches of rain fell and there was no freezing weather, the lowest temperature being 26° F. for only a few hours. The results secured in 1923-'24 are almost identically the same as were secured in 1922-'23. [Project 110; Department of Animal Husbandry; state fund.]

Mineral Supplements in Swine Feeding. Twelve lots of pigs were used in this work. Lots 1 to 6, inclusive, received corn and tankage as a basal ration and lots 7 to 12, inclusive, received corn, tankage, and alfalfa hay. The additional feeds for each of the lots of these two series, lots 1 to 6 and 7 to 12, were: Lots 1 and 7, basal ration, no mineral added; lots 2 and 8, basal ration plus salt; lots 3 and 9, basal ration plus ground limestone; lots 4 and 10, basal ration plus 20 per cent acid phosphate; lots 5 and 11, basal ration plus salt, ground limestone, and 20 per cent acid phosphate; and lots 6 and 12, basal ration plus salt and earth. The most striking result of this test is the fact that the pigs receiving corn, tankage and alfalfa hay gained 0.51 of a pound per head per day, whereas the pigs fed corn, tankage, alfalfa hay and mineral made a daily gain of 0.52 of a pound per head. The results of this particular test are in harmony with previous work done at this station and point strongly to a conclusion that minerals are not needed with an ordinary, well-balanced ration, and when considered with the results of other work, that vitamins are of far more importance in planning hog rations than minerals in this section of the country. [Project 110; Department of Animal Husbandry; state fund.]

Feeding Western Lambs. There are two phases to this year's lamb-feeding investigations: (1) A comparison of the value of alfalfa, sweet clover, Sudan grass and cowpea hays as roughages when

fed with shelled corn to lambs being fattened for market. (2) A comparison of the value of threshed kafir and unthreshed kafir heads as the grain portion of a ration when fed with alfalfa hay to lambs being fattened for market. The efficiency of the roughages fed, based upon the return received per ton for each was as follows: Alfalfa, 100 per cent; sweet clover, 95 per cent; cowpea hay, 87 per cent; Sudan grass hay, 56 per cent. The relative efficiency of corn, threshed kafir, and unthreshed kafir heads, when each was fed with alfalfa hay, was: Corn, 100 per cent; unthreshed kafir heads, 96 per cent; threshed kafir, 90 per cent. [Project 111; Department of Animal Husbandry; state fund.]

A Study of Pasture Values and Pasture Methods for Horses, Cattle, Sheep, and Swine. The past two years' work has been a continuation of a study of methods of securing stands of different kinds of pasture crops and observing their response to grazing. An important feature that cannot be fully reported on at this time is the susceptibility of Sudan grass to chinch bugs. Sudan grass suffered more last year from the attacks of chinch bugs than any other crop, grain or forage. Cowpeas were tried as a sheep pasture, but sheep refused to eat it until starved to it and then ate it very sparingly. They cleaned every weed out of the cowpeas before touching the cowpeas. This same cowpea pasture crop made a splendid hay crop, which was eaten readily by the same sheep that refused to eat it as a pasture crop. Soybeans have been planted and its adaptability as a sheep pasture crop for this section of Kansas will be tested this year. Sweet clover studies to date indicate that a good seed bed is essential to successful sweet clover production. It has also been found that scarification is essential and that much seed represented to be scarified is not, and that in most instances where a stand is not easily secured either an improper seed bed or unscarified seed is responsible. [Project 142; Department of Animal Husbandry; state fund.]

Farm Flock Management. Conditions prevailing on most farms in Kansas are such that a farm flock of sheep should return a greater net income than any other class of live stock, poultry included, but there are very few definite data available to guide farmers in establishing and handling a farm flock. Farm flocks may be handled in at least two ways: (1) Purchasing old ewes in the early fall, breeding early, and marketing ewes, lambs and wool before the following July. (2) Purchasing young ewes, breeding early in the fall, and marketing lambs and wool before July, keeping the ewes

for several years before marketing them. In the fall of 1923 it was planned to secure data relative to the first method mentioned, and fifty old broken-mouthed western ewes were purchased at Kansas City on September 28, 1923. They weighed 119 pounds and cost \$7 per hundred weight, or \$8.33 per head. They were divided into three groups and one group had the service of a Hampshire ram, another group a Shropshire ram, and a third group a Dorset ram, from October 1 to November 1, 1923. These ewes were fed through the winter principally on cheap roughages. The estimated cost of feed per ewe to June 1, 1924, is \$3.

One ewe died and two ewes proved not to be breeders. The 47 that bred were suckling 55 lambs that averaged 68 pounds in weight on June 1, 1924, at an average age of approximately 82 days. The ewes averaged 131 pounds in weight and have produced an average of 8 pounds of wool per head. The lambs sired by the Hampshire ram averaged 70.3 pounds, those by the Dorset ram, 69.2 pounds, and those by the Shropshire, 64.3 pounds per head. This is a matter of considerable importance that must be given further study. With a bunch of young ewes that can be kept for a term of years it would be possible to check more carefully by alternating groups. It is particularly desirable that this be done with the Dorset and Shropshire rams. It is planned to repeat this test next year with the purchase of a small band of young western ewes. [Department of Animal Husbandry; state fund.]

The Influence of Exercise on Reproduction in Hogs. Eight closely related sows farrowed in the spring of 1922 were divided into four lots of two each in November, 1922. They were all bred to the same boar. The method of feeding, exercise given, and the average weight per pig at farrowing time and at 30 days of age, in the spring of 1923, are shown in Table XVIII.

TABLE XVIII.—Results of test on influence of exercise on reproduction in hogs.

Lot No.	Ration.	Exercise.	Av. weight per pig at birth.	Av. weight per pig at 30 days of age.
1	Corn alone	Yes	<i>Pounds.</i> 1.97	<i>Pounds.</i> 11 75
2	Corn, tankage.	Yes	2.07	14 08
3	Corn alone.	No	1.97	7.67
4	Corn, tankage.	No	1.90	11 84

The fact that the pigs from sows fed corn alone during pregnancy and the first 30 days of nursing, but *having exercise*, were practically as large as pigs from sows fed corn and tankage during pregnancy and the first 30 days of nursing, but *having no exercise*, is a strong indication of the influence of exercise upon the strength, thrift and growth of pigs sows produce. [Department of Animal Husbandry; state fund.]

Growing Stocker Pigs. Indications point strongly to the practice in Kansas of producing stocker hogs out of spring pigs and finishing them on the new corn crop as being more profitable than full feeding from weaning time. There are many angles to this problem. An important one is making, as cheaply as possible, the spring pig grow thrifty but thin and weigh 100 pounds around November 1. A start was made during the past year in studying this problem. The test was started June 15, 1923. Results are given in Table XIX.

TABLE XIX.—Results of test in growing stocker pigs, summer of 1923.

Lot No...	3	4	5	6	7
Number of days of test ..	90	90	120	120	120
	<i>Pounds.</i>	<i>Pounds.</i>	<i>Pounds</i>	<i>Pounds</i>	<i>Pounds.</i>
Av. weight per pig at weaning time when test started	53 81	51 45	43 11	41.59	44.26
Av. final weight per pig.	105 89	105 89	102 33	102 33	102 45
Av. daily gain.... . . . .	.59	.61	.49	.51	.48
Av. daily ration:					
Corn...	1 40	1 40	1 43	1.43	1 43
Tankage.... . . . .	.11	.11	.15	.15	.15
Concentrates fed after weaning to produce a 100-pound feeder pig on alfalfa:					
Corn	126 00	126 00	171.00	171.00	171.00
Tankage	9 90	9 90	18 00	18 00	18 00

The larger and older pigs made better use of their feed and made the 100 pounds by September 15. The smaller and younger pigs required a longer time and more feed. This problem will receive further study in which special attention will be given age of individual pigs as well as groups. [Department of Animal Husbandry; state fund.]

Factors Influencing Mineral Metabolism of Dairy Cows. The first work on this project is a study of the influence of the ovaries on calcium retention in lactating dairy cows. Four lactating dairy cows were selected. A metabolism experiment was conducted with these animals through a period designated as A, consisting of four weekly trials known as Trials I, II, III and IV. During this period

the cows were in a normal condition. At the end of the period the ovaries were removed from two of the cows. As soon as these animals had recovered from the operation the project was resumed and Period B started. This period was conducted in the same manner as Period A, excepting that the two normal animals were injected daily with ovarian extract in amounts varying from 15 to 55 cubic centimeters. Owing to the fact that the removal of the ovaries so affected the animals that they went off feed, it was necessary to extend this period somewhat to get the necessary comparison. Accordingly the two animals receiving ovarian extract were on experiment for five weekly trials known as Trials I, II, III, IV and V. One of the animals with ovaries removed was subjected to four trials and the other to three trials. At the completion of the metabolism experiment, and in consideration of the preponderance of data already collected, it was thought advisable to treat these animals with ultraviolet light to see if it might be possible to influence further the calcium metabolism. Accordingly, Period C, consisting of a one-week trial, was conducted with the animals whose ovaries had been removed. The various daily samples have been composited to make 127 samples. These samples have been analyzed and part of the data compiled, but it will be some time before these data are ready for publication. It is hoped that by July 1 the results on the calcium balance will be available, and barring extensive repetition of analyses, the remainder of the figures should be available by August 1.

Owing to the fact that the equipment and personnel from the previous work were available and could be used, it was considered expedient to go ahead with the test of ultra-violet light. Four lactating dairy cows were selected. A metabolism experiment is now in progress, This project is divided as follows: Period D, two weekly trials, I and II, animals fed and cared for in a normal manner; Period E, two weekly trials, I and II, animals fed and cared for as in Period D, but treated daily for 15 minutes with ultra-violet light; Period F, two weekly trials, I and II, conducted in exactly the same manner as Period D. The object of Period F is to determine how long the effects of the light treatment in Period E will influence the calcium balance. [Project 147; Departments of Dairy Husbandry, Chemistry, and Veterinary Medicine; state fund.]

Sunlight in Relation to the Growth of Calves. Work on this project was purposely postponed until the period of the year when the days are longer and the sunlight brightest. Eight grade Hol-

stein calves dropped between May 6 and 25 were obtained from the State Hospital herd at Topeka. The calves were weighed and measured on June 5, 6 and 7, after which time they were placed on the experiment. The calves are all being fed the same, the only difference being that four of the calves have access to sunlight and four are deprived of sunlight. There are no results to report at this time. [Project 148; Departments of Dairy Husbandry and Chemistry; state fund.]

Dairy Cattle Feeding Investigations. The work of this project consisted of the feeding of one lot of cows and one lot of heifers to determine the efficiency of ground kafir seed as compared with corn chop, for milk production, and to compare the efficiency of ground kafir seed and ground cane seed with corn chop in growing dairy heifers.

One lot of eight cows was fed by the double reversal method through three 30-day periods. Each period consisted of a 10-day preliminary period and a 20-day feeding period proper, from which data were used. It became necessary to use one of the cows in the lot for another experiment, so that results were obtained from only seven animals. A basal ration of alfalfa hay and cane silage was used and in addition a grain mixture consisting of four parts of the grain to be compared, two parts of wheat bran, and one part of linseed oil meal. Corn chop was used in the grain mixture during periods one and three, and kafir chop during period two. While on the kafir chop ration the lot averaged slightly higher in body weight, but the difference was not significant. As in the previous trial, both the milk and the fat production were lower while the cows were receiving the kafir grain ration, but the decrease in production was only 4.8 per cent in milk and 3.1 per cent in fat.

Three lots of four heifers each were used to compare corn, kafir, and cane seed as grains for growing heifers. The heifers varied in age from eight to fourteen months at the beginning of the experiment and represented four breeds. They were as evenly divided according to size as possible. All heifers were fed a good quality of alfalfa hay, supplemented in Lot I with corn chop, in Lot II with white kafir chop, and in Lot III with ground cane chop. Feeding was regulated by the weight of the calves and in accordance with the requirements for growth as given by Morrison. The heifers were weighed for three successive days each month, height at withers being determined the middle day of each weighing period. Salt was provided for each heifer and water was available during the day.

The heifers were fed individually, but were given access to a dry lot during the day. The heifers were placed on feed on January 7. The results indicate a slight superiority of the corn over the kafir and of kafir over cane so far as weight and condition are concerned. However, the kafir lot has made an average increase of 8.12 centimeters in height as compared to 7.12 centimeters for the corn lot. The average increase in height of the cane lot is only 5.75 centimeters for four months. [Project 34; Department of Dairy Husbandry; state fund.]

The Palatability of Ground Wheat in Grain Mixtures for Dairy Cows. Many inquiries have been received concerning the feeding of wheat to dairy cows. In order to test the palatability of ground wheat in grain mixtures of various proportions two tests were conducted last year. Sixteen cows were used. They were divided into four lots of four cows each and a different mixture was fed each lot. In the second trial the same mixtures were used, but the lots were reversed. The grain was given the animals before they were offered any silage or hay. The following mixtures were used:

Mixture No.	Wheat. <i>Lbs.</i>	Corn. <i>Lbs.</i>	Bran. <i>Lbs.</i>	Oil meal. <i>Lbs.</i>
1	300	200	100	100
2	400	...	200	100
3	600	...	...	100
4	300	300	...	100

The results showing the number of animals which had cleaned up their feed in different length of time follow:

FIRST TRIAL.							
Mixture No.	5 min.	10 min.	15 min.	20 min.	25 min.	30 min.	
1	1	3	3	4	..	..
2	2	3	4	..	..	..
3	0	0	2	2	3	3	
4	1	3	3	4	..	..
SECOND TRIAL.							
1	0	2	3	3	3	3	
2	1	2	4	..	..	..
3	0	0	2	3	3	3	
4	1	2	4	..	..	..

Mixture No. 2 seemed the most palatable, with No. 4 a close second. No. 3 was easily the least palatable, due, no doubt, to the high percentage of wheat contained in it, which made a gummy mass when chewed. One cow failed to clean up either mixture No. 3 or mixture No. 1 in 30 minutes. Another failed to clean up No. 3 in 30 minutes, although she had readily cleaned up No. 2 in 15

minutes. Previous to these trials four cows were offered a mixture of five parts wheat and one part oil meal after they had their regular grain and silage ration, and they all refused to eat the wheat. An experimental feeding trial may be conducted next year to determine the feed value of wheat as a constituent of a dairy ration. [Department of Dairy Husbandry; state fund.]

Normal Growth of Dairy Cattle. In this study the plan is to weigh each calf dropped in the dairy herd at birth and to measure the height at withers as soon as the calf is able to stand. The weight and height of each calf is to be determined at 30-day intervals until two years of age or as long as maintained in the herd, except that males will not be weighed or measured after one year of age. Weights are obtained in the afternoon before feeding. The height at withers is obtained at the same time, when the animal is standing squarely on its feet and is an average of two or more measurements. In this manner it is hoped to obtain enough data to determine the normal size of calves and heifers of the four major dairy breeds. This data would be of value in future experimental feeding work. This work was started in January, 1922, and to June 10, 1924, the following numbers of individuals have been weighed and measured:

BREED.	At birth.		6 mos.		12 mos.		24 mos.
	F.	M.	F.	M.	F.	M.	F.
Holsteins	24	23	19	10	18	1	7
Ayrshires	18	12	14	7	16	1	9
Guernseys	7	16	8	6	12	2	4
Jerseys	13	17	12	7	10	3	3
Totals	62	70	53	30	56	7	23

The table shows that only 23 females have been carried through for the entire two years. A preliminary survey of these available weights shows a close correlation with those reported by Missouri Agricultural Experiment Station with the exception of Holstein weights, which tend to run much higher here. This work will be continued for several years or until enough data are available for all breeds and sexes. [Department of Dairy Husbandry; state fund.]

Ice Cream Investigations. The work has consisted of a study of some of the factors affecting viscosity in the ice-cream mix and the influence of viscosity on yield. A preliminary attempt was also made, in cooperation with the Department of Chemistry, to determine what factors other than viscosity influence yield in ice cream. It was found that the practice of collecting the ice-cream mix directly into cans from the cooler after homogenizing and then aging

in the cans resulted in a mix of ununiform physical condition; that is, each separate can of mix showed a difference in viscosity and in the ease of obtaining the desired yield. This difference could be overcome by dumping the contents of all the cans into a mixing vat before freezing, although a more desirable method is to mix in the vat before aging if it is necessary to store in 10-gallon cans. In an attempt to determine the reasons for this difference in viscosity and yield, an analysis of each can of mix was made with practically identical results on fat and total solids. The titratable acidity and hydrogen ion concentration were determined, and only slight differences were found. An examination of the lime salts and casein also showed no significant differences. Further work is necessary on this phase before it will be possible to draw conclusions as to the reasons for the differences in uniformity and yield. The work will be continued during the coming summer.

There is a point of optimum viscosity in the ice-cream mix for proper yield and texture in the finished ice cream. If the viscosity of the mix is very low the mix will be unable to retain the air and the finished product will be lacking in the desired smooth texture. If the viscosity is excessive the resistance to the incorporation of air becomes too great for the freezer dasher to overcome, and low yield results. The results secured are indefinite, for two possible reasons: (1) The difficulty of making definite viscosity measurements in an ice-cream mix. In the work performed last year, viscosity was determined with a Mojonnier viscosimeter at 40° F. directly in eight-ounce tumblers which had been held undisturbed until just before the mix, which was held in cans at 40° F., was frozen. The slightest agitation changes the viscosity of an ice-cream mix, so the results are only roughly comparative. (2) It is probable that some other physical phenomenon may enter as a factor in obtaining yield. An attempt was made to see whether surface tension of the mix in air might be a factor, but the results were negative. It is probable that interfacial surface tension is a factor, but there has as yet been no method discovered for measuring this properly. As a general rule it is possible to correlate the many factors which affect viscosity in such a way as to obtain the desired viscosity, and in turn proper yield and texture, under all practical conditions, the knowledge and skill of the operator in recognizing varying conditions being the greatest limiting factor. The studies on viscosity in relation to yield in ice cream will be continued. Studies will also be made on the factors responsible for increases in viscosity on aging the ice

cream mix. [Project 124; Department of Dairy Husbandry; state fund.]

Bacteriological Study of Ice Cream. During the summer of 1923 the Department of Bacteriology continued the work on bacteriological investigation of ice cream in cooperation with a local creamery. A very complete set of data was obtained, covering the influence of the various manufacturing operations on the bacterial content of the finished product. A thorough study was made of the influence of the ingredients of the ice-cream mix on bacterial numbers. The results indicate that the cream is the most important source of bacteria in ice cream, contributing on the average about 70 per cent of the total number of organisms present. The importance of the other ingredients, from the standpoint of bacterial numbers, was found to be in the following order: Milk, butter, skim-milk powder, gelatin, water, and sugar. It is believed that the study of the effect of plant operations on the number of bacteria in ice cream is reasonably complete, and that attention now should be given to a survey of the sanitary condition of the product of representative Kansas plants. It is important to establish the relationship between the sanitary conditions under which ice cream is produced and the final bacterial count, before it can be assumed that good ice cream must contain few bacteria. Very little work has been done to determine whether clean ice cream, produced under strictly sanitary though practical conditions, and properly cared for, will invariably have a low bacterial count. Six manuscripts based on the work of this project were prepared for publication. [Project 124; Department of Bacteriology; state fund.]

Improving Mongrel Flocks Through Selected Standardbred Cockerels. During the past year the four groups of third-generation grades and mongrels have completed their first laying year. The females used in the third generation were sired by selected standardbred White Orpington, White Wyandotte, Single Comb Rhode Island Red, and unselected mongrel cockerels, respectively. The mean egg production per hen of the respective groups for their first laying year is given in Table XX.

TABLE XX.—Average first year's egg production per hen.

Year ..	1919-'20.	1920-'21.	1921-'22.	1922-'23.
Group .	Mongrel mothers	First generation.	Second generation.	Third generation.
Grade White Orpingtons	135 7	124 2	106 0	102 1
Grade Wyandottes	121 4	167 1	168 0	140 3
Grade Rhode Island Reds.	111 1	172 1	150 8	140 4
Mongrels.	134 0	141 0	124 8	124 8

This subproject was discontinued after the third generation completed their first year's egg record. It will be noted that the grade White Orpingtons failed to show improvement, but that the grade Wyandotte and Rhode Island Reds were distinctly more productive than their mongrel ancestors. [Project 77—1; Department of Poultry Husbandry; state fund.]

The Feeding Value of Milo, Cane, Kafir and Mixed Feed for Pullets. Forty Single Comb White Leghorn pullets (half sisters) from last year's matings were grown to maturity on rations similar to those received by the parent stock, with the exception of milk and a limited outdoor range, to which the chicks had access until October 1, 1923, when they were placed into their permanent quarters. The rations for these pens are given in Table XX.

TABLE XXI.—Rations fed pullets on feeding test.

Pen No.	Dry mash.	Grain.	Other feed.
8	Ground milo, 75 per cent; meat scrap, 25 per cent.	Whole milo.	Green feed, water, grit, and shell.
9	Ground cane, 75 per cent; meat scrap, 25 per cent.	Whole cane seed.	Green feed, water, grit, and shell.
10	Ground kafir, 75 per cent; meat scrap, 25 per cent.	Whole kafir.	Green feed, water, grit, and shell.
11	Ground corn, wheat, and oats, 60 per cent; bran, 20 per cent; meat scrap, 20 per cent.	Cracked corn, 75 per cent; wheat, 25 per cent.	Green feed, water, grit, and shell.

The hens from which the pullets in pens 8, 9, 10 and 11 originated, designated as D in Table XXII, were kept through a second laying year, as indicated under E, and mated with one cockerel, resulting in a third group of half sisters which are to be used to continue the experiment. The pullets have been confined in pens 5 by 16 feet throughout the experiment, while the hens have had the use of a small outdoor bare yard. The record of egg production for the past four years and to June 1, 1924, is shown in Table XXII.

Historical Document
Kansas Agricultural Experiment Station

TABLE XXII.—Record of egg production.

Group.....	A.	B.	C.	D.	E.	D.	D.
PEN NO. AND GRAIN RATION.	Average production pullet year, 1920-'21.	Average production hen year, 1921-'22.	Average production daughters, pullet year, 1921-'22.	Average production half sisters, pullet year, 1922-'23.	Average production daughters of half sisters to June 1, 1924.	Per cent fertile of eggs set, 1924.	Per cent hatched of fertile eggs, 1924.
8—Milo.....	153	100	160	130	88	90	59
9—Cane.....	129	99	136	99	37	89	66
10—Kafir.....	153	102	161	153	108	81	59
11—Adequate.....	133	88	114	158	120	89	69

The various groups of birds are designated as A, B, C, D and E, respectively. Group A was the original flock from which two (C and D) generations of pullets were reared. Each pen in the C group came from a different sire in the spring of 1921, while each pen in the D group came from the same sire in the spring of 1922. The pens in Group E are also from D pullets, all mated with the same male. Group E is the first generation that has been reared from the beginning on the rations similar to those received by the laying hens. The cane pen in group E has been very backward in both maturity and egg production. A second flock of pullets from D are being reared under conditions similar to those of group E. The latter group (E) will be kept through a second laying year on the respective grain rations listed above with the meat scrap removed. [Project 77—2; Department of Poultry Husbandry; state fund.]

The Inheritance of Eye Color in Chickens. The standard eye color in Single Comb White Leghorns and Single Comb Rhode Island Red is a deep reddish bay. However, in both breeds there are occasionally found individuals with dull pearl eyes (lacking red). Individuals showing the dull eye were mated in each breed to try to establish families which will breed true for this character. Dull-eyed individuals of the two breeds were also crossed to determine whether this type of eye was due to the same factors in the two breeds. The offspring are being reared, but are not yet old enough to classify as to eye color. The progeny will be classified and if the variation in eye color is shown to be due to a single genetic factor, matings will be made to analyze the manner of its inheritance. If it appears that several factors are involved selection will be continued for the establishment of a pure breeding strain. [Project 77—3; Department of Poultry Husbandry; state fund.]

A Study of the Inheritance of the Characteristics in Which the Single Comb White Leghorns and the Jersey Black Giants Differ. This study is being made in order to obtain information necessary for the intelligent establishment of a new breed of White Giants. Several types of crosses have been made between the two breeds and between these breeds and first-generation crosses. The inheritance of the following characters is being followed:

	Black Giant.	Leghorn.
Plumage	Black.	White.
Shanks	Black.	Yellow.
Eye	Dark Brown.	Red bay.
Earlobe	Red.	White.
Size	Cock, 12 pounds; hen, 9 pounds.	Cock, 5 pounds; hen, 4 pounds.
Egg color	Brown.	White.
Rate of feathering	Slow.	Rapid.
Broodiness	Broody.	Nonbroody.
Rate of growth	Slow.	Rapid.
Side sprigs	Frequent.	Very seldom.

The offspring of these crosses are not yet old enough to make accurate analyses possible, but the data now available indicate rather positively that in the case of the rate of feathering, the difference is due to a single sex-linked factor. After the progeny are mature they will be classified, and in 1925 proper matings will be made to analyze any differences which the present crosses fail to clear up. In the light of the results from these crosses, matings will be made for the establishment of the White Giants. [Project 77—4; Department of Poultry Husbandry; state fund.]

The Inheritance of Egg Production in the Single Comb White Leghorns. For the establishment of a low-producing strain, a pen of birds was obtained from a strain which had never been trap-nested, and it is hoped by selection to be able to establish a uniformly low-producing strain which may be used in crosses with the College stock of rigidly selected high producers for the study of the inheritance of egg production. Since the experiment is in its initial state, no results are yet available. Trapnest records are to be kept on the offspring of the lowest-producing females from this new pen, and the strain will be continued by mating the offspring of these females. [Project 77—5; Department of Poultry Husbandry; state fund.]

Poultry Flock Management. This work has consisted of the application of a management system to a flock of 93 Single Comb Rhode Island Red to find a practical method of handling the farm poultry flock to obtain maximum egg production in the fall and winter, and maximum matchability of vigorous chicks in the early spring. The house used for this work is 15 by 30 feet in size with a partition in the middle. Forty-two hens and two cockerels were placed in one pen last fall and allowed free range in a large yard all winter and spring. Fifty-one pullets were confined in the other half of the house from October 1, 1923, to April 15, 1924, and forced for egg production. Approximately 200 chicks were hatched from the

hens to replace the pullets this fall. After the breeding season (about April 15) both pullets and hens are allowed free range until September when the 50 best individuals from both hens and pullets will be selected and kept for the next year's breeders. About October 1, 75 of the best pullets from the 1924 hatch will be confined and forced for winter egg production. The average production of eggs for the first eight months is given in Table XXIII.

TABLE XXIII.—Average egg production of each group for eight months.

GROUP.	Winter period.						Mar.	Apr.	May.	Total.
	Oct.	Nov.	Dec.	Jan.	Feb.	Total.				
Hens	3.5	3.2	6.4	5.8	10.7	29.6	14.4	14.0	10.7	68.7
Pullets	4.2	5.3	9.8	10.5	10.5	40.3	17.8	18.4	17.2	93.7

During the eight-month period the hens have consumed an average of 49 pounds of feed per hen, while the pullets have consumed on the average 52 pounds each. From the hens 272 eggs were set and 205 strong chicks hatched. Ninety-five per cent of the eggs were fertile, seventy-nine per cent of which hatched. [Project 77—6; Department of Poultry Husbandry; state fund.]

Incubation Studies. The studies in incubation are grouped under three headings: (1) The effect of freezing the comb and wattles of cockerels on the reproductive organs and the fertility of hatching eggs. (2) Calcium metabolism of the developing chick. (3) The effect of sunlight, ultra-violet rays, prolonged cooling, and high and low temperature on the hatchability of eggs. Two Single Comb White Leghorn cockerels were exposed last winter and their combs and wattles allowed to freeze. Ten days following, one died and the other one was killed. The testicles were examined and compared with those of a bird that had not been frozen. The organs from the bird that received the less severe freeze were sent to the Department of Veterinary Medicine for sectioning and to determine whether or not spermatogenesis had ceased. A fertility test was made with two other cockerels of the same variety—and later they were subjected to a freezing temperature for eight hours and subsequent fertility tests conducted. The testicles of one of the frozen cockerels weighed 3 grams, while the weight of testicles from an unfrozen bird was 15 grams. A report on the histological condition of these organs has not been received. The freezing was not severe enough to make any material difference in the fertility of eggs.

Five eggs from each of five hens were divided into five groups as follows:

- Group 1—Five fresh eggs stored at a temperature of 45° F. for 19 days.
- Group 2—Five eggs incubated under a hen 19 days.
- Group 3—Five eggs incubated artificially and normally 19 days.
- Group 4—Five eggs incubated artificially 19 days, during the last three of which carbon dioxide was added to the egg chamber to the amount of 20 parts of carbon dioxide to 10,000 parts of air.
- Group 5—Five eggs that were incubated as Group 4 were allowed to hatch. All the chicks were normal.

A chemical analysis will be made of each group to determine the amount of calcium carbonate in the egg shell, and in the contents of the shell.

Trays of eggs were exposed to sunlight 15 minutes daily, and to the ultra-violet light 5, 10 and 20 minutes, respectively, daily. Other trays were cooled 5 hours daily and 10 hours daily during certain periods of incubation. Three other groups of eggs were incubated for three days at 95° F., 101° F., and 105° F., respectively, after which time the first and last groups were placed with the second group and incubated at the normal temperature of 101° F. The hatching percentages are shown in Table XXIV.

TABLE XXIV.—Results of experiments in incubation.

TREATMENT.	Breed.	Number set.	Number infertile and cracked.	Number dead in snell.	Number chicks hatched.	Per cent of fertile eggs hatched.
Eggs Set April 15, 1924 (Series 11).						
Cooling Experiment.						
Cooled 5 hrs., 10th and 17th days of incubation.....	Leg.	192	31	76	85	52.8
Cooled 10 hrs., 17th day of incubation.....	Leg.	192	25	73	94	56.2
Cooled 5 hrs., 17th day of incubation.....	Red	95	18	42	35	44.1
Check tray, normal treatment.....	Red	95	13	44	38	46.3
Check tray, normal treatment.....	Leg.	191	13	65	113	63.4
Eggs Set April 22, 1924 (Series 12).						
Ultra-Violet Rays and Sunshine.						
Violet rays, 5 min. daily, 1st to 18th day, inclusive.....	Leg.	192	29	34	129	79.1
Sunshine, 15 min. daily, 3d to 18th day, inclusive.....	Leg.	192	16	46	130	73.8
Check trays, normal treatment.....	Leg.	192	19	65	108	63.0
Eggs Set April 29, 1924 (Series 13).						
Ultra-violet Rays and Sunshine.						
Violet rays, 5 min. daily, 2d to 18th day, inclusive.....	Red	186	28	63	95	60.1
Violet rays, 5 min. daily, 7th to 19th day, inclusive.....	Leg.	192	18	48	126	72.4
Sunshine, 15 min. daily, 3d to 18th day, inclusive.....	Red	96	11	25	60	70.5
Sunshine, 15 min. daily, 3d to 18th day, inclusive.....	Leg.	96	8	32	56	63.6
Check tray, normal treatment.....	Leg.	96	10	23	63	73.2
Check tray, normal treatment.....	Red	96	8	23	65	73.8

Ultra-violet Rays.

Violet rays, 10 min. daily, 1st to 19th day, inclusive.....
 Violet rays, 20 min. daily, 1st to 19th day, inclusive.....
 Check trays, normal treatment.....

EGGS SET MAY 6, 1924 (SERIES 14).					
Leg. $\frac{3}{8}$	288	24	123	141	53.4
Red $\frac{1}{4}$					
Leg. $\frac{2}{3}$	288	31	96	161	62.6
Red $\frac{1}{3}$					
Leg. $\frac{1}{2}$	192	15	87	90	50.8
Red $\frac{1}{2}$					

Temperature Experiment.

101° F. first week; check tray, normal treatment (a).....
 95° F. first 3 days; low temperature (a).....
 105° F. first 3 days; high temperature (a).....

EGGS SET APRIL 30, 1924.					
	37	0	12	25	67.5
	34	1	6	27	81.8
	32	0	24	8	25.0

(a) The eggs subjected to the high temperature started to hatch 12 hours after the check lot, and the eggs incubated at the low temperature were delayed in hatching about 27 hours. The eggs were from White Leghorn pullets.

[Project 77-7: Department of Poultry Husbandry; state fund.]

The Effect of Inadequate Rations on the Production and Hatchability of Eggs. Seven pens of Single Comb White Leg-horns, consisting of one male and ten females each, have received the rations shown in Table XXV, which also shows the production, fertility, and hatch of eggs.

TABLE XXV.—Effect of certain rations on the production and hatchability of eggs.

Pen No.	RATION.	Number hens that finished.	Number eggs set.	Number infertile.	Per cent fertile.	Per cent of fertile eggs hatched.
I	Kansas Adequate, green feed inside.	10	285	17	94	74
II	Kansas Adequate, green feed, inclosed coop outside . .	8	230	8	97	64
III	Chemically Adequate, green feed, yellow corn, inclosed coop outside.	9	327	11	97	75
IV	Chemically Adequate, green feed, yellow corn	10	327	25	92	76
V	Chemically Inadequate, no green feed, yellow corn	8	212	11	95	72
VI	Chemically Inadequate, no green feed, white corn . . .	4	85	4	95	17
VII	Chemically Inadequate, no green feed, pearl hominy..	9	179	32	82	46

NOTE.—The duration of the experiment was from November 1, 1923, to May 1, 1924. All the eggs were incubated that were produced from February 12 to April 15, 1924.

A further study of white and yellow corn will be made, the mineral content of the rations will be lowered, and the substance “biose,” which will not cure beri beri, but is said to promote growth, will be investigated. The rations mentioned in Table XXV are as follows:

Kansas Adequate.

DRY MASH	{	Ground corn, wheat, and oats	60 pounds
		Wheat bran	20 pounds
		Meat scrap	20 pounds
SCRATCH FEED	{	Cracked corn	75 pounds
		Wheat	25 pounds

Chemically Adequate.

DRY MASH	{	Yellow corn	70 pounds
		Tankage	10 pounds
		Casein	10 pounds
		Bone ash	5 pounds
		Butter	5 pounds
SCRATCH FEED		Yellow corn	100 pounds

Chemically Inadequate.

(Pen VI, low in Vitamins A, C, and D.)

DRY MASH	{	White corn 70 pounds Tankage 10 pounds Extracted casein 10 pounds Bone ash 5 pounds Lard 5 pounds
SCRATCH FEED		White corn 100 pounds

Chemically Inadequate.

(Pen VII, low in Vitamins B and C.)

DRY MASH	{	Pearl hominy 64 pounds Tankage 10 pounds Extracted casein 10 pounds Yellow corn 5 pounds Bone ash 5 pounds Butter 5 pounds Cod liver oil 1 pound
SCRATCH FEED		Polished hominy 100 pounds

Long, green sprouted oats was the source of green feed for pens I, II, III and IV. All pens had access to tap water, oyster shell, and grit. [Project 127; Departments of Poultry Husbandry and Chemistry; Adams fund.]

Relation of Vitamin Content of Feed and of the Use of Light to Immunity to Roup and the Production and Hatchability of Eggs. The work this past year has been a repetition of the work of the previous year, with the following two additions: (1) Blood samples have been collected each month from each pen and analyzed for nitrogen, urea, uric acid, sugar, and alkaline reserve. (2) One pen receiving ultra-violet light treatments each day from January 23 to May 11, 1924, was added. Six pens of twelve White Leghorn pullets each were started on this experiment October 24, 1923. They received the following rations:

PEN I	{	Yellow corn 82 pounds Tankage 5 pounds Casein 5 pounds Butter 5 pounds Bone ash 3 pounds Sprouted oats.
-----------------	---	--

This mixture contains some of all vitamins, but is probably low in Vitamin D. Pen I also received ultra-violet light 10 minutes twice a day from January 23 to May 11, 1924.

PEN II Same ration as Pen I, but no light treatment.

PEN III Same ration as Pen II without sprouted oats.

This feed contains very little of Vitamins C or D.

PEN IV	}	White corn 82 pounds Tankage 5 pounds Extracted casein 5 pounds Lard 5 pounds Bone ash 3 pounds
------------------	---	---

This mixture contains very little of Vitamins A, C or D.

PEN V	}	Pearl hominy 84 pounds Tankage 5 pounds Extracted casein 5 pounds Butter 5 pounds Cod liver oil 1 pound
-----------------	---	---

This mixture is low in Vitamins B and C. Pen V received only polished rice after January 10, 1924.

PEN VI Same ration as Pen I but were kept outside so they received sunlight.

All pens had access to oyster shells at all times. The ultra-violet light showed such a marked effect on the egg production in Pen I that a chemical analysis was made on the eggs from this pen and from Pens II and VI for comparison. A number of eggs from each of these three pens were incubated by the department. As far as the influence of the lack of Vitamins A and B on the mortality of the chicken is concerned the results are in accord with previous ones, *i.e.*, the lack of Vitamin A causes nutritional disease and the lack of Vitamin B causes beri beri. When both Vitamins A and B are lacking, some will die with nutritional disease and some with beri beri. The lack of Vitamin C has not caused the death of hens during the length of this experiment, 8 months. This is shown by the fact that the hens get along very well without any green feed.

A new difficulty was encountered in Pen II. Five hens, all showing the same symptoms, have died in this pen, while only two have died in Pen III, which gets the same feed as Pen II minus the sprouted oats. The first symptom shown by these hens which died in Pen II was lameness. This was followed by almost a complete paralysis of the legs, so they could not raise their bodies off the floor. They would slide along by a slight use of their legs and wings. In each case, on post-mortem examination, the egg yolks were found broken in the body cavity. A more careful examination of the last one to be posted showed the bone to be very weak and beading on the ribs, which is characteristic of rickets. This indicates that the mineral metabolism is at fault. The thin shell on the egg from this pen and the low calcium and phosphorus content of the blood indicate the same difficulty. This faulty mineral metabolism was probably caused by a lack of ash in the feed consumed. The hens were given large quantities of sprouted oats, so they did not consume as much of the grain mixture which contains the bone ash as Pen III, which did not receive the oats. There

was not enough Vitamin D in the oats to enable them to get along on the low mineral intake. The ultra-violet light treatments would account for the fact that this condition did not develop in Pen I, which also received large quantities of sprouted oats and thus were on a low mineral intake as they did not consume so much of the grain mixture which contained the ash. Ultra-violet light has been shown in other experiments to enable an animal to utilize calcium and phosphorus to better advantage than without the light. The number of chickens which died during the experiment is shown below:

Pen No.	VITAMIN CONTENT OF FEED.				Nutritional disease.	Death from		
	A	B	C	D		Beri. beri.	Rickets (??).	Unknown causes.
I.....	+	+	+	+(?)	0	0	0	1
II.....	+	+	+	+(?)	0	0	5	0
III.....	+	+	-	(?)	0	0	0	2
IV.....	-	+	-	-	10	0	0	0
V.....	+	-	-	+	0	1	0	1
After Jan. 10th..	-	-	-	-	4	4	0	2
VI.....	+	+	+	+(?)	0	0	0	0

During the period Pen I received the ultra-violet light they produced 492 eggs. During this same time Pen II produced only 134 eggs. The shells of the eggs from Pen I contained one-third more calcium than those from Pen II. Of 295 fertile eggs from Pen I, 75.6 per cent hatched and only 32.6 per cent of the 46 fertile eggs from Pen II hatched.

The influence of light on egg production is shown in Table XXVI. The influence of light on hatchability of eggs produced may be seen from Table XXVII, and the influence of light on the composition of the eggs is indicated in Table XXVIII.

TABLE XXVI.—Influence of light on egg production.

PERIOD.	EGG PRODUCTION					
	Pen I	Pen II.	Pen III.	Pen IV.	Pen V.	Pen VI.
BEFORE LIGHT WAS USED						
Nov. 5-30	27	41	31	33	35	12
Dec 1-31	50	88	51	34	27	33
Jan 1-22	30	44	16	6	12	19
Total, Nov 5 to Jan 22	107	173	98	73	74	64
PEN I, ULTRA-VIOLET LIGHT						
Jan. 23-31	33	20	13	5	5	31
Feb. 1-29	133	58	70	12	12	133
Mar. 1-31	142	23	56	13	12	168
Apr. 1-30	131	26	25	6	1	182
May 1-11	53	7	10	0	0	83
Total, Jan. 23 to May 11.	492	134	174	36	30	597

TABLE XXVII.—Influence of light on hatchability of eggs produced:
Summary

Pen No.	Light treatment.	Number of fertile eggs.	Number hatched.	Per cent hatched.
I	Ultra-violet light, 10 minutes twice a day.....	295	223	75.6
II	None.....	46	15	32.6
VI	Sunlight.....	207	126	58.4

TABLE XXVIII.—Influence of light on the composition of eggs.

(All weights are for seven eggs.)

Pen Nos.....	I.	II.	VI.
LIGHT TREATMENT.....	Ultra-violet light.	Inside away from light.	Sunlight.
GREEN WEIGHT IN GRAMS.			
White.....	218.3000	204.4000	215.2000
Yolk.....	116.6000	110.5000	125.0000
Shell.....	34.4000	25.3000	32.3000
DRY WEIGHT IN GRAMS.			
White.....	26.7000	22.7000	26.1000
Yolk.....	58.2000	54.3000	63.1000
Calcium in shells.....			
Calcium in whites.....	12.8000	9.0700	11.9800
Calcium in yolks.....	.0232	.0133	.0214
Calcium in yolks.....	.1410	.1150	.1670
Phosphorus in whites.....			
Phosphorus in whites.....	.0339	.0220	.0305
Phosphorus in yolks.....	.6720	.5920	.7310
Phosphorus in yolk residue after extraction.....	.3470	.3250	.3760
Phosphorus lipoids in yolks.....	.3250	.2670	.3550
PER CENTS OF INGREDIENTS.			
Calcium (in white).....	.0870	.0585	.0820
Calcium (in yolk).....	.2420	.2120	.2640
Phosphorus (in white).....			
Phosphorus (in white).....	.1270	.0970	.1170
Phosphorus (in yolk).....	1.1550	1.0900	1.1600
Phosphorus (in yolk extracted).....	.5970	.5970	.5960
Yolk extracted.....	60.0000	60.7000	61.2500

The chemical analysis did not show anything so far as total nitrogen, urea and alkaline reserve, and sugar are concerned. The chickens in advanced stages of nutritional disease had a much higher uric acid content than normal. The chickens in Pen II showed a lower calcium and phosphorus content than the other pens. [Project 131; Departments of Chemistry, Bacteriology, and Poultry Husbandry; state fund.]

Studies in Animal Reproduction and Inheritance. The past year has been an even more prosperous one, from the standpoint of numbers of animals produced and results obtained, than the preceding one. At least 2,500 guinea pigs, 200 rats and 200 rabbits have been born. In spite of additions to the guinea-pig ration, it is not

as yet perfect as a winter feed. Small percentages of tankage and linseed oil meal have been added to both the guinea-pig and the rabbit rations with beneficial effects. However, it has been found that the mortality in the winter among the guinea pigs still continues to be greater than it is in the summer. There seems to be something in alfalfa grown outdoors that makes it superior to sprouted oats grown indoors. It is probably a question of vitamins. Next winter it is hoped to remedy this deficiency by adding one-fourth per cent cod liver oil to the mixed ration.

It had been planned to feed sprouted oats throughout all of last summer. This had to be discontinued because the heat caused the oats to rot. In addition there was a comparatively high mortality among the animals. The object in feeding sprouted oats in the summer was to determine whether it was possible to produce a ration which could be fed throughout the year. Seasonal differences in the sex ratio had been noted and the idea was to determine whether this might be due to changes in the feed or in the temperature. By keeping the feed constant it was thought that the effects of changes in temperature could thus be ascertained. Good progress has been made in the study of the inheritance of salmon-eye in guinea pigs. A paper on the subject will probably be written this summer. The problem of the production of giant chinchilla rabbits involves the production of an entirely new type, the "steel gray" chinchilla. Measurements and weights are being taken with the idea of getting material for the study of size inheritance in these animals. No experiments have been completed during the past year. From present indications, however, a number will be finished during the coming year. This applies particularly to the study of the aberrant ratios in a multiple allelomorph series in guinea pigs, and to the linkage relations of six pairs of factors in these animals. It is also possible that complete data will be obtained on the inheritance of blue-eye and the "light" factor in chinchilla rabbits.

Two new mutations were reported last year—"pigmentless" eye and the "partial extension" of the intensity factor. In neither has very great progress been made, although a large number of offspring have been produced. The reason is that the inheritance is more complicated than had been expected. Other mutations have appeared in the meantime. One of these has been called the "kodak" factor. The few animals possessing this factor have been pink-eyed whites at birth, and when they were about two months old pigmented spots began to appear in various parts of the body. Another muta-

tion being studied affects the agouti—agouti belly, (Ag) factor. Those agoutis carrying the “extreme extension” mutation are almost black at birth and remain consistently darker than the ordinary agoutis.

The original inbred line of guinea pigs has been lost, due to the death of the few remaining females during the winter. The mortality was not any greater than in other experiments, but unfortunately the animals lost could not be replaced. A year or so ago one of the inbred males was bred to an unrelated female. A new inbred line has been started from this mating. Thus far there are two or three inbred generations. No marked changes have as yet been observed.

The weights of all guinea pigs at birth and of their mothers at parturition are still being taken. Data of this sort have been recorded for the past eleven years. The numbers are quite large now, but the larger the numbers the more conclusive will be the results obtained. As previously reported, some peculiar sex ratios in guinea pigs have been obtained. The plan at present is to gather more data during the present year and also next year, and at the end of this period compare the new data with the old. If the two results agree it will be more conclusive evidence that such factors as the age of the mother, for instance, have an important bearing on the sex ratios of the offspring. [Project 93; Department of Animal Husbandry; state fund.]

Studies of Inheritance in the Grouse Locusts (*Tettigidae*).

When it was found that the extended paper describing inheritance in *Apotettix eurycephalus* could not be published until after July 1, 1924, another year's (the twelfth) results were incorporated in it. While these added data do not materially change the conclusions, they nevertheless strengthen the paper as a whole, adding about 15 per cent to the total of the data. There are shown about 500,000 reactions of factors, such as segregations, couplings, and repulsions, etc. The paper is now ready for publication, and it is hoped to have it published this summer or fall. Two new factors in this group were added last fall. Work on *A. eurycephalus* has been lessened, and *P. texanus* are being studied again on a large scale, and with several new factors secured during the past two field trips to Texas. The first work (published 1914 and 1917) was with this form. Many matters needed further investigations, and new work in the light of the suggestions and criticisms of the publications can now be carried on profitably. Work on *A. eurycephalus* will be continued, but on a smaller scale until the benefits from the publications can be

gathered. One assistant is working out the inheritance relations of five factors in a new group, *Talmatettix aztecus*, which was brought in from Texas last fall. Another is starting a promising piece of work on the inheritance of characters in the mantids (*Orthoptera*). About 100,000 reactions of factors were added to data which are to be included in the paper on *A. eurycephalus*. Two new factors to this group were added from the field. There were also added four or five new factors to those (now 21 or 22) in use in the *Paratettix texanus* group, and many additional data (not yet tabulated) were secured on the inheritance of factors. [Project 72; Department of Zoölogy; Adams fund.]

Influence of Climate on Inheritance and Parthenogenesis in the Grouse Locusts (Tettigidæ). During the period December 20, 1923, to April 10, 1924, 20 to 23 cages of *Paratettix texanus* and 12 to 16 cages of *Apotettix eurycephalus* were kept in the control chambers. The temperature was kept at 90° F. and the humidity at 73 per cent. An extra half generation was gained over the normal number in the general greenhouse. The results on the inheritance of characters appeared to be negative. However, it cannot yet be stated definitely that the results were negative, as an examination of the data of other years indicate possibly positive results. If the cages can be operated within a rather close range of accuracy, the effects of high temperatures and high moisture content of the air will be tried on crossing over, and on parthenogenesis. [Project 104; Department of Zoölogy; Adams fund.]

Bee Investigations. Valuable data were secured on brood rearing and on conditions which affect it. It was found that the peak of brood rearing usually comes in Kansas about the first week in May, but if the weather conditions which are usually present at that time occur again before the honey flow begins, there will be a second peak of brood rearing in those colonies which are plentifully supplied with food. It was found that there is an inverse correlation between the rate of brood rearing and the nectar flow. Brood rearing begins and ends in response to a temperature stimulus. A surprisingly large percentage of the eggs deposited by a queen bee do not develop into adults. It appears to be indicated that the amount of brood reared by a colony of bees depends upon the number of worker bees in that colony which are available to care for the larvæ. Valuable data were secured on the progress of development of colonies built up from package bees. It was found that a direct correlation exists between a plentiful supply of stores and its rate of brood rearing before the honey flow starts. It was shown that 4,000, or about

one-third of a three-pound package, died before any new bees appeared. Owing to the fact that the amount of work in such a colony at this time was so great that all of the original package bees died, as well as some of the newly emerged ones, during the second 21 days. This indicates that by hard work the life of a bee may be shortened considerably below six weeks, which is the length of time usually allotted them as a life span during the busy season of the year. The average amount of honey consumed during winter was determined for different wintering conditions from a study of the data secured during four years' winter observations. A cooperative experiment was begun with the Texas Agricultural Experiment Station to determine the feasibility of shaking bees into combless packages and sending them to Texas at the end of the honey flow. A similar number of bees are to be returned to Kansas in time to take part in the Kansas honey flow. Observations were continued on honey plants, and a large number of specimens were collected and mounted. An effort has been started to develop a strain of bees by using as breeders those queens whose progeny show desirable physical characters. Coöperative experiments have begun with commercial queen rearers to carry on work along this line. Valuable data were secured on granulation and fermentation of honey. [Project 126; Department of Entomology; state fund.]

DISEASES OF FARM ANIMALS

The principal work of the Agricultural Experiment Station during the past two years with reference to diseases affecting farm animals is briefly discussed below.

Miscellaneous Animal Disease Investigations. This project is concerned with miscellaneous animal diseases as they occur from time to time in different parts of the state. It consists, in part, of the examination of diseased animals and diagnosis of and directions for controlling well-known diseases and in part of studying methods of controlling diseases less well known. During the past year the project included 208 agglutination tests for abortion, 31 abortion suspect examinations, 146 rabies examinations, 262 post-mortems on farm animals, and 299 examinations of blood, feces, etc. The total number of veterinary examinations of all kinds made during the biennium was 2,860. The experiments on posterior paralysis of swine were completed, and a very successful treatment, involving vitamins in the ration, is being recommended and extensively followed. [Project 102; Department of Veterinary Medicine; state fund.]

Abortion Disease Investigations. During the biennium the work has consisted in part of revaccination and observation on the

experimental herd. The herd is being used chiefly in an attempt to induce immunity by one or more of several methods of vaccination. The animals have been bled at weekly intervals and on the day of calving and tested as in previous years. Isolations from aborted fetuses, afterbirth, milk, and vaginal discharges of the dams are made when possible. Some of the cows have completed their records for the two calving periods, while most of the others will complete their records by September, 1924. The data, therefore, are too incomplete to enable one to make a full report at this time. Completion and publication of results secured in this phase of the experiment are expected within a year. Another important phase of the experiment consists of a study of the abortion organism to secure a better understanding of its behavior. A third phase consists of clinical studies of abortion cases as they occur in the College dairy herd. The results of the past five years of work on the abortion project are being prepared for publication. [Project 135; Department of Veterinary Medicine; state fund.]

Blackleg Investigations. In this project work started last year on the pathogenicity of *Clostridium chauvei* cultures was continued; experiments on the keeping qualities of blackleg filtrate and aggressin were continued; a comparison of the aggressiveness of filtrate produced from virulent and avirulent strains of *Clostridium chauvei* was made; bacteriological and serological reactions of a number of strains of *Clostridium chauvei* and *Clostridium edematis* were studied; the effect of heat up to 65° C. on blackleg filtrate and aggressin was studied; and the efficacy of filtrate and of aggressin were compared. It was found that liver pulp could be substituted for brain pulp in the preparation of the brain-liver medium. This liver broth medium proved as satisfactory for the production of virus and of filtrate as the medium previously used. This change enabled the department to effect a considerable saving in the production of blackleg filtrate. The keeping qualities of blackleg filtrate and aggressin were shown to be high. The aggressive strength of filtrate and aggressin after standing for from one to six years is indicated below:

Product.	Year produced.	Original aggressive strength.	Year retested.	Final aggressive strength.
Fil. 1	1917	13.50	1923	19.00
Fil. 380	1922	21.65	1923	20.00
Fil. 1195	1922	21.65	1923	21.65
Fil. 1196	1922	12.50	1923	16.50
Agg. 206	1920	21.50	1923	13.60
Agg. 207	1920	13.00	1923	16.25
Agg. 208	1920	16.25	1923	21.50
Average		17.20	....	16.84

The aggressive strength of filtrates produced from avirulent strains of *Clostridium chauvei* was found to be as high as that of filtrates produced from virulent strains. This determination has enabled the department to use avirulent strains in the production of blackleg filtrate and thus insures the use of a larger number of strains, and therefore the production of a more highly polyvalent product than if only virulent strains were used. This insures a better product, which will protect against a greater proportion of outbreaks than a product produced from only a few strains. [Department of Veterinary Medicine; state fund.]

Poultry Disease Investigations. The work on this project has been divided into three phases. The first is a general study of poultry diseases and consists of examining diseased birds sent to the laboratory. The second phase is a study of the agglutination test as applied to white diarrhea in adult birds. The third is a study of the antigenic action of *P. avicida*, the organism causing chicken cholera. A record has been kept on all post-mortem examinations made during the past year. An examination has been made of 1,450 birds from 710 flocks. No new diseases were found during the year. About 30 common diseases were represented by the 1,450 birds examined, as shown in the following table:

DISEASE.	Number of cases.	Number of birds.
Fowl cholera	59	119
Fowl typhoid	24	42
Bacillary white diarrhea	68	228
Adult <i>S. pullora</i> infection	11	21
Ovarian infection (<i>S. pullora</i>)	23	28
Tuberculosis	25	37
Ocular roup	39	69
Chicken pox	5	9
Coccidiosis	45	128
Blackhead	12	12
<i>B. coli</i> infection	2	5
Botulism	8	24
Vent gleet	2	2
Favus	1	1
Intestinal parasites:		
Large round worms	73	146
Small round worms	54	112
Gizzard worms	12	20
Tapeworms	82	154
Air-sac mites	4	8
Chiggers	2	6
Scaly leg	5	10
Nutritional disease	41	75
Beri beri	12	14
Rickets	6	13
Sod disease	1	1
Tumors	8	8

DISEASE.	Number of cases.	Number of birds.
Paralysis	2	2
Injuries	5	5
Internal hemorrhages	2	2
Poisoning	4	5
Post-mortem decomposition	12	19
Bumblefoot	3	28
Miscellaneous	58	97
Total	710	1,450

Some of the interesting points brought out by this investigation are: (1) That the largest number of cases of chicken cholera are found during the winter months. It is also interesting to note that this disease was closely associated with ocular roup in these flocks. Several cases of fowl cholera in young chicks were diagnosed. In nearly all these cases a previous history of roup or cholera in the adults of the flock had been noted. The symptoms of this disease in very young chicks are similar to those of white diarrhea and a differential diagnosis in these cases is difficult without a bacteriological examination. (2) Eleven cases of adult infection with *S. pullora*, the organism causing white diarrhea, were found with symptoms very similar to those of fowl typhoid. Bacteriological examination alone makes it possible to diagnose such conditions. A study is now under way to determine the relations of this type of white diarrhea in young chicks. (3) A study of tuberculosis in chickens has been made to determine the distribution of the lesions throughout the body. The results recently secured are shown in the following table in which the figures from the examination of 33 cases are summarized:

AREAS OF LOCALIZATION.	Number.	Per cent.
Liver	32	96.9
Spleen	32	96.9
Intestines	25	75.7
Lungs	9	27.3
Bones	6	18.2
Kidneys	5	15.2
Skin	2	6.6

(4) Two cases of infectious *enterohepatitis* (blackhead) in chicks were diagnosed. On post-mortem examination the lesions found in these cases were typical of the disease found in turkeys. While this disease is rarely serious in chickens, it is very severe in turkeys. This emphasizes the importance of keeping turkeys away from chickens and runs occupied by chickens. (5) A careful record of birds infested with worms was made to determine the percentage of all cases diagnosed that were infested. In many of the cases re-

ported the worms were found with other diseases. The large number found indicates that these parasites have much to do with lowering the resistance of birds and thus making them susceptible to more serious diseases. Gizzard worm infestation seems to be relatively common in the state. Eleven cases were diagnosed this year in contrast to one last year. Arecoline hydrobromide was tried in a few cases of tapeworm infestations, and found to be very efficient. The correct dosage of this drug for fowls has not been determined, but 0.1 grain seems to be about the therapeutic dose. The drug was given orally in 2cc. of water to each individual bird, and results were often obtained within one-half hour. More work needs to be done with this drug before it can be recommended to the layman. (6) Nutritional disease in chicks has been prevalent recently. Only a few of the cases in young chicks have shown the eye lesion that is common in nutritional disease of adult birds. Only one case showed nodules in the oesophagus. The kidneys have been the most common seat of the disease. (7) Two cases of vent gleet reported showed severe infection of the ovaries. In both cases pure cultures of *Salmonella pullora* were isolated from the infected ovaries. It is suggested that this disease may be due to the organism of white diarrhea in many cases. Two manuscripts based on the work of this project were prepared for publication.

The work on white diarrhea consisted of studies on the relation of *S. pullora* infection to hatchability, bacillary white diarrhea in young chicks, and the agglutination test as a means of diagnosis of infection in adult birds. Special emphasis has been laid on the value of the agglutination test as a means of detecting carriers of *S. pullora* infection. In coöperation with the Division of College Extension an attempt was made to determine the prevalence of bacillary white diarrhea in Kansas. In this connection 10 birds, picked at random from 74 flocks from various sections of the state, were tested by means of the agglutination test. These flocks were distributed in 13 counties located in different sections of the state. About 78 per cent of the flocks and 31 per cent of the birds examined gave positive reactions.

The following is a summary of all the agglutination tests that have been made, including those mentioned above: Total number of tests, 2,152; number of reactors, 825; per cent of reactors, 38.3; number of flocks represented, 90; number of counties represented, 25.

The following summary shows the number of cases of both adult and chick infection with *S. pullora* diagnosed upon post-mortem examination during the past year:

TYPE OF INFECTION.	Total number of cases.	Total number of birds.	Total number of counties represented.
Bacillary white diarrhea in chicks.	68	228	20
Adult <i>S. pullora</i> infection (acute).	11	21	6
Ovarian infection.	23	28	5

Some of the difficulties in making the test have been brought out in the agglutination studies made during the past year. These are: (1) A fatlike suspension may appear and prevent an accurate reading; (2) a large number of birds possess serum that partially agglutinates *S. pullora* antigen, thus giving a doubtful reaction; (3) a large number of blood samples could not be tested because of contamination, freezing en route, etc. Efforts have been made to overcome the first obstacle by the use of various methods of making antigens and by changing the technic in general, but with little success. Attempts at correcting the condition by regulating the diet previous to bleeding the birds for the test also failed. More work must be done on this problem during the coming year. The problem of whether the birds whose sera give doubtful reactions are carriers or not has likewise been left unsolved. Several such birds have been added to the experimental flock and a bacteriological examination of all eggs laid by them is being made in hope of determining whether they are carriers. As soon as the laying season is over it is planned to kill and carefully autopsy these fowls, with the hope of determining this factor by culturing from the ovaries. The third difficulty encountered in making these tests—that of hemolyzed blood samples—can be overcome only by careful attention to shipment of blood to the laboratory. Correspondents being advised of these difficulties.

It has been observed that pullets fail to give as strong an agglutination reaction as do adults, and an experiment is now under way in which it is hoped to determine the age when agglutinins begin to appear in the blood serum of carriers. It was observed that one particular strain of Barred Plymouth Rocks, of which several flocks were tested, showed a high percentage of reactors. This particular strain originated in the eastern part of the United States, and it was possible to get samples of blood from five cockerels purchased directly from the originator of this strain. Four out of five of these cockerels proved to be reactors to the agglutination test. This is an example of the manner in which bacillary white diarrhea is introduced into the state. Another similar example was found in which a cock was sent into the state from an Eastern state and later found to be a reactor. Several day-old chicks bought from the original

owner of the cock also died with bacillary white diarrhea within a few days after arriving at their destination. A general certification of flocks would eliminate such introductions as this. Several male birds that have reacted to the agglutination test have been purchased, and it is planned to start an experiment to determine the possibility of males transmitting *S. pullora* infection to hens. Little is known about this problem and it is one that is of great practical importance. An experimental flock of reactors to the agglutination test has been kept for several years. Most of the original birds are now dying and some interesting pathological changes are being found upon post-mortem examination. All birds that have died from this flock this year have shown typical lesions of ovarian infection and in every instance cultures of *S. pullora* have been obtained from the infected ovaries. One case showed a generalized diseased condition, the lesions appearing in the liver, spleen, intestinal tract, ovaries and kidneys in form of abscesses. Cultures of *S. pullora* were obtained from the liver and ovaries.

Eleven cases of an acute disease resembling fowl typhoid and caused by an organism showing cultural characteristics like those described by Hadley, Gage and others as *S. pullora*, type B, were studied at the laboratory during the year. The study of this disease will continue during the coming year. At the present time a detailed study is being made of cultures obtained from chicks dead from bacillary white diarrhea, from infected ovaries, and from the acute infection described above.

The work on the problem of developing a vaccine against chicken cholera has been continued. Recently the work has been confined to a study of certain antigenic strains that were received from various sources in this country, and local strains. Chickens were used as experimental animals and the complement fixation test was used to indicate the development of immunity following vaccination. An attempt is being made to develop a vaccine with which it will be possible to immunize birds with one dose, although in some of the experiments it is the practice to vaccinate several times. There was found to be a direct correlation between the antibody content of the blood serum of fowls, as indicated by the complement fixation test, and immunity, as indicated by use of virulent cultures. The birds giving a positive complement fixation test were found to have a much stronger immunity to the chicken cholera organism (*P. avicida*) than those giving a negative test. An attempt was made to increase immunity by nonspecific protein therapy following vaccina-

tion. The birds were first vaccinated and one week later were given 1 cc. of normal inactivated horse serum intravenously. This treatment increased the complement fixing antibody content of the serum of both vaccinated and nonvaccinated birds, but seemed to exert no influence in protecting the birds against a virulent culture injected at a later date. The increased antibody content of the serum due to the injection of horse serum was of very short duration, returning to the normal level in 48 hours. From the work this year the non-specific protein therapy, at least with normal horse serum, cannot be relied upon to increase the immunity to *P. avicida* infection in chickens. The results of specific protein therapy (vaccination with killed cultures of *P. avicida*) were very good. In the last experiment several strains were used that had proved to be antigenically active by previous tests. These were pooled and heated at 60° C. for 1 hour to kill the organisms. This vaccine was used in 2.5 cc. doses, given subcutaneously. Twenty-eight birds were put on test. Twelve were vaccinated and sixteen kept as controls, unvaccinated. One week after vaccination all the birds were given five minimum lethal doses of a virulent culture of *P. avicida*. All the birds showed some reaction as indicated by inappetence and rise in temperature. Of the 12 vaccinated birds, 9, or 75 per cent, recovered. Of the 16 unvaccinated birds, 16, or 100 per cent, died. It is hoped to continue this work next year in an attempt to find strains that will give better results, and to combine the specific and nonspecific protein therapy, [Project 85; Department of Bacteriology; state fund.]

A Study of the Relation of Adequacy of Diet to Disease. This project has been continued in much the same manner as previously. The Department of Chemistry has made chemical examinations of blood, but the blood examinations for bacteria have been discontinued because it was impossible to obtain any marked differences in previous years. The individual total blood counts, the differential blood counts, the complement content of the serum were too variable to give significant indications. Post-mortem examinations were made on all birds which died. The results of these examinations are summarized in Table XXIX.

The losses in Pen II were much greater than they should have been according to the feed given. These birds gave signs of rickets in most cases. This probably resulted from the fact that they were given too much sprouted oats. This resulted in decreasing the amount of the basic feed, containing ash, consumed. In the absence of sunlight or ultra-violet light, the mineral metabolism of

TABLE XXIX.—Poultry losses due to lack of vitamins in feed.

Pen No.	Number of birds.	Vitamins lacking in ration.	Number dead.	Per cent dead.	Average number of days to death.	Nutritional disease.	Beriberi.	Rickets.
I	12	None	1	8.3	10	.....	.....	.....
II	12	D (?)	5	41.6	200	.....	.....	5 (?)
III	12	C	2	16.6	180	.....	.....	.....
IV	12	ACD	10	83.3	190	9	1	.....
V	12	BC	12	100.0	187	4	4	1 (?)

the body of the fowl seems to be upset. The birds in Pens I and II received the same ration, but Pen I received radiations of ultra-violet light. The difference in results may be accounted for on the basis of the above explanation. While the results of the recent work are not quite so clear cut as those of last year, it may be concluded that lack of vitamin A generally leads to nutritional disease; lack of vitamin B to beri beri; lack of both A and B to beri beri and nutritional disease (if the bird does not die early of beri beri it usually dies late of nutritional disease); lack of vitamin C to very poorly nourished feathers, dry, brittle, and ragged; lack of vitamin D to improper mineral metabolism and rickets. Rickets does not develop to any extent in adult birds but may be quite commonly seen in young, rapidly growing chicks. [Project 131; Departments of Bacteriology and Chemistry; state fund.]

BRANCH EXPERIMENT STATIONS

Thanks to the liberality of the 1923 legislature, it has been possible to improve materially the physical equipment of the branch experiment stations. Improvements were urgently needed because of the enforced neglect of physical equipment during the five years following the close of the war, when operation costs increased so much that the funds available to the stations were barely sufficient to support the regular work. The appropriations made by the 1923 legislature for repairs, new construction, and machinery for the branch stations amounted to \$21,250. This fund has made it possible to improve the efficiency of the branch stations, and its expenditure should be regarded as a sound investment for the state. Due partly to the availability of this fund, partly to a general improvement in labor conditions, and largely to the industry and loyalty of the superintendents, the work at the branch stations has progressed very satisfactorily during the biennium. Brief statements regarding the work of these stations follow.

FORT HAYS BRANCH EXPERIMENT STATION

The Fort Hays Branch Experiment Station consists of 3,600 acres of land, about 2,000 being under cultivation and the remainder used as pasture, and a full complement of buildings and equipment for the conduct of field experiments with soils, crops, and live stock. The principal projects of this station are briefly discussed below:

Dry-land Agriculture. The work on the dry-land project consists largely of a continuation of the work originally outlined and established in 1906 with additions which have been made since that date. The primary purpose of the project is to endeavor to determine by what methods of cropping the largest average yields may be secured and maintain the fertility of the soil. A total of 431 tenth-acre plots were used for the work during the past season. Methods of seed-bed preparation are being tried for continuous cropping of spring grains including barley, oats, spring wheat, corn, kafir and milo. The methods include spring plowing, fall plowing, subsoiling, and listing. For continuous cropping of winter wheat the methods include late fall plowing, early fall plowing, early fall listing, subsoiling, and stubbling in, and experiments in frequency of plowing; also the effect of seeding the wheat in 30-inch strips, alternating with unseeded areas of the same width which are inter-tilled. Experiments are being conducted to determine the best methods of preparing tall or heavy wheat stubble land for a second crop of winter wheat. This includes such methods as late fall plowing, early fall plowing, disking, disking and plowing, listing, double listing, seeding in the stubble without any tillage, and seeding on ground where the stubble has been burned off. A drill test is being made to determine the advantage, if any, of the furrow drill over the ordinary drill when used on ground prepared by the various methods of seed-bed preparation. Experiments are being conducted to try out methods of handling the soil during a fallow period, and to determine what crops make the best response to fallow, and how often it is best to fallow. The methods include plowing at different dates, listing, subsoiling, deep tillage, and dynamiting. In addition to crops listed under continuous cropping, alfalfa, brome grass, Canada field peas, winter rye, and cane are included in the experiments in the rotations. The rotations vary in length from two to six years and the crops are arranged in numerous combinations. Some include a grain crop every year, some include a season of fallow once in two, three, or four years. Others include peas or rye

as a green manure crop once in four years. Some include an application of straw, barnyard manure, or commercial fertilizer. Others include a grass crop, alfalfa or brome grass three years out of six. In a series of rotations where kafir follows winter wheat, experiments are being conducted to determine the most practical method of preparing wheat stubble land for kafir. The rotations include single and double spacing of corn and kafir.

Throughout the season soil-moisture determinations are made at intervals to determine the effect of various tillage methods upon the storage of moisture in the soil and to determine the changes that take place in the moisture content of the soil during the season of seed-bed preparation and during the development of the crops.

A set of instruments is maintained for the purpose of securing daily records of the temperatures, humidity, wind velocity, sunshine, precipitation, and evaporation. Because of a hailstorm which completely destroyed all small-grain crops, no yields were secured in 1923. The row crops were badly damaged and retarded in development, so that but little of the difference in yields can be definitely attributed to the methods of treatment. The average yields for a number of years indicate several things of interest, some of which are: (1) Generally, fall plowing has given considerably better results than spring plowing for barley, oats, and spring wheat. On the other hand, spring plowing has given better results for the row crops. (2) All crops respond to fallow with increased yields over all other methods of seed-bed preparation, but the increase is not sufficient to justify fallowing as often as every other year except perhaps in the case of milo, which has produced an average yield for nine years of 42 bushels as against 24.1 bushels on the best continuously cropped plot. (3) Winter wheat responds to fallow with a second crop nearly equal to the first crop after fallow. (4) Rotations including green manure crops thus far have not responded with increased yields over those produced on fallow. Neither have barnyard manure nor commercial fertilizers increased the yield significantly. (5) Barley sown on sorghum stubble has produced practically the same as barley sown on corn stubble. (6) Early fall listing for continuous wheat has given better yields than any other method.

During the past year 18 plots were added to the work to duplicate and furnish checks on some of the experiments which have been running for a number of years with only a single plot to represent each method. Twelve pairs of plots were added for experi-

ments in alternating small-grain crops (winter wheat and barley) with row crops (corn and kafir). The purpose of this work is to attempt to determine what advantage, if any, there may be to the small-grain crops to leave the corn and kafir stalks on the ground instead of removing all the stover as is the common practice in this locality when row crops are grown. The corn will be husked and kafir headed except for certain plots, which will be harvested in the usual manner for checks. Some extremely thick plantings of winter wheat on fallow land were made to furnish opportunity for study of the effect of thick plantings on the behavior of wheat on a seed bed containing a supply of stored moisture. [Fort Hays Experiment Station; state and federal funds.]

Cereal Investigations. The work has consisted of varietal and cultural testing of wheat, barley, oats, sorghums, and corn. In addition, a barley nursery was maintained in which 756 selections from foreign and domestic sources were grown with the object of isolating more desirable varieties for western Kansas. An extensive sorghum nursery was also included in which promising selections and hybrid material were under observation. The experiment in the rate and date of seeding winter wheat indicates that the optimum date of seeding lies between September 20 and October 1. The optimum rate of seeding was four pecks to the acre. The yield of winter wheat is closely correlated with the amount of precipitation which falls during the late summer and early autumn. The farmers' chances of securing a profitable wheat crop are precarious if the seed bed is short of moisture as late as October 1. Even under favorable conditions the yield of wheat gradually decreases after the October 1 date of seeding. The three-year average yields from 1920 to 1922 for the rate and date of seeding winter wheat are given in Table XXX.

TABLE XXX—Three-year average yields in experimental work in rate and date of seeding winter wheat.

(1920 to 1922.)

Rate of seeding, pecks per acre.	Date of seeding and yields in bushels per acre.							
	9-8	9-15	9-22	9-29	10-6	10-13	10-20	10-27
1	16.2	18.9	19.5	21.5	16.6	12.4	8.9	8.7
2	21.2	23.7	25.0	27.8	24.5	13.1	11.7	9.8
3	26.3	25.2	29.5	28.0	23.8	15.1	13.5	11.9
4	28.1	28.2	30.8	27.7	27.0	15.5	13.1	12.6

Comparative average yields of the leading varieties fo the five major crops grown in western Kansas are given below:

CROP AND VARIETY.	Years.	Av. yield per acre.
WHEAT:		
Kanred	1919 to 1922	20.7
Kharkov	1919 to 1922	19.1
Turkey	1919 to 1922	17.9
Prelude (spring)	1919 to 1922	11.6
Marouani (Durum)	1919 to 1922	15.2
BARLEY:		
Stavropol (local type).....	1919 to 1922	36.8
Coast	1919 to 1922	37.8
White Smyrna	1919 to 1922	37.0
OATS:		
Fulghum	1919 to 1922	55.5
Burt X Sixty Day	1919 to 1922	47.2
Kherson (generally grown).....	1919 to 1922	43.2
GRAIN SORGHUMS:		
Dwarf yellow milo	1919 to 1923	42.5
Feterita	1919 to 1923	40.6
Dawn kafir (Dwarf Blackhull).....	1919 to 1923	40.2
Pink kafir	1919 to 1923	35.4
CORN:		
Freed	1919 to 1923	17.4
Bloody Butcher	1919 to 1923	16.2
Pride of Saline.....	1919 to 1923	15.0

Proposed work for 1924 includes the continuation of varietal tests of the crops listed above, following the elimination of unsatisfactory varieties and the substitution of new and selected strains from nursery rows, or seed obtained from outside sources; sorghum hybridization, with particular reference to obtaining a high-yielding straight-necked milo which will be nonshattering and suitable for harvesting with a grain header; and increases of rate of seeding winter wheat from one to four pecks to one to seven pecks in order to ascertain at what rate limit the decline in yield occurs. [Fort Hays Experiment Station; state and federal funds.]

Forage Crop Investigations. The work on this project has consisted of field experiments with sorghums, Sudan grass, millet, alfalfa, sweet clover, and annual legumes. The experiment with alfalfa in row widths from 6 to 42 inches on upland, seeded in 1913, has now been carried through 10 consecutive seasons of cutting, and shows definitely that the wider the spacing between rows the lower the hay yields. There are also disadvantages attached to alfalfa in cultivated rows, such as poorer quality of hay and expense of cultivation. The average yields of hay in tons per acre for the different row widths for the years 1914 to 1923, inclusive, are shown below:

Inches between rows	Tons of hay per acre, average, 1914 to 1923.
6	1.07
12	1.05
24 . . . . .	.97
30 . . . . .	.94
36 . . . . .	.93
42 (single) . . . . .	.80
42 (double) . . . . .	.93

NOTE.—The single row differs from the double row in that the latter consists of two drill rows 6 inches apart.

Extensive variety tests of forage sorghums have continued with a view to improvement and distribution of the best strains. Early Sumac is a variety now being increased as a result of this work and is in great demand by farmers who have tried it. Selections of numerous lots of sumac are being grown with a view to further progress along this line. Sorghum, Sudan grass, and millet have been compared in close-drilled seedings for hay production, and it is concluded that the first two are much superior to millet. The higher tonnage of the sorghum is offset by the finer stems of the Sudan grass. The average yields of the three crops are given below:

CROP.	Average yield of hay per year, 1914 to 1923 Tons.
Red Amber sorghum	3.34
Sudan grass	2.76
German millet	2.26
Common millet	2.03

An unusual climatic feature of the past year was a very severe hailstorm on June 29, 1923, that cut all crops to the ground. Two important points observed in this connection were that the sorghums were able to renew growth and make almost a full crop, and that a series of the sorghum varieties planted on July 3 was able to produce an excellent yield of forage without any tillage after planting, though the rows were 40 inches apart, surface planted. [Fort Hays Experiment Station; state and federal funds.]

Bindweed Eradication. The work recently has consisted mainly in cleaning up a field of 14 acres where experimental work had been conducted during the previous four years. Intensive fallow through the season was followed. Probably 98 per cent of the bindweed existing at the beginning of the season was eradicated, and the rest is very weak, yielding readily to further treatment. The results of the four years of eradication experiments were published in December, 1923, as circular 101 of the Agricultural Experiment Station. [Fort Hays Experiment Station; state and federal funds.]

Dairy Cattle Feeding Investigations. The dairy cattle feeding investigations this past year were planned to study the comparative feeding values of alfalfa and Sudan-grass hay for cows in milk. A Sudan-grass pasture experiment was ready to begin on July 1 last season when hail completely destroyed the crop. The field never recovered. The results of the feeding work show that cows fed Sudan-grass hay with kafir silage and a liberal grain ration produced slightly more milk than the same cows when fed alfalfa hay and the same supplements. The difference in production was less than one pound of milk per cow daily. The fat production was practically the same on both feeds. The cows gained in body weight when changed to alfalfa hay and lost weight when changed to Sudan. The alfalfa hay was of only fair quality. A Sudan-grass pasture experiment will be put under way beginning about July 1, 1924. Winter feeding experiments have been tentatively outlined and will include comparisons between cane and Sudan-grass hay as roughage for dairy cattle. One publication, a summary of the feeding experiments for the past year, was published in April, 1924. [Fort Hays Experiment Station; state fund.]

Beef Cattle Feeding Investigations. The beef cattle feeding experiments during the past year were planned to study several methods of maintaining the beef cow herd during the winter months upon western Kansas feeds. These feeds included cane hay, Sudan-grass hay, alfalfa hay, wheat straw, and silage. Ten lots of ten cows each were used in the experiments. The results of the work show that: (1) Cane hay fed alone at the rate of 26.7 pounds per head per day is less valuable pound for pound than 26.7 pounds of alfalfa hay per day fed alone. (2) Alfalfa hay fed alone at the rate of 26.7 pounds per head per day is less valuable than 26.7 pounds of Sudan-grass hay per day fed alone. (3) A combination of 22.42 pounds of Sudan-grass hay and 4 pounds of alfalfa hay per head per day was less valuable than 26.7 pounds of Sudan-grass hay per day fed alone, and more valuable than 26.7 pounds of alfalfa hay per day fed alone. (4) A combination of 22.42 pounds of cane hay and 4 pounds of alfalfa hay per head per day was more valuable than 26.7 pounds of cane hay or 26.7 pounds of alfalfa hay per day fed alone. (5) A combination of 22.42 pounds of Sudan-grass hay and 4 pounds of cane hay per head per day fed alone proved more valuable than 26.7 pounds of cane hay per day fed alone, but less valuable than 26.7 pounds of Sudan-grass hay per day fed alone. (6) A combination of 21.12 pounds of

wheat straw and 4 pounds of cane hay per day proved more valuable than 21.43 pounds of wheat straw and 4 pounds of Sudan-grass hay per day. (7) A combination of 11.61 pounds of Sudan-grass hay and 30.2 pounds of kafir silage per day is more valuable than a ration composed of the same amounts of cane hay and kafir silage. This particular experiment shows that silage is the most valuable feed that can be produced for stock cattle. Supplemented with a little hay, a cheap and effective ration is supplied for stock cattle.

On the whole, the most valuable information derived from this year's work arises from the fact that 10 lots of cows were fed 10 different feeds or combinations of feeds that are commonly grown in western Kansas, and each lot came through the winter in a strong, vigorous condition, with prospects for at least a 90 per cent calf crop. [Fort Hays Experiment Station; state fund.]

The State Forest Nursery. The work in the Forest Nursery has consisted of experiments to determine the adaptability of trees and shrubs to western Kansas conditions and the propagation and distribution of types found hardy and well adapted. Methods of cultivation were studied, looking towards moisture conservation and the production of more sturdy fibrous root systems. The following varieties have given satisfactory indication of hardiness and adaptability to this section and will be propagated for distribution: Bull pine (*Pinus ponderosa*), Black Hill spruce, Silver Leaf poplar, Chinese elm, Tulip poplar, Northwest poplar, Golden poplar, Privet Amoor River North, Privet Ibota. Varieties not found well adapted at this station are Sweet gum, Scarlet maple, Cork elm, American linden, Willow oak, hemlock, *Pistachis chinensis*, *Calycanthus*, hazelnut, and *Althea rosa*. Of all sorts on trial the Chinese elm (*Ulmus pumila*) gives by far the greatest promise. It has proved extremely hardy and is a vigorous grower. This tree has made from three to four feet of growth in one season in the nursery. Special efforts have been made to increase the stock of the Chinese elm, but considerable difficulty has been experienced in getting vital seed, and propagations will be attempted from cuttings. During the biennium a total of 52,991 trees and shrubs were distributed among the citizens of central and western Kansas, who paid the Forest Nursery \$8,335 for these plants. [Fort Hays Experiment Stations; state fund.]

Vegetable Garden. The vegetable garden work at the Fort Hays station has been limited to the testing of varieties for adap-

tability to conditions in western Kansas under natural rainfall, and also under conditions of supplemental water supply. Owing to a severe hailstorm on June 29, 1923, all of the later-maturing vegetables were destroyed and the experiments made valueless for the season. Plans for the vegetable garden for this season include the introduction of many new varieties for trial. The garden plot has been cut into three divisions in order that different methods of cultivation for moisture conservation, using different machines, may be studied. One publication is now being compiled in which the principal results so far secured will be reported. [Fort Hays Experiment Station; state fund.]

GARDEN CITY BRANCH EXPERIMENT STATION

The Garden City Branch Experiment Station contains 320 acres of upland about five miles northeast of Garden City, Finney county. The work of this station is divided into three general classes: Dry-land agriculture investigations, experiments in irrigation agriculture, and a few simple experiments with the use of live stock in disposing of crops produced under irrigation. The dry-land agriculture work includes investigations of crop rotation, tillage, methods of planting, and tests of varieties of corn, oats, wheat, and barley. The irrigation agriculture work includes experiments with crop rotation and commercial fertilizers, tests of pasture grasses, and tests of varieties of irrigated crops and of various methods of utilizing irrigation water. Simple pasturing and feeding tests are carried on with dairy cattle and hogs.

In the fertilizer experiment with alfalfa the use of acid phosphate produced a yield of 7.27 tons per acre in 1923 as compared with an average of about 7 tons on untreated plots. No increase in the yield of alfalfa was secured from the use of potassium sulphate. Some very satisfactory results were again secured by irrigating land in the fall. One field of alfalfa produced 5.66 tons of hay to the acre from one irrigation applied in the fall, with no subsequent irrigation, as compared with a yield of 5.99 tons to the acre on a field which received irrigation both in the fall and in the spring. Excellent progress was made in testing varieties of grasses. Among other things it was noted that the Kentucky blue grass, either mixed with white clover or grown alone, orchard grass, tall oat grass, and slender wheat grass began growth very early in the spring. Meadow fescue, perennial rye grass, and both white and alsike clover suffered considerably from winterkilling. Kentucky blue grass mixed with white clover is particularly promising as a

pasture crop and white sweet clover appears to be a close rival. These preliminary tests are being carried on chiefly for the purpose of determining what grasses and grass mixtures will be the most suitable to use in more extensive plantings and in practical pasturing tests later on.

Very satisfactory returns are being secured by pasturing alfalfa with hogs when the alfalfa is supplemented with a moderate quantity of grain. The indications are that to use alfalfa as a hog pasture can be made one of the most profitable methods of disposing of a part of the alfalfa crop on the irrigated lands in southwestern Kansas. A complete reorganization has recently been made in the dairy herd. The old stock has been disposed of and a new herd of Holsteins is being developed.

The electrically operated irrigation pumping plant has been used with complete satisfaction. No delays from any cause have been encountered. The plant lifts water approximately 125 feet. During the season of 1923 the plant was operated for a total of 320 hours at an average operating cost of \$10.55 per acre foot of water, or slightly more than 8 cents per acre foot of water per foot of lift.

COLBY BRANCH EXPERIMENT STATION

The Colby Branch Experiment Station occupies a tract of 314 acres of land adjacent to the town site of Colby, Thomas county. This station is concerned with the investigation of agricultural problems of northwestern Kansas. The projects carried on during the biennium under review included experiments in crop rotation, tillage, and the use of green manure; soil moisture investigations; variety tests with corn, forage sorghum, grain sorghum, wheat, oats, and barley; feeding and pasturing experiments with dairy cattle; and tests of the furrow method of seeding wheat.

The wheat variety test included a study of the winter-hardiness of 24 varieties of winter wheat. Kanred and Minhardi showed the greatest winter-hardiness. Blackhull was decidedly deficient in this respect. The average winter survival of Blackhull in 1922-'23 was only 41 per cent, as compared with the average winter survival of 89 per cent for Kanred.

The 10-year average yields in the corn variety test showed the superiority of the Colby and Freed White Dent varieties. Their 10-year average yields were about 24.5 bushels per acre, or 4 bushels per acre above the 10-year average yield of Pride of Saline.

In a test of Sudan grass as pasture for dairy cows, 1.75 acres furnished ample pasturage for two cows for 98 days in 1921, 58

days in 1922, and 101 days in 1923. Sudan-grass pasture was a decided stimulant to milk production.

In an experiment with dairy cows on native pasture, the feeding of a moderate grain ration was very effective in maintaining milk production, especially between June 1 and October 1. This is the period when the milk production of cows on native pasture ordinarily declines sharply. The increase in milk production amounted to 1.1 pounds of milk for each pound of grain consumed. In another experiment the feeding of silage to cows on native pasture increased the milk production about 20 per cent as compared with that of cows receiving no feed in addition to the native pasturage.

TRIBUNE BRANCH EXPERIMENT STATION

The Tribune Branch Experiment Station contains about 100 acres of land situated about two miles west of the town of Tribune, Greeley county. During the biennium under review, the projects carried on included variety tests of grain and forage sorghums as feed crops for the high plains of western Kansas, corn, oats, barley, wheat, and beans; experiments with methods of seeding winter wheat, corn, and soybeans; tests of methods of utilizing manure; trials of trees and ornamental shrubs; and a simple test of Sudan grass as pasture for dairy cows.

The best results were secured with Kanota and Burt oats, common barley, Cassel White Dent and Blue Squaw corn, Red Amber forage sorghum, and Sunrise kafir.

In 1923 a field of 2.5 acres of Sudan grass furnished very satisfactory pasture for 3 cows for 44 days and for 2 cows for 19 days additional. The pasture period began on July 8. The pasture was used intermittently from then until October 31.

PUBLICATIONS

STATION PUBLICATIONS

The regular station publications issued during the biennium are listed in the following table:

GENERAL BULLETINS

<i>No.</i>	<i>Title.</i>	<i>Edition.</i>	<i>Pages.</i>	<i>Total pages.</i>
229.	Farm Storage as a Factor in the Marketing of Kansas Wheat	15,000	32	480,000
230.	Marketing Milk in Six Cities of Kansas	15,000	32	480,000
231.	Potato Disease Control in Kansas	6,000	45	270,000

TECHNICAL BULLETINS

10.	Blackleg Vaccines; Their production and Use	2,500	24	60,000
11.	The Hessian Fly in Kansas	10,000	96	960,000
12.	Relative Water Requirement of Corn and Sorghums	8,000	34	102,000
13.	13. Small Grain in Furrows	3,000	55	165,000

CIRCULARS

No.	Title.	Edition.	Pages.	Total pages.
94.	Russian Knapweed: A New Weed in Kansas.....	5,000	4	20,000
95.	Filling Silos	5,000	8	40,000
96.	Sheep Feeding Investigations, 1920-'21.....	10,000	7	70,000
97.	Cattle Feeding Investigations, 1921-'22.....	15,000	8	120,000
98.	Swine Feeding Investigations, 1921-'22.....	15,000	11	165,000
99.	Poultry Breeding Records	20,000	34	680,000
100.	House Plants and Their Care	15,000	16	240,000
101.	The Eradication of Bindweed.....	40,000	18	720,000
102.	Pruning Fruit Plants	15,000	24	360,000
103.	How to Produce Ice Cream With a Low Bacterial Content	3,000	4	12,000
104.	A Simplified Method of Standardizing the Ice-cream mix	4,000	12	48,000
105.	Silage Feeding Investigations, 1922-'23.....	15,000	10	150,000

INSPECTION CIRCULARS

16.	Fertilizer Control in 1920.....	1,000	31	31,000
17.	The Enforcement of the Kansas Live-stock Remedy Law,	2,500	60	150,000
18.	Fertilizer Control in 1921.....	1,500	20	30,000
19.	The Enforcement of the Kansas Feeding Stuffs Law....	2,500	181	452,500
20.	State Live Stock Registry Board Report.....	8,750	4	35,000

DIRECTOR'S REPORTS

Director's Report, 1920-1922	2,500	45	112,500
------------------------------------	-------	----	---------

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

Send No.	Year of issue.	Title, author, and publication.
4	1922	Farm Storage as a Factor in the Marketing of Kansas Wheat. R. M. Green. Kan. Bul. 229.
5*	1923	Marketing Milk in Six Cities of Kansas. F. L. Thomsen. Kan. Bul. 230.
6	1923	Fallacies of a Plan to Fix Prices of Farm Products by Government Control of the Exportable Surplus. Eric Englund. Jour. Farm Econ., v. 5, No. 2, pp. 86-101.
7	1923	The Problem of Interest and Rent in Cost Determination. W. E. Grimes. Jour. Farm Econ., v. 5, No. 2, pp. 79-85.
8	1923	Can a Farmer Acquire a Farm Out of His Farm Earnings? W. E. Grimes. Twenty-third Bien. Rept. Kan. St. Bd. Agr., pp. 39-46.

Department of Agronomy

140	1922	Relation of Crop Yields to Quantity of Irrigation Water in South-western Kansas. George S. Knapp. Kan. Bul. 228.
141	1922	Russian Knapweed: A New Weed in Kansas. R. L. Hensel and Mr. E. P. Harling. Kan. Cir. 94.
142	1923	Effect of Burning on Vegetation in Kansas Pastures. R. L. Hensel. Jour. Agr. Res., v. 23, No. 8, pp. 631-643.
143	1922	Increasing the Efficiency of Agronomic Research. Amer. Soc. Agron., v. 14, No. 9, pp. 329-338.
144	1923	Some Limitations in the Application of the Method of Least Squares to Field Experiments. S. C. Salmon Amer. Soc. Agron., v. 15, No. 6, pp. 225-239.
145	1923	Laboratory Instruction in Field Crops. John H. Parker. Amer. Sot. Agron., v. 15, No. 2, pp. 43-54.
147	1923	Wheat Production in Kansas. S. C. Salmon and H. M. Bainer. Kan. Exten. Bul. 41.
148	1923	The Eradication of Bindweed. L. E. Call and R. E. Getty. Kan. Cir. 101.
153	1924	Seeding Wheat in Furrows. S. C. Salmon. Kan. Tech. Bul. 13.

*Erroneously marked as No. 4 in the publication.

Department of Animal Husbandry

Serial No.	Year of issue.	Title, author, and publication.
68	1922	Sheep Feeding Investigations, 1921-'22. A. M. Paterson and H. B. Winchester. Kan. Cir. 96.
69	1922	Kansas State Live-stock Registry Board Report No. 12. B. M. Anderson. Kan. Imp. Cir. 20.
70	1923	Cattle Feeding Investigations, 1921-'22. C. W. McCampbell, H. B. Winchester, and H. W. Marston. Kan. Cir. 97.
71	1923	Swine Feeding Investigations, 1921-'22. F. W. Bell, H. B. Winchester, and H. W. Marston. Kan. Cir. 98.
72	1924	Silage Feeding Investigations, 1922-'23. C. W. McCampbell and W. R. Horlacher. Kan. Cir. 105.

Department of Bacteriology

36	1922	A Method of Cultivating Anaerobes. L. D. Bushnell. Jour. Bact., 7:277-281.
37	1921	Influence of Vacuum Upon Growth of Some Spore-bearing Bacteria. L. D. Bushnell. Jour. Bact., 7:277-281.
38	1921	Stimulating the Growth of Azotobacter by Aeration. O. W. Hunter. Jour. Agr. Res., v. 23, No. 8, pp. 665-677.
39	1921	The Production of a Growth-promoting Substance by Azotobacter. O. W. Hunter. Jour. Agr. Res., v. 23, No. 10, pp. 825-831.
40	1921	Protein Synthesis by Azotobacter. O. W. Hunter. Jour. Agr. Res., v. 24, NO. 3, pp. 263-274.
41	1921	Quantitative Determinations of Some of Biochemical changes Produced by a Saprophytic Anaerobe. L. D. Bushnell. Jour. Bact., V. 7, NO. 4, pp. 373-403.
42	1921	Clinical Aids in the Differential Diagnosis of Common Poultry Diseases. F. R. Beaudette. Jour. Vet. Med. Assoc., 13:283-290.
43	1921	Laboratory Diagnosis of Poultry Diseases. L. D. Bushnell and F. R. Beaudette. Jour. Vet. Med. Assoc., 13:729-733.
44	1921	Substitution of Brom-thymol-blue for Litmus in Routine Laboratory Work. H. R. Baker. Jour. Bact., 7:301-305.
45	1921	The Study of an Organism Resembling <i>B. pullorwn</i> Isolated from the Unabsorbed Yolk of Chicks "Dead in the Shell." F. R. Beaudette, L. D. Bushnell, and L. F. Payne. Jour. Infect. Diseases, v. 32, No. 2, pp. 124-132.
46	1922	On the Use of Calcium Carbonate in Nitrogen Fixation Experiments. P. L. Gainey. Jour. Agr. Res., v. 24, No. 2, pp. 185-190.
47	1922	The Correlation of Sod Reaction with the Presence of Azotobacter in Soils. P. L. Gainey. Science, 56:21.
48	1922	A study of the Effect of Changing the Absolute Reaction of Soils Upon Their Azotobacter Content. P. L. Gainey. Jour. Agr. Res., v. 24, No. 4, pp. 289-296.
49	1922	Influence of H-ion Upon Growth of Azotobacter. P. L. Gainey and H. W. Batchelor. Science, v. 56, No. 1437, pp. 49-50.
50	1922	The Influence of the Hydrogen-ion Concentration Upon the Growth and Fixation of Nitrogen by Culture of Azotobacter. P. L. Gainey. Jour. Agr. Res., v. 24, No. 11, pp. 907-938.
51	1922	The Influence of the Absolute Reaction of the Soil Upon Its Azotobacter Flora and Nitrogen Fixing Ability. P. L. Gainey. Jour. Agr. Res., v. 24, No. 11, pp. 907-938.
52	1922	Differential Diagnosis of Some of the More Common Diseases of Poultry. F. R. Beaudetts. No. Amer. Vet., 2:587-592.
53	1923	The Bacterial Content of Some Kansas Ice Cream. A. C. Fay. Jour. Dairy Sci., 6:283-291.
54	1924	Natural Anti-sheep Amboceptor and Complement in the Blood of Fowls. F. R. Beaudette and L. D. Bushnell. Jour. Agr. Res., v. 27, No. 9, pp. 709-715.
55	1923	Agglutinins for <i>Bacterium pullorum</i> in Hens' Eggs. F. R. Beaudette. Jour. Immunology, v. 7, No. 6, pp. 493-499.
56	1923	Single Tube Method for Determining Carriers of <i>Bacterium pullorum</i> . F. R. Beaudette. Jour. Amer. Vet. Med. Assoc., v. 17, No. 2, pp. 225-227.
57	1923	The Relation of <i>Bacterium pullorum</i> the Hatchability of Eggs. F. R. Beaudette, L. D. Bushnell, and L. F. Payne. Jour. Infect. Diseases, v. 33, No. 4, pp. 331-337.
56	1924	The Calcium Content of Soil in Relation to Absolute Reaction. C. O. Swanson, P. L. Gainey, and W. L. Latshaw. Soil Sci., 17:181-191.

Serial No.	Year of issue.	Title, author, and publication.
59	1923	The Relation between <i>Bacillus avisepticus</i> Types Isolated from Roup and Fowl Cholera. L. D. Bushnell. Abs. Bact., 7:30-31.
60	1923	Agglutinins for <i>Bacterium pullorum</i> in Hens' Eggs. F. R. Beaudette. Abs. Bact. 7:32-33.
Department of Botany		
185	1922	Rust Resistance in Winter Wheat Varieties. L. E. Melchers and J. H. Parker. U. S. Dept. Agr. Bul. 1046.
186	1922	Inheritance of Resistance to Black Stem Rust in Crosses Between Varieties of Common Wheat (<i>Triticum vulgare</i>). L. E. Melchers and J. H. Parker. Phytopathology, 12:31-32 (Abstract).
187	1922	Foot Rot Disease of Wheat in Kansas. H. H. McKinney and L. E. Melchers. Phytopathology 12:27-28 (Abstract)
189	1923	Influence of the Moonlight on Movements of Leguminous Leaflets. F. C. Gates. Ecology, 4: 37-39.
190	1923	Relative Water Requirement of Corn and Sorghums. E. C. Miller. Kan. Tech. Bul. 12.
192	1922	Potato Diseases Prevalent in Kansas, and Their Control. L. E. Melchers. Bien. Rept. Kan. St. Hort. Soc., 36:124-125. (1920-'21.)
193	1923	Wheat Smut Investigations in Kansas Report of Progress, 1920-'21. C. O. Johnston. Phytopathology, 13:36 (Abstract)
194	1923	Corn Root, Stalk and Ear Rot Disease Investigations in Kansas: Report of Progress, 1922. L. E. Melchers and C. O. Johnston. Phytopathology, 13:52 (Abstract).
200	1923	Some Observations on the Temperature of the Leaves of Crop Plants. E. C. Miller and A. R. Saunders Jour Agr. Res 26:15-43.
201	1922	Meteorological Summary, Douglas Lake, Michigan, 1922. F. C. Gates. Mich Acad Sci., 2:161-163
203	1922	Contribution to the Flora of Cass County, Ill. F. C. Gates. Ill. Acad Sci, 15:165-170.
204	1924	Annual Growth of <i>Pinus resinosa</i> and <i>Pinus strobus</i> . Dorothy J. Cashen Papers Mich. Acad. Sci., Arts and Letters, 3:67-86.
208	1924	The Persistency of <i>Scirpus validus</i> F. C. Gates Ecology, 5:5.
209	1924	Meteorological Data, Douglas Lake, Michigan. F. C. Gates. Mich. Acad. Cci, 3:301-302.
210	1924	The Rate of Spread of Wheat Foot Rot in Tillage Plots in Kansas. L. E. Melchers and M. C. Sewell. Phytopathology, 14:41 (Abstract)
212	1924	Studies on Corn Seed Germination and the Prevalence of <i>Fusarium maniliforme</i> and <i>Diplodia zeae</i> : Second Report of Progress, 1923. L. E. Melchers and C. O. Johnston. Phytopathology, 14:45 (Abstract).
213	1924	Fungicidal Treatment for the Control of Sorghum Kernel Smut. C. O. Johnston and L. E. Melchers. Phytopathology, 14:44 (Abstract).
214	1924	Bunt of Wheat Investigations in Kansas: Second Report of Progress. C. O. Johnston Phytopathology, 14:37 (Abstract).
215	1924	Tomato Wilt. R. P. White. Phytopathology, 14:28 (Abstract).
216	1924	Loss of Strength of Mercuric Chloride Solutions Used for Treating Potatoes R. P. White. Phytopathology, 14:58 (Abstract).
218	1924	Potato Disease Control in Kansas. E. A. Stokdyk and L. E. Melchers Kan. Bul. 231.
222	1922	Extensions of Range of Plants in the Douglas Lake Region, Cheboygan County, Michigan. F. C. Gates. Mich. Acad. Sci, 2:47-48.
Department of Chemistry		
96	1922	Fertilizer Control in 1920. C. O. Swanson and W. L. Latshaw. Kan. Insp. Cir. 16.
97	1922	Fertilizer control in 1921. W. L. Latshaw. Kan Insp Cir. 18.
98	1922	The Adsorption and Orientation of the Molecules of Diabasic Organic Acids and Their Ethereal Salts in Liquid Vapor Interfaces. H. H. King and R. W. Wampler. Jour. Amer. Chem. Soc. v. 44, No. 9, Part II, pp. 1894-1902.
99	1922	Sulphur as an Important Fertility Element. C. O. Swanson and W. L. Latshaw. Soil Sci., v. 14, No. 6, pp. 421-430.

<i>Serial No.</i>	<i>Year of issue.</i>	<i>Title, author, and publication.</i>
100	1923	Sod Reaction in Relation to Calcium Adsorption. C. O. Swanson Jour. Agr. Res., v. 26, No. 3, pp. 83-123.
101	1923	The origin, Distribution, and Composition of Laterite. C. O. Swanson. Jour. Amer. Ceramic Sm., v. 6, No. 12, pp. 1248-1260.
102	1923	Physicochemical Basis of Physic Phenomena. J. S. Hughes and H. H. King. Science, 57:590-591.
104	1923	The Calcium Content of Soil in Relation to Absolute Reaction. C. O. Swanson, P. L. Gainey, and W. L. Latshaw. Soil Sci., v. 17, No. 3, pp. 181-191.
Department of Dairy Husbandry		
42	1922	Filling Solos J. B. Fitch, Kan. Cir. 95.
43	1922	Is a Preliminary Dry Milking Essential in Semiofficial Tests? J. B. Fitch, R. B. Becker, and P. C. McGilliard. Jour. Dairy Sci., v. 5, No. 3, pp. 259-272.
44	1923	The Production of Good Cream. N. E. Olson. Kan. Exten., X-Form 201.
45	1924	The Place of the Dairy Cow in Diversified Farming J. B. Fitch. Kan. Exten. X-Form 208.
46	1924	How to Produce Ice cream with a Low Bacterial Content. 2. Olson and A. C. Fay. Kan. Cir. 103.
47	1924	Standardization of the Ice Cream Mix. N. E. Olson. Kan. Cir. 104.
48	1924	Bacterial Content of Ice Cream. N. E. Olson and A. C. Fay. Jour. Dairy Sci., v. 7, No. 4, pp. 330-356.
49	1924	Variation in Amount and Per Cent of Fat in the Milk from Different Quarters of the Cow's Udder. J. B. Fitch and Lynn Copeland Jour. Dairy Sci., v. 7, No. 2, pp. 169-173.
50	1924	A study of Birth Weights and Gestation of Dairy Calves. J. B. Fitch P. C. McGilliard, and George Drumm. Jour. Dairy Sci., v. 7, No. 3, pp. 222-233.
Department of Entomology		
298	1922	Honey Plants of Kansas. J. H. Merrill. Amer. Bee Jour., v. 62, No. 1, pp. 7-10.
299	1922	Observations of Insects Attacking Sorghums. Wm. P. Hayes. Jour. Econ. Ent., 15:349-356.
300	1922	Longevity of the Larval State of the Cadelle. J. W. McColloch. Jour. Econ. Ent., 15:240-243.
301	1922	Methods of Procedure in Insect Life History Investigations. Wm. P. Hayes. Canad. Ent., 54:73-77.
302	1922	The Correlation Between Some Physical Characters of the Bee and Its Honey-storing Abilities. J. H. Merrill. Jour. Econ. Ent., 15:125-132.
303	1922	Some Insects Injurious to Ornamentals. Geo. A. Dean. Bien. Rept. Kan. St. Hort. Soc., 36:170-178.
304	1923	Sod Temperature and Its Influence On White Grub Activities. J. W. McColloch and Wm. P. Hayes. Ecology, 4:29-36.
305	1922	The Reciprocal Relation of Sod and Insects. J. W. McColloch and Wm. P. Hayes. Ecology, 3:288-301
306	1922	Hatching in Three Species of Neuroptera. Roger C. Smith, Ann. Ent. Soc. of Amer., 15:169-176.
307	1922	The Cooperation of High School and Agricultural College in Economic Entomology. E. G. Kellv. Jour. Econ. Ent., 15:54-58.
308	1922	The Phyllophaga (Scarab Coleop) of Hawthorn (<i>Crataegus</i>). J. W. McColloch and Wm. P. Hayes. Brookyn Ent. Soc., 17:131-135
310	1922	The Value of Winter Protection for Bees J. H. Merrill. Jour. Econ. Ent., 16:125-129.
311	1923	The Resistance of Wheat to the Hessian Fly: A Progress Report. J. W. McColloch and S. C. Salmon. Jour. Econ. Ent., 16: 293-298.
312	1923	Another Step in the Control of the Hessian Fly. Geo. A. Dean. Jour. Econ. Ent., 16:288-291.
313	1923	The Life Histories and Stages of Some Hemerobids and Allied Species. Roger C. Smith. Ann. Ent. Soc. of Amer., 16:129-148.
314	1923	Inside History of a Bee Hive. J. H. Merrill. Gleanings Bee Cult., v. 63, No. 7, pp. 452-454.
315	1923	Queen Introduction Under Unfavorable Conditions. J. H. Merrill. Amer. Bee Jour., v. 63, No. 8, pp. 395-396.
316	1923	The Hessian Fly in Kansas. J. W. McColloch. Kan. Tech. Bul 11.

Serial No.	Year of issue.	Title, author, and publication.
317	1923	The Relation of Some of the Physical Characteristics of the Honey- bee to its Length of Life. J. H. Merrill. Amer. Bee Jour., v. 63, No. 11, pp. 559-560.
318	1923	Response to the Nectar Stimulus. J. H. Merrill. Amer. Bee Jour., v. 63, No. 12, p. 607.
320	1924	A New Species of Anomala (Coleop. Scarabaeidae). Wm P. Hayes and J. W. McColloch. Ent. News, 35: 138-140.
323	1924	Are Package Bees Short Weight? J.H. Merrill. Amer. Bee Jour., v. 64, No. 2, pp. 81-82.
325	1924	<i>Caenurgi erechtea</i> Cram (Noctuidae) as an Alfalfa Pest. Roger C. Smith. Jour. Econ. Ent., 17:312-319.
329	1924	The Time of Planting Corn as a Factor in Earworm Control. J. W. McColloch. Jour. Econ. Ent., 17:320-323.
331	1924	Bees and Brood from May 1 until Frost. J. H. Merrill. Amer. Bee Jour., v. 64, No. 5, pp. 281-282.
332	1924	Observations on Brood Rearing. J. H. Merrill. Amer. Bee Jour., v. 64, No. 7, pp. 337-338.
338	1924	New Species of <i>Bolbocerosoma</i> (Scarabaeidae). R. W. Dawson and J. W. McColloch. Canad. Ent., 56:9-15.

Department of Horticulture

53	1923	House Plants and Their Care. Walter B. Balch. Kan. Cir. 100.
54	1924	Pruning Fruit Plants. R. J. Barnett. Kan. Cir. 102.

Department of Milling Industry

22	1922	The Enforcement of the Kansas Live-stock Remedy Law. L. A. Fitz and A. E. Langworthy. Kan. Insp. Cir. 17.
23	1922	The Enforcement of the Kansas Feeding-stuffs Law. L. A. Fitz and A. E. Langworthy. Kan. Insp. Cir. 19.

Department of Poultry Hubandry

18	1922	Culling Farm Poultry. L. F. Payne. Kan. Cir. 93.
19	1923	Poultry Breeding Records. W. A. Lippincott. Kan. Cir. 99.
20	1923	Genes for the Extension of Black Pigment in the Chicken. W. A. Lippincott. Amer. Nat., 57:284-287.
21	1923	The Hereditary Relation of Dominant White and Blue in the Chicken. W. A. Lippincott. Poultry Sci, v. 2, No. 5, pp. 141-145.
22	1923	Study of an Organism Resembling <i>Bacterium pullorum</i> from Unab- sorbed Yolk of Chicks "Dead in Shell." F. R. Beaudette, L. D. Bushnell, and L. F. Payne. Jour. Infect. Diseases, v. 32, No. 2, pp. 124-132.
23	1923	The Relation of <i>Bacterium pullorum</i> to the Hatchability of Eggs. F. R. Beaudette, L. D. Bushnell, and L. F. Payne. Jour. Infect. Diseases, 32 : 124.
24	1923	Poultry as a Required Course in the Agricultural Curriculum. L. F. Payne. Poultry Sci., v. 2, No. 3, pp. 78-84.

Department of Veterinary Medicine

	1922	The Production and Potency of Antibleckleg Serum. J. P. Scott. Ohio State Univ. Vet. Alumni Quart, v. 10, No. 2, pp 47-53.
...	1923	Notes on Blackleg Immunization. J. P. Scott. No. Amer. Vet., v. 4, No. 4, pp. 267-270.
29	1923	Blackleg Vaccines: Their Production and Use. J. B. Scott. Kan. Tech. Bul. 10.
...	1923	Potency tests for Bleckleg Filtrate and Aggressin Based on the Ag- gressive Action of These Products. J. P. Scott. Jour. Amer. Vet. Med. Assoc., v. 17, No. 1, pp. 67-74.

Department of Zoology

53	1922	Investigations on the Control of Hookworm Disease: II. The De- scription of an Apparatus Isolating Infective Hookworm Larvæ from Soil Wm. W. Cort, J. E. Ackert, D. L. Augustine, and Florence King Payne. Amer. Jour. Hyg., 2:1-16.
54	1922	Investigations on the Control of Hookworm Disease: III. Discussion of the Finding of Unsheathed Hookworm Larvæ in Soil Wm. W. Cort, J. E. Ackert, D. L. Augustine, Geo. C. Payne, and Florence King Payne. Amer. Jour. Hyg., 4:17-25.

<i>Serial No.</i>	<i>Year of issue.</i>	<i>Title, author, and publication.</i>
55	1922	Investigations on the Control of Hookworm Disease: IV. The Relation of the Domestic Chicken to the Spread of Hookworm Disease. J. E. Ackert. Amer. Jour. Hyg., 2:26-38.
56	1922	Investigations on the Control of Hookworm Disease: V. The Domestic Pig and Hookworm Dissemination. J. E. Ackert and Florence King Payne. Amer. Jour. Hyg., 2:39-50.
57	1922	Concerning the Origin of the Notochord in the Chick. Mary T. Harmon. Anat. Rec., v. 23, No. 7, pp. 363-369.
58	1922	A New Parasite of the Pig. J. E. Ackert and Florence King Payne. Jour. Amer. Vet. Med. Assoc., V. 61 (n. S., V. 14), pp. 186-188.
59	1922	The House Fly and Fowl Tapeworm Transmission. J. E. Ackert. Kan. Acad. Sci., 30:202-204.
60	1922	Studies on the Occurrence and Development of <i>Ascaridia perspicillum</i> Parasitic in Chickens. Bertha L. Danheim. Kan. Acad. Sci., 30:204-205.
61	1923	Investigations on the Control of Hookworm Disease: XII. Studies on the Occurrence, Distribution and Morphology of <i>Necator suillus</i> . Including Descriptions of the Other Species of Necator. J. E. Ackert and Florence King Payne. Amer. Jour. Hyg., 3:1-24.
62	1923	Investigations on the Control of Hookworm Disease: XIII. Observations on Conditions Under Which Hookworm Eggs and Larvae Develop. J. E. Ackert. Amer. Jour. Hyg., 3:26-34.
63	1923	Feeding Habits of Moles. F. L. Hisaw. Jour. Mammalogy, 4:9-20.
64	1923	The Burrowing Habits of Moles (<i>Scalopus auguaticus machrinoides</i>). F. L. Hisaw. Jour. Mammalogy, 4:79-88.
65	1923	Growing Experimental Chickens in Confinement. C. A. Herrick, J. E. Ackert, and Bertha L. Danheim. Jour. Agr. Res., 25:451-455.
66	1923	On the Habitat of <i>Ascaridia perspicillum</i> (Rud.). J. E. Ackert. Jour. Par., 10:101-103.
67	1923	A New Dominant Color Pattern and Combinations That Breed True in the Grouse Locusts. R. K. Nabours. Genetica, v. 5, Nos. 5-6, pp. 477-480.
68	1924	The Absorption of the Pubic Symphysis of the Pocket Gopher. <i>Geomys bursarius</i> (Shaw). F. L. Hisaw. Amer. Nat., 58:9396.
69	1924	Ecological Studies of Aquatic Insects: I Adaptations of Mayfly Nymphs to Swift Streams. G. S. Dodds and F. L. Hisaw. Ecology, 5:137-149.
71	1924	Notes on the Longevity and Infectivity of Hookworm Larvae. J. E. Ackert. Amer. Jour. Hyg., 4:222-225.
Director's Office		
29	1922	Director's Report, 1920-1922. F. D. Farrell.

PUBLICATION DIFFICULTIES

The publication difficulties which were discussed at some length in the report for the biennium ending June 30, 1922, have not decreased. The station has about 30 manuscripts which should be published as bulletins or circulars for the use of farmers, teachers, and students of agriculture. The state owes it to itself and to its farmers, young and old, to provide some practical means for getting this material printed and for insuring the prompt publication of the results of station work as they become available from time to time. It is false economy and unwise business practice to perpetuate the present limitations on the publishing of adequate bulletins and circulars describing the results of station work and showing how these results can be applied in the upbuilding of the agriculture of the state.

FINANCIAL STATEMENT, 1922-'23

(The Kansas Agricultural Experiment Station in account with federal and state appropriations.)

	Federal appropriations.	State appropriations and receipts.	Totals.
Main station	\$30,000.00	(a) \$60,387.86	\$90,387.86
Branch stations, appropriations.....		(b) 39,670.87	39,670.87
Branch stations, sales		37,140.96	37,140.96
Totals	\$30,000.00	\$137,199.69	\$167,199.69
Salaries	\$20,000.00	\$30,129.88	\$50,129.88
Labor	7,250.85	45,486.12	52,736.97
Publications	6.26	254.82	261.08
Postage and stationery	215.47	910.53	1,126.00
Freight and express	8.80	1,077.68	1,086.48
Heat, light, water and power.....	.60	2,656.77	3,657.27
Chemicals and laboratory supplies	246.35	1,428.60	1,674.95
Seeds, plants and sundry supplies.....	311.64	5,440.15	5,751.79
Fertilizers			
Feeding stuffs	352.97	2,067.09	2,420.06
Library		70.05	70.05
Tools, machinery and appliances.....	510.17	8,853.67	9,363.84
Furniture and fixtures	55.45	1,247.17	1,302.62
Scientific apparatus and specimens	65.25	259.41	324.66
Live stock	472.85	5,180.73	5,653.58
Traveling expenses	482.78	2,935.78	3,418.56
Contingent expenses		10,477.16	10,477.16
Buildings and land	20.66	7,630.76	7,651.42
Balance, June 30, 1923		10,093.32	10,093.32
Totals	\$30,000.00	\$137,199.69	\$167,199.69

(a) Includes a balance on hand June 30, 1922, of \$3,789.51.
 (b) Includes a balance on hand June 30, 1922, of \$1,633.87.

FINANCIAL STATEMENT, 1923-'24

(The Kansas Agricultural Experiment Station in account with federal and state appropriations.)

	Federal appropriations.	State appropriations and receipts.	Totals.
Main station	\$30,000.00	(a) \$59,206.15	\$89,206.15
Branch stations, appropriations.....		(b) 51,341.54	51,341.54
Branch stations, sales		61,450.94	61,450.94
Totals	\$30,000.00	\$171,998.63	\$201,998.63
Salaries	\$20,000.00	\$26,891.87	\$46,891.87
Labor	7,844.66	55,569.73	63,414.39
Stationery and office supplies	81.09	1,375.88	1,456.97
Scientific supplies, consumable	479.19	3,571.26	4,050.45
Feeding stuffs	342.74	12,952.80	13,295.54
Sundry supplies	202.00	9,309.79	9,511.79
Fertilizers	87.63		87.63
Communication service	47.91	1,604.72	1,652.63
Travel expenses	296.00	4,933.00	5,229.00
Transportation of things	8.05	2,065.85	2,073.40
Publications	6.28	1,509.55	1,515.83
Heat, light, water and power.....		3,847.98	3,847.98
Furniture, furnishings and fixtures	73.61	856.55	930.16
Library		327.31	327.31
Scientific equipment	6.21	342.05	348.26
Live stock	239.00	5,291.00	5,530.00
Tools, machinery and appliances	157.45	9,793.72	9,951.17
Buildings and land	128.18	10,378.95	10,507.13
Contingent expenses		2,731.91	2,731.91
Unexpended balance, June 30, 1924.....		18,645.21	18,645.21
Totals	\$30,000.00	\$171,998.63	\$201,998.63

(a) Includes a balance on hand June 30, 1923, of \$4,206.15.
 (b) Includes a balance on hand June 30, 1923, of \$2,791.54.