

AGRICULTURAL EXPERIMENT STATION

KANSAS STATE AGRICULTURAL COLLEGE
MANHATTAN, KANSAS

DIRECTOR'S REPORT

1926-1928



PRINTED BY KANSAS STATE PRINTING PLANT
B. P. WALKER, STATE PRINTER
TOPEKA 1928
12-5328

KANSAS AGRICULTURAL EXPERIMENT STATION

STATE BOARD OF REGENTS

W. Y. MORGAN, *Chairman*, Hutchinson

C. M. HARGER, Abilene
C. W. SPENCER, Sedan
C. B. MERRIAM, Topeka
B. C. CULP, Beloit

E. W. EVANS, Wichita
Mrs. J. S. PATRICK, Satanta
M. G. VINCENT, Pittsburg
W. E. IRELAND, Yates Center

H. E. SHRACK, *Business Manager*, Topeka

STATION STAFF

F. D. FARRELL, *President*

L. E. CALL, *Director*

AGRICULTURAL ECONOMICS

W. E. GRIMES, *in Charge*
R. M. GREEN, *Marketing*
HAROLD HOWE, *Land Economics*
MORRIS EVANS, *Farm Organization*
J. A. HODGES, *Farm Organization*
HOMER J. HENNEY, *Marketing Live Stock*
R. D. NICHOLS, *Farm Organization*

AGRONOMY

R. I. THROCKMORTON, *in Charge*
A. E. ALDOUS, *Pasture Management*
S. C. SALMON, *Crops*
JOHN H. PARKER, *Plant Breeding*
F. L. DULEY, *Soils*
H. H. LAUDE, *Coöperative Experiments*
M. C. SEWELL, *Soils*
J. W. ZAHNLEY, *Crops*
C. O. GRANDFIELD, *Coöperative Experiments*
I. K. LANDON, *Experimental Fields*
R. H. DAVIS, *Soil Survey*

ANIMAL HUSBANDRY

C. W. McCAMPBELL, *in Charge*
H. L. ISEN, *Genetics*
H. E. REED, *Sheep*
B. M. ANDERSON, *Cattle*
C. E. AUBEL, *Hogs*
D. L. MACKINTOSH, *Meats*
M. A. ALEXANDER, *Live Stock*

BACTERIOLOGY

L. D. BUSHNELL, *in Charge*
A. C. FAY, *Dairy Bacteriology*
P. L. GAINY, *Soil Bacteriology*
C. A. BRANDLY, *Poultry Disease Investigations*

BOTANY

L. E. MELCHERS, *Plant Pathologist, in Charge*
E. C. MILLER, *Plant Physiology*
O. H. ELMER, *Plant Pathology*

CHEMISTRY

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

BRANCH EXPERIMENT STATIONS

FORT HAYS

L. C. AICHER, *Superintendent*

GARDEN CITY

F. A. WAGNER, *Superintendent*

DAIRY HUSBANDRY

J. B. FITCH, *in Charge*
H. W. CAVE, *Dairy Production*
W. H. MARTIN, *Dairy Manufactures*
H. J. BROOKS, *in Charge of Official Tests*

ENTOMOLOGY

G. A. DEAN, *in Charge*
J. W. McCOLLOUGH, *Staple Crop Insects*
R. L. PARKER, *Apiculture, Fruit Insects*
R. C. SMITH, * *Staple Crop Insects*
HARRY R. BRYSON, *Staple Crop Insects*
R. H. PAINTER, *Staple Crop Insects*

HOME ECONOMICS

MARGARET M. JUSTIN, *in Charge*
MARTHA KRAMER, *Human Nutrition*
KATHERINE HESS, *Clothing and Textiles*
MARY TAYLOR, *Household Economics*

HORTICULTURE

ALBERT DICKENS, *in Charge*
R. J. BARNETT, *Pomology*
W. F. PICKETT, *Orchard Investigations*
W. B. BALCH, *Vegetable Gardening and Floriculture*
L. R. QUINLAN, *Landscape Gardening*

MILLING INDUSTRY

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

POULTRY HUSBANDRY

L. F. PAYNE, *in Charge*
D. C. WARREN, *Genetics*
H. M. SCOTT, *Poultry Production*

VETERINARY MEDICINE

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

ZÖOLOGY

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

COLBY

B. F. BARNES, *Superintendent*

TRIBUNE

T. B. STINSON, *Superintendent*

* On leave.

LETTER OF TRANSMITTAL

OFFICE OF THE DIRECTOR,

June 30, 1928.

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

I have the honor to submit herewith the report of the Agricultural Experiment Station of the Kansas State Agricultural College for the biennium ending June 30, 1928. The report includes a brief statement of the work in progress during this period, changes in personnel of the station staff, a list of publications of the station and of the scientific contributions of the station staff, and a statement of receipts and expenditures of the biennium under review.

L. E. CALL, Director.

TABLE OF CONTENTS.

	PAGE
LETTER OF TRANSMITTAL	3
INTRODUCTION	5
COÖPERATION WITH OTHER AGENCIES	5
THE PURNELL ACT.....	6
THE SOIL SURVEY.....	6
LAND, BUILDINGS, AND, EQUIPMENT	7
PERSONNEL.....	9
SCOPE OF THE STATION WORK, JULY 1, 1926, JUNE 30, 1928	11
STUDIES IN THE ECONOMICS OF AGRICULTURE	16
CONSERVATION OF THE SOIL	22
INVESTIGATIONS IN THE PLANT INDUSTRIES	32
DISEASES OF PLANTS	60
INJURIOUS INSECTS AND OTHER PESTS	67
INVESTIGATIONS IN THE LIVE-STOCK INDUSTRIES	82
DISEASES OF FARM ANIMALS	109
STUDIES IN HOME ECONOMICS	122
BRANCH EXPERIMENT STATIONS.....	126
Fort Hays Branch Experiment Station.	127
Garden City Branch Experiment Station.	134
Colby Branch Experiment Station.....	137
Tribune Branch Experiment Station.....	139
STATION PUBLICATIONS.....	140
SOME INFORMATION REGARDING EACH PUBLICATION ISSUED.....	141
PUBLICATIONS BY DEPARTMENTS	146
FINANCIAL STATEMENT, 1926-'27.....	152
FINANCIAL STATEMENT, 1927-'28.....	153

DIRECTOR'S REPORT¹

INTRODUCTION

During the biennium ending June 30, 1928, the work of the Agricultural Experiment Station, including the four branch stations, comprised 115 active major projects which had been definitely organized and planned. These projects included studies in five distinct fields of rural endeavor, as follows: Studies in the economics of agriculture, studies in soil conservation, investigations in the plant industries, investigations in the animal industries, and studies in home economics. A number of miscellaneous agricultural problems were also investigated. The following report makes brief mention of each of the more important projects and summarizes the more important results secured during the biennium.

COÖPERATION WITH OTHER AGENCIES

The station has been fortunate in having coöperative relationships with a number of related agencies. The extensive and cordial coöperation that has existed in the past with the United States Department of Agriculture has been continued and the work somewhat expanded.

The coöperative work with the United States Department of Agriculture has included investigations in small grain production and breeding, corn breeding, and the control of cereal diseases with the Office of Cereal Crops and Diseases; investigations in dry-land agriculture with the Office of Dry-land Agriculture; investigations with alfalfa diseases with the Office of Forage Crops and Vegetable Diseases; and experiments with alfalfa, the sorghums, turf grass, and other forage crops with the Office of Forage Crop Investigations of the Bureau of Plant Industry; a survey of five counties with the Division of Land Classification and Survey of the Bureau of Chemistry and Soils; a study of factors influencing the palatability and quality of meat and other live-stock problems with the Division of Animal Husbandry of the Bureau of Animal Industry; investigations in the propagation and distribution of forest trees with the Forest Service; and investigations in farm organization, cost of production, land utilization, wheat marketing, and hay grading in coöperation with the Bureau of Agricultural Economics.

Coöperative relations have been continued with the Kansas State Board of Agriculture in connection with the regulatory activities of the board. The station has provided facilities for analytical determinations of feeding-stuffs, live-stock remedies, and dairy products and has maintained in coöperation with the board a state seed-testing laboratory. Coöperative research in a limited way has also been undertaken on industrial projects with two commercial agencies.

1. Contribution No. 39 from the director's office.

THE PURNELL ACT

The Purnell act, approved by President Coolidge February 24, 1925, authorized a federal appropriation for the support of the Agricultural Experiment Station of \$20,000 for the fiscal year ending June 30, 1926, with increases of \$10,000 annually until the fiscal year ending June 30, 1930, when a maximum annual appropriation of \$60,000 would be made. The grants of money authorized by the Purnell act were "made subject to legislative assent of the several states and territories to the purpose of said grants." The Kansas legislature, complying with this provision, passed in its forty-second regular session, February, 1927, house concurrent resolution No. 13 as follows:

RELATING to the acceptance by the State of Kansas of the provisions of an act of congress approved February 24, 1925, for the more complete endowment of agricultural experiment stations.

"Be it resolved by the house of representatives of the state of Kansas, the senate concurring therein: That the provisions of the act of congress entitled 'An act to authorize the more complete endowment of agricultural experiment stations, and for other purposes,' approved February 24, 1925, be and the same is hereby accepted by the state of Kansas, and the federal appropriations are hereby placed under the control of the State Board of Regents, subject to the rules and regulations expressed or implied in the act of congress above named."

The Purnell act particularly authorizes investigations in the fields of agricultural economics, rural life, and home economics, as well as support for investigational work "bearing directly upon the production, manufacture, preparation, use, distribution, and marketing of agricultural products."

For the fiscal year ending June 30, 1928, the Kansas Agricultural Experiment Station received as a result of the Purnell act a grant of \$40,000. The money was expended as follows: 35 per cent for investigational work in agricultural economics, including marketing, 20 per cent for investigational work in home economics, and 45 per cent for the support of all other kinds of investigational work of the station.

THE SOIL SURVEY

The state soil survey resumed in 1925 has been continued during the past biennium. The survey is being made in coöperation with the Bureau of Chemistry and Soils of the United States Department of Agriculture. Prior to this biennium, a reconnaissance soil survey had been made of the western half of the state and a detailed survey of 11 counties and some smaller areas in the eastern part of the state. During the past biennium detailed surveys of Clay, Labette, Wilson, and Doniphan counties have been completed and are now in progress in Johnson and Crawford counties. There remain 42 counties in eastern Kansas yet to be surveyed. (Fig. 1.). It is planned to push these fundamental investigations of the soil resources of Kansas as rapidly as the support of the work will permit.

LAND, BUILDINGS, AND EQUIPMENT

One tract of land embracing 1.6 acres was purchased during the biennium from Mr. Wm. M. Aye. This tract was secured to complete the area purchased during the preceding biennium to provide a larger area for plant breeding for the Department of Agronomy.

New buildings constructed during the biennium include a sheep barn for the Department of Animal Husbandry, a laying house for the Department of Poultry Husbandry, a new residence for the superintendent of the Fort Hays Branch Experiment Station, and other smaller buildings for the branch stations mentioned later in this report.

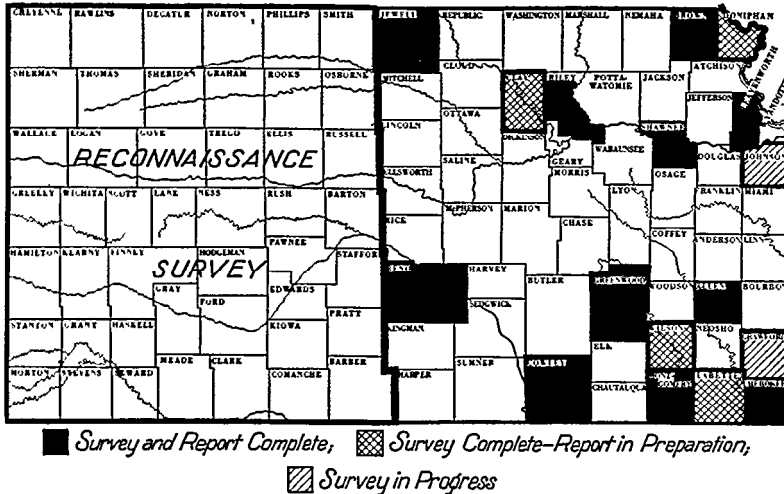


FIG. 1.—Map of Kansas showing progress of state soil survey.

The new sheep barn is used primarily for housing the flock of sheep maintained for investigational and instructional purposes. The barn consists of a two-story central portion 32 feet wide and 52 feet long, with one-story wings 32 feet wide and 90 feet long on each side. The first floor of the central portion is divided into bins, a combination lambing and shearing room, a sleeping room for the shepherd, and a central driveway. The upper story is used for hay and a central driveway. Each wing has a 5-foot alley its entire length. The remainder is divided into six pens, each 15 feet wide and 27 feet deep. Each pen opens into the alleyway and into an outside lot.

The new residence for the superintendent at the Fort Hays Branch Experiment Station was completed in June 1927. It is a two-story building built of brick and hollow tile. The building is modern in every respect; has a complete basement; is furnished in hardwood

throughout; and is provided with hot-water heat. The cost of construction, not including station labor, was \$12,000. (Fig. 2.)

New equipment installed during the biennium includes special low-temperature equipment for winter-hardiness studies, mill equipment for investigational work in milling technology, and specially constructed physical equipment for clothing-fabric studies.

The principal features of the special equipment for the study of winter hardiness and other temperature relations of grain and forage crops are a greenhouse divided into three compartments which can be maintained at different temperatures, and a refrigeration machine with suitable compartments for maintaining below-zero tempera-



FIG. 2.—The new residence of the superintendent, Fort Hays Branch Experiment Station.

tures. With the latter temperatures as low as 30 degrees below zero Fahrenheit may be secured.

The refrigeration equipment consists of a Brunswick-Kroeschell carbon dioxide machine, an insulated chamber approximately 10 by 45 by 3.5 feet, and a hardening room approximately 20 by 4 by 4 feet. The latter is connected with the outside air so that plants may be hardened by prevailing temperatures if so desired. A part of the hardening room is fitted with coils so that it may be refrigerated if occasion demands. In the insulated chamber a temperature of 30 degrees below zero may be secured. Plants to be frozen are placed in this chamber either in ordinary greenhouse pots, dug up from the field and placed in flats, or directly from the field with roots exposed.

A special appropriation for laboratory equipment made possible

the allotment of \$12,000 for the purchase of new equipment and for the remodeling of the mill to provide for investigational work in milling technology. Among the more important pieces of new equipment added are the following: A Carrier air conditioning system, a Carrier wheat conditioner, hopper scale, specially constructed tanks for water used in tempering, equipment for determining rate of flow of mill streams, a small experimental sifter, wheat washer, a wheat scourer by means of which the amount of scouring may be varied at will, experimental roll stands, and purifier rebuilt for experimental purposes.

Special equipment has been designed and built by the Department of Physics for the study of the protective value of clothing fabrics. By means of this equipment it has been possible to measure accurately the protective value against temperature changes of different clothing fabrics under different environmental conditions.

PERSONNEL

Appointments. The average number of persons regularly employed on the scientific staff during the biennium was 105. A total of 20 new appointments has been made, the number of appointments equaling 19 per cent of the average personnel. The appointments made during the biennium are listed below:

- Millard Peck, land economics.
- C. O. Grandfield, coöperative experiments.
- M. A. Alexander, animal husbandry.
- C. A. Brandly, poultry disease investigations.
- O. H. Elmer, plant disease investigations.
- C. H. Ficke, plant pathology investigations.
- E. J. Coulson, assistant chemist.
- H. J. Brooks, in charge official tests of dairy cows.
- Lela Ascham, food economics and nutrition.
- Esther Bruner, clothing and textiles.
- W. C. Frost, landscape gardening.
- L. R. Quinlan, landscape gardening.
- R. O. Pence, milling technology.
- H. M. Scott, poultry production.
- R. H. Davis, assistant in soil survey.
- W. J. Caulfield, dairy manufacturing.
- Carl Bower, field agent, U. S. D. A., corn investigations.
- C. E. Crews, superintendent Agronomy Farm.
- E. W. Johnson, forest nurseryman, Fort Hays branch station.
- J. B. Kuska, scientific assistant, Colby branch station.

Resignations. A total of 20 members of the staff resigned during the biennium, the number of resignations being 19 per cent of the average personnel. The persons who resigned from the staff during the biennium are listed below:

- Eric Englund, land economics.
- Charles R. Enlow, cooperative experiments.
- H. W. Marston, animal husbandry.
- A. D. Weber, animal husbandry.
- W. R. Hinshaw, poultry disease investigations.

- R. P. White, plant disease investigations.
- C. D. Tolle, assistant chemist.
- W. H. Riddell, in charge official tests of dairy cows.
- Leila Dunton, food economics and nutrition.
- Lela Ascham, food economics and nutrition.
- W. C. Frost, landscape gardening.
- A. H. Helder, landscape gardening.
- H. H. Steup, poultry production.
- N. D. Harwood, veterinary medicine.
- K. M. Renner, dairy manufacturing.
- George H. Phinney, foreman Agronomy Farm.
- E. C. Converse, meteorologist (deceased).
- D. D. Wilson, forest nurseryman, Fort Hays branch station.
- W. H. von Trebra, scientific assistant, Colby branch station.
- J. G. Willier, assistant agronomist, U. S. D. A., corn investigations.

SCOPE OF THE STATION WORK, JULY 1, 1926, TO JUNE 1, 1928.

A list of the principal active projects carried on during the biennium ending June 30, 1928, 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 in Farm Organization and Cost of Production.....	95	Agricultural Economics.	Purnell and State.. . . .	16
Investigations in Land Tenure and Other Land Problems.....	132	Agricultural Economics.	Purnell.....	17
The Marketing of Kansas Wheat.....	143	Agricultural Economics..	Purnell.....	18
The Economics of the Poultry Industry on Kansas Farms. ...	144	Agricultural Economics.	Purnell.....	20
The Marketing of Kansas Live Stock and Live-stock Products,	149	Agricultural Economics.	Purnell.....	20
Soil Fertility Investigations.....	17	Agronomy.....	Hatch and State.	22
The Residual Effect of Alfalfa on the Soil.	17	Agronomy.....	Hatch and State.	24
Tillage Investigations.....	18	Agronomy.....	Hatch.....	25
Plant Nutrition Investigations.....	152	Chemistry and Agronomy. . .	State.....	25
The Influence of Legumes and Free Living Organisms on the Growth of Plants and on the Nitrogen Balance in Kansas Soils.....	172	Agronomy and Bacteriology. .	State.....	27
The Relation of the Absolute Reaction of the Soil Solution to the Quantity of Nitrogen Fixed by Azotobacter.	128	Bacteriology	Adams.....	28
A Study of the Soil Solution as Governed by H-ion Concentration.....	155	Chemistry	State.....	29
Soil and Crop Experimental Fields,		Agronomy.....	State.....	30
Work on the Flora of Kansas.	137	Botany	State.....	32
Drought Resistance in Crop Plants.....	74	Botany	State.....	32
Temperature Relations of Crop Plants.	157	Agronomy.....	Purnell.....	34
Small Grain and Sorghum Improvement.....	67	Agronomy	Hatch.....	36
A Genetic Study of Aberrant and False Wild Types in Kanota Oats.....	146	Agronomy.....	Adams.....	37

SCOPE OF STATION WORK—CONTINUED.

NAME.	Project No.	Departments.	Funds.	Discussed on page
Sorghum Varietal Tests.	129-1	Agronomy	Hatch.	37
Small Grain Tests.	129-2	Agronomy.	Hatch.	38
Alfalfa Production Experiments.	129-3	Agronomy	Hatch.	39
Soybean Production Experiments.	129-4	Agronomy.	Hatch.	40
Leguminous Forage Crop Tests.	129-5	Agronomy.	Hatch.	41
Pasture Improvement Investigations.	96	Agronomy.	Purnell	45
Corn Production and Improvement.	156	Agronomy.	Purnell	45
Turf and Lawn Grass Experiments.	167	Agronomy.	State.	46
The Effect of the Ensiling Process and of Freezing upon the Germination of Weed Seed. ....	.....	Agronomy and Dairy Husbandry.	State.	47
Bindweed Eradication with Chemical Sprays.	166	Agronomy and Chemistry. ..	State.	48
Cooperative Experiments with Crops. ....	....	Agronomy	State.	48
Chemical Factors Influencing Quality of Wheat and Flour. . . .	60-A	Milling Industry.	State.	50
The Quality of Wheat as Influenced by Cropping Systems and Fertilizer Treatments.	60-B	Milling Industry.	State.	51
The Quality of Wheat as Affected by Seedbed Preparation and Tillage Methods.	60-C	Milling Industry.	State.	51
The Relation of Variety to Quality in Wheat.	60-D	Milling Industry	State.	51
A Comparison of the Quality of Wheat Varieties Grown in Different Parts of Kansas.	60-E	Milling Industry.	State.	52
A Study of the Protein Content of Some Common Kansas Wheat Varieties.	60-F	Milling Industry.	State.	53
Milling Work on Shrinkage, Loss, and Damage of Wheat in Farm Storage.	143	Milling Industry.	Purnell.	53
Tempering Factors Affecting the Quantity and Quality of Wheat Flour.	170	Milling Industry.	Purnell.	54
Flour Chemistry Investigations.	60	Chemistry and Milling Industry.	State.	55

NAME.	Project No.	Departments.	Funds.	Discussed on page
Orchard Investigations	25	Horticulture.	State	56
Small Fruit Investigations	26	Horticulture	State	58
Experiments with Vegetables.	27	Horticulture.	State	59
Forest Tree Investigations	82	Horticulture.	State	59
Cereal and Forage Crop Disease Investigations	76	Botany	State	61
Fruit and Vegetable Disease Investigations	130	Botany	State	64
A Study of Resistance of Winter Wheat to Leaf Rust	171	Botany	Purnell	65
Climate and Injurious Insect Investigations	6	Entomology.	Hatch.	67
Hessian Fly and Other Wheat Insects.	5	Entomology.	Hatch.	69
Corn Earworm and Other Insects Injurious to Corn	9	Entomology.	Hatch.	71
Fruit and Vegetable Insects.	13	Entomology.	Hatch.	72
Control of Insects Attacking the Sorghums.	92	Entomology.	Hatch.	73
Insects Attacking the Roots of Staple Crops.	100	Entomology.	Hatch.	74
Insects Injurious to Alfalfa and Allied Plants.	115	Entomology.	State	75
Shade Tree Insects	116	Entomology.	State	78
Codling Moth Investigations	163	Entomology.	Purnell.	78
The Resistance of Crop Plants to Insect Injury.	164	Agronomy and Entomology. .	Purnell and State.	79
Investigations in the Control of Injurious Rodents	84	Zoölogy	State.. ..	81
The Nutritive Requirements of Swine	38	Animal Husbandry, Chemis- try, and Veterinary Medi- cine	Adams and State.	82
Investigations in the Use of Silage in the Fattening of Beef Cattle	78	Animal Husbandry.	State	83
Methods of Utilizing Native Pasture in Beef Cattle Feeding. .	151	Animal Husbandry.	State	84
Swine Feeding Investigations	110	Animal Husbandry.	State	85
Lamb Feeding Investigations	111	Animal Husbandry.	State	86
A Study of Pasture Values and Pasture Methods for Horses, Cattle, Sheep, and Swine	142	Animal Husbandry.	State	87

SCOPE OF STATION WORK-CONCLUDED.

NAME.	Project No.	Departments.	Funds.	Discussed on page
The Influence of Feed on the Color, Chemical Composition, and Cooking Quality of Meat of Grass Fat Cattle.	165	Animal Husbandry, Chemistry, and Home Economics,	Purnell	87
Factors Influencing the Mineral Metabolism of Dairy Cows. . .	147	Chemistry and Dairy Husbandry	State	89
Dairy Cattle Feeding Investigations.	34	Dairy Husbandry.	State.	91
Kafir Versus Sorgo for Dairy Calves.. . . .	154	Dairy Husbandry.	State	94
Silage Investigations.	34	Dairy Husbandry and Chemistry	state	
Normal Growth of Dairy Cattle. . . . .	....	Dairy Husbandry.	State.	95
A Study of the Use of Fly Repellents for the Control of Flies on Dairy Cattle. . . . .	....	Dairy Husbandry.	State	95
A Study of the Cost of Milk Production . . . . .	....	Dairy Husbandry.	State.	96
The Relation of Type of Construction to the Winter Temperature of the Floors of Dairy Barns.. . . .	162	Dairy Husbandry.	State.	96
Ice Cream Investigations	124	Dairy Husbandry.	State.	97
Bacteriological Study of Ice Cream.	124	Bacteriology.	State.	98
Inheritance of Standard Characteristics of Breeds of Poultry..	77-3	Poultry Husbandry	State.	98
A Study of the Inheritance of Characters in Single-comb White Leghorns and Jersey Black Giants:	77-4	Poultry Husbandry	State.	99
The Inheritance of Egg Production in Single-comb Rhode Island Reds	77-5	Poultry Husbandry	State.	101
Poultry Flock Management.	77-6	Poultry Husbandry	State.	101
A Study of the Dissemination of Bacillary White Diarrhoea in Incubators	77-10	Poultry Husbandry and Bacteriology	State.	102
A Study of the Use of Hydrolyzed Feathers as a Feed for Chickens.	77-11	Poultry Husbandry	State.	102

NAME.	Project No.	Departments.	Funds.	Discussed on page
The Effect of an Inadequate Ration on the Production and Hatchability of Eggs.....	127	P o u l t r y a n d Chemistry.....	Adams.....	103
The Relation of the Vitamin Content of the Feed to Immunity to Roup.....	131	Poultry Husbandry, Chem- istry, and Bacteriology....	State.....	105
Studies in Animal Reproduction and Inheritance.....	93	Animal Husbandry.....	State.....	106
Studies in the Inheritance of the Grouse Locusts.....	72	Zoölogy.....	Adams and State.....	107
The Influence of Climate on Inheritance in the Grouse Locust, Bee Investigations.....	104 126	Zoölogy..... Entomology.....	Adams..... State.....	108 108
Miscellaneous Animal Disease Investigations.....	102	Veterinary Medicine.....	State.....	109
Abortion Disease Investigations.....	135	Veterinary Medicine.....	State.....	110
Blackleg Investigations.....	....	Veterinary Medicine.....	State.....	111
Studies in Hog Cholera Immunity.....	150	Veterinary Medicine.....	State.....	113
The Histo-pathology of Poultry Diseases.....	168	Veterinary Medicine.....	State.....	113
Poultry Disease Investigations.....	85	Bacteriology.....	State.....	114
Relation of Adequacy of Diet to Disease.....	131	Bacteriology.....	State.....	118
Parasitological Investigations.....	79	Zoölogy.....	Adams and State.....	119
A Study of the Resistance of Chickens to Parasitism.....	169	Zoölogy.....	Purnell.....	120
Studies in the Embryology of Parasitic Worms.....	119	Zoölogy.....	State.....	121
Factors Affecting the Seasonal Variation in the Growth Curve of Children.....	158	Home Economics.....	Purnell.....	122
The Vitamin Content of Some Common Fruits.....	158	Home Economics.....	Purnell.....	123
Utilization of Calcium and Phosphorus from Fresh, Dried, and Canned Milk.....	159	Home Economics.....	Purnell.....	124
A Study of the Change of the Ash Content of Vegetables Dur- ing Storage and Cooking.....	.....	Home Economics.....	State.....	125
The Protective Value of Certain Clothing Fabrics.....	161	Home Economics.....	Purnell.....	125

STUDIES IN THE ECONOMICS OF AGRICULTURE

Studies in the business aspects of agriculture, conducted under the leadership of the Department of Agricultural Economics, have made, during the biennium, the same substantial growth that has characterized the work during the two preceding biennia. Increased allotments of federal funds made possible some further expansion of the work in this field. As in the past, these studies have been pursued along five major lines, each of which is, discussed briefly in the following pages:

Studies in Farm Organization and Cost of Production. The detailed farm-cost work begun in Bourbon county March 1, 1925, was continued until March 1, 1927, when the records were closed. A number of typed and mimeographed reports dealing with particular enterprises or phases of the work have been prepared from time to time for the coöperating farmers and other interested persons. Some of the McPherson and Jackson county data also have been subjected to further analysis. The reports have served several objectives; namely, to give the individual coöperator the results of his own records; to allow him to compare his results for different periods of time with other farmers keeping records, both in his county and in other sections of the state; to suggest good practices for the enterprises concerned; to present timely outlook material; and to furnish the farm management demonstrator and others with requested material.

The cost route studies have furnished the data, from which standards of production could be determined. These give the labor and material requirements of crops and the feed and labor requirements for live stock, together with the probable production from each. Examples of the standards for McPherson and Jackson counties were given in the last biennial report. Similar standards for Bourbon county have since been suggested.

Partly as a result of these studies improved systems of farming for the Bourbon county area are being suggested.

Considerable time has been spent on a type-of-farming study covering the entire state. Data were secured from the biennial reports of the Kansas State Board of Agriculture, the assessors' reports, the federal census for 1925, the cost route studies, and other pertinent sources. The state has been divided into 12 type-of-farming areas as shown in figure 3. The factors having most weight in the selection of these areas were soil and rainfall as affecting crop adaptation, the per cent of crop area occupied by various crops, the numbers of live stock on farms, and the trends of crop and live-stock production over a period of years. An outline for a manuscript setting forth the basic material of this study has been completed and the work of preparing the data for publication is in progress.

A study of the effect of the combine in southwestern Kansas (area 10) has been made and systems of farming to meet the new

conditions have been suggested. A manuscript embodying the results of this work is ready for publication.

Another phase has consisted of a cooperative study of the harvesting of grain sorghums in southwestern Kansas. Cooperating agencies were the Kansas Agricultural Experiment Station, the Kansas Engineering Experiment Station, the Bureaus of Agricultural Economics, Plant. Industry, and Public Roads of the United States Department of Agriculture, and the Oklahoma Agricultural Experiment Station. A manuscript reporting the results of this study is now being prepared. [Project 95; Department of Agricultural Economics; Purnell and state funds.]

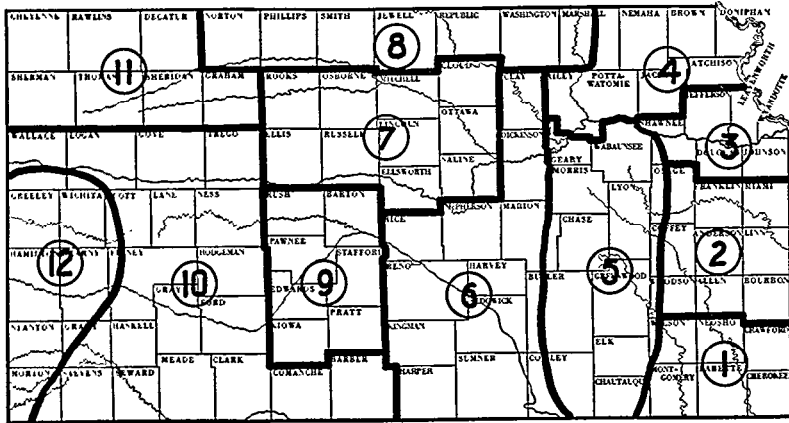


FIG. 3--Type-of-farming areas in Kansas.

Investigations in Land Tenure and Other Land Problems.

During the past two years an analysis of farm-land values covering the years 1924 to 1926, inclusive, has been made. The average value of land per acre in Kansas fell very rapidly during the years 1921, 1922, 1923, and 1924. During 1925 and 1926 the trend has been slightly upward. The average price per acre of farm land in Kansas in 1926 was \$48 as compared with \$47.52 in 1925 and \$46.65 in 1924.

TABLE I.-ACTUAL AND DEFLATED SELLING VALUE OF FARM REAL ESTATE IN KANSAS, 1910 AND 1924-1926, INCLUSIVE

SECTION.	1910.		1924.		1925.		1926.	
	Actual.	Deflated.	Actual.	Deflated.	Actual.	Deflated.	Actual.	Deflated.
Corn Belt.....	\$63.41	\$62.85	\$81.96	\$54.75	\$75.44	\$47.54	\$82.16	\$54
General Farming Region.....	46.86	46.44	54.54	36.43	57.69	36.35	56.70	37
Flint Hills Region	35.33	35.01	52.16	34.84	47.34	29.83	49.27	32
Eastern Wheat Belt.....	44.36	43.96	53.74	35.90	58.25	36.70	56.33	37
Western Wheat Belt.....	17.60	17.44	27.19	18.16	27.66	17.43	28.80	19
Western Grazing Region.....	9.32	9.24	13.83	9.24	15.07	9.50	15.61	10
State average.....	\$36.79	\$36.46	\$46.65	\$31.16	\$47.52	\$29.94	\$48.00	\$31

For the purpose of analyzing land values in Kansas more accurately the state has been divided into six sections as follows: Corn Belt, General Farming Region, Flint Hills Region, Eastern Wheat Belt, Western Wheat Belt, and the Western Grazing Region. The data for each region are shown in Table I. In four of the six sections the trend of land values was slightly upward in both 1925 and 1926. As early as in 1924 the trend had turned upward in two sections, and in the Western Wheat Belt it had turned upward in 1923. The rise in the Western Wheat Belt is accounted for by the introduction of the combine and the adoption of improved dry-farming methods, which with favorable weather and good prices for wheat have resulted in a relatively large income per acre during the past few years. This increase in the income per acre explains the slow but steady rise from \$25 per acre in 1922 to \$29 per acre in 1926. [Project 132; Department of Agricultural Economics; Pur-nell funds.]

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

The Availability of Short-time Bank Credit and Its Effect on the Marketing of Wheat. Work during the past two years has consisted mainly of the revision and checking of previous preliminary reports. Bulletin 244, "The Effects of Shortage of Farm Storage Space and Inability to Get Local Bank Credit on the Movement of Kansas Wheat to Market," was published.

The results of this study indicate in a general way that in the important wheat sections of Kansas some 15 to 16 per cent of the farmers market wheat before they otherwise would because of credit needs. On an average, 55 to 60 per cent of the wheat produced by such farmers is thus forced on to the market. This means that only about 10 to 12 per cent of the total crop movement is affected in this way. It is proposed to repeat this study for the years 1928, 1929,

and 1930, so as to note any change in the trend of credit influence since the depression period.

Premiums Paid for High-protein Wheat. This study, which began as a survey of high- and low-protein wheat areas in the state, became the past two years, an investigation into causes and tendencies of premiums paid for high milling quality. The study shows that since about 1918-'19 premiums for best-quality wheat have been much more frequent than was the case from 1910 to 1918. The secular trends for top and bottom No. 2 hard wheat at Kansas City by months, as shown in Table II, have been tending farther apart since 1893. The growth of the milling industry in the Southwest, the consequent increase in demand for milling-quality wheat, and weather conditions some years unfavorable to the production of a large per cent of high-quality wheat are the factors apparently gradually increasing the importance of premium wheat.

TABLE II-DIFFERENCE BETWEEN SECULAR TRENDS OF
 TOP AND BOTTOM NO. 2 HARD WINTER WHEAT AT
 KANSAS CITY.
 Monthly data; 1892 to 1912 and projected.

YEAR.	Difference (cents per bu.)
1892-'93.....	6.90
1902-'03.....	9.29
1912-'13.....	11.68
1922-'23.....	14.07
1927-'28.....	15.27

The study further shows that the premium for quality wheat is not dependent upon the general trend of wheat prices. Large premiums are associated about one-half of the time with declining prices and about one-half of the time with advancing prices. Likewise, small premiums are found in years of advancing price tendencies as frequently as in years of declining prices.

Factors Affecting Seasonal Price Fluctuations. The work on this phase of the project during the biennium has consisted of a study of (1) the influence of the September and October export market on Kansas City wheat prices, (2) the price spread between Kansas City and Liverpool as influenced by the size of the Kansas wheat crop, and (3) the relation of April price advances to subsequent old-crop and new-crop prices. As a result of these studies, the following conclusions were reached:

1. The trend of cash wheat prices from July to September or October is highly indicative of the subsequent general trend of prices for the crop years.
2. A small Kansas wheat crop, combined with a small world crop, intensifying both foreign and domestic demand, causes Kansas City prices to be pushed up closer to Liverpool prices than usual and results in the smallest of price spreads between the two markets.

3. Kansas City price follows Liverpool price most consistently when there is a small world crop, making good foreign demand, and a large Kansas crop, giving ample local supplies. The spread between Kansas City price and Liverpool price is largest in such years.

4. The degree to which Kansas City prices depend upon Liverpool prices varies with size of the Kansas crop and the size of the world crop and with the different possible combinations of these two situations.

5. Extremely large April advances in cash wheat prices are most frequently followed by further advances in May, by June declines, and by a generally declining price tendency the succeeding crop year.

[Project 143; Department of Agricultural Economics; Purnell funds.]

The Economics of the Poultry Industry on Kansas Farms.

The work on this project during the past biennium has been a continuation of the work previously reported. The place of poultry in various types of farming has been studied in connection with the "type-of-farming" studies previously reported (project 95). Price studies have been carried on and used partly as a basis for the monthly forecast of the poultry and egg situation. [Project 144; Department of Agricultural Economics; Purnell funds.]

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

Organizations Engaged in Marketing Kansas Live Stock and Live-stock Products. The study of the organizations engaged in marketing Kansas live stock has been continued. The results of this study have been prepared for publication as a bulletin entitled "The Status of Coöperative Live Stock Shipping in Kansas."

When and Where Kansas Live Stock and Live-stock Products Move to Market. The work on this phase of the project has consisted entirely of the first part of the study, namely, when and where such movement takes place. Data were obtained from the office of the state statistician and the general offices of the railroads which carry live stock in Kansas. Complete analysis of the data will not be made and conclusions drawn until a larger number of years can be included. However, from the limited information assembled, it appears that:

1. Live stock from Kansas does not move to the different markets in the same proportion each year.
2. Some markets show a proportionate increase in receipts from Kansas each successive year though total markets have fluctuated up and down from year to year.
3. Kansas cattle influence the Kansas City market more than those from any other state, especially during the months of August and September.

Economic Factors Influencing the Time and Place of Marketing Live Stock and Live-stock Products. The work on this phase of the project has consisted chiefly in gathering information from the railroads relative to the number of cars of live stock forwarded and received within each of the nine crop-reporting districts. An anal-

ysis for the last eight years indicates the necessity for additional data. The results have been confined to clerical compilation and the following tentative conclusions can be drawn at this time:

1. There is a shifting in the proportion of live stock within the districts of Kansas from year to year and from one period of years to another.
2. There has been a gradual increase in the number of hogs and cattle in the east central section of the state during the last eight years.
3. In the northeastern section there has been a marked increase in the number of sheep the past six years.
4. For the state as a whole there has been an increase of 25 per cent in the number of sheep handled since 1921.
5. There has been a larger increase in the number of sheep in northern Kansas than in southern Kansas.

Price Trends and Price-making Factors in the Live-stock Industry. A study has been made of a number of factors influencing the price of different grades of cattle and of hogs at the Wichita, Kansas City, and Chicago markets. Some of the factors which have been studied and the bearing that they appear to have upon live-stock prices are as follows:

1. Price premiums for light and heavy fat cattle fluctuate within certain regular intervals and these periods are easily influenced in length by the price changes in the corn crop.
2. The spread in price for the same grades of cattle at different markets varies due to a shifting in the supply which is due principally to the corn-crop influences.
3. The supply of cattle can be determined more accurately by a study of corn prices than from a study of corn-cattle ratios.
4. The price of common grades of cattle is influenced more by changes in the number of people employed than are the better grades.
5. Hide prices are a result rather than a cause of cattle prices and cannot be used to determine cattle values.
6. The price of cattle appears to have little effect upon the price of hogs and *vice versa*.
7. The future monthly supply of hogs can be fairly accurately determined when the influence of present corn prices and the corn-hog ratios one year past are considered.
8. A price trend of hogs determined by grouping the years according to the corn crop has more significance than a statistical correlation using several influencing factors.
9. Lamb and sheep values are influenced alike by factors other than wool-price changes. Changes in wool prices affect both sheep and lamb values in nearly the same proportion.
10. The changes in the Bureau of Labor wholesale commodity index and in Fisher's index do not indicate the same trend in prices for different classes of live stock.

During the next biennium the study of relationships between prices for different classes of live stock will be continued, as will also efforts to determine the factors which increase or decrease the stocks in storage. The study of the relationships between Fisher's index and the Bureau of Labor index of wholesale price of all commodities and, if possible, the influence of the futures market for provisions on the price of live hogs will be prosecuted. [Project 149; Department of Agricultural Economics; Purnell funds.]

THE CONSERVATION OF SOIL

Soil conservation is a problem that is receiving careful consideration by the Agricultural Experiment Station. No problem is of greater fundamental importance, since the soil constitutes the state's most important source of wealth. A brief report of the soil investigations conducted by the station during the past biennium is given in the following pages.

Soil Fertility Investigations. The work on this project during the past biennium has consisted chiefly of a continuation of that which has been in progress since 1910. A few new features have been started in which certain laboratory studies are being made to determine the effect of various treatments on the soil. This is being done in order to explain more fully the results obtained in the field.

During the past two years rather extreme climatic conditions have prevailed, the season of 1926 being very hot and dry while that of 1927 was cool and moist. The crop yields, therefore, have varied widely. The effect of different cropping systems on the yield of corn is given in Table III.

TABLE III.—THE EFFECT OF THE CROPPING SYSTEM ON THE YIELDS OF CORN.

CROPPING SYSTEM.	Yield, bushels per acre.		
	1926.	1927.	Average, 1911-1927.
16-year rotation: Alfalfa, 4 years; corn; wheat; wheat; not manured.....	0.4	72.6	31.8
16-year rotation, as above; manured.....	0.5	74.5	34.0
16-year rotation, as above except Brome grass instead of alfalfa; manured...	7.8	67.4	32.9
3-year rotation: Corn; cowpeas; wheat.....	10.2	68.7	30.4
3-year rotation: Corn; corn; wheat.....	7.5	60.6	26.1
Corn continually.....	4.3	45.2	20.6

During the season of 1927 the highest yield of corn, 83 bushels per acre, was obtained in the 16-year rotation where the soil had been treated with rock phosphate and green manure. This was an increase of 37.8 bushels over the untreated land growing corn continually.

The wheat yields for 1926 were quite variable and some were very low, but the 1927 yields were on the whole much higher. Exceptionally good yields were obtained in the 16-year rotation on land that had been broken out of alfalfa in the fall of 1925.

In the 16-year rotation one plat in the alfalfa series is grown to Brome grass during the same years as the alfalfa. The effect of this nonlegume sod on the following grain crops has been somewhat different than has been found in many other places. Thus the yield of corn after alfalfa has been 1.1 bushels higher than after Brome grass; but the yield of wheat has been 1.4 bushels less for those cases

where the immediately preceding crop is corn and 2.5 bushels less where the preceding crop is wheat. These losses, however, are more than balanced by the greater yield and value of the alfalfa crop as compared with the Brome grass.

The protein content of wheat has been materially lower where this crop followed Brome grass than where it followed alfalfa.

Determinations of the nitrate content of the surface three feet of soil on those plats growing wheat are now being made in the fall and in the spring. Some of the results of this study are presented in Table IV. Some significant differences are found between the different rotations. Land growing a summer crop like corn or cowpeas usually has a low nitrate content in the fall. This probably accounts for the rather poor start that wheat often makes after cowpeas. The nitrate content after corn in the alfalfa rotation is higher than where corn follows Brome grass, a nonlegume.

TABLE IV-THE EFFECT OF CROPPING SYSTEM ON THE AMOUNT OF NITRATES IN THE SURFACE THREE FEET IN THE FALL.

CROPPING SYSTEM.	Previous crop.	Nitrates p. p. m., surface 3 ft. of soil.			
		1925.	1926.	1927.	Average.
16-year rotation: Alfalfa (a)	Corn	51	59	4	38
16-year rotation: Alfalfa (b)	Wheat	47	45	42	45
16-year rotation: Manure; alfalfa	Corn	73	48	6	42
16-year rotation: Manure; Brome grass	Corn	24	13	3	13
16-year rotation: Alfalfa; manured	Wheat	.....	57	42	32
16-year rotation: Brome grass; manured	Wheat	.....	29	16	23
3-year rotation: Corn; cowpeas; wheat	Cowpeas	14	27	12	18
3-year rotation: Corn, corn; wheat	Corn	10	21	3	11
Continuous wheat	Wheat	51	33	33	39

(a) Alfalfa 4 years, corn, wheat, wheat. First crop after corn.
(b) Second wheat crop in the rotation.

The high nitrate content of the land in wheat continually is due to the early preparation of the seedbed. This may account for the high yield often secured with this system of cropping.

Moisture determinations to a depth of 10 feet are being made on both the land in continuous alfalfa and that in rotation. So far the results seem to indicate that there is not much change in the subsoil moisture below the fifth foot during average years. Moisture is used soon after it falls and is taken out by the crop before it penetrates very deep. Determinations on land one, five, and nine years after alfalfa has been plowed up indicate that the accumulation of subsoil moisture is very slow where the land regularly produces other crops.

An experiment was begun in the fall of 1926 to determine the

effect of applying fertilizers in different ways with reference to the location of the seed. Superphosphates and a 2-12-2 fertilizer were used at the rate of 175 pounds per acre. The results for 1927 are summarized in Table V.

TABLE V.—THE EFFECT OF METHOD OF APPLYING FERTILIZER UPON THE YIELD OF WHEAT.

METHOD OF FERTILIZER APPLICATION.	Wheat yield, 1927.	Increase over no treatment.
	<i>Bushels.</i>	<i>Bushels.</i>
No fertilizer.....	23.0	
Broadcast and worked in.....	33.0	10.0
in row with seed.....	38.0	15.0
in row 1 inch above seed.....	35.8	12.8
in row 1 inch below seed.....	36.0	13.0

While these are only preliminary tests they perhaps indicate two things which may be of value in further work. First, the application of fertilizers on medium to thin land may be profitable in this section of Kansas; and second, that the application of fertilizer in the row by means of a fertilizer drill may give more satisfactory results than broadcast applications.

Laboratory studies have been made on a number of soils from alfalfa demonstration fields to determine the amount of calcium that is soluble in carbonated water. The results so far indicate a very close inverse correlation between soluble calcium and returns from the use of lime. Thus with as much as approximately 700 pounds per acre of calcium soluble by this method only slight to medium returns have been obtained from liming. Where the amount is decidedly less than 700 pounds, good results can usually be expected. Returns can probably be obtained on alfalfa or sweet clover where the amount of replaceable calcium is somewhat higher than 700 pounds per acre. Attempts are being made to so simplify the method that it can be used for determining the lime needs of individual farms. [Project 17; Department of Agronomy; Hatch and state funds.]

The Residual Effect of Alfalfa on the Soil. This project was begun in the fall of 1922 with 18 plats in alfalfa and 9 plats in wheat. Each year on August 1, 2 plats of alfalfa have been plowed and later seeded to wheat each year thereafter. Comparisons of wheat grown after alfalfa and wheat grown continuously are therefore possible.

The average yields, protein content, test weight, and nitrates in the soil at seeding time are given in Table VI for wheat grown continuously on the same land and for wheat grown on alfalfa sod. The figures, in each case, are averages for four years.

TABLE VI.-THE INFLUENCE OF ALFALFA ON THE YIELD AND QUALITY OF WHEAT IMMEDIATELY FOLLOWING.

	Yield, bus. per acre.	Per cent protein.	Test weight.	Nitrates at seeding, pounds per acre.
at immediately following alfalfa.....	23.8	15.3	57.1	397
at continuously.....	18.7	12.9	55.8	229
Difference.....	5.1	2.4	1.3	168

These data show a distinct advantage in favor of the wheat following alfalfa, the average differences being 5.1 bushels, 2.4 per cent in protein, 1.3 pounds in test weight, and 168 pounds in nitrates at seeding time. It is not intended to recommend the growing of wheat immediately after alfalfa; other crops can usually be grown to better advantage. These data are of interest in showing the effect of alfalfa on the soil and the crop which follows. [Project 17; Department of Agronomy; Hatch and state funds.]

Tillage Investigations. This project consists of 30 one-tenth acre plats, 15 of which are cropped to winter wheat continuously and 15 are rotated in blocks of five with corn and oats. Various methods of seedbed preparation, including different depths and dates of plowing, are used in the production of the wheat crop. Soil moisture and nitrate studies have been made from the time the project was established in 1910 until 1924. During the past biennium soil moisture and nitrate determination have been made only occasionally in order to note any change in former results.

The results secured for the past two years are in line with results previously reported. They show that in eastern Kansas the time of preparation is the most important factor in determining the yield of the wheat crop. Early plowing, for example, has resulted in a gain in yield of eight bushels per acre as compared with late plowing. The reason has been shown to be the relation between time of tillage and the development of nitrates in the soil, more nitrates being available when the land is plowed early. For the same seedbed treatment the yields average five bushels per acre greater for wheat grown in rotation than for wheat grown continuously. [Project 18; Department of Agronomy; Hatch and state funds.]

Plant Nutrition Investigations. Five phases of plant-nutrition investigational work of a laboratory character have been conducted during the past biennium. These have had to do with the lime and fertilizer requirements of 10 different soil types from southeastern Kansas, the relation of the growth of alfalfa in sand cultures to the reaction of the nutrient solution and the relation between base exchange, crop response, and fertilizer practice. Each is briefly discussed below.

1. *The Lime and Phosphate Requirements of Cherokee Silt Loam, an Acid Soil from Southeastern Kansas.* This study was begun in 1925 and has been repeated with fresh soil of the same type during the past year. Superphosphate in addition to lime considerably increased the growth of alfalfa. Light applications of lime, not exceeding 2,000 pounds per acre equivalent of hydrated lime, and a 300-pound rate of superphosphate produced growth equal to that from heavier applications of lime and the same amount of phosphate.

Analyses of top growth of alfalfa for nitrogen, phosphorus, calcium, and potassium, showed that the applications of lime and superphosphate caused a change in the amount of these elements in the dry matter. Lime increased the per cent of calcium. Phosphate, however, did not increase the per cent of phosphorus. Applications of superphosphate without lime caused a slight reduction in the acidity of the soil. Further analyses will be made during the current year.

2. *The Fertilizer Requirements of Cherokee Silt Loam.* In this study the triangular system was used to determine the effect of combinations of sodium nitrate, superphosphate, and potassium sulphate, with and without additions of calcium carbonate. Winter wheat was grown one year and alfalfa the following year. The plants were grown in four-gallon earthenware jars. Fertilizers were applied only to the wheat crop.

Lime did not increase the yield of wheat. On the contrary, the average yield of the triangles receiving no lime exceeded the average yield of those receiving lime. Soils receiving nitrogen most frequently produced the largest yields of grain.

Phosphorus greatly increased the dry weights of the first cutting of alfalfa in the triangle receiving no lime and also in the triangle receiving lime at the rate of 1,200 pounds per acre. Heavier rates of liming in combination with fertilizer treatment did not increase the yield.

3. *The Comparative Effect of Lime and Superphosphate on Ten Different Soil Types from Southeastern Kansas.* Ten different soil types from southeastern Kansas were potted in the greenhouse and treated with lime and superphosphate. They were fertilized and planted to wheat. Wheat was followed by alfalfa without further fertilizer treatment. With all of the ten soils studied, superphosphate alone produced a better growth of both crops than lime alone, but a combination of lime and superphosphate produced the best results. Phosphates seemed to increase the nodulation on the roots of the alfalfa.

4. *The Effect of the Reaction of the Nutrient Solution on the Growth of Alfalfa in Sand Cultures.*--Alfalfa was grown in sand cultures in which the same complete nutrient solution was varied in acidity by changing the concentration of potassium dihydrogen and dipotassium phosphate. The alfalfa grew as well in the most acid solution, pH 4.5, as in those maintained at pH 6.0 and pH 7.0. This

experiment seems to indicate that acidity in itself is not injurious to alfalfa when there is present available nutrient elements, particularly calcium.

The experiment will be repeated and a study made of the effect of solution reaction on the inoculation of alfalfa roots by symbiotic bacteria when nitrogen is not supplied in the nutrient solution.

5. The Correlation of Base Exchange with Crop Performance and Fertilizer Practice. These studies were conducted with 11 different soil types from southeastern Kansas. Replaceable bases were determined by leaching with 0.05 normal hydrochloric acid. The following relationships are indicated, although it should be noted that data are altogether too meager to admit of any but tentative conclusions.

A relationship appears to exist between the yield of alfalfa and the per cent, of calcium in the exchangeable bases and between the yield of alfalfa and the amounts of exchangeable calcium and magnesium.

The response of soils to liming is closely associated with the amount of hydrogen absorbed. The correlation between liming response and the pH value of the soil is not consistent.

There seems to be a positive correlation between the yield of corn and the content of exchangeable potassium in the soil.

Soils with a high content of aluminum that is leachable with 0.05 normal hydrochloric acid produced in general the lowest yields of corn and alfalfa.

The largest yields of alfalfa were secured on those soils that contain a comparatively large amount of soluble silica. [Project 152; Departments of Agronomy and Chemistry; state funds.]

The Influence of Legumes and Free Living Organisms on the Growth of Plants and on the Nitrogen Balance. This project was planned and begun in June, 1926, to find the comparative effect of alfalfa, sweet clover, soybeans, and free living nitrogen-fixing organisms on the crop yields of corn, oats, and wheat and upon the nitrogen in the soil. The legumes are grown in rotation with the cereal crops. In one pair of rotations, sweet clover grown one year is compared with soybeans. In another pair, sweet clover grown two years is compared with alfalfa two years. These four rotations are duplicated. In another rotation, alfalfa is grown four years for comparison with alfalfa grown two years. For a study of the extent and effect of free fixation of nitrogen, rotations of corn, oats, and wheat under three different conditions--(1) limed, (2) unlimed, and (3) limed and inoculated with *Azotobacter*--are included.

Fifty-two one-tenth-acre plats comprise the project. Samples of soil from each plat were taken to a depth of three feet, in three sections for total nitrogen determinations when the project was started and will be repeated at five-year intervals. Samples of all crops removed from the plats are analyzed for total nitrogen. With this information it is hoped it will be possible to determine the effect of

different cropping systems and management on the nitrogen economy of the soil.

Problems incident to legume production will also be considered in connection with this project, such as: (1) The renewal of stands; (2) optimum soil reactions; and (3) moisture conditions of the soil following the various legumes. [Project 172; Department of Agronomy; state funds.]

The Relation of the Absolute Reaction of the Soil Solution to the Quantity of Nitrogen Fixed by Azotobacter. The cylinder experiments started in 1923 with the object of definitely determining the influence of Azotobacter upon the nitrogen balance of the soil have been continued, being cropped to oats in 1927 and 1928. By the addition of lime to certain cylinders, it was hoped to make the soil a suitable pabulum for Azotobacter. In addition, certain cylinders have received annual applications of organic materials in the form of straw and dextrose. Since the soil upon which the cylinders are located normally does not contain Azotobacter, the inoculation of certain cylinders was essential in order to insure the presence of these organisms. The expectation, based upon previous data, that Azotobacter would disappear from unlimed soils regardless of food supply has been realized, as the following data will show.

Cylinder No.	Treatment.	Presence of Azotobacter.			
		1924.	1925.	1927.	1928.
1	Sugar	0	0	0	0
2	Inoculated	+	+	0	0
3	Limed	0	0	0	0
4	Lime-inoculated	+	+	+	+
5	Lime-inoculated-sugar	+	+	+	+
6	No treatment.....	0	0	0	0
7	Lime-inoculated-straw	+	+	+	+
8	Lime-inoculated-fallow	+	+	+	+
9	Straw	0	0	0	0

Records of yield from the cylinders have been kept, but so far no significant differences have appeared.

Very extensive studies of the relationship between the energy content of the organic material available as food for Azotobacter and the quantity of nitrogen fixed have been conducted. These studies included a very careful comparison of the rate of growth and quantity of nitrogen fixed by different cultures when supplied a very wide variety of organic food substances, special consideration being given to the lower fatty acids. The following are some of the significant observations:

The same organic substances may serve as a food for one strain or species and be useless or even toxic to another. Thus erythritol is readily assimilated by *A. vinelandii* but is nonavailable to *A. chroococcum*.

The cation with which organic radicle is combined may have a marked influence upon its availability. Thus aluminum acetate is readily available while uranium acetate is nonavailable.

One of a series of isomeric compounds may be available while

others are not. Thus sorbitol serves readily as an organic food for various strains while dulcitol is not available. Likewise the structure of the molecule is very important in determining its availability. Thus normal caproic acid is an excellent food while the iso compound is nonavailable.

One available organic food may stimulate vegetative growth more than another, while their effects upon nitrogen fixation may be the reverse. For example, the vegetative growth of 10 different cultures in the presence of normal valeric acid was, with one exception, very abundant, while the growth of the same cultures in the presence of isovaleric acid was either invisible or very slight, yet the quantity of nitrogen fixed per gram of acid consumed was 6.25 mg. in the first instance and 8.50 mg. in the second.

It has usually been assumed that the processes by which nitrogen is brought into combination are endothermic in nature and that the organic food consumed by the nitrogen-fixing organisms supplies the necessary energy. It might be supposed, then, that the quantity of nitrogen fixed would be directly proportional to the energy content of the food consumed. It has been pointed out by previous investigations that such a relationship actually exists. The tabulated summary (Table VII) of the investigations bearing on this point shows that as the heat of combustion of the lower members of the fatty acid series increases the quantity of nitrogen fixed also increases, but if comparisons are made upon a calory basis the acids of higher molecular weight are utilized much more efficiently than those of lower molecular weight. [Project 128; Department of Bacteriology; Adams funds.]

TABLE VII.-RELATIVE EFFICIENCY WITH WHICH AZOTOBACTER CAN UTILIZE FATTY ACIDS IN THE FIXATION OF NITROGEN.

ORGANIC FOOD.	Mgs. nitrogen fixed per gram.	Heat of combustion, calories per gram.	Mgs. nitrogen fixed per calory.
Formic acid	0.0	1.34	0.0
Acetic acid	2.6	3.48	0.7
Propionic acid	5.6	4.97	1.1
Butyric acid	8.5	5.94	1.4
Valeric acid	10.7	6.68	1.6
Caproic acid	17.9	7.16	2.5
Dextrose	8.8	3.76	2.3

A Study of the Soil Solution as Governed by H-ion Concentration. The outline developed in 1926 has been expanded and somewhat altered as a result of data published by Gedroiz of Russia and Hissink of Holland. The work was changed from a base solubility to a base exchange problem, and instead of considering hydrogen

as an individual ion, it has been considered as one of the basic ions. Ten soils from southeastern Kansas and an Oswego silt loam soil from Manhattan were used in addition to the Derby silt loam that had been used previously. The content of exchangeable bases including hydrogen were determined by the n/20 hydrochloric acid and normal barium chloride methods. The normal twentieth HCl method of determining the content of exchangeable bases was checked by leaching southeastern Kansas soils with normal solutions of ferric aluminum, calcium, magnesium, and barium chlorides. In general it has been found that the same amount of iron, calcium, magnesium, potassium, and sodium could be obtained from the soil regardless of the base used in leaching, provided equilibrium was reached. This tends to prove that there is a definite formation in the soil that holds the basic elements, and that the soil has a definite capacity to hold bases.

The colloidal fraction has been separated from Derby silt loam by gravity. Brief experiments show that much larger amounts of colloidal material remain in suspension in water when the colloidal is saturated with sodium than with any other base. Theory indicates that this is because of a greater degree of hydration of the sodium compound and consequently a lowered specific gravity which makes separation easier. After separation from the soil the colloid has been saturated with iron, aluminum, calcium, magnesia, potassium, sodium, ammonia, and hydrogen. Conductivity determinations are being made on these compounds. [Project 155; Department of Chemistry; state funds.]

Soil and Crop Experimental Fields. Experimental fields were established in 1923 on five of the more extensive and important soil types in southeastern Kansas. Except for a few improvements in the plan of some of these fields and the addition of certain new projects, the work during the past biennium has been a continuation of that started in 1923.

The work consists chiefly in determining under field conditions the effect of different soil treatments, such as barnyard manure, crop rotations, fertilizers, green manures, and lime on various field crops. Variety tests of the principal crops are also included.

Some treatments show extremely practical results. This is well illustrated by those secured with soil treatments for alfalfa as given in Table VIII.

TABLE VIII.-THE EFFECT OF SOIL TREATMENTS ON YIELD OF ALFALFA.
SOUTHEASTERN KANSAS EXPERIMENTAL FIELDS, AVERAGE 1925 TO 1927.

SOIL TREATMENT.	Average yields of alfalfa, tons per acre.					
	Columbus.	Ft. Scott.	Moran.	Parsons.	Rest.	Average, all fields.
No treatment.....	1.2	1.8	1.7	0.9	1.9	1.5
Lime.....	2.7	1.8	2.8	1.5	2.1	2.2
Lime and superphosphate.....	3.2	2.8	3.8	1.7	2.9	2.9
Lime, superphosphate, and potash.....	3.2	2.1	3.2	1.9	.....	2.6
Lime and manure.....	3.8	2.3	3.5	2.5	3.0	3.0
Lime, manure, and superphosphate.....	3.7	3.3	4.0	2.5	3.5	3.4
Lime, manure, and rock phosphate.....	3.8	3.5	3.9	2.5	3.6	3.5
Manure.....	.....	2.2	2.4	2.3	2.4	2.3

On most of the fields alfalfa has given very low yields where the land has not been fertilized or limed. With the best treatments yields of nearly 3.5 tons per acre have been obtained. That is, land which is not adapted to the production of alfalfa can often be made to produce this crop in a very satisfactory manner by means of proper soil treatments. In nearly all cases a combination of lime with a phosphatic fertilizer or with barnyard manure has given best results. These fertilizers have also materially increased the yield of corn as shown by results secured at the Parsons field and presented in Table IX.

TABLE IX.-EFFECT OF ALFALFA ON THE YIELD OF CORN.
Parsons, Kansas, 1927.

SOIL TREATMENT.	Yield in bushels per acre.		
	After alfalfa.	No alfalfa.	Average increase from soil treatment.
No treatment.....	40.6	27.4	.....
Lime.....	49.7	36.9	9.3
Manure.....	58.6	48.3	19.4
Lime and manure.....	70.6	55.4	29.0
Lime, manure, and rock phosphate.....	72.0	58.0	31.0

[Department of Agronomy; state funds.]

INVESTIGATIONS IN THE PLANT INDUSTRIES

There are under cultivation in Kansas 22 million acres devoted to the production of crop plants. In addition, approximately 23 million acres of grass land are utilized as pasture for live stock. In 1926 the value of the crop plants produced in the state, excluding grass utilized as pasture, was in excess of 316 million dollars as reported by the State Board of Agriculture, wheat alone representing a value of nearly 180 million dollars. The following pages contain a brief summary of some of the work that the Agricultural Experiment Station has done during the past two years relating directly to the problems of crop-plant production.

The Flora of Kansas. During the past biennium the herbarium was maintained in good working order and about 4,000 sheets were added. About 250 miscellaneous Kansas specimens and about 700 sheets from Pearl Maus, Auburn, Kan., collected in various Kansas counties, were received. There were also received 300 specimens of New York plants from Alwin Berger, State Agricultural Experiment Station, Geneva, N. Y., about 450 from LeRoy Abrams, Leland Stanford University, and 100 from A. H. K. Petrie, Australia, by exchange. The herbarium of B. B. Smyth, of about 7,000 specimens, was donated by Mrs. B. B. Smyth, of Topeka.

There remain about 2,000 specimens to be mounted and a series of Kansas collections numbering over 2,000 to be gone over.

A manuscript on the poisonous plants of Kansas has been completed for publication. Part II of the "Trees of Kansas" has been completed and is in process of publication as a quarterly report by the State Board of Agriculture. [Project 137; Department of Botany; state funds.]

Drought Resistance of Crop Plants. During the biennium the work on this project was limited for the most part to two lines of investigation; namely, the relation between water requirement and blossom-end rot of tomato, and the effect of Bordeaux mixture on the rate of transpiration. The results are briefly presented below.

The Relation Between the Water Requirement and Blossom-end Rot of the Tomato. Since blossom-end rot of tomato is generally recognized as being due to an unbalanced water relationship between the soil, the plant, and the atmosphere, it was considered advisable to study the relation of the water requirement of the plant to this disease. In this experiment the plants pruned to one stem were grown in large galvanized-iron cans containing soil in good tilth with a moisture content of approximately 20 per cent. The plants under these conditions had a vigorous vegetative growth and produced a normal crop of fruit.

In 1926 the experiment included 85 plants of *L. esculentum* var. Louisiana Red and 16 plants of *L. pyriforme* var. Red Pear. In 1927 the experiment was expanded to include 3 species and 4 types of the genus, namely, *L. esculentum* var. Louisiana Red, *L. pyriforme* var. Red Pear and var. Yellow Plum, and *L. cerasiforme* var. Red Cherry.

The results obtained during the two years are summarized in Table X.

TABLE X. - WATER REQUIREMENT OF TOMATOES AND PER CENT OF BLOSSOM-END ROT.

VARIETY.	Per cent blossom-end rot.	Year.			
		1926.		1927.	
		Number of plants.	Water requirement.	Number of plants.	Water requirement.
<i>L. esculentum vulgare</i> var. Louisiana Red.	0	24	516.6	1	431.7
	1- 10	20	503.2	2	399.5
	11- 20	17	523.3	2	313.5
	21- 30	11	517.3	1	446.6
	31- 40	7	517.9	2	392.0
	41- 50	1	528.9	6	403.3
	51- 60	3	499.3	6	384.5
	61- 70	2	522.5	9	413.6
	71- 80	.....	.....	2	411.5
	81- 90	.....	.....	3	439.3
	91-100	.....	.....	3	560.3
<i>L. pyriforme</i> var. Red Pear	0	11	531.7	12	488.1
	1- 20	5	528.8	7	455.1
<i>L. pyriforme</i> var. Yellow Plum	0	.....	.....	17	391.6
	1- 10	.....	.....	2	355.0
<i>L. cerasiforme</i> var. Red Cherry	0	.....	.....	20	486.6

In these experiments no correlation was found between the water requirement of the plants and the prevalence of blossom-end rot. There seems also to be no correlation between the number of fruit per plant and the severity of blossom-end rot. In general it appeared that the varieties with smaller fruit were more resistant. For example, the Red Cherry variety, which has the smallest fruit, was entirely free from the disease.

The Effect of Bordeaux Mixture Upon the Rate of Transpiration.

During the past two years the investigations on this subject have been confined entirely to the tomato plant. It has frequently been stated that spraying with Bordeaux mixture greatly increases the transpiration rate of this plant and hence it was considered advisable to investigate this vegetable.

In these experiments the plants were arranged in pairs and the ratio of the transpiration of one plant to another in each of the pairs was obtained for a period of ten days. One of the plants of each pair was then sprayed with 4-8-50 Bordeaux mixture and the ratio of the transpiration of the same plants for another ten-day period was again obtained.

In 1926 the transpiration rate was decreased by spraying in 33 cases and increased in 16 cases. The average transpiration rate of the 49 plants after spraying was 0.97 of that which prevailed before the plants were sprayed. In 1927 the plants were sprayed with 4-5-50 Bordeaux mixture. The data obtained from 47 experiments showed that spraying decreased the transpiration rate in 27 cases

and increased it in 20 cases. The average transpiration rate of the plants after spraying was 0.994 times that which prevailed previous to spraying. These changes in the transpiration rate are probably not significant and indicate that the application of Bordeaux mixture as a spray need not to be considered as a factor in relation to the loss of water from plants under the conditions which prevail in the field during the growing season in Kansas. [Project 74; Department of Botany; state funds.]

Temperature Relations of Crop Plants. Studies during the biennium have been directed principally to three objectives: (1) To determine the relation between the resistance of winter annuals to low temperature and the resistance to winterkilling in order to find if winter hardiness is purely a matter of resistance to low temperature, and also to find if relative winter hardiness can be determined by artificial freezing; (2) to determine the relation of winter hardiness to hardening off; and (3) the effect of chilling (temperatures slightly above zero) on certain summer plants.

The relation between resistance to winterkilling and resistance to low temperature was studied by subjecting a considerable number of varieties of known but variable degrees of hardiness to low temperature and recording the degree of injury. In general it was found that varieties and crops characterized by a high degree of winter hardiness were among those best able to survive low temperatures and vice versa. It seems clear, therefore, that in the Great Plains, winter hardiness is to a large extent synonymous with ability to survive low temperature, and that artificial freezing may be regarded as a promising means of determining the relative winter hardiness of unknown strains. It may be mentioned, however, that in the accurate determination of the latter a number of precautions are essential.

It was found that both the absolute and the relative ability to survive low temperatures depend very materially on the temperature to which the plants have been subjected previous to freezing, and also that some varieties require a much longer time than others to acquire their full compliment of hardiness. Thus Minhardi winter wheat, which is the most winter hardy of any of the commercially grown varieties, proved to be relatively nonhardy when frozen without previous hardening, but when thoroughly hardened it survived better than any other variety. It is of interest to note that a month of rather severe winter weather with temperatures considerably below zero for a part of the time was necessary under field conditions to harden off this variety to that degree where it was able to survive low temperatures as well as Kanred.

In 1926-'27, 10 varieties were grouped into three divisions according to their reaction to low temperatures: (1) Those which are relatively hardy when thoroughly hardened and relatively nonhardy when frozen without previous hardening. This group included Minhardi, Minturki, and Buffum. (2) Varieties which are fairly

hardy, but less hardy than the above when thoroughly hardened before freezing, and which carry a relatively high degree of hardiness in the unhardened condition. In this class are Kanred, Kharkof, and possibly Harvest Queen. (3) Varieties which are relatively non-hardy regardless of whether they are hardened prior to freezing. Such varieties are Blackhull, Fulcaster, Nebraska No. 28, and Tenmarq.

Studies in 1927-'28 confirmed the above results and served also to place winter rye in the same class with Kanred and Kharkof so far as ability to survive low temperatures in the unhardened condition is concerned. Rye that had been hardened off was not included in these tests. Winter oats proved to be less resistant than winter barley, and winter barley less resistant than the most susceptible winter wheat when frozen in the unhardened condition. The relation is the same as the relative winter hardiness of these crops determined by field tests.

The effect of chilling was studied by subjecting young plants of various summer annuals to temperatures of approximately 0.5 to 5° C. for various periods of time up to 120 hours. In no case was the temperature permitted to drop to zero.

It was found that certain plants were easily injured by this treatment. Thus an exposure of 36 hours was fatal to rice, velvet beans, and cotton. Cowpeas exposed 36 hours were defoliated. Peanuts, Sudan grass, and teff grass exposed for 48 hours appeared at first to be uninjured but eventually died.

Corn, sorghum, watermelon, and pumpkin were slightly injured. Soybeans, potatoes, buckwheat, Tepary beans, tomatoes, and flax proved to be highly resistant, exposure for 96 hours in some cases producing no apparent injury.

Injury to the more sensitive crops occurred also at a temperature of 5 to 10° C., but longer exposures as a rule were necessary.

Marked varietal differences were observed. Thus Trice cotton proved more hardy than Delfos, and Westex was more easily injured than either of the foregoing. Whippoorwill cowpeas were more sensitive than early Buff. Spanish peanuts were less hardy than Virginia bunch but more hardy than Valencia.

In general more injury occurred with wet soil than with dry soil. Applications of potassium nitrate decreased the degree of injury, whereas sodium nitrate increased it. The effect of calcium chlorate, calcium nitrate, and sodium chlorate was intermediate.

It is hoped that future investigations will show, among other things, (1) the relation between moisture content of the soil and injury, (2) supply further information regarding hardening off, (3) develop a better and simpler technique for determining the relative hardiness of varieties and strains, (4) develop a means for determining the critical or lethal minimum temperature for each crop and variety, and (5) afford more complete information regarding the reasons for differences in hardiness that are known to

exist. Also it is hoped that by means of the artificial freezing method numerous varieties and strains now being grown in the cereal crop nursery and in plots can be tested for winter hardiness. [Project 157; Department of Agronomy; Purnell funds.]

Small Grain and Sorghum Improvement. Experimental work in small grain and sorghum breeding was continued during the year along much the same lines as in previous years. Wheat breeding was emphasized somewhat more and sorghum breeding slightly less than heretofore.

Considerable space in the greenhouse was devoted to wheat used in freezing trials and to wheats used for crossing. A large number of F_1 plants were grown, mostly of crosses involving earliness and winter hardiness. F_3 populations of Kanred \times Blackhull and of the back-cross (Kanred \times Marquis) \times Kanred were also grown in the greenhouse. A large population of Kanred \times Nebraska No. 28 was grown to compare the results on the relation between earliness and cold resistance in F_3 with those secured in the F_1 generation.

The wet spring of 1927 caused most of the wheats in the nursery to lodge in late April and early May. The epidemic of red leaf rust was the most severe ever observed at Manhattan. These seasonal conditions provided an opportunity to secure reliable data on the resistance of old and new wheats to lodging and rust. Very little was learned about winter hardiness.

Many new hybrid wheats were discarded because of lodging and a very large number of head selections were made for resistance to leaf rust.

Some very promising nonlodging, high-yielding strains have been isolated, especially from a cross between Kanred and Hard Federation. Some of them are also early maturing, which is considered desirable.

Special efforts were made to secure reliable tests of the quality of the Tenmarq wheat grown in 1927. It was found to give high viscosity readings and its loaf volume, color, and texture scores are excellent.

The nursery test at Columbus, Kan., has been continued. Blackhull and Superhard made the highest yields (22 bushels per acre) in 1927. The average yield of nine Fulcaster checks in the same nursery was 15.5 bushels.

In a special advanced nursery test, consisting of 10 pairs of 3-row plats of Kawvale and Fulcaster, the average yields were 12.5 and 11.5 bushels, respectively.

The 1927 crop in the Columbus nursery completed a three-year period. Forty-one varieties, selections, and crosses have been grown in each of the three years. Only a very few have yielded more than Fulcaster during this period. Blackhull has the highest average yield, 20 bushels. Three of the winter \times spring crosses developed at Manhattan have yielded slightly more than Fulcaster. Kawvale, Minturki, and Turkey \times Harvest King from the Colorado station also have average yields slightly higher than Fulcaster.

As in the wheat nursery, lodging was very general in the oats nursery at Manhattan in 1927, only a very few strains remaining erect at harvest time. There was also a very severe epidemic of crown rust, but there was less smut than usual. Lodging and rust greatly reduced the yields. However, fairly high yields were obtained, ranging from 36.1 bushels for Red Coast to 67.2 bushels per acre for an early pedigree selection of Red Texas.

A large number of pedigree selections of Kanota are being tested. One of these, Kansas No. 6121, appears promising. This selection was compared with ordinary Kanota in a special or advanced nursery test, using 50 pairs of rod rows. Average yields were 62.1 bushels for the pedigree selection (No. 6121) and 57 for the Kanota. This difference in yield of 5 bushels per acre is highly significant, statistically.

About thirty strains of barley were grown in triplicated rod rows in the nursery at Manhattan in 1927. Better yields than usual were obtained, due to favorable seasonal conditions and much less damage than usual from chinch bugs. The highest yielding strain was a pedigree selection of Stavropol, H. C. No. 249, from the Hays station. The two lowest-yielding varieties were Pandora (2-row) and Cornfort, a late, smooth awn barley developed at the Minnesota station.

More than 400 headrows of sorghum were grown at the Agronomy Farm in 1927. Selections of the Red Amber \times Feterita cross did not appear promising, and were nearly all discarded. A number of new lots of seed of "kafirita" were received from Mr. Walter Peirce, a farmer of Darlow, Kan. Many of these were rather late, but due to the favorable fall weather in 1927, matured well and made very high yields. Some of them are highly resistant to kernel smut. [Project 67; Department of Agronomy; Hatch funds.]

A Genetic Study of Aberrant and False Wild Types in Kanota Oats. More than 400 pedigree cultures, or headrows, of Kanota oats were grown in the 1927 nursery for a study of false wild types. About 100 of these were planted from normal-type panicles, about 200 were from intermediate or heterozygous false wild types, and about 100 were from individual panicles described as extreme or homozygous false wild. These cultures were all space-planted, and individual plants were all harvested separately and carefully threshed.

Kernel descriptions of this material, consisting of about 4,000 individual plants, have not yet been completed. When completed, these data and those previously secured will be summarized in the form of a project report. A paper on "False Wild Types in Kanota Oats" is projected. Literature reviews and photographs for this manuscript are on hand. [Project 146; Department of Agronomy; Adams funds.]

Sorghum Varietal Tests. In the sorghum variety tests Atlas, a newly named selection from a Blackhull \times Sourless cross, proved decidedly superior to Kansas Orange from the standpoint of lodging

and appears to be practically equal in yield and other important characteristics. The grain is white and in other respects is similar to Blackhull kafir. It exhibits a tendency to mature slightly later than Blackhull and may not prove to be adapted to northern and western Kansas.

A small increase field was grown at the Agronomy Farm in 1927 from which seed has been distributed to about 20 farmers in 12 counties in eastern Kansas. These have agreed to have their fields inspected and certified if found suitable for pure seed. If the variety is given final approval, these fields will serve as sources for general distribution.

No grain sorghum has been discovered or produced which seems to be superior to Blackhull or Pink kafir for the conditions to which they are respectively adapted. [Project 129-1; Department of Agronomy; Hatch funds.]

Small Grain Varietal Tests. The past season, like all others since 1917, was characterized by mild winters and no winterkilling. Moisture conditions in general were satisfactory and relatively high yields were secured.

The new varieties of wheat, Tenmarq and Kawvale, gave a good account of themselves, being the highest or among the highest yielders of the hard winter and soft winter wheats, respectively. Tenmarq seems to be of especially good quality but is deficient in winter hardiness.

Blackhull again outyielded Kanred, and the latter produced more than Turkey. As an average for the past nine years, Blackhull has produced 2 bushels per acre more than Kanred and 3.5 bushels more than Turkey. It does not seem likely that it will maintain this record during a period including the usual allotment of hard winters.

Superhard Blackhull produced essentially the same yields as Blackhull. It appears to differ from Blackhull mainly in appearance of the grain and possibly in quality. With respect to the latter there is no evidence that would suggest superiority and there is some to indicate that it may be decidedly inferior.

Early seeding of wheat, that is, previous to October 1, was decidedly superior to late seeding in point of yield this past season, again demonstrating the danger of delay unless necessary because of Hessian fly, inclement weather, etc. It seems to have been clearly demonstrated, as a result of tests covering about twelve seasons, that the best time for seeding for the control of Hessian fly does not necessarily coincide with the best date for those seasons and those localities where no Hessian fly is present. Considering the time required for seeding and possible delays because of bad weather it seems that in the vicinity of Manhattan, when no Hessian fly is present, seeding should begin a week or 10 days earlier than the fly-safe date.

An unusual epidemic of crown rust damaged the oat varieties to a marked degree, causing a severe crinkling of the straw, premature

ripening, and reduced yields. Plats which looked good for at least 75 bushels per acre produced from 40 to 50.

Kanota and Fulghum strains were the first to suffer. Kherson and Burt before harvest appeared to have been injured less than Kanota and Fulghum, but relative yields failed to verify this observation. Likewise Red Texas escaped injury for a time, but produced no higher yields than other varieties.

The grain of all varieties **was** light, the best one, a Kanota selection, testing only 30.9 pounds per bushel.

The data from the time-of-seeding test with oats verify those of previous years in showing that Kanota must be sown early to secure the usual advantage of growing this variety. In other words, if sown after about April 1 it matures as late or later than Red Texas, yields no more than Red Texas, and considerably less than Burt. This is of more technical than practical interest since profitable yields of any variety are seldom secured when sown in Kansas as late as April 1. [Project 129-2; Department of Agronomy; Hatch funds.]

Alfalfa Production Experiments. In variety tests with alfalfa which have been conducted for five years those varieties now having the best stand are Ladak, Provence, Turkestan, and Kansas Common. Grimm and Cossack have very poor stands, as also have all other varieties and regional strains included in the tests. Alfalfa introduced from Spain and South Africa has proved to be especially unadapted. Argentine alfalfa did well for two or three years and then rapidly deteriorated.

Bacterial wilt seems to have been the main factor in reducing the stand during the past two years, thus suggesting a marked difference in susceptibility to this disease. In fact, very few diseased plants have been found in Ladak, Provence, or Turkestan. The particular strain of Provence used in these tests seems not to be entirely typical since other strains received at various times have proved decidedly inferior. Unfortunately Ladak does not seem to do well during the summer and may not be suitable for Kansas even though resistant to wilt.

Arrangements have been made to secure more accurate information regarding varietal resistance to bacterial wilt, and it is hoped that it will be possible to propagate plants from those varieties that are most resistant and most desirable in other ways.

The time-of-cutting experiment with alfalfa, designed to determine the feasibility of taking off the first crop or the first two crops of the season in an early stage of growth in order to secure a better quality of hay and a better distribution of labor, has not been entirely successful the past two seasons. The growth of the alfalfa has not been satisfactory in any of the plats due, it seems, to the fact that the field has almost constantly been in alfalfa for the past 17 or 18 years, and also to the fact that the stand has been rather thin. An earlier experiment on another field gave more satisfactory results than have been secured in the present case and afforded

some evidence for the belief that a portion of the crops during the season can be taken off early without serious damage to the stand.

In the present experiment the plats which have been cut in full bloom throughout the season have given the largest yields of grass-free hay. Marked deterioration in stand has occurred on those plats cut in the bud stage throughout the season, thus agreeing in a very satisfactory way with results previously reported by this station. In some cases there has been marked deterioration in stand in certain plats where the first crops only of the season have been taken off in an early stage of growth. The results, however, have not been consistent.

There is some evidence to show that the loss in stand on those plats cut frequently has been due to bacterial wilt, thus suggesting a relation between frequency of cutting and the onset of this disease. The project will be continued for at least three or four years longer. A new set of plats has been laid out in a new field where it is hoped more satisfactory results will be secured. [Project 129-3; Department of Agronomy; Hatch funds.]

Soybean Production Experiments. Thirty-five varieties of soybeans were grown in 1927. Fifteen new varieties were introduced in the spring of 1927, and several varieties that had been tested for six years or more were discontinued. Yields of both hay and seed were obtained for all varieties. Three standard varieties of cowpeas and one of mung beans were also grown for comparison with soybeans. Tests to determine the best method of planting soybeans for hay have also been made by planting in (1) ordinary drill width with corn planter, (2) double rowed with corn planter, and (3) broadcast with a grain drill. Increase plats of five varieties were grown to supply seed for coöperative experiments with farmers.

Laredo has produced consistently high yields of hay. It was first grown at this station in 1925. Although it is too late for certain maturity of seed in all seasons, satisfactory yields of seed have been obtained. It may be regarded as a promising variety for hay and green manure in this section and southward.

In the method-of-planting tests, the highest yield was obtained from the broadcast seeding and the lowest from the double-drilled rows spaced 21 inches apart. Only one year's results are available for these tests, and as 1927 was an unusually favorable season for forage production the results are worthy of but little emphasis. [Project 129-4; Department of Agronomy; Hatch funds.]

Miscellaneous Legumes for Forage. A legume nursery is maintained for tests of miscellaneous legumes to determine their adaptability and possible value as crops for Kansas. The following have been grown: Subterranean clover, Korean Lespedeza, Japan Lespedeza, Ladino clover, White or Dutch clover, three strains of Red and Alsike clover from Sweden, Crimson clover, Bur clover, Dalea, Kudzu, six varieties and strains of sweet clover, and several others. Observations to date seem to justify the following conclusions:

Korean Lespedeza has a distinct advantage over Japan Lespe-

deza due to its ability to mature seed and reproduce voluntarily in this section. It is worthy of trial in pastures in the eastern third of Kansas as far north as Japan Lespedeza matures seed.

Ladino clover produces nearly double the amount of forage secured from White clover and may be of value in pasture mixtures in the eastern third of Kansas.

Bur clover and Subterranean clover are of little value.

Dalea has made good growth but it is doubtful if it can compete with soybeans, cowpeas, or sweet clover as a leguminous green-manure crop.

Kudzu appears to hold some promise as a forage crop on land which is well drained and can be left permanently in that crop. It starts slowly, grows slowly the first year, and is not ready for utilization before the third year after planting. A plat planted with 100 roots in the spring of 1927 had 247 plants growing in May, 1928. Some new plants had started from runners 13 feet from the parent plant. Vines 40 feet long were produced in the summer of 1927 from roots that were planted April 1 of the same year.

Of the six varieties and strains of sweet clover tested the white biennial produced the highest yields of forage, and Hubam second highest. Albotrea White and Biennial Yellow produced the finest stemmed hay, but the yield was approximately 30 per cent less than that of the Biennial White. [Project 129-5; Department of Agronomy; Hatch funds.]

Pasture Improvement Investigations. The work on this project is divided into six phases which are briefly discussed below.

Management of Live Stock on Bluestem Pastures. Data have been obtained relative to the advantages of deferred and rotation grazing as compared with season-long grazing. Comparisons are made on the basis of grazing capacity and the effect of the two systems on the growth and succession of vegetation. The gains made by the live stock are also determined.

A little less than 1,500 acres of pasture land are used in conducting the experiments. This area is divided into three small pastures of approximately 120 acres each and one large pasture of about 1,100 acres. The large pasture (No. 1) is grazed under a season-long system to about the intensity practiced by the more conservative stockmen, while one of the small pastures (No. 3) is rather heavily grazed, possibly overgrazed under this system. The other two small pastures (Nos. 2 and 4) are grazed according to deferred and rotation system.

The average grazing capacity of the four pastures for the eight years that data are available is shown in Table XI.

TABLE XI.-GRAZING CAPACITY OF PASTURE.

Pasture.....	1	2	3	4	Average.
Acres per head.....	6.09	3.61	3.75	4.39	4.46

These figures are based on the amount of forage consumed by a two-year-old steer. The average number of acres required per head for pastures Nos. 1 and 3, grazed season-long, was 4.92, while the average of pastures Nos. 2 and 4, grazed under a deferred and rotation system, was 4 acres per head, or approximately 20 per cent less.

In considering the effect of the two systems on the growth and succession of the vegetation, sufficient data for making comparisons are available only for pastures Nos. 1 and 2. These data consist of records on about 50 quadrats located in each of these pastures so distributed as to represent the differences in density and composition of the vegetation.

These data show that pasture No. 2 made much greater improvement than pasture No. 1, even though it carried nearly double the number of stock. In order that a determination can be made of the effect of this system of grazing in pastures Nos. 3 and 4, 11 quadrats were established in 1927 in representative areas in each one. Twenty-five additional quadrats were also established in pasture No. 1 and 10 in pasture No. 2.

Effect of Burning Prairie Grass Pastures on the Yield and Succession of the Vegetation.--This phase of the project was planned to furnish information upon the following points: (1) The effect of burning upon early vegetative growth in the spring; (2) the effect of burning in controlling the growth of weeds and brush; (3) the effect of burning on the vigor and yield of grass; (4) the effect of burning on the life history and succession of vegetation; (5) the desirability of burning to remove the unutilized vegetation remaining from the previous year; (6) the effect of burning on the fertility of the soil; and (7) to determine when burning can be done with the least damage to the soil and to the vegetation.

The investigations conducted last season bear out the conclusions previously arrived at to the effect that burning does stimulate early growth. Some of the results secured in 1927 were as follows:

1. Burnings caused a more rapid early growth of the grass.
2. The number of specimens of vegetation ranged from 7 to 31 per cent higher on the burned than upon the unburned plots in the first part of the growing season.
3. The number of specimens increased on the unburned plots until on July 10 they nearly equaled the number on the burned area.
4. While burning increased the early growth of the vegetation, it decreased the total yield of dry vegetation for the season.
5. The yield of hay on the unburned plots was approximately 20 per cent higher than on the burned plots.
6. The larger numbers of specimens of vegetation on the burned plots during the early part of the season may be accounted for by the higher temperatures of the soil on the burned plots.
7. The temperatures of the soil at a depth of 1 inch averaged 8.2° F. higher on the burned than on the unburned plots during the early part of the season.
8. Burning had a very noticeable effect upon the growth of weeds and brush.
9. There were approximately only one-half as many weeds upon the late burned as upon unburned plots.

10. The time of burning is an important factor in weed control. Late burning is more effective than early burning.

11. Late burning was also found to be effective in controlling brush.

12. While it is too early to draw definite conclusions, it appears from the data available that burning is very detrimental to plants that start growth early in the spring. Kentucky blue grass and sedges already have been eliminated from all the burned plots.

13. When it is necessary to burn prairie-grass pasture to remove unutilized vegetation remaining from the previous year the burning should be done as soon as hard-freezing weather is over and before vegetation starts growth. This is usually sometime between March 10 and 20 in this section of Kansas.

14. There are good indications that burning should not be practiced any more often than is absolutely necessary to obtain uniform distribution of live stock over the pasture.

Effect of Frequent Harvesting on the Vegetative Growth in Prairie Grass Pastures.--This is a new phase of the project started in the spring of 1927 to obtain more information under controlled conditions regarding the life history and growing requirements of native vegetation. Eleven plats one meter square were established and clipped at different times and frequencies, to represent as nearly as possible various methods and intensities of grazing. Before clipping, the plats were carefully charted so that the exact location and number of species of vegetation were obtained. Table XII shows the results for the season of 1927.

TABLE XII.-THE EFFECT OF FREQUENCY OF CLIPPING UPON YIELD AND DENSITY OF PRAIRIE VEGETATION.

PLAT No.	Number of times clipped.	Total weight; hay per acre.	Density of vegetation, sq. cm. per plat.	Plan of clipping.
CV1	14	2,815	1,533	Clipped every 10 days
CV2	7	3,337	1,196	Clipped every 20 days
CV3	5	3,497	1,309	Clipped every 30 days
CV4	4	3,441	1,178	Clipped every 40 days
CV5	11	3,369	1,218	Clipped every 10 days after June 1
CV6	9	3,321	1,136	Clipped every 10 days after July 1
CV7	0	.....	1,787	Check, unclipped
CV8	5	3,068	1,187	Clipped every 10 days after August 1
CV9	2	4,634	1,837	Clipped every 10 days after September 1
CV10	1	2,220	1,785	Clipped at maturity of vegetation
CV12	8	2,190	1,464	Clipped every 10 days until August 1

The plats will be recharted from time to time in order to determine the effect of clipping on the density and succession of the vegetation.

At the close of the growing season samples of roots collected at a depth of 7 inches were taken from five of the plats, including the

check plat, for chemical analysis. It was found that the roots from the plats that were clipped every 10 days contained only about one-half as much starch as the roots from the unclipped plat. The treatment that was given this plat would be comparable to very close grazing. It is believed that all the perennial species of vegetation found on this plat will be killed by the end of the second year.

Another very interesting result was the high starch content of the roots from the plat protected until August 1 and clipped every 10 days afterwards until the close of the season. This plat has more stored food material than the plat clipped every 20 days. This indicates that prairie grasses begin to store food material early in the season rather than near the close, as is true of some other grasses. This information is particularly valuable in connection with the application of the deferred and rotation system of grazing in that it sheds considerable light on the question of how long the grazing should be deferred in order to obtain the maximum benefits and at the same time make the fullest use of the vegetative growth.

The Eradication of Undesirable Plants from Pasture Lands.- This phase of the project was started in August, 1926, and has for its object the determination of the most feasible time and method of eradicating brush and weeds from pastures.

The work was started with sumac and buck brush. Both shrubs were cut just above the surface of the ground at two-week intervals during the growing season. At the time of cutting, counts were made of the number and height of stems, and notes were taken on the vigor of the growth. Samples of both the roots and stems were also collected for a determination of the starch content.

An examination of this material during the past winter shows that buck brush has the least amount of stored starch in both roots and stems about the middle of May, while the minimum amount in the sumac is found in the stems about a month later. The time when the brush has the least amount of stored food material checks with the effectiveness of cutting. Cuttings made of the buck brush about the middle of May were approximately 75 per cent effective, while the sumac cut a month later was about 50 per cent effective. The effectiveness decreased in both cases with earlier and later cuttings.

Pasture and Forage Crop Nursery. A nursery was established for testing the adaptability of different tame grasses and mixtures of grasses and legumes for pastures. The first plantings were made in September, 1926, when 14 species of tame grasses and 6 mixtures of grasses and legumes were seeded. In the spring of 1927, 28 species of grasses obtained mainly through the forage office of the Bureau of Plant Industry were planted. Since that time various plantings have been made and the nursery now contains 30 plats. In addition to testing the adaptability of grasses and pasture mixtures, a selection study has been started with native grasses, including bluestem and Blue Gamma, to obtain strains that will produce seed of high enough viability to be used in reseeding depleted pasture lands.

Effect of Fertilizers on the Yield, Vigor, and Succession of the Vegetation in Native and Tame Pastures. This is a new phase of the project started during the spring of 1927 to test the effect of various fertilizers on native and tame grasses. The plats were so located as to include both hill-top and slope types of vegetation. The north half of all plats are fenced and the south half grazed. On the protected part, one plat, 4 meters square, was located on each of the areas for obtaining yields of the vegetation produced under the different fertilizer treatments and also to record any changes that take place in the vegetation due to the treatment. It is also planned to collect samples of grass from the different plats for chemical analysis to determine the effect of the different fertilizer treatments on the nutritive content of vegetation. [Project 96; Department of Agronomy; Purnell funds.]

Corn Production and Improvement. The corn project, coöperative between the Department of Agronomy and the Office of Cereal Crops and Diseases, Bureau of Plant Industry, of the United States Department of Agriculture, has been continued during the last biennium along lines similar to those followed in the past.

The seasons of 1926 and 1927 represented contrasting extremes. The summer of 1926 was hot, dry, and very unfavorable for corn production, whereas the summer of 1927 was cool, had ample rainfall, and was unusually favorable. This contrast produced strikingly different results in the cultural experiments with corn. For instance, listing produced higher yields with every date of planting in the dry year of 1926, whereas, no consistent difference was observed in 1927. Moreover, in rate-of-planting tests the wide spacings were more productive in 1926 and the narrower spacings in 1927.

Again, in variety trials the small early sorts, led by Hays Golden and followed closely by Cassel and Freed White, produced the highest yields in 1926, while in 1927 the largest late varieties were most productive, the three highest being Hildreth, Kansas Sunflower, and Commercial White, respectively.

Various seed treatments for corn were tested in coöperation with the Department of Botany in 1927. Five replications each of good Pride of Saline seed and poor Kansas Sunflower seed treated with each of six disinfectants and corresponding untreated checks were planted. In general, a slight but significant increase in field germination was noted for the good seed, but no advantage was obtained in the case of the poorer seed. In the yield results none of the treatments gave a significant gain over untreated seed for the one year's trial.

The season of 1927 gave the first opportunity for comparing the performance of strains of Pride of Saline increased in 1926 from selections of ear-row tests in 1924 and 1925. As an average of eight replications planted on two different dates the high-yield selection

gave an appreciable advantage in erectness and yield over the composite which may be considered to represent the original strain.

The strain of pop corn selected for high popping expansion gave good results in both years. It seems likely that under favorable conditions it will not yield so much as larger adapted varieties, such as Queen's Golden, but in popping expansion it has consistently surpassed all other varieties tested, both at Manhattan and in outlying fields. [Project 156; Department of Agronomy; Purnell funds.

Turf and Lawn Grass Experiments. During the last biennium this project, which is conducted in coöperation with the greens committee of United States Golf Association, has had three major objectives: (1) To determine the adaptability of certain grasses for greens and fairways on golf courses and for lawns; (2) to ascertain the best cultural methods of establishing and maintaining turf; and (3) to determine the effect of fertilizers and compost on the control of weeds and maintenance of turf.

In addition two minor lines of work have been under way as follows: (1) Tests to determine the effect of closeness of cutting. Eight strains of creeping bent and Kentucky blue grass are included in this series. (2) Trials with various chemicals for controlling clover, dandelions, and other lawn weeds. In these tests, the following chemicals were used: Sodium nitrate, iron sulphate, zinc chloride, sodium chlorate, sodium arsenite, ammonium sulphate, sodium dichromate, sulphur, and a commercial product sold by the trade name of Mission dandelion killer.

The tests of adaptability comprise 13 varieties and strains of bent grass in addition to Red Top, Buffalo grass, and Kentucky blue grass. The results show that Washington and Metropolitan bent grass are the most desirable turf grasses for this section. Chewings Fescue failed so completely that it has been replaced by creeping bent. Selected strains of creeping bent produce a putting turf far superior in density and evenness of texture to that of the mixed bents, the German or the Rhode Island. Neither buffalo grass nor blue grass are well adapted for putting greens. Blue grass does not withstand close clipping so well as the bent grasses and the turf is so open that it is almost impossible to keep white clover from encroaching on the plats. The bents seem to thrive especially well under the close clipping of the greens mower.

Brown-patch disease was a constant menace during the summer of 1927. Only by close attention and frequent treatment with turf calomel was it kept under control.

Striking results have been obtained with fertilizers. The grass on areas which have had neither fertilizer nor compost and those which have received compost alone is thin and sickly in appearance and has formed an unsatisfactory turf. The bent grasses have suffered more severely from lack of fertilizer than blue grass. This is probably due mainly to the very shallow root system of the bent grasses.

It is obviously impossible to maintain a putting turf with creeping bent grass without compost and fertilizer and frequent light applications of water. Ammonium sulphate has been the most satisfactory fertilizer for the bent grasses. [Project 167; Department of Agronomy; state funds.]

The Effect of the Ensiling Process and of Freezing Upon the Germination of Weed Seed. One hundred seeds of each of 11 species of weeds were sown in muslin sacks and buried in a silo filled with sorgo silage on October 5 to 10, 1927. Four of the sacks were buried at different depths as the silo was being filled. As the silage was used, the samples were recovered and exposed to the weather, the remainder of the winter. On March 21 the seeds were germinated. The samples (Nos. 1, 2, 3, and 4, respectively) were removed from the silos on November 7, December 6, January 5, and February 6. An additional sample was exposed to the weather from the time the seed was gathered in the summer and fall until placed in the germinator March 21 as a check.

Alternating temperatures of 20°C. for 18 hours and 30°C. for 6 hours each day were maintained in the germinator. The samples were left, in the germinator for 70 days. The results of the germination tests are given in Table XIII.

TABLE XIII.—EFFECT OF ENSILING PROCESS AND OF FREEZING UPON GERMINATION OF WEED SEEDS.

KIND OF WEED SEED.	Per cent germination.					Check.
	After ensiling.					
Sample No.	1	2	3	4	Av.	
Pigweed	0	0	0	0	0	22
Yellow foxtail	0	0	0	0	0	25
Field bindweed	32	35	34	47	37	50
Giant ragweed	0	0	0	0	0	0
Johnson grass	0	0	0	0	0	2
Morning glory	10	26	15	29	20	2
Smart weed	0	0	0	0	0	4
Barnyard grass	0	0	0	0	0	51
Velvet leaf	86	88	85	81	85.5	40
Sunflower	0	0	0	0	0	30
Cocklebur	0	0	0	0	0	30

As shown in Table XIII only three of the eleven species of weed seed germinated after going through the silo. Two of these gave higher germination than the check which was not put in the silo, but was left outside under natural conditions. [Departments of Agronomy and Dairy Husbandry; state funds.]

Bindweed Eradication with Chemical Sprays. The work during the past biennium has consisted of trials of various chemicals used mainly as sprays. Since sodium chlorate had proved to be the most promising, tests have been confined mainly to a determination of the best methods of using this material. Twenty-six plots of one one-hundredth acre each were under observation in the summer of 1926. In the spring of 1927, 12 additional experimental plots were laid out to determine the best strength of solution to use and 8 were added to test the effect of sodium chlorate applied as a dry salt. Field trials on large areas were also inaugurated, partly to serve as a further test of the value of this chemical and partly as a practical demonstration.

Sodium chlorate is the only chemical tried to date that is effective in killing bindweed. Sodium arsenite, zinc chloride, copper sulphate, and K. M. G. weed killer proved to be of little value.

The optimum time for the first application of sodium chlorate seems to be about the time the bindweed is in full bloom. Succeeding applications must be made when the plants show full recovery from the effects of previous applications. Usually from four to six weeks will elapse between treatments. Three treatments have been found to be sufficient to kill most of the old plants. A vigorous stand may require an additional treatment.

A solution made up of 100 pounds of sodium chlorate dissolved in 100 gallons of water seems to be about the proper strength. This is sufficient for one application per acre.

Dry sodium chlorate proved to be somewhat less effective than the same amount of material applied as a spray.

Results of field trials were very satisfactory. A two-acre tract was cleared of all old bindweed plants with three applications of the spray.

The effect of sodium chlorate on the soil has been a matter of some concern but does not seem to be very serious, since wheat and sorghums have been grown successfully on land treated with this chemical. Some other crops seem to be somewhat more sensitive. Cow-peas and oats have failed to grow on land the first season after treatment, but no effect is apparent after the first year. [Project 166; Departments of Chemistry, Agronomy, and Horticulture; state funds.]

Coöperative Experiments with Farmers. Coöperative experiments with farmers during the biennium comprised 834 tests with major field crops in all parts of the state. (Fig. 4.) The kinds of tests, the number placed, and the number of counties in which they were located are shown in Table XIV for each year of the biennium.

TABLE XIV.—COÖPERATIVE TESTS CONDUCTED DURING THE BIENNIUM, 1926-'28.

KIND OF TEST.	Number of tests.		Number of counties.		Total number of tests.
	1926.	1927.	1926.	1927.	
Corn variety.....	89	82	45	53	171
Sorghum variety.....	83	80	35	47	163
Wheat variety.....	62	60	46	47	122
Wheat fertilizer tests.....	16	9	13	9	25
Wheat; date of seeding.....	19	7	10	6	26
Oat variety.....	17	16	17	16	33
Barley variety.....	13	17	12	15	30
Alfalfa variety.....	15	39	13	29	54
Alfalfa fertilizer tests.....	32	48	24	24	80
Soybean variety.....	28	22	24	19	50
Other varietal tests.....	17	23	12	17	40
Other treatment and miscellaneous tests.....	14	26	12	18	42
Totals.....	405	429	79	81	834

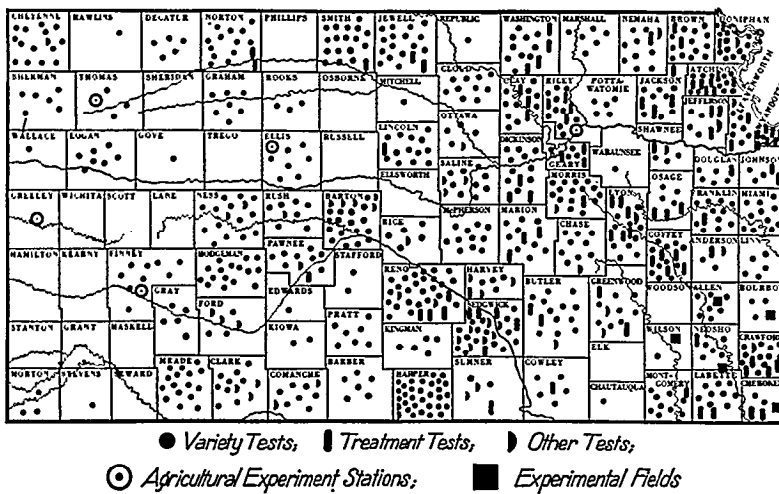


FIG. 4.—Map of Kansas showing location of coöperative tests, outlying experimental fields, and agricultural experiment stations.

The following are some of the outstanding results secured in these tests.

1. In the corn variety tests, Pride of Saline outyielded other varieties in the east half of the state, as it has done over a period of 15 years, and Freed White Dent maintained its superiority in western Kansas.

2. Recent tests have indicated progress in finding superior yellow varieties of corn suitable for the sections in greatest need of yellow varieties; namely, the northeastern and the central and western parts of the state.

3. A strain of red kafir from southwestern Kansas made a good showing in comparison with pink, having yielded one bushel higher than pink in 1926 and three bushels higher in 1927.

4. Blackhull outyielded other varieties of wheat in both 1926 and 1927, the average annual increase over Turkey being 3 and 4 bushels respectively. Kanred yielded about a bushel more than Turkey each of the two seasons and has outyielded Turkey an average of 2 bushels per acre over a period of 15 years. In 477 tests conducted since 1919, Blackhull averaged 22.2 bushels and Kanred 20.7 bushels, a difference of 1.5 bushels. Tests during the last two years have shown no difference in yield between Blackhull and Superhard Blackhull. Michigan Wonder has done well in northeastern Kansas where it has averaged somewhat higher in yield than Harvest Queen.

5. Kanota oats outyielded Red Texas 6.2 bushels in 1926 and 13.5 bushels in 1927. In 200 farm tests over a period of nine years Kanota has averaged 40 bushels as compared with 30.2 for Red Texas, a difference of 9.8 bushels or 33 per cent in favor of Kanota.

6. Club Mariout made the highest yields of the barleys both in 1926 and 1927. It has outyielded Stavropol in five of the last six years and has outyielded Coast every year. Unfortunately it does not seem to possess the quality of straw desirable in a variety for western Kansas.

7. Kansas Common and Grimm were generally the most satisfactory varieties of alfalfa tested, considering yield, hardiness, and adaptation. In all tests thus far they have made equal yields, averaging 2.5 tons per acre.

8. Superphosphate and manure have given about equal increases in yield when applied on alfalfa in eastern Kansas, the increase amounting to about one ton in 1927 and one-half ton in all tests made since 1914. The combination of manure and superphosphate usually increased the yield of hay a little more than either one.

9. For the six-year period it has been tested, A. K. was the most satisfactory variety of soybeans for both grain and hay. It has made the highest yield of grain, averaging 11.5 bushels, and has been exceeded in yield of hay by Peking only, the difference being only 0.07 of a ton, which probably is within the limits of experimental error.

[Department of Agronomy; state funds.]

Chemical Factors Influencing Quality of Wheat and Flour.

The work under this project has been centered during the past biennium mainly on methods for testing flour.

A special study has been made of the action of yeast in dispersing the phosphatides in the dough as a factor in dough development. Such dispersion seems to be one of the results accomplished by fermentation. During this process alcohol and acids are produced as by-products. By adding alcohol, acids, and water soluble phosphatides it should be possible to dispense with all but the fermentation in the pan, and this has been shown to be the case. By observing these principles, bread may be made in two hours from the time the mixing starts. Similar results may be accomplished by the use of oxidizing agents such as chlorates and bromates. Their action may be explained on the assumption that they make the phosphatides more easily dispersable in water. [Project 60 A; Department of Milling Industry; state funds.]

The Quality of Wheat as Influenced by Cropping Systems and Fertilizer Treatment. Forty samples of wheat in 1926 and 35 in 1927 from the fertility and rotation plats mentioned on page 22 have been analyzed, milled, and baked.

The most notable effect of the cropping system and fertilizer treatments is on the protein content. Those soil treatments give a seedbed well supplied with nitrates and produce high-protein wheat.

The technique of the milling and baking tests is not sufficiently refined to reflect quality differences due to soil treatments except in a general way. Protein tests will hereafter be made on samples from all the fertilizer and rotation plats on the Agronomy Farm but milling and baking tests will be omitted. [Project 60 B; Department of Milling Industry; state funds.]

The Quality of Wheat as Affected by Seedbed Preparation and Tillage Methods. Milling, baking, and chemical tests were made in 1926 and 1927 on wheat from the five rotation plats, and in 1927 on wheat from 12 nitrogen fixation plats mentioned on page 27. In 1926, 24 samples from the rate- and date-of-seeding experiment were also tested.

Time and depth of plowing had a notable influence on the protein content of the wheat, as shown by the data in Table XV. Greater differences were obtained in 1926 than in 1927. [Project 60 C; Department of Milling Industry; state funds.]

TABLE XV.—THE INFLUENCE OF SEEDBED PREPARATION ON THE PROTEIN CONTENT OF WHEAT.

METHOD OF SEEDBED PREPARATION.	Per cent protein.	
	1926.	1927.
Plowed, July, 12 inches	15.5	13.3
Plowed, July, 7 inches	14.9	12.1
Plowed, July, 3 inches	14.5	11.8
Plowed, August, 7 inches	12.6	13.4
Plowed, September, 3 inches	11.0	11.6

The Relation of Variety to the Quality of Wheat. Milling, baking, and chemical tests were made on 26 samples from varieties grown at Manhattan, and on 7 samples grown at Hays, from the crop of 1926. Similar tests were made on 30 samples grown at Manhattan, and 9 samples grown at Hays, from the crop of 1927. In addition, protein determinations were made of 631 samples from the nursery crop of 1927.

Results for several of the leading varieties grown in 1927 are shown in Table XVI. The data on loaf volume and texture were obtained by the severe baking method.

TABLE XVI.—MILLING AND BAKING RESULTS FROM KANSAS WHEAT VARIETIES.

VARIETY.	Yield per acre.	Test weight.	Per cent flour.	Per cent protein in wheat.	Loaf volume.	Texture.
Grown at Manhattan.						
Kharkof.....	35.3	59.3	70.3	12.7	1,875	94
Superhard Blackhull.....	40.5	62.4	70.4	12.9	1,760	89
Fulcaster.....	44.0	61.3	70.1	11.9	1,890	90
Kanred.....	35.5	59.3	70.1	12.6	1,930	95
1066 X Marquis.....	40.3	58.5	70.5	11.8	1,980	96
Kawvale.....	43.8	61.4	70.3	11.9	1,870	92
Regal.....	25.5	59.7	70.1	13.1	1,870	95
Tenmarq.....	47.5	60.7	73.3	11.8	2,085	98
Blackhull.....	41.1	62.0	70.5	12.8	1,725	85
Grown at Hays.						
Kanred.....	6.3	57.8	66.0	16.4	2,055	94
Turkey.....	10.9	58.7	66.0	15.0	2,060	97
Tenmarq.....	8.1	55.6	62.8	16.8	2,065	98
Blackhull.....	8.1	59.9	66.5	16.0	1,625	87
Superhard Blackhull.....	9.2	60.4	66.5	16.1	1,895	86

It is proposed to continue the work along similar lines. If possible more theoretical work will be done to develop methods which will make possible a closer evaluation of the results in terms of commercial bake-shop practice. [Project 60 D; Department of Milling Industry; state funds.]

A Comparison of the Quality of Wheat Varieties Grown in Different Parts of Kansas. Milling, baking, and chemical tests were made on 107 samples from the crop of 1926, and 131 samples from the crop of 1927 secured from the coöperative experiments with farmers. The severe method of mixing the dough was used beginning with the crop year of 1925. The varieties compared were Kanred, Turkey, Blackhull, and Fulcaster. In addition, 35 samples in 1926, and 32 samples in 1927, from the prize wheat grown by county wheat champions were milled and baked.

It has been clearly shown that when tested by the severe method of mixing the dough, Blackhull gives a much smaller loaf volume and poorer texture than Kanred or Turkey. If mixed by gentler methods, Blackhull produces as good bread as any of the hard winter wheats. This appears to mean that the range of conditions under which Blackhull may be used satisfactorily in the bake shop is restricted. The variety known as Superhard has given even less

satisfactory results than Blackhull. [Project 60 E; Department of Milling Industry; state funds.]

A Study of the Protein Content of Some Common Kansas Wheat Varieties. During the past biennium 733 samples representing 22 varieties of wheat grown in Kansas were analyzed for protein. The results of the analyses of the eight more common varieties are given in Table XVII. The protein content of all varieties averaged high in 1926 and low in 1924.

TABLE XVII.-THE PROTEIN CONTENT OF SOME KANSAS WHEAT VARIETIES .

VARIETY	Protein per cent.			
	1924.	1925.	1926.	1927.
Kanred.....	11.2	13.0	14.5	12.5
Turkey.....	11.4	12.8	14.5	12.4
Blackhull.....	11.7	12.4	14.2	12.2
Fuleaster.....	11.8	13.0	14.7	12.3
Harvest Queen.....	12.0	12.3	14.2	11.0
Currell.....	12.0	12.7	14.5	11.0
Fultz.....	11.8	12.7	14.5	11.2
Poole.....	12.1	12.4	15.0	10.6

[Project 60F; Department of Milling Industry; state funds.]

Shrinkage, Loss, and Damage to Wheat in Farm Storage. A field of uniform wheat grown on the Agronomy Farm at Manhattan in 1927 was selected for this study. It was cut at four stages of maturity; namely, green, barely ripe, ripe, and dead ripe. The first stage of cutting was chosen to represent wheat greener than would be cut with a combine; the second, to represent conditions that might occur in spots or in low places in the field at the time of combining; the third, to represent the earliest that combining usually is started; and the fourth, to represent wheat fully ripe with no danger of damage in storage if cut with a combine.

The wheat was threshed and taken to the laboratory immediately after cutting. The general plan was to place the wheat in flat tin gallon cans and heat at four different temperatures for periods ranging from one to ten days. The temperatures used were 40°, 45°, 50°, and 55° C. The cans were closed with cotton plugs to prevent loss of water but not so closely as to prevent escape of expanding air or carbon dioxide gas. Five-pound samples were used in each case. The heating was done in specially constructed well-insulated wooden boxes or bins heated by electric current under thermostatic control. The air inside the bins was kept in circulation with a small fan. It was possible to control the temperatures in all parts of each bin within 1 degree.

Each sample was weighed when placed in the bin and when removed. There was practically no loss of moisture in any case. As soon as removed from the bin the wheat was emptied into shallow paper boxes where it was rapidly cooled and dried. When air dry it was returned to the can. The samples were then milled and the flour baked. Germination tests were also made. Some of the results secured the first season are as follows:

1. The germination of wheat cut before it was fully matured was greatly reduced by high temperatures. That which was cut after full maturity may be heated for 10 days at 50 °C., or five days at 55 °C., without apparent injury.
2. There was an increase in test weight as the wheat matured.
3. The per cent of flour showed no regular increase or decrease corresponding with the stage of cutting or the amount of heating.
4. Flour from wheat cut the greenest had the highest ash content and flour from the most mature wheat had the lowest ash content. Heating increased the ash content except in the flour from the mature wheat. This indicates that the presence of bin-burnt wheat in the mill mix mill raise the per cent of ash.
5. All wheat cut green produced bread of poor volume and texture. Bread from wheat cut in the second and third stages was distinctly improved both in volume and texture by heating at 40 °C., the best bread being obtained from the longest period of heating. It was also improved by heating at 45 °C., the most improvement in this case being obtained by heating for five days. Temperatures of 50° and 55 °C., proved injurious to all samples of wheat cut in stages two and three. The fourth stage was neither improved nor injured in quality by heating. The effect on color was not definite, but it may be said that heat injured the color whenever the volume and texture were unfavorably affected.

[Project, 143; Department of Milling Industry; Purnell funds.]

Tempering Factors Affecting the Quantity and Quality of Wheat Flour. Considerable time has been spent the past year in remodeling the mill so as to adapt it for experimental work in milling technology. The mill now has the following features which provide facilities for experimental work in wheat tempering.

1. A Carrier air-conditioning system which maintains a uniform condition of temperature and humidity in the mill.
2. A Carrier wheat conditioner by means of which the temperature or moisture content of the wheat may be raised or lowered. Thus the wheat may be heated before the tempering water is added and cooled again before it goes to the rolls.
3. Hopper scales so placed that the wheat may be weighed between the different processes of conditioning.
4. Specially constructed water tanks by means of which the water used for tempering is accurately measured.
5. A unique device by means of which it is possible in a few minutes to obtain samples of all the mill-stream flours. It is also possible by means of this device to determine the rate of flow of each mill stream as influenced by different milling conditions, such as the tempering factors.
6. A small experimental sifter by means of which the products under the different rolls may be studied. In this way the effects of varying the tempering or other milling factors may be measured.
7. Two experimental roll stands by means of which it is possible to make

comparisons of the behavior of different types of rolls in relation to the various tempering factors.

8. A small Allis double-stand experimental mill, and a single-stand Ehram mill for use in making preliminary tempering experiments on small samples.

Besides the above the mill contains the usual features found in a flour mill. To the present equipment will be added a wheat washer, and a second wheat scourer by means of which the amount of scouring may be varied at will. A set of cyclone dust collectors will be installed and the present purifiers will be rebuilt for experimental purposes.

The experiments this year have been to a large extent of a preliminary nature. The work has consisted of a study of the effect of length of tempering with some variation in the amount of water added and also on the use of heat in connection with tempering. Time of tempering has varied from 4 to 24 hours. Some of the results obtained are as follows:

1. The best milling results were obtained when wheat was tempered at 15 per cent moisture or a little above. When tempered to this moisture content for 24 hours or more a second temper was necessary to obtain the best results.

2. Tempering wheat to a moisture content of 16 per cent seems to be a little beyond the upper limit for best milling results. At this moisture content it is difficult to get a good yield of flour, the moisture content of the flour is higher than accepted standards, and the streams in the mill do not run satisfactorily. These difficulties were experienced with both the long and the short tempers.

3. Tempering wheat to a moisture content of 14.5 per cent did not give satisfactory results. It thus follows that the range of moisture at which the wheat may be tempered for best results is rather narrow. This means that the controls for adding water to the heat in tempering have to be very accurately calibrated.

4. A few experiments were tried where the wheat was heated as a part of the conditioning process. This caused a more rapid penetration of water, permitting a shorter tempering period. Short tempers with heat gave better results than long tempers with heat.

5. A few experiments have been conducted to determine the rate of water penetration in wheat. In many ways, a short temper of 6 hours was better than a long temper of 24 hours. It seems that 6 hours at room temperatures is sufficient for the tempering water to penetrate to all parts of the kernel. A longer time of tempering at this temperature appears to have a detrimental effect on the quality of the protein of the endosperm.

[Project 170; Department of Milling Industry; Purnell funds.]

Flour Chemistry Investigations. For the past two years the work on flour investigations has been carried out along the following lines:

1. The work on the hydration capacity of flour has been continued. This work is based on the vapor pressure of mixtures of flour and water. Owing to the difficulty of removing the occluded air from the above mixtures, considerable investigation of the proper kind of apparatus has been necessary.

2. A thorough study of gels from different flours has been made. It has been found that the strength of a flour gel runs parallel with the baking strength of the flour.

3. An investigation into the spectra-photometric properties of the different constituents of flour has been started. This promises to give reliable information along lines which are very difficult with the ordinary chemical methods.

4. A study of the lecithin content of different flours has been made. Preliminary results indicate that the lecithin content increases the colloidal properties of a flour and thus has a very beneficial effect on the baking qualities.

5. The collaborative work with the American Association of Agricultural Chemists has been continued. This work is concerned with a method for the determination of the diastatic activity of wheat flours.

[Project 60; Departments of Milling Industry and Chemistry; state funds.]

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

Spraying Apples. The spraying problems involved in growing sound crops of apples in the experiment station orchard are chiefly concerned with the control of apple scab and codling moth. In recent years, however, apple scab has not caused the loss that it formerly did. This change has been brought about by sanitary orchard practices and by following a successful spray schedule.

Codling moth, on the other hand, is one of the most serious insect pests. Acid lead arsenate is the standard insecticide used for the control of this pest. Calcium arsenate has a higher per cent of arsenic content but is less efficient. The reason is probably related to the intimate union of the arsenic with the calcium and there is not sufficient arsenic soluble in the digestive tracts of the insects.

Apple trees sprayed with lead arsenate varied to some extent in the per cent of wormy and "stung" apples. The per cent of "stung" apples was higher on the sprayed than on the unsprayed row. This is evidently due to the fact that more larvæ were successful in gaining entrance into the apples when no insecticide was present. The insecticide protected the apples against most of the larvæ, but in some cases the latter had punctured the skin before the spray was fatal.

Volck, a commercial miscible oil, when used alone at a strength of 2 per cent, did not give satisfactory results in the control of the codling moth in 1926. During the season of 1927 a combination spray consisting of Volck at a strength of 2 per cent plus acid lead arsenate at the rate of 1 pound of the powder to 50 gallons of spray was used. Favorable results were observed. In this combination the Volck serves as an ovicide and the lead arsenate as a larvacide.

In the fall of 1927, specimens of San José scale were observed on a few Winesap apples. This is the first time this insect has been discovered in this orchard, the oldest trees of which were planted in 1911. Each tree in the orchard was carefully inspected and a total of 235 trees were found to be infested.

The control measures tried during the past year consisted in spraying with five different contact insecticides as follows: Dendrol, 2 per cent; Volck Kleenup, 4 per cent; Sunoco, 3 per cent; Rex oil emulsion, 2 per cent; and lime-sulphur 1-7. All of the oil sprays gave better control than did lime-sulphur. The only spray, however, that gave satisfactory results was the 4 per cent Volck Kleenup

oil. Although the Volck was the most costly spray used, it may prove to be economical if one dormant spray will eradicate the pest.

Methods of Pruning Fruit Trees. During the past biennium experimental work in pruning has followed two fairly distinct lines: (1) Corrective pruning of bearing trees, and (2) pruning for form and strength of young trees.

Pruning of bearing apple trees has dealt with the problem of how best to reduce the number of frame-work and secondary branches in trees which were improperly pruned while they were young. Results from both immediate, drastic removal of these excess branches, and their gradual removal, one or two each year, have been encouraging. The amount and grade of fruit are improved and the branches remaining assume a better habit of growth. This operation does, however, involve danger of introducing blister canker.

The study of the effects of disbudding one-year-old apple trees at time of setting has been continued through the biennium. Cedar apple rust and the 1926 drought have seriously injured these trees, but records have been taken and conclusions of some value are in prospect.

Orchard Soil Management Experiments. Experimental work on this phase of the project has made progress during the past biennium. Three subdivisions of the studies have had special attention; namely, (1) use of commercial fertilizers, (2) cover-crop relations, and (3) the straw mulch method of orchard soil management. The comparative effects of these various treatments on both vegetative responses and fruit bearing were recorded.

Of the plats fertilized with commercial fertilizer, the highest yield of fruit, 7Job #: 2408 Title: Web page developer Start: Job Duties: Deadline: 9/04/98
ceived nitrate and phosphate. However, the plat to which only potash was applied was a very close second with a yield of 7.5 bushels per tree. The Jonathan trees to which phosphates were added show no consistent gain over those which are not fertilized.

Two plats of Delicious have been under the straw mulch method of management since 1921. The superiority in both growth and fruit yield of the mulched plats over the cultivated plat continues as in former years. However, straw for mulching is increasingly difficult to obtain and that used in 1926 was hauled five miles. The moisture content of the soil under the mulch fell as low as 18.5 per cent, dry-weight basis, during the drought of 1926. Minima as low as 15 per cent were observed in adjacent cultivated plats.

During the biennium plats of the following-named cover crops were seeded: Winter vetch, rye, cowpeas, and dwarf Essex rape. The compeas and rape were not wholly successful either year. In 1926 the seed of both of these crops germinated after being drilled in the dust and the seedlings quickly died. In 1927 the plants lived but made only a weak growth. In contrast the winter vetch and the rye made good growth both seasons.

During both years of the biennium studies were made of the

relation between the soil moisture and soil nitrates and the dates on which the cover crops were plowed under. The straw mulch plats also received attention. Soil samples were taken and the determinations made at varying intervals, usually one week during the growing season and two or more weeks during early spring and fall.

In the summer of 1926, a very dry season, all the various treatments resulted in low nitrate and low moisture content of the soil during the period of twig extension of the apple trees. Following this period, of from approximately the first of July on, the soil moisture continued to decline but the nitrates increased very rapidly until the close of the growing season. Differences in moisture and in nitrates due to varying the date on which rye or winter vetch cover crop was plowed under were not great.

Rainfall was much more abundant during the summer of 1927 and at only one date, July 19, did any of the plats under test fall below 18 per cent of soil moisture, dry weight basis. The lowest for the season was on a check plat with clean cultivation and no cover crop. The straw mulch plat consistently showed the highest moisture content. Nitrate content fluctuated much less violently than in the dry year of 1926. The plats sown to rye as a cover crop averaged lower in available nitrates than the check plat, while winter vetch increased the nitrate content, regardless of the time it was plowed under, as compared with the check plat.

Testing New and Promising Varieties of Tree Fruits. In this project the adaptation of varieties previously planted have been observed and recorded and a number of new varieties of tree fruits have been introduced. The season of 1927 was favorable for tree growth and a great majority of the varieties under test made good development. However, some died due to diseases and other causes and others continued to show poor adaptation. Ensee was discarded, the trees being removed and replaced by more promising ones.

Of the 12 varieties of hybrid pears set in March, 1926, S. P. I. 642238 died during the drouth of that summer. The others are variable in form but have all shown fair vigor. S. P. I. 64227 is making a very strong growth. One tree of pear S. P. I. 64226 became infected with fire blight in June, 1927. It was not treated and almost the entire tree was killed. No blight appeared on any others.

Variety tests of *Prunus* and *Amygdalus* were continued during the biennium. Baldwin sour cherry again failed to bear, as did the several Russian varieties. For the first time since they were planted, about 15 years ago, the surviving sweet cherry trees bore a light crop. Very little varietal resistance to cherry leaf spot during the outbreak of 1927 was observed. [Project 25; Department of Horticulture; state funds.]

Small Fruit Investigations. Experiments with small fruits were conducted during the past biennium in accordance with the plan of the project. It is becoming increasingly evident that but little ad-

vance can be made with work on the brambles because of the inhospitable character of the soil on the horticultural farm. The drought of the summer of 1926 nearly ruined the bramble plantation. No variety of any kind ripened its fruit and many plants of some varieties, as Snyder blackberry, died outright.

In contrast, the grapes show better adaptation to their site as they approach maturity and their roots become established to greater depths in the soil. The first planted 14 rows of the vineyard have reached maturity and yields of fruit are available as criteria of the value of cultural methods applied.

During both 1926 and 1927 Concord was the leader in yield among the varieties. In 1926, when the rainfall from April to September was not sufficient to reach the subsoil, the acre yield for Concord was 5,449 pounds, and in 1927 with adequate rainfall it was 9,434 pounds, a large commercial crop for this section of Kansas. Worden ranked next to Concord in 1926 with an acre yield of 4,998 pounds, but fell below Moore in 1927 when the yield was 5,912 pounds. Moore gave an average crop for the variety in 1926 of 4,604 pounds per acre, and a heavy crop of 6,201 pounds in 1927. Niagara seems too tender in bud and shoot to give sustained high yields in this vineyard, and Lucile has been disappointing. However, the Lucile vines are still young. Brighton, a high-quality red grape, has proved the best among the small selection of hybrid varieties grown.

No marked differences in yields per acre based on system of training appeared in 1926, though the Munson was slightly in the lead. The half row of Agawam, a low-yielding hybrid variety, regularly reduces the average yields on the two-cane Kniffin trellises. In 1927 there was a significant superiority of the fan system followed in order by the four-cane Kniffin, the Munson, and the two-cane Kniffin.

Black rot appeared in the vineyard in 1926, but was quickly brought under control by spraying with Bordeaux mixture. Late infestations of downy mildew in 1927 did considerable damage. It appeared during harvest time on the principal varieties when a fungicidal spray would have badly injured the appearance of the fruit. Since the vines had nearly completed their growth, sprays were not applied. But little injury to the labrusca varieties followed, but some of the hybrids, especially Niagara and Brighton, were nearly defoliated. Brighton put out a new set of leaves in October, which will probably reduce its yield for 1928. This late growth kept bunches of bagged grapes entirely fresh on the Brighton vines until early in November. Those remaining froze, while still plump and sweet, on November 6, 1927.

On April 7 and 8, 1928, the buds of all varieties of grapes were severely injured by a temperature of 18° F. Particulars of this freeze will be given in the next report when the resulting injury can be computed.

Studies on the relation between diameter, length, and yields of

selected canes of the Worden in 1926 and the Worden and Concord varieties in 1927 were made. Conclusions reached were that, for the Worden, there is so little correlation between diameter of canes and the crop borne that careful selection of canes on this basis at pruning time is not necessary. To an extent with Worden, but more so with Concord, length of cane before pruning is correlated with yield of fruit, the long canes giving the larger crops.

Work has been continued on testing grafted plants of weak labrusca grape varieties, but no results have as yet been obtained. [Project 26; Department of Horticulture; state funds.]

Experiments with Vegetables. This project has been inactive during the past biennium, an effort having been made to bring the fertility of the experimental plats up to a satisfactory point. One test on lettuce fertilization was carried through in the greenhouse. One hundred fifty square feet were devoted to the trials. Sodium nitrate, bone meal, sheep manure, and mixtures of these fertilizers were applied. Marked increases in yield were secured where fertilizers were applied, indicating, as in previous years, that fertilizers are of value under greenhouse conditions. [Project 27; Department of Horticulture; state funds.]

Forest Tree Investigations. The season of 1927 confirmed the opinion that Western Yellow pine (*Pinus ponderosa*) may well replace the old Austrian pine (*Pinus austriaca* or *Pinus nigra*) for heavy land that is likely to be water-logged. In several wet seasons, during the past 20 years, the Austrian pine has shown considerable injury in leaf-from-leaf rust and the height and diametric growth have both been affected in years succeeding this infection. So far, no infection has been noted on the Western Yellow pine. Western Yellow pine is also making a height growth for a longer period than the Austrian pine. The observations of the plantings here at Manhattan are confirmed by the growth at the Fort Hays Branch Experiment Station and the R. W. Greene farm near Lincoln, Kan.

The distribution of pecans continues to increase. During the past year, a number of new coöperators have been interested and the old ones have, in most cases, increased their requests for stock.

Data have been collected concerning the growth of this species and a short bulletin concerning the growth and adaptability of the pecan is in preparation. There is justification for recommending the pecan for a wider range of soil and conditions than was previously considered advisable. The preparation of planting hills has given particularly fine results in several cases. [Project 82; Department of Horticulture; state funds.]

DISEASES OF PLANTS

While Kansas is fortunate in having fewer serious crop diseases than many agricultural regions, nevertheless there has been within recent years an increase in the number of diseases and the severity of

damage. The loss sustained amounts annually to many millions of dollars and the prevention of this loss constitutes an important feature of the work of the Agricultural Experiment Station. Some of the important phases of this work are discussed below.

Cereal and Forage Crop Disease Investigations. The work of this project consists of seven distinct phases, each of which are briefly discussed below.

Wheat Smut Investigations. A study has been made during the past biennium of some factors affecting stinking smut (bunt) infection and of the use of copper carbonate in its control. Early plantings in September resulted in little or no smut, while plantings in October and up to the middle of November gave the highest infection. Soil temperatures between 40° and 60° F., together with sufficient soil moisture (20 to 30 per cent), apparently are the most favorable conditions for smut infection.

Brands of copper carbonate having 50 to 55 per cent metallic copper were more efficient for controlling wheat smut than those with 18 to 20 per cent or extended grades when used in equal amounts. In using the 18 to 20 per cent grades three ounces to the bushel of seed were more effective than two ounces, and four ounces were better than three if the seed was heavily infected. Generally speaking, two ounces of the 50 to 55 per cent grades controlled smut about as efficiently as four ounces of the 18 to 20 per cent grades. Formaldehyde as a soaking or sprinkling treatment was more efficient than any of the grades of copper carbonate in controlling smut when the seed was heavily smutted.

Two years' results indicate that heavy soil contamination results in smut infection even though the seed has been treated with copper carbonate. Smutted seed which has been treated with copper carbonate and reinoculated will also produce heavy smut infections. The amount of smut used for the recontamination experiments, however, was larger than would ordinarily occur by soil contamination in Kansas, or in the use of contaminated sacks, bins or drills.

Oat Smut Investigations. There are indications that physiologic strains of oat smut occur in Kansas. Some of these strains are apparently more pathogenic on Kanota oats than on other varieties.

The formaldehyde mist method has been proved to be the most practicable, efficient, and inexpensive treatment for the control of oat smut. It should not be used for hull-less oats because of serious seed injury. None of the fungicidal dust treatments which have been tested are satisfactory for smut control in hulled varieties of oats. New dust treatments, including formaldehyde dust, iodine dust and other compounds, are being tested.

Sorghum Smut Investigations. It has been proved that the finer grades of sulphur dust are nearly as efficient as copper carbonate for the control of sorghum kernel smut. The high-grade and the low-grade brands of copper carbonate are about equally effective for sorghum smut control. Varieties retaining the glumes must be

more thoroughly treated than those which thresh clean because dust treatments often do not reach spores which are inside the glumes.

In a date-of-sowing experiment at Manhattan the heaviest smut infections were obtained in plantings made in May. Early plantings in April and plantings in June contained only a small amount of smut.

It has been definitely proved that there are two physiologic strains of sorghum kernel smut besides the common kernel smut. Each of these two strains is able to attack one or more of such varieties as milo, hegari and feterita, which heretofore have been regarded as immune. Extensive varietal tests have been made in which these strains of smut have been used. These studies are being continued. The most promising selections and hybrids are grown and tested for their resistance or susceptibility to these physiologic forms of sorghum smut. The strain of smut attacking milo and hegari is controlled by copper carbonate. The one attacking feterita has not been available in sufficient quantities for seed treatment experiments.

Corn Smut Investigations. In date-of-planting experiments in which inbred lines of Commercial White corn were grown it was found that the date of planting does not change their reaction to smut. Inbred lines from several standard varieties have been obtained which vary greatly in their susceptibility to smut under field conditions. A number from Commercial White, Pride of Saline and Kansas Sunflower have been obtained which have shown very low smut when exposed to natural infection during the last three years. Inbred lines of corn which are highly resistant to or free from smut under field conditions react in a susceptible manner when hypodermically inoculated. This suggests that any line of corn may be made to take smut when hypodermically inoculated and that it is questionable whether protoplasmic immunity from smut exists.

Smut cultures from various states in the United States are not equally pathogenic. The explanation for this and the changes which are occurring in the cultures are being studied in detail. A detailed study is being made of the growth of corn smut cultures on artificial media.

Dusting sweet corn with copper carbonate and sulphur dusts at frequent intervals throughout the season reduces the amount of smut. It does not completely control smut, however. It is questionable whether such treatments will be profitable for sweet corn. The studies are being continued.

Millet Smut Investigations. Two seasons' results prove that millet smut may be completely controlled by copper carbonate. Sulphur dusts do not, however, control this disease.

Alfalfa Diseases. This phase of the project is coöperative with the Office of Vegetable and Forage Diseases of the Bureau of Plant Industry, United States Department of Agriculture. Rather extensive field observations have been made during the past biennium

with a view to determining what diseases are responsible for the greatest amount of injury to alfalfa plants, and also to ascertain whether or not diseases are important factors in the loss of alfalfa stands. A study of winter injury of alfalfa has been made. Likewise, a new disease of alfalfa due to *Fusarium oxysporum* var.

medicaginis n. var. has been studied. This disease is known definitely to occur only in the state of Mississippi, but since it is caused by a fungus so like that which causes wilt of Irish potatoes in Kansas and elsewhere it is important to know if it can attack this crop.

Field studies have shown that the two most important causes of the rapid thinning out of the older alfalfa stands in Kansas are bacterial wilt caused by *Aplanobacter insidiosum* and winter injury. Several leaf-spot diseases, stem nematodes, anthracnose, and other diseases are present in Kansas and at times cause considerable loss, but are relatively unimportant as compared with wilt and winter injury.

Lesions so commonly found in the upper parts of tap roots of alfalfa plants have been demonstrated to be due to low temperatures. It has been determined that alfalfa plants may be killed at a temperature of from 10° to 20° C. in only a few minutes, or that they may withstand this temperature for an indefinite period depending upon the hardiness of the plants and the conditions under which the exposures are made. Two manuscripts have been prepared for publication embodying the studies on the various phases of winter injury.

Certain phases of the *Fusarium* wilt studies will be carried further, although the major part of this work is completed. The winter injury studies will probably be discontinued soon, due to a lack of facilities for this type of work.

Wheat Foot-rot Disease. This phase of this project is coöperative with the Office of Cereal Crops and Diseases, Bureau of Plant Industry, United States Department of Agriculture. Some of the work during the biennium is as follows:

1. The two organisms chiefly responsible for foot rot, namely, *Ophiobolus graminis* and *Helminthosporium sativum*, have been tested for their ability to withstand cold. The tests were made with the organisms in pure culture and in naturally infested field soil. The experiments have been carried on both at outside temperatures and artificially produced low temperatures in the greenhouse.

2. Fertilizers when mixed with naturally infested soil have a marked effect on the severity of foot rot on wheat. Efforts are being made to determine the effect of different kinds of fertilizers on foot rot.

3. It is of interest to know how far the foot-rot organisms may extend through the wheat plant from the original point of infection. Data concerning this may be of importance in methods of control. Such experiments have been under way for the last two years.

4. There is often confusion as to whether the chinch bug or foot rot is responsible for injury to wheat plants. Work concerning the comparative symptoms is under way in coöperation with the Department of Entomology.

5. Efforts are being made to find varieties of wheat which may be resistant to foot rot. Each year 181 varieties are planted in infested spots in the field.

Observations are made at the end of the growing season for indications of resistance.

6. There has been some evidence that heat and dryness during the summer may partially sterilize the soil with respect to foot-rot organisms. Tests to determine the truth of this theory are being made, both in the greenhouse and field.

7. Investigations also are being conducted to determine whether yellow spots occurring in fields of wheat in the spring are due to foot rot or lack of soil nitrogen.

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

Fruit and Vegetable Disease Investigations. Investigations on certain diseases that affect fruit and vegetable crops were continued during the past biennium. Special attention was given to the Rhizoctonia, scab, blackleg, and spindle tuber diseases of potatoes, Fusarium wilt and blossom-end rot of tomatoes, and cedar apple rust of apples.

Rhizoctonia. The object of the potato Rhizoctonia investigations has been to determine the most efficient and practical method of treating potato seed for the control of this disease. Tests included the use of hot formaldehyde, corrosive sublimate, a number of organic mercury compounds and certain copper-dust compounds. The hot formaldehyde treatment has given the best control. In 1926 the highest yields were obtained from seed treated by this method, but in 1927 seed injury from treating sprouted seed resulted in reduced yields as compared with untreated seed. In 1926 comparative tests were made to test the value of a number of copper-dust compounds (copper carbonate, Corona, copper-carb, and copper stearate) for controlling Rhizoctonia. The copper dusts delayed germination and did not control the disease. In 1927 comparative tests were made with certain organic mercury compounds (Semesan Bel, Semesan 12 Bel, Semesan 37 Bel, and Bayer dip dust). The cost of treatment with these compounds is comparatively high and they did not control the Rhizoctonia disease so efficiently as hot formaldehyde.

Potato Scab. The investigations with potato scab consisted in attempting to find practical methods of procedure by which potato growers can increase the acidity of scab-infested soil to the degree where this disease does not develop. Applications of various amounts of sulphur and combinations of sulphur and green manure crops were made in various duplicated plats on scab-infested soil. None of the treatments produced the required amount of acidity and no appreciable increases in scab-free tubers resulted from any of the treatments either in 1926 or 1927.

Potato Blackleg. The potato blackleg disease has been investigated during 1926 and 1927 with the object of learning how infection of the Kansas crop occurs and how losses from this disease may be reduced.

It had been learned for other sections of the country that the blackleg-producing bacillus is carried to potato plants both through

infected seed and through the agency of the corn-seed maggot. This method of transmission has also been found to apply for Kansas-grown potatoes. Tests made in 1926 of coating the seed pieces with mercuric poisons indicate that such treatment may be of value in killing the maggots and thus reduce the infection that results through this disseminating agent.

Observations in 1927 indicate that late-season infection of blackleg occurs more generally on plants with *Rhizoctonia* lesions than on *Rhizoctonia*-free plants. The corn-seed maggot and the adult of this insect are attracted by decaying vegetable matter, and potato plants with decaying *Rhizoctonia*-infected tissue are more attractive to them than are the healthy plants. This correlation indicates that control of *Rhizoctonia* in seed-potato fields will result in a smaller amount of blackleg-infected seed.

Spindle Tuber. This disease was investigated with the object of determining (1) the effect on yield and (2) whether the spindle tuber disease spreads in Kansas, and if so, how. Plants from infected seed were found to yield from 25 to 60 per cent less than healthy plants. Tests on transmission of the disease to healthy plants indicate that the virus may be transmitted through the cutting knife and through the agency of certain insects.

Fusarium Wilt of Tomatoes. The investigations with the *Fusarium* wilt disease of tomatoes have consisted of testing different varieties and hybrid selection for wilt resistance and for desirability for the Kansas grower. Ten different varieties and 48 selections from hybrids were planted in 1926. The varieties were destroyed by a storm before complete data could be taken.

In 1927, 60 per cent of the Kanora plants were infected when grown in wilt-infected soil in the field. Further selections will be made to increase the degree of resistance of this variety, and in addition other varieties will be tested. The object will be to secure a desirable type for the Kansas grower that is highly resistant to the *Fusarium* wilt disease.

Cedar-apple Rust. Observations were made on the comparative degree of susceptibility to cedar-apple rust of 38 varieties of apples. Great differences in susceptibility were noted, the more resistant widely grown varieties being Northwestern, Yellow Transparent, and the Winesap group. Highly susceptible varieties include Wealthy and Jonathan.

Tests were made to prevent cedar-apple rust infection by dusting the apple trees with a sulphur dust (Kolodust) after each rain, or at the time the spores were being discharged from the galls on the cedars. No adequate control was obtained from the sulphur, although there were somewhat fewer infections on the dusted trees. [Project 130; Department of Botany; state funds.]

Resistance of Winter Wheat to Leaf Rust. This project is cooperative between the Office of Cereal Crops and Diseases, United

States Department of Agriculture, and the Agricultural Experiment Stations of Kansas, Oklahoma, and Texas. Field studies were conducted in uniform leaf-rust nurseries at Manhattan, Harper, Hays, Colby and Columbus, Kan., Stillwater, Okla., and Denton, Tex., during the biennium of 1926-'28. The most intensive studies have been conducted in the greenhouse and rust nursery at this station. Field studies have related to (1) reaction of varieties, selections and hybrids in the uniform nurseries to leaf rust, and the selection of promising strains for more detailed studies; (2) inheritance of resistance and other desirable characters; (3) oversummering, overwintering, and epidemiology of leaf rust in the southwestern part of the hard red winter wheat belt; and (4) prevalence and distribution of physiologic forms of leaf rust in the Southwest.

The greenhouse studies have consisted principally of (1) controlled crossing of desirable varieties of wheat and studies on the inheritance of resistance in combination with other characters in several crosses; (2) culturing of leaf-rust collections from many points in the Southwest and determination of the distribution and prevalence of physiologic forms; (3) testing of many varieties, selections and hybrids of wheat with the most prevalent, physiologic form of leaf rust and the isolation and propagation of resistant strains; (4) effect of age of plant on the reaction of certain varieties and hybrids of wheat to leaf rust; and (5) effect of leaf-rust infection on yield.

Several varieties and hybrids of both winter and spring wheats have proved to be resistant to leaf rust in practically all of the uniform nurseries. Kawvale seems particularly promising, due to the fact that it also is very winter hardy, somewhat resistant, to Hessian fly attack and high yielding.

Many promising resistant hybrid lines have been isolated and grown. The Kanred X Fulcaster cross has been extensively tested in the agronomy nursery and several strains have proved to be high-yielding, but most of them are characterized by weak straw.

Numerous hybrid strains of Kanred X Hard Federation and Kanred X Prelude were found to be highly resistant to leaf rust under severe epidemic conditions in the agronomy nursery. These strains are of particular interest because many of them are very early and stiff-strawed as well as resistant to leaf rust. Many head selections were made in these two crosses and in certain strains of other crosses and varieties exhibiting resistance in the agronomy nursery. These will be studied in detail, both in the field and greenhouse.

The studies on oversummering, overwintering and epidemiology indicate that leaf rust usually lives over summer in Kansas on volunteer wheat. Heavy fall infections occurred in 1925, 1926 and 1927. The leaf rust survived the winter of 1926-'27 in small amounts in Kansas as far north as Manhattan. The rust failed to survive the winters of 1925-'26 and 1927-'28 at the same station under normal

field conditions, however. Leaf rust usually overwinters in abundance in northern Texas and Oklahoma. During the last biennium the rust, has usually begun to spread rapidly in that region early in March and has reached epidemic proportions by the middle of April. The prevailing strong south winds of April and May apparently carry many rust spores northward into Kansas and are responsible for much of the leaf-rust infection in this state.

The reaction of varieties of known differential reaction in the uniform nurseries indicates that physiologic form 9 is the most widely distributed and abundant in the Southwest. Several other physiologic forms have been found each year. Many rust collections have been made for greenhouse studies.

The inheritance of resistance to physiologic form 9 has been studied in the F_1 , F_2 , F_3 generations of 15 crosses in the greenhouse. Freedom from rust, or a very high type of resistance, has proved to be recessive in most cases with a single main factor difference indicated. The presence of modifying factors has been noted, however. No linkage has been found between resistance to leaf rust and any morphologic character in crosses between varieties of common wheat.

Forty-five cultures of rust from various points in the Southwest were studied in the greenhouse in 1926-'27. Twenty of these proved to be composed entirely of physiologic form 9, while others were composed principally of form 9 with small mixtures of others. Forms 5 and 11 and several undetermined forms were also isolated.

About 200 varieties of wheat have been tested in the greenhouse for the presence of strains resistant to form 9. Resistant strains have been isolated from 28 varieties and increased for nursery trials. These strains usually have been similar in morphologic characters to susceptible plants of the same variety. Resistant strains have been found in winter and spring, awned and awnless, and soft- and hard-kerneled types. Most of them have been found in soft red winter varieties.

Several varieties and many hybrid lines of wheat have been found to be susceptible to form 9 in the seedling stage of growth and highly resistant to the same form at heading time. The proof of this phenomenon in the greenhouse throws considerable light on the apparent resistance of several varieties of wheat in the field. [Project 171; Department of Botany; Purnell funds.]

INJURIOUS INSECTS AND OTHER PESTS

Investigations of injurious insects have been continued as in previous years.

Climate and Injurious Insect Investigations. Some important observations were made during the spring of 1927 on the behavior of the codling moth with the aid of the air-conditioning apparatus. It was found that the female would not oviposit unless the ventilating fan was stopped. In other words, the light breeze in the cages

set up by this fan was sufficient to prevent oviposition. When there was no perceptible breeze the moths readily oviposited just after sundown. These observations have been corroborated in the field, when it was found that the moths oviposit after sundown on still evenings. This is considered to be an important point in determining periods of oviposition and, what is more important, the time of spraying for this insect.

A thermocouple was used for investigating the temperatures of insects with respect to their position on the plant and the surrounding air. Some of the more common alfalfa insects were used in this work. Three consecutive readings of the galvanometer were made of certain insects in the shade and in the sun on various parts of alfalfa or other plants. Temperatures of the soil, just below the surface, of plants and of the air at various heights above the surface of the soil were recorded. Lethal temperatures at the surface of the soil were determined for various kinds of insects and for several sizes of the same insects. These data are difficult to interpret and their meaning is not quite clear. The following tentative conclusions appear to be indicated:

- 1. Small insects died more quickly on the surface of the soil on hot days than did larger ones of the same kind.**
- 2. There is a difference among different species as to their ability to withstand the high temperatures of the soil. Insects living in the upper foliage of plants were less resistant to heat than those living lower down or on the ground.**
- 3. If larvæ climbed up a stubble or plant, they could hold out successfully for hours, in the hottest weather, even though they were only a few inches above the surface of the soil. With soil temperatures from 120° 150° F., they succumbed to the heat in from 30 seconds to around 5 minutes if placed on the bare ground. It appears that insects in the field often survive by climbing up the plants.**
- 4. Insects were not visibly affected when placed on the ground in the shade, though they were quickly killed when moved a few inches into the sun. The soil temperature was lower in the shade than in the sun.**
- 5. The temperature of an insect is slightly lower than air temperature. When the insect is killed this difference disappears. It is, therefore, possible to tell when an insect dies by watching only the galvanometer.**

Experiments were conducted to determine the temperature and humidity inside of rearing cages, jars, lamp chimneys over plants, and similar confining appliances used in rearing insects. It was found that there was little difference between the air temperatures, but the humidity within the cages, except in screen cages, was always high, approximating 90 to 100 per cent. This shows that insects reared in cages are required to live in a more humid atmosphere than that to which they would normally be exposed, except possibly for short periods during rain.

The study of insect abundance in comparison with weather data was continued. It is clear from the work so far done that precipitation is a far greater factor in determining insect abundance than is temperature. Precipitation affects the insect directly and it controls plant growth upon which these insects feed. Dry summers are

generally hot and wet summers are cool. The average temperature and precipitation of the state are favorable to insect development. This is very likely due to the adaptation of the insects over a period of years to the climate of the state. Precipitation is important in influencing bacterial and fungous diseases of the insects. It is well known that wet years are unfavorable to chinch bugs, because of the fungous disease.

The topography and geography of the state have a direct bearing on insect abundance. The question is complicated by control campaigns which disturb the normal increase in numbers and thus prevent outbreaks the following years when the weather conditions would indicate a very favorable year.

Some insects appear to develop in cycles. Grasshopper outbreaks in the state are normally three to five years apart. It appears that the enemies of grasshoppers increase to such numbers that the latter are held in check for a few years, but with the arrival of more favorable conditions a more or less extensive outbreak occurs. Hence the question is an exceedingly complicated one. Since weather plays an important role and cannot be predicted with any significant degree of accuracy very far ahead, the accurate prediction of insect outbreaks cannot be anticipated in the near future. [Project 6; Department of Entomology; Hatch funds.]

Hessian Fly and Other Wheat Insects. During the past biennium the work on this project has consisted of a number of phases, each of which is described briefly below:

1. *Distribution of the Hessian Fly.* For several years the Hessian fly has been spreading westward with the increasing wheat acreage in western Kansas. Several surveys have been made each year to determine the distribution, spread, and areas of commercial damage. These surveys show that the western line of distribution has been extended to include Meade, Gray, Finney, and Scott counties.

The area where commercial damage has occurred during the past two years extends from the Kansas and Saline rivers south to the Oklahoma line and from Sumner and Dickinson counties west to Comanche, Ness, and Trego counties. The loss in this area to the 1927 crop was estimated at 20,000,000 bushels.

2 *Life History of the Hessian Fly in the Field.* There were three distinct broods of fly in 1926, while five broods occurred in 1927. The fly emerged earlier and was present later in the season in 1927 than at any other time in the past 20 years. The first spring brood of adults began emerging the middle of March. Maggots developed with such rapidity that lodging of wheat occurred early in May. A large second spring brood emerged about the middle of May. The abundant rainfall during the summer brought out a strong midsummer brood on the volunteer wheat. There was a large main fall brood and due to the open fall weather there was late emergence. Eggs could be found in numbers until November.

3. *Hessian Fly Reservoirs.* Owing to the absence of the fly in many localities it was possible in 1926-'27 to investigate the reservoirs or hold-over places described several years ago. Several of the same reservoirs in Dickinson, Saline, Wabaunsee, and McPherson counties were visited and in every case fly was found.

4. *History of the Hessian Fly in Kansas.* Considerable progress was made during the past two years in compiling a history of the Hessian fly in Kansas. The files of the *Kansas Farmer* from 1870 to date have been consulted, as have the reports of the State Board of Agriculture. The correspondence files of the Department of Entomology have also furnished much information. The data thus secured are valuable in showing the distribution, spread, relative abundance, and seasonal history of the fly in the state. They also show the losses due to this insect. An attempt is now being made to correlate these data with climatic conditions, agronomic practices, and other factors which may influence the activities of the fly.

5. *Time of Planting Wheat.* Very few time-of-planting experiments were conducted in 1926 and in most cases these showed little or no infestation in the fall. In 1927 twenty-three experiments were conducted in nine counties. The data secured show wheat planted on or after the recommended safe-sowing date was free from infestation.

The year 1927 completes 20 years of time-of-seeding wheat experiments to escape Hessian fly injury. The data obtained from a large series of experiments conducted in many localities of the state during this period are now being summarized. Approximately 250 separate time-of-planting experiments have been conducted during this period and each experiment has involved from four to ten separate plats. The summary, while incomplete, indicates that wheat may be planted somewhat earlier than the dates heretofore recommended.

6. *Influence of Cultural Measures on Insect Injury.* Studies at the Agronomy Farm during the past year indicate that considerable chinch-bug damage can be prevented by proper cultural methods. For example, in the seedbed preparation plats for wheat, it was found that the bugs concentrated in the disked-at-seeding and the plats plowed shallow in September, while the early deep-cultivated plats had comparatively few bugs. Observations in general fields where different cultural methods had been practiced also showed that the fields which had been plowed early suffered much less injury than late-plowed fields.

7. *Food Requirements of Stored Grain Insects.* The study of insects attacking stored grain was limited to an investigation of the food requirements. Extensive studies were made with the confused flour beetle, the saw-tooth grain beetle, and the cadelle beetle on a great variety of foods. A summary of the work shows that insects can be used for testing the nutritive value of feed. The most in-

dispensable dietary constituents of the insects studied seem to be vitamins A and B. A well-balanced protein is not necessary and the mineral requirement is low. Grain insects apparently select their food on the basis of nutritive value, size of particle, and physical texture.

8. *Insect Census of Wheat Fields.* Work was started in the spring of 1928 to make a complete study of all insects found in the wheat fields of Kansas. About 90 species have been collected, some of which are proving very interesting as potential pests.

9. *True Army Worm in Wheat.* An outbreak of the true army worm in wheat during the spring of 1927 was studied. Particular attention was paid to losses and to parasitism. [Project 8; Department of Entomology; Hatch funds.]

Corn Earworm and Other Insects Injurious to Corn. The work of this project during the past biennium has consisted of the following lines of investigation.

1. *Corn Earworm Investigations.* Time-of-planting experiments were continued in coöperation with the Department of Agronomy. Plantings were made at 10-day intervals through April and May. Three methods of planting were used; namely, listing, surface planting, and open furrow. Owing to the dry weather in 1926 no data were recorded on per cent of ears injured. Injury by the first brood of earworms was determined, and these data indicate that injury by this brood decreases with delay in planting. Counts made in 1927 show that corn planted about May 1 escaped with the minimum amount of injury.

2. *Chinch Bug Barriers.* The heavy infestation of chinch bugs in the wheat before harvest in 1926 offered an excellent opportunity to continue the study of barriers to protect corn from injury. The work consisted of an extensive study of the efficiency of the creosote post-hole barrier developed in 1924. The conditions at harvest time were very favorable for the migrating bugs and put the barriers to a very severe test. In spite of this condition, however, the barriers proved adequate.

A few preliminary tests were made of some materials which might be used as a substitute for creosote. Studies were also made on the migratory habits of the chinch bug, and on methods for determining the number of bugs migrating from a given field. The data indicate that, chinch bugs migrate from the field in all directions.

3. *Biological Study of the Corn Leaf Aphid.* It was planned to concentrate during the summers of 1926 and 1927 on some of the points relating to corn-leaf aphid that were still obscure. Considerable interest, centers especially on the exact status of this aphid as a corn pest. The studies were curtailed in 1926 by the dry weather and poor condition of the corn plants. A more severe infestation occurred in the summer of 1927. The results of the work to date indicate that in Kansas this insect is primarily a sorghum pest and occurs in numbers on corn during the tasseling period only.

4. *Biological Study of the Southern Corn Rootworm.* Considerable progress was made in the study of this insect during the past biennium. Two full generations were reared in the field insectary and rather complete data obtained on the length of the egg, larva, and pupa stages. The results of three summers' work on the life history have been summarized. Additional data have been collected with reference to the food plants of both the adult and the larva. Attempts to determine the overwintering stage in the vicinity of Manhattan have been unsuccessful. The beetles have been taken on a large number of plants, but very little progress has been made in determining the food of the larvæ. There are indications, however, that the larvæ prefer corn to sorghums.

5. *Influence of Cultural Systems on Insect Injury.* This work is being done at Agronomy Farm in connection with experimental work of the Department of Agronomy. Special attention has been given to the effect of different cultural systems on insect injury. The relation of rotation, fertilizers, and methods-of-planting were studied. Thus far wireworms and cutworms have been the only insects of sufficient importance to warrant investigation. The heaviest infestations of these insects have occurred in fields which were in wheat the previous year and in oats preceding the wheat. Very little damage occurred in fields where small grains had been grown only one year. There has also been very little damage where corn has been grown continuously. In the method-of-planting plats, wireworm damage has been most severe in the surface planting, and least in the listed plats. More attention will be paid to this phase of the work in the future in anticipation of the European corn borer.

6. *Stalk Borers and the Western Corn Rootworm.* A severe outbreak of the common stalk borer (*Papaipema*), which occurred in the season of 1927, offered an opportunity to make some studies of this pest. Some rearing was done in the field insectary. In the field studies were made of the per cent of stalks lodged, the effect on the root system, and the effect on yield. Approximately 40 per cent of the stalks had fallen before harvest. The root systems were badly damaged and the yield decreased materially. A large number of ears from injured and noninjured stalks were studied carefully to determine the effect of root injury on grain production.

7. *Insect Census of Corn Fields.* During the past biennium collections were made of the insects of the cornfield. A total of 132 species were collected during July and August, and considerable information was obtained as to their relative abundance. [Project 9; Department of Entomology; Hatch funds.]

Fruit and Vegetable Insects. Early in the summer of 1926 a green flea-beetle (*Haltica foliacea*) caused much damage to nursery apple stock and young orchards. It may be controlled by using 5 to 6 pounds of lead arsenate to 50 gallons of water, or a 4-4-50 Bordeaux mixture, which acts as a repellent.

The diamond-back moth has become a pest of cabbage in the

vicinity of Manhattan. It cuts the heads badly, making them unsalable. This insect may be controlled by using 2 pounds of lead arsenate to 50 gallons of water, with 2 pounds of resin soap added for a "sticker."

A heavy loss of transplanted cabbage plants in the spring of 1927 was caused by the seed-corn maggot. This insect is directly associated with organic refuse and fertilizer. Where cabbage is to be transplanted there seems to be less damage when manure is applied and worked into the soil the fall before.

Bands treated in various ways were used on apple trees as a supplementary control measure for the codling moth. A band which would work automatically and at the same time would not injure the tree was sought for. Several materials were tried and, among others, beta-naphthol and a medium lubricating oil, Volck, and crude oil gave the most promise. The betanaphthol and oil showed the best results for the one year. [Project 13; Department of Entomology; Hatch funds.]

Control of Insects Attacking the Sorghums.The work on the control of sorghum insects during the past biennium has had to do with (1) studies of the importance of Sudan grass in relation to chinch bugs, (2) life-history studies of the southern corn rootworm, (3) the relative effect of various types of injury caused by *Aphis maidis* Fitch upon the germination of sorghum seed and the rate of development of the plants, and (4) a survey of the insects of the sorghum field and a study of insects infesting sorghum seeds in storage.

The studies to determine the effectiveness of Sudan grass bunches as overwintering quarters for chinch bugs were continued, and the counts for all of the years summarized and submitted for publication. An examination of 604 bunches of Sudan grass, taken from various types of fields and covering a period of four years, showed a maximum of 540 bugs in a single clump, with an average of 21.1 live bugs per bunch. The counts also showed that Sudan grass, although not as suitable as the native bunch grass, serves as efficient hibernating quarters for the chinch bug.

In summarizing three years' work relating to the life history of the southern corn root-worm it was found that the average length for the egg stage was 7.9 days, for the larval stage, 30.7 days, and for the pupal stage, 12.1 days. It is interesting to note that in 1926 the larvæ hatched from eggs laid in May and June required, on the average, 11 days more to complete their growth than did those hatched from eggs laid in July and August. The attempts to carry the adults over the winter in hibernating cages were unsuccessful. Efforts to determine the overwintering stage of this insect in the vicinity of Manhattan also have been unsuccessful. Studies were continued on the food habits and other activities of this insect.

A study of *Aphis maidis* injury of sorghum seed showed that the germinating power of the seed and the rate of growth of the plants were reduced in proportion to the amount of injury.

During the past biennium one species of the snowy tree cricket and at least one species of the meadow grasshopper were found to cause injury to Sudan grass panicles and to the heads of other sorghums. This injury was produced by the female making egg-laying punctures in the peduncles of the heads, causing them to break over. As many as 30 punctures were observed in one peduncle of Sudan grass.

The studies of insects infesting sorghum seed were confined chiefly to the family *Dermestidae*. Over one hundred larvæ were collected in the fall of 1926, for the purpose of determining the species commonly infesting sorghum seed in storage. A collection of heads of several sorghum varieties was made to determine whether or not they were infested in the field with the *Angoumois* grain moth. There has been no emergence of adults from these heads. Observations were also made on injury by the rice weevil and the lesser grain borer. [Project 92; Department of Entomology; Hatch funds.]

Insects Attacking the Roots of Staple Crops. During the past biennium studies of the white grub were devoted principally to closing up the various lines of investigation, analyzing the data, and planning new lines of attack. Ecological data relating to 200,000 individuals have been summarized and published.

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

Studies were begun also on the *Scarabæidæ* of the Medora sand hills, Medora, Kan. Several visits to that area resulted in the collection of 20 species, as well as the addition of considerable information regarding the habits of the various species. New data were collected on species not previously studied; namely, the sand-hill goldsmith beetle and the green June beetle. New data were also obtained on species that have been studied in the past.

An extensive study of the wireworm of Kansas has been continued, approximately 6,500 specimens having been collected for rearing to determine the length of the life cycle as well as the species that occur in Kansas. A systematic plan for collecting larvae and adults is under way so that the occurrence and abundance of species can be ascertained. Considerable progress has been made toward the preparation of a list of *Elateridæ* known to occur in Kansas.

Studies dealing with the use of attractant and baits to attract click beetles indicate that the beetles are attracted to syrups, honey, exuding sap, honeydew, watermelon pulp, and other sweet substances. Laboratory tests with a bait consisting of bran, honey, and sodium arsenite show that the beetles are attracted to it and are readily killed by it. The tests offer the suggestion that poisoned

baits might be used to attract and kill the beetles if the proper ingredients can be found.

Studies have been made to determine the hibernating habits of white grubs and wireworms. A total of 76 holes has been dug during this investigation, representing an area of 673 square feet and 1,019 grubs have been collected, making an average of 1.5 grubs per square foot. It appears that the larvæ are stratified as to species. Seventy-five per cent of the white grubs were taken in the first foot. One species was taken at the depth of 40 inches. One hundred wireworms were taken, but they were seldom found deeper than 6 inches.

The burrowing habits of soil-inhabiting insects were studied. An attempt was made to ascertain the effect of burrowing upon the soil, the amount of organic matter incorporated into the soil, the interchange of soil and subsoil through the process of burrowing, and the factors which influence the distribution of insects. Data on 900 burrows are available and are being summarized.

Somewhat extensive investigations have been undertaken relating to the control of underground insect pests. An attempt has been made to determine the effect of soil insecticides upon (1) insect forms in the soil, (2) different types of vegetation, and (3) the physical condition of the soil.

The work consists of both greenhouse and field tests. In the greenhouse tests were conducted in flower pots to determine the effect of insecticides upon the soil and the germination of seeds.

A series of 52 permanent field plats have been laid out for the field tests. Twenty-seven of these have been treated with recommended strengths of the insecticides. Many of the materials proved injurious to the soil, particularly the sodium compounds. The arsenic compounds, especially the calcium arsenate, proved very deleterious to the plants, tending to retard root development. [Project 100; Department of Entomology; State funds.]

Insects Injurious to Alfalfa and Allied Plants. The work during the past biennium was directed in general to supplying information on points which have been incompletely studied and to the confirmation of other matters which could be studied because of available material. Special attention was given to the study of the geometers in alfalfa; to the control of the large immaculate blister beetle (*Macrobasis immaculata* Say.) ; to a seasonal series of rearings on the pea aphid (*Illinoia pisi* Kalt) in cages and to certain control experiments; to a study of *Euplectrus platyhypena* How., a parasite of Noctuid larvæ, especially of the variegated cutworm; to observations on the damage done to alfalfa by the corn earworm; and to making additions to the alfalfa insect collection. A short paper emphasizing control primarily of the important injurious insects was prepared for Bulletin 242 of the Kansas Station.

The work during the summer of 1927 was unfavorable for work on alfalfa insects, because of heavy precipitation during July and

August. Special attention was given to a series of rearings of a Tortricid in alfalfa (*Tortrix pallorana* Rob.). It was found that this insect molted five times during its life and that the life cycle required 31 to 47 days. It occurs from July to September, but is most abundant normally during June and July. The eggs are deposited in flat, scalelike masses on the leaves, and the larvæ web together loosely a few leaves, forming a shelter within which they feed.

It was found that the common apple-leaf hopper (*Empoasca fabæ* Herr.) is capable of exerting severe injury to alfalfa. This insect was exceedingly plentiful during early August in the alfalfa fields.

Euplectrus platyhypenæ How., a small chalcid parasite of the variegated cutworm, had never been reported for Kansas before the summer of 1926. An outbreak of the variegated cutworm appeared certain during June, 1925, but natural enemies, particularly grackles and this small parasite, held it in check. *Euplectrus*, deposits its eggs on the backs of caterpillars, especially in the thoracic region of the variegated cutworm and some other Noctuids. The larvæ feed externally on the host by lapping up the blood which exudes from punctures made with the needlelike mandibles. When mature they spin silken cocoons, generally under the dead larvae, and the adults emerge in about five days. The total life cycle requires only about two weeks. This parasite was found plentiful at Hays, Kan., in July, but in August it had entirely disappeared at both Hays and Manhattan, and it has not been seen since. This state is perhaps the northern limit of its range.

A special study was made of the tarnished plant bug. This insect is abundant in alfalfa. In the fall, when the frost has killed most of the vegetation, alfalfa fields still remain green. These insects congregate in the alfalfa fields and overwinter there. Only adults overwinter in cages, but both sexes hibernate successfully. Cage-overwintering studies with 200 adults on clumps of alfalfa covered with grass or dry hay yielded from 3 to 31 adults in the spring. A number of variable factors are involved, but their relative scarcity in alfalfa in the spring is further proof that the normal winter fatality is high.

The damage done by the tarnished plant bug is not apparent in the field generally, but when concentrated on potted plants, even under favorable conditions, the plants quickly showed injury. Ten bugs on healthy clumps killed the plants in 7 to 10 days.

Dusting alfalfa with sulphur, sodium fluosilicate, and calcium cyanide at the rate of 20 pounds to the acre gave poor control. This work was done in October, and temperature conditions may have been an important factor. Cutting alfalfa just after the majority of the eggs are in the stems should reduce the size of the next generation. But it is difficult to determine the time of cutting as the broods overlap. One case of apparent control in this manner makes this worthy of further observation.

An attempt was made to transmit the organism of bacterial root rot (*Aplanobacter insidiosum* L. McCo.) from diseased alfalfa to healthy clumps, but without apparent success. Theoretically the tarnished plant bug would be a perfect disseminator of this disease, but special difficulties were encountered in clearly demonstrating the transmission of the disease experimentally.

During September and October, 1927, there was a small outbreak of the fall army worm, *Laphygma frugiperda* S. and A. This was confined to the bent grasses largely, and lawns suffered most. Only a few outbreaks were reported in alfalfa.

During the spring of 1928 the pea aphid again appeared in numbers in the eastern part of the state. Damage to alfalfa was reported from many localities. Relatively few aphids went into hibernation in the fall, but the winter was drier and warmer than usual. March also was drier and warmer than the average, but cool weather in April greatly delayed the spring growth of alfalfa. Severe freezes occurred from April 12 to near the end of the month, which damaged the foliage somewhat. The progress of the aphids in the field and their damage was normal in every respect, though the damage was greater than was anticipated. Ladybird beetles scattered widely during the warm days of March and began reproducing perhaps a little earlier than usual. They served as important checks in lightly infested areas, but were ineffective in concentrated areas.

Harrowing and severe brush-dragging were attempted as control measures on a small local outbreak. Harrowing gave no perceptible results by way of control. The severe brush-dragging in opposite directions resulted in a heavy fatality among the small aphids, but the larger nymphs and adults escaped. The young alfalfa in particular was injured by this treatment. It was concluded that brush-dragging was not worth while as a control measure. This leaves the use of calcium cyanide in spots in the early spring and the aphidozer, when the aphids have spread over the whole field, as the only effective controls worthy of the time and effort.

In addition to these major interests, some 15 additional species were added to the alfalfa insect collection. Some parasites of several forms hitherto not encountered in this work were reared. The hosts included the serpentine leaf miner (*Agromyza pusilla* Mg.), the fall army worm (*Laphygma frugiperda* S. and A.), and the yellow striped army worm (*Prodenia ornithogalli* Guen). One small larva of the alfalfa caterpillar overwintered successfully, substantiating earlier results as the normal overwintering stage of this species. In another case a pupa of this species attached to the cage overwintered, and on April 3, 1928, many specimens of *Pteromalus eurymi* (Gahan), a chalcid parasite, emerged. The green clover worm (*Platylipena scabra* Fabr.) and the forage looper (*Cænurgis erechtea* Cram) overwintered successfully as pupæ. [Project 115; Department of Entomology; state funds.]

Shade Tree Insects. A number of trees were banded during the biennium and observations made as in previous years. These observations indicate that the majority of the fall cankerworms do not emerge until the latter part of January and the first part of February. The spring cankerworms emerge the latter part of February and in March. In the fall of 1927 the first female was taken on November 24, and the first male on November 15. On January 10, 1928, two females and four males were taken from the bands. The last female was taken on April 9, 1928. The maximum emergence, 43 females, on any one tree was on March 22, 1928. The greatest number of females observed on one tree during the fall of 1927 and the spring of 1928 was 294.

In late May and June, 1927, the larvæ of the Sumac flea-beetle were found defoliating smoke bush (*Rhus cotinus*) in several of the plantings on the campus. These larvæ were reared and determined as *Blepharida rhois* Forst. The biology of this insect, is being worked out. Hibernation is within a few inches of the host plant and only one or two inches below the surface of the ground. [Project 116; Department of Entomology; state funds.]

Codling Moth Investigations. This project, in coöperation with the Bureau of Entomology, United States Department of Agriculture, was started in 1926. The work consists of (1) testing old and new insecticides for the control of the codling moth, (2) testing different strengths of lead arsenate, (3) the use of supplementary control measures, (4) the timing of sprays with egg-laying experiments, and (5) ecological experiments.

The spray materials used were Paris green, London purple, calcium arsenate, magnesium arsenate, barium arsenate, aluminum arsenate, iron arsenate, zinc arsenate and zinc arsenate, Volck, and lead arsenate and Volck. Lead arsenate alone was the best of the insecticides in both years of the biennium.

All of the arsenical substitutes, with the exception of aluminum arsenate, failed. Even the Volck oil failed when it was used alone, but used with either lead arsenate or calcium arsenate it gave fairly good results. In all tests with these substitutes some burning resulted. Some of the substitutes completely defoliated the trees. With the exception of zinc compounds, the burning was not serious on the apples, but was very severe on the leaves, especially with the zinc and calcium arsenates.

In a heavy infestation the 1-50 solution of the lead arsenate for the first two cover sprays did not control the worms. A 2-50 solution reduced the injury only slightly. A 3-50 solution gave reasonable control.

Banding work was undertaken, using a number of chemicals for treatment. Bands of cheese cloth and burlap were used both alone and with the cloth beneath the burlap. The burlap bands gave the best results. The materials used were very heavy oil (Standard Diamond steam cylinder oil), beta-naphthol, and tar oil. They were

used on all of the various types of bands and compared with a burlap untreated check. The oil, beta-naphthol, gave best results with the heavy oil alone second. This was very effective for about a month, but lost its efficiency late in the season. The beta-naphthol oil bands gave about 85 per cent kill, which approaches that of hand-run bands. This year no injury to the trees was noticed, but it is not known what may happen if the banding is continued for several years.

Weather conditions were noted throughout the season and correlated with moth emergence and egg-laying. Egg-laying was heavy when the temperature in the early evening was above 65° F. and the air quiet. No eggs were laid where the temperature was below 65° F. [Project 163; Department of Entomology; Purnell funds.]

The Resistance of Crop Plants to Insect Injury. Except for a few observations on other forms made as opportunity presented itself, most of the time has been devoted to a study of two insects, the chinch bug and Hessian fly. Most of the studies with the chinch bug were made during the summer. During the winter greenhouse and field studies were made of the Hessian fly and laboratory studies of preserved material of both forms.

Chinch Bug Experiments. In the spring observations were made on the migration of the overwintering adults to the different varieties of the small grains in the agronomy nursery. Of the small grains barley showed the largest number of bugs and the greatest injury. Among the commoner varieties of barley Club Mariout showed least injury while Smyrna was among those varieties most injured. Relatively little injury was shown by the varieties of oats, and most of the wheat varieties showed little injury.

On the Agronomy Farm a plat of corn and sorghum varieties was planted so that the chinch bugs would migrate in from one end of the rows. Studies were made of the relative abundance of bugs and amount of injury to different varieties. There were striking differences among the 58 varieties of sorghum. The most resistant were Blackhull kafir, Kansas Orange, and a Kansas Orange x milo hybrid, all of which had less than 4 per cent dead plants due to this insect. Of several varieties of milos that were tested the dead plants ranged from 49 to 69 per cent. The kafirs were all near the top of the list of the varieties, with Dawn kafir the most susceptible.

The area planted to corn consisted of four plats, each containing 18 varieties. The fourth plat was arranged with staggered rows so that, although the chinch bugs came in from two sides, each variety was equally exposed to attack. Due to the relative scarcity of bugs only this latter plat received enough of an infestation to show differences; one or two plants were killed in each of five varieties. Many of the other plants were broken over as a result of chinch-bug attack. Of the varieties tested Midland, Hildreth, Pride of Saline, and Champion White Pearl showed up best, while Wallace

Hybrid, Golden Beauty, Yellow Pearl pop corn, and Minnesota No. 13 were the poorest.

In order to study the behavior of individual plants under various infestations single plants of sorghums were surrounded by a ring of creosote barrier, and migrating chinch bugs placed on the plant. The results suggest that resistance may in part be due to a repellent in Kansas Orange sorgo or an attrahent in the milos, or both.

An examination was made of the method of feeding of the chinch bug. A number of the insects were killed with their stylets in the plant tissue, preserved, sectioned, and the punctures studied. Some of the results of this study were as follows:

1. Evidence was secured to show that probably the dissolving action of the salivary fluid plays an important part in enabling the chinch bug to puncture the plant cells. It is aided by pressure on the stylets.
2. The sheath formed about the stylets consists of two layers of separate staining reactions. The inner is stained black with iron hæmotoxylin, the outer brown or yellow and is especially prominent in the epidermal cells and the xylem.
3. The objective of the stylets is usually the phloëm tissue of the vascular bundles where a number of branches are sent to the various tubes.
4. Besides the phloëm, the xylem, epidermis, mesophyl, sclerenchyma, protoxylem, and bundle parenchyma tissues are pierced.
5. The stylets enter the vascular bundles between the two masses of lignified tissue usually found between the epidermis and the bundle, but sometimes they go through the heaviest part of the sclerenchyma, always passing intracellularly. More than one bundle may be tapped without withdrawing the stylets. The smaller vascular bundles, unprotected by the lignified tissue, are, considering their greater number, no more often attached than the larger bundles.
6. There is relatively very little injury to the cells pierced by the stylets. The injury to the plants comes mainly from the withdrawal of the fluid from the phloëm and xylem tubes and the stoppage of these conducting tissues by sheath material resulting in the starvation of the roots for food and the leaves for moisture.
7. The source of the food supply of the chinch bug is almost entirely the phloëm tissue.
8. The feeding punctures of the nymphs and adults show only small differences correlated with the doubling of the size of the stylets during growth.
9. Preliminary evidence was secured to show that the presence of tannins or related products may be of importance in the problem of resistant and susceptible varieties.

Hessian Fly Experiments. Two studies of the resistance of wheat to Hessian fly were made in the greenhouse during the winter of 1926-'27, and two in the winter of 1927-'28. Each test consisted of about 30 strains of 10 plants in the first two tests and 50 plants each in the last two. In the fall of 1927 a duplicate series of 200 varieties and hybrids were planted in a special fly nursery and infested with fly from a field near Chapman, Kan. Fly counts were made of 20 plants of each variety and later another 20 plants were counted of certain varieties where it seemed desirable.

Certain general conclusions may be drawn from these experiments. The best criterion to compare infestations seems to be the per cent of tillers infested. The experiments seem to supply some evidence

for three kinds or expressions of resistance. In the first place there seems to be a slowing up of the development of the fly, as shown by the presence on certain selections of larvæ or young larvæ, instead of flax seeds or old larvæ as found on other more susceptible varieties. In the second place there seems to be a kind of tolerance so that as many as three flies may develop on one tiller without killing it. In the third place there is a decided difference in the number of flies which develop on the various selections. The results confirm earlier observation in showing marked differences in resistance which seem to be definitely inherited.

To secure data on the fundamentals of the method of feeding, age at commencement of feeding, effect on plant tissue, and a comparison of resistant and susceptible plants in regard to these factors, some 300 samples of infested plants have been preserved for sectioning and study. These samples consist of the larvæ from one to thirteen days old preserved *in situ* in the crown of Kanred wheat, which is susceptible, in Illini Chief wheat which is resistant, and in Kanota oats, on which the larvæ are not known to develop. In these latter two cereal varieties the larvæ remain in position for about 10 days, but do not increase in size. Some of this material has been sectioned and examined, but detailed studies are yet to be made. In this connection, microscopic preparations have been made of the head, mouth parts, and alimentary tracts of larvæ. [Project 164; Departments of Entomology and Agronomy; Purnell and state funds.]

Investigations in the Control of Injurious Rodents. The work on this project during the past biennium has consisted of (1) hibernation studies on the thirteen-lined ground squirrel (*Citellus tridecemlineatus*), (2) experiments on poisoning moles, (3) removal and transplantation of ovaries in guinea pigs, (4) effect of removal of ovaries in pregnant ground squirrels, (5) life-history studies on young ground squirrels, (6) hibernation studies on prairie dog, pocket mouse, gray ground squirrel, and lizards, and (7) effect of bovine anterior pituitary extract upon the growth of rats, mice, and ground squirrels.

More complete data were procured on the very low-respiration rate, heart-beat rate and temperature in hibernation. The changes in respiration, heart beat and temperature in making from and in entering into hibernation have been further studied.

A weak solution of thyroxin and pituitrin and of anterior pituitary extract showed no effect on hibernation when injected. A stronger extract of the anterior pituitary seemed to produce an inhibitory effect. Heavy animals, precooled animals, and, in the spring, castrated males appear to hibernate more readily than normal controls.

Pocket mice, grey ground squirrels, and prairie dogs have been found to hibernate, but not to the extent to which the thirteen-lined ground squirrels do. Pocket gophers failed to hibernate.

Over 30 moles were used in poison experiments in the summer of 1926 and about 20 in the summer of 1927. Treating corn with strychnine seemed to have some effect in protecting it against moles. Carbolineum was less effective than strychnine.

A strong anterior pituitary extract (bovine) was found to produce increased size in rats. Similar work with mice and ground squirrels was inconclusive. [Project 84; Department of Zoölogy; state funds.]

INVESTIGATIONS IN THE LIVE STOCK INDUSTRIES

The live-stock industry of Kansas ranks high among the agricultural industries of the state. In 1926 the total value of live stock as reported by the Kansas State Board of Agriculture amounted to more than 176 million dollars. Kansas ranked ninth among the states of the Union in the number of swine, twelfth in the number of dairy cattle, and fourth in the number of other cattle. A brief report of the work which the Agricultural Experiment Station has done during the past two years on problems relating to the live-stock industries of the state is contained in the following pages.

Nutritive Requirements of Swine. During the past biennium a study of the effect of vitamin deficiencies in swine rations has been continued. That phase of the project which had to do with the requirements of vitamin A and vitamin C have been completed and the results have been reported in Technical Bulletin 23. Some of the results were as follows:

1. The lack of vitamin A in the diet of pigs resulted in a degeneration of the nervous system, characterized in the advanced stages by striking nervous disorders such as impaired vision, extreme incoördination, and spasms.
2. Histological examination showed definite degeneration of some nerve bundles. This was observed in portions of the spinal cord, optic, sciatic, and femoral nerves.
3. Eye lesions were of minor importance in extreme avitaminosis A.
4. Gilts with avitaminosis A showed irregularity in the œstrus cycle. The cycle occurred more frequently and was of longer duration.
5. Gilts bred prior to the onset of the nervous disorders either aborted or farrowed dead pigs.

Throughout the above experiment the mortality of the young pigs was very high. An attempt was made to determine whether the death rate could be lowered by including in the feed of the pregnant sows wheat-germ meal, a food rich in vitamins B and E. The results are presented in Table XVIII.

TABLE XVIII.—THE EFFECT UPON THE MORTALITY OF PIGS OF INCREASING THE VITAMIN B AND E CONTENT OF THE RATION OF PREGNANT SOWS.

Sow No.	Number farrowed.				Number dying.				Number raised.	Milking qualities.
	Total.	Alive.	Strong.	Weak.	Before 10 days.	10 to 20 days.	After 20 days.	Total.		
Lot I. Ration Low in Vitamins B and E										
30.....	8	8	8	0	1	1	1	3	5	Good
8.....	8	7	7	0	4	0	0	4	4	Poor
26...	9	9	9	0	5	0	0	5	4	Good
11...	14	13	11	2	13	0	0	13	1	Poor
1.....	12	11	9	2	9	0	1	10	2	Poor
Totals .	51	48	44	4	32	1	2	35	16	.....
Lot II. Ration High in Vitamins B and E										
3.....	9	9	9	0	1	0	1	2	7	Good
28.....	4	4	4	0	0	0	0	0	4	Good
55...	11	11	10	(a)1	3	0	0	3	8	Very good
42...	9	9	8	(a)1	2	5	0	7	2	Very good
29.....	13	13	13	0	3	5	0	8	5	Good
Totals .	46	46	44	2	9	10	1	20	26	.....

(a) Medium.

At this writing the oldest pigs in this experiment are seven weeks and the youngest fifteen days old. While definite conclusion cannot be drawn at this date, the preliminary results indicate much better results with the high vitamin B and E ration. The project will be continued and this phase of the work repeated. [Project 38; Departments of Animal Husbandry, Chemistry, and Veterinary Medicine; Adams and state funds.]

Investigations in the Use of Silage for Fattening Beef Cattle.

During the past biennium a third study was completed in which a comparison was made of the relative value of alfalfa and prairie hay with and without the addition of calcium carbonate fed with and without silage as rations for fattening cattle. Each ration contained cottonseed meal and corn in addition to the feeds under study. In 1926 straight calcium carbonate was fed. In 1927 and 1928 finely ground limestone testing approximately 99 per cent calcium carbonate was used. The principal results secured may be summarized as follows:

1. The addition of calcium carbonate in the form of ground limestone to a corn, cottonseed meal, and alfalfa ration did not increase daily gains, selling price per pound, or profit per head.

2. The addition of calcium carbonate in the form of ground limestone to a corn, cottonseed meal, alfalfa, and silage ration, and to a corn, cottonseed meal, and prairie hay ration increased somewhat the daily gains, the selling price per pound and the profit per head.

3. The addition of calcium carbonate in the form of ground limestone to a corn, cottonseed meal prairie hay, and silage ration increased decidedly the daily gains, the selling price per pound, and the profit per head.

4. The marked value of adding calcium carbonate to a ration consisting of corn, cottonseed meal, prairie hay, and silage is shown in Table XIX.

TABLE XIX.-THE EFFECT OF ADDING CALCIUM CARBONATE TO THE RATION FOR BEEF CATTLE. Average of three trials.

RATION.	Corn and cottonseed meal. (Fed in each lot.)		
	Alfalfa hay and silage.	Prairie hay and silage.	Prairie hay, silage and calcium carbonate.
Lot No.	1	2	3
Average daily gain per head.....	2.37 lbs.	2.12 lbs.	2.40 lbs.
Average selling price per cwt.....	\$10.83	\$10.33	\$10.75
Average profit per head.....	12.90	6.00	13.59

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

Methods of Utilizing Native Pasture in Beef Cattle Feeding.

The work conducted on this project during the biennium consisted of two phases. Phase I involved a first year's comparison of wintering without grain and with a limited amount of grain, calves that are to be grazed without grain from approximately May 1 to August 1 and then full fed in a dry lot for 100 days. Phase II involved a first-year study of the returns that may be expected from buying yearlings in the fall, wintering them on roughage supplemented with a small amount of cottonseed meal, and grazing the next season on bluestem pasture.

The more important results secured with the first phase of the project may be summarized as follows:

1. The calves wintered on silage, alfalfa hay, cottonseed meal, without grain gained 209.4 pounds in 135 days compared to 281.87 pounds for calves wintered on the same ration plus an average of 4.66 pounds of corn per head per day.

2. At the end of the wintering period the calves that had received a limited grain ration showed a margin of \$1.16 per head compared to \$3.92 per head for those that had received no grain.

3. The calves that had received no grain the previous winter, when put on grass from May 1 to August 1, gained 113.5 pounds compared to 76.3 pounds for those that had received a limited grain ration. The results agree with earlier work of this nature and indicate that the gain cattle make on grass is determined, in the main, by the amount of fat they carry when they go to grass.

4. The calves (now yearlings) that had received no grain the previous winter ate 0.89 of a pound of corn per head per day more during the dry-lot feeding—August 1 to November 7—and gained 28.5 pounds per head more than those that had received a limited grain ration the previous winter.

5. Each lot of cattle was appraised at the same figure at the end of the test—\$16 per hundred weight, Kansas City—indicating practically no difference in the finish of the two lots. This, together with the fact that it would have required 44 cents per hundred weight more to break even on the cattle that had been fed a limited grain ration during the winter, would seem to indicate that when good silage, alfalfa hay, and a limited amount of cottonseed meal are available, it is not advisable to feed grain to calves during the winter if they are to be put on grass and then full fed 100 days in a dry lot.

The principal results of the second phase may be summarized as follows:

1. Calves wintered on ground cane fodder *ad. lib.* and 1 pound of cottonseed meal per day gained 1.31 pounds per head per day as compared with 1.30 pounds per head per day for those wintered on cane silage *ad. lib.* and 1 pound of cottonseed meal.

2. With silage at 85 per ton, ground cane fodder at \$8 per ton, and cottonseed meal at \$35 per ton, it required a selling price of \$8.72 per hundred weight to break even on the calves wintered on ground cane fodder, and \$8.98 per hundred weight on the calves wintered on cane silage. Both lots were appraised at the same price, \$9.25 per hundred weight at the feed lot.

3. The calves wintered on silage gained 1.25 pounds per head per day during the 160 days they grazed on bluestem grass. Those wintered on ground cane fodder gained 1.20 pounds per head per day.

4. The calves (now yearlings) that had been wintered on ground cane fodder returned \$16.95 per head for the grass they consumed as compared with \$16.43 for those wintered on cane silage. It should be emphasized that these returns are based upon an initial cost of \$10 per hundred weight at the feed lot and a selling price of \$8.75 per hundred weight at home at the end of the grazing season. The going price for grazing yearlings was \$7 per head.

5. This test indicates the possibility of profitably substituting yearling steers for aged steers for the purpose of utilizing Kansas bluestem grass, particularly in those cases where the grass owner also raises feed crops and can winter calves purchased in the fall.

[Project 151; Department of Animal Husbandry; state funds.]

Swine Feeding Investigations. The work on this project has consisted of a study of the value of cottonseed meal as a protein supplement for corn in a swine-feeding ration. As in previous years, two phases of the work were conducted: (1) Summer feeding on pasture, and (2) winter feeding in a dry lot. The results secured during the summer period may be summarized as follows:

1. The swine fed cottonseed meal as a protein supplement to corn and alfalfa pasture made a better showing than in previous years, but the gain and finish was less satisfactory than where tankage was used as a protein supplement. This agrees with previous results.

2. The addition of ground limestone or bone meal did not increase materially the value of cottonseed meal as a protein supplement.

3. The addition of a combination of ground limestone and bone meal, half and half, increased the gains materially and reduced the cost.

4. A comparison of summer and winter feeding indicates that cottonseed meal is more valuable as a protein supplement with corn when fed with alfalfa pasture than when fed with alfalfa hay.

A similar test conducted during the winter of 1926-'27 gave the following results:

1. Cottonseed meal alone proved to be decidedly inferior to tankage.
2. Cottonseed meal plus bone meal was decidedly superior to cottonseed meal alone and almost as satisfactory as tankage.
3. The addition of ground limestone did not materially improve the value of cottonseed meal.

[Project 110; Department of Animal Husbandry; state funds.]

Lamb Feeding Investigations. During the past winter a study was made of the influence of ground limestone to a supposedly adequate ration consisting of grain, cane silage, and alfalfa hay upon the growth and wool production of native lambs. The results of this test. are given in detail in Table XX. The feeding period was 150 days.

TABLE XX.—THE VALUE OF ADDING GROUND LIMESTONE TO A SUPPOSEDLY ADEQUATE RATION FOR NATIVE LAMBS.

Lot No.	1	2
Average initial weight per lamb	96.53 lbs.	95.05 lbs.
Average final weight per lamb	119.82 lbs.	116.23 lbs.
Total gain per lamb	23.29 lbs.	21.18 lbs.
Average daily gain per lamb .....	.16 lb.	.14 lb.
Average weight of fleeco.	7.72 lbs.	7.30 lbs.
Average daily ration per lamb:		
Grain—Corn, 1 part;		
Oats, 4 parts;		
Bran, 2 parts;		
Linseed oil meal, 1 part.	1.28 lbs.	1.29 lbs.
Cane silage	1.92 lbs.	1.92 lbs.
Alfalfa hay .....	.73 lb.	.73 lb.
Ground limestone .....		.25 oz.
Blue grass pasture	158.5 hrs.	158.5 hrs.

It will be noted that the addition of limestone did not increase the gains. In a previous test the addition of ground limestone to a similar ration, except that it did not contain alfalfa hay, increased the gains. These results would seem to indicate that the addition of alfalfa hay to the extent of three-fourths of a pound per head per day furnishes sufficient calcium for normal growth and development of lambs when fed with silage and a grain mixture consisting of oats, corn, bran, and linseed-oil meal. The addition of ground limestone did not increase wool yield in this test. The effect, if any, on the breaking strength of the wool fiber is being studied by the Department of Physics, a report of which is not yet available. [Project 111; Department of Animal Husbandry; state funds.]

A Study of Pasture Values and Pasture Methods for Horses, Cattle, Sheep, and Swine. A study of several tame pastures has been continued during the past year. Certain results were observed as follows :

1. Considerable warmth is necessary to cause second-year sweet clover to make an early growth. The cool weather of the spring of 1928 made second-year sweet clover approximately two weeks later than the average for the previous five-year period.
2. Brome grass continues to be a satisfactory tame pasture crop on the upland as well as the bottom land of the Animal Husbandry Farm.
3. Orchard grass produced more pasture per unit of area on bottom land, but less on the upland, than brome grass.
4. Sudan grass proved to be the best of all midsummer pastures tried.
5. A 60-acre field was divided into four equal strips. Alternating strips were planted to brome grass and orchard grass in the fall of 1927. The brome grass made a better start in the fall and a much more vigorous growth during the dry weather of the following spring than did the orchard grass.

It is planned next year to make a study of the comparative palatability and adaptability of brome grass and orchard grass as a cattle-pasture crop under practical conditions. In addition studies will be continued on other pasture crops for the different classes of farm animals. [Project 142; Department of Animal Husbandry; state funds.]

The Influence of Feed on the Color, Chemical Composition, and Cooking Quality of the Meat of Grass-fat Cattle. This project has been conducted both years of the biennium. For the work during the past year 18 head of three- and four-year-old Texas Panhandle steers grazed during the summer of 1927 and 1928 on bluestem pastures near Manhattan, Kan., were purchased by the College and on August 3 were weighed, lotted, and strapped with identification tags. They were then divided into three lots of six each. Lot 1 was killed on August 4 and 5. Lot 2 was continued on bluestem pasture for an additional 28 days, and lot 3 for an additional 56 days.

Immediately after slaughter the carcasses were shrouded and run into a cooler, the temperature of which averaged between 32° and 34°F. It was endeavored to maintain the cooler at an even temperature during the entire period of storage. The shrouds were removed after 24 hours. The carcasses were then cut similar to the Chicago style, dividing them into eight wholesale cuts.

Samples of meat for color readings were taken 120 hours (5 days) after slaughter and readings were made (1) immediately after cutting, (2) 30 minutes after cutting, (3) 3 hours after cutting, and (4) 24 hours after cutting. Samples were taken from the following muscles, each sample being cut one-half to three-fourths of an inch thick and from 3 to 6 inches in diameter: (1) Prime rib (*longissimus dorsi*). This sample was taken from the portion between the twelfth and thirteenth ribs. The reading was made as near the external surface of the muscle as possible. (2) Round bone pot roast (cross arm) (*triceps brachii*). This sample was taken on the out-

side of the arm, just above the lateral condyle of the humerus. (3) Inside or top of round (adductor muscles). This sample was taken from the fresh-cut surface of the first cut of round. (4) Outside or bottom of round (biceps femoris). This sample was taken directly opposite from the sample of the adductor muscle or from the bottom or outside of the fresh cut surface of the first cut of round.

All color readings taken in the laboratory were made with the Munsell color wheel, using the following four disks: Standard red (11/4), black (N/1), yellow red (6/5), and white (N/9). Each reading was measured by means of a calibrated disk.

During the two years that this project has been conducted the pasture situation has presented two extreme conditions and, although the results of both years' work are nearly parallel, there are too many possible variables in the work to warrant the deduction of any definite conclusions. However, the following tentative conclusions seem warranted:

1. All cuts of beef brighten very materially after cutting and exposing to the air. This brightening process is most rapid during the first thirty minutes after cutting, but continues for about three hours, after which there is a tendency for the cuts to become darker.

2. The condition of the cattle apparently influences the color of the beef. A better finish seems to render the beef darker in color at the time of cutting.

3. Few, if any, of the carcasses handled in 1926, and not more than one in 1927, could in any way be discriminated against on account of the color, particularly after thirty minutes' exposure to the air.

4. Discrimination against grass-fat cattle on the basis of color of beef alone does not seem warranted. The quality of the cattle seems to have more influence upon the quality of the beef than does the nature of the feed. One way to improve the quality of grass beef is to graze better quality of cattle.

Complete cutting records have been kept on all carcasses and photographs have been taken of all carcasses and all rib cuts. These photographs are proving to be very valuable for comparison.

Samples of meat representing the lean portion of typical cuts of cross arm, round, and rib, were selected for chemical analyses from the 20 animals slaughtered during the late summer and fall of 1926. The per cent of fat, lean, and bone was determined on each cut. Chemical analyses of the lean portion of each cut were made for the moisture, protein, fat, and ash content.

Similar determinations were made in 1927, except that the lean portion of the rib was divided into the eye, muscle of rib, and lean of rib and chemical analysis made of each. The eye muscle of the rib cut was analyzed for its collagen and elastin content. The fat of the rib sample was purified and the iodine number, melting point, specific gravity, saponification number, and index of refraction were determined.

The results were similar to those secured in 1926, indicating very definitely that the variation in the feed of the animals during the period of the project had little, if any, influence on the composition of the meat; also that the length of the pasture period had no influence on the chemical composition of the meat.

A comparison of the analyses of the several cuts of meat indicates that lean muscle tissue has nearly a constant chemical composition. The average moisture content of the rib samples was 71.8 per cent; round, 73.9 per cent; and cross arm, 75 per cent. The average ash content of the rib sample was 1 per cent; round, 1.2 per cent; and cross arm, 1.1 per cent. The average protein (N X 6.25) content of the round and cross arm was 21.2 and 20.4 per cent, respectively.

The analyses of the rib fat proved interesting. The ash or mineral content was about one-half that of lean meat, averaging 0.46 per cent. The moisture content shows the greatest variation, a maximum of 37 per cent and minimum of 18.2 per cent being recorded. Just why the fat of one animal contains double the amount of moisture of another is not known; however, it is conceivable that this difference may have some influence on the keeping qualities of the meat. The subject will bear further investigation.

The analyses of the purified fat from the rib sample show a variation in melting point from 37.4° to 45°C. The iodine number which represents the degree of unsaturation of the fat varied inversely with the melting point. The other constants showed very little variation and none of the analyses shows any correlation between length of time the animals were on pasture and the chemical composition.

Beef roasts, consisting of the ninth, tenth, and eleventh ribs from the left side of the carcass, were oven roasted for palatability tests according to methods proposed for the National Coöperative Project. Observations were made of time and temperature changes and of losses in weight by evaporation and through drippings. The roasts were carved and graded by the judges according to the suggested plan. [Project 165; Departments of Animal Husbandry, Chemistry, and Home Economics; Purnell funds.]

Factors Influencing the Mineral Metabolism of Dairy Cows.

Work on four phases of this project has been under way during the biennium, each of which are briefly described below.

1. The Relation of Sunshine and Pasture to the Vitamin D and Vitamin C Content of Milk. To determine the influence of sunshine and pasture on the vitamin D and C content of milk two cows were kept in the barn out of direct sunshine. These cows received the ordinary winter feed used for the dairy herd, but no fresh green feed. Two other cows were kept in the sunshine on pasture during the spring and summer months. The vitamin C content of the milk from these cows was determined by the usual feeding experiment with guinea pigs. The vitamin D content was determined by feeding the whole milk to chickens and also by making butter from the milk and testing the vitamin D content of the butter by the usual feeding tests with rats.

No difference was found in the vitamin C content of the milk from the two lots. This indicates that this constituent does not vary with the vitamin content of the feed. This is in accord with the results obtained at this station in previous years, but is at variance with

the results obtained at other stations. It was found that the vitamin D content of milk from the cows in sunshine was much greater than that from those kept in the barn. Whether the increase was due entirely to the vita radiation of the sun on the cows themselves or to the formation in the grass was not determined.

2. *The Vitamin C Content of Silage and the Influence of Silage on the Vitamin C Content of Milk.* Silage of a very fine quality was obtained fresh each day. The vitamin C content of the silage and of the milk was determined by feeding to guinea pigs,

Practically no vitamin C was found in the silage and there was no difference in the vitamin C content of the milk from silage-fed and nonsilage-fed cows.

3. *The Growth of Calves on Milk Alone.* Four calves were placed on a milk diet January, 1927. They all had access to hydrant water which contains some iron: Two of them received iron citrate in their milk each day. All calves were muzzled except at feeding time and allowed to run in the yard so as to receive direct sunshine. They were given sufficient milk to supply the requirements of the Armsby-Eckles standard. Due to the fact that they were far below normal in weight on September 22, 1927, the feed was raised to 20 per cent above requirements, and on October 25, 1927, to 40 per cent above requirements. In spite of this they were all far below normal in height and body weight at all times.

One of the calves died at 10 months of age, the cause of death being spasms. Another became very weak and out of condition. An attempt was made by the use of grain and hay to restore its health, but it died at 13 months of age. It lost in weight for three months previous to death. Two of the calves developed a highly nervous condition and were given wheat-germ stock at the rate of about one-half pound daily. This relieved the condition.

One of the calves which did not receive iron citrate developed a severe case of anemia after being on the milk diet for about one year. This was relieved by the use of liver. After the calf was well on the way to recovery it died as a result of bloat. The other calf which did not receive iron in the diet is now showing symptoms of anemia.

4. *The Growth of Small Animals on Milk Alone, With Special Reference to Anemia.* During the past year experiments have been carried on with rabbits, feeding them a milk diet modified in some cases with mineral elements in an attempt to discover what element, or elements, is necessary in hemoglobin building.

Thirty rabbits have been used during the past year. It was found that the average length of life of a rabbit on a milk diet without supplement is three to four months, while the addition of an iron salt plus the ash of lettuce, cabbage, or alfalfa seemed to insure normal growth. Preliminary experiments indicate a decided response to manganese in the form of the carbonate added to the diet. [Project 147; Departments of Chemistry and Dairy Husbandry; state funds.]

Dairy Cattle Feeding Investigations. Eight different phases of this project have been active during the biennium. Five have had to do with the effect of certain feeds on milk and butterfat production, one with the effect of feed on the per cent of fat in milk, and two with the value of certain feeds for the growth of dairy heifers. Each phase of the project is briefly discussed below.

1. *Ground Soybeans Versus Linseed Meal for Milk Production.* During the biennium a third trial comparing soybeans and linseed meal for milk production has been completed. A total of 23 cows were fed for three 30-day periods by the reversal method. The first 10 days of each period were considered as preliminary. The basal ration was alfalfa hay and sorgo silage plus a grain ration composed of 4 parts corn chop and 2 parts of wheat bran. The protein supplement, either ground soybeans or linseed meal, consisted of 1 part by weight. The results of the trial are given in Table XXI.

TABLE XXI.—A COMPARISON OF GROUND SOYBEANS AND LINSEED MEAL FOR MILK PRODUCTION.
Average of three trials.

PROTEIN SUPPLEMENT.	Average live weight during the feeding period.	Total feed consumption.			Total production.	
		Grain.	Hay.	Silage.	Milk.	Fat.
Linseed meal.....	Lbs. 1,139	Lbs. 2,800.5	Lbs. 4,156.6	Lbs. 15,518.0	Lbs. 7,965.0	Lbs. 298.79
Soybeans	1,130	2,536.5	4,067.0	15,377.0	8,006.0	302.35

The lot receiving linseed meal ate somewhat more feed, especially grain, were slightly heavier, and produced slightly less milk and fat. The differences probably were not significant, the difference in milk being only 0.51 per cent and in fat 1.2 per cent.

2. *White Sweet Clover Hay Versus Alfalfa Hay for Milk Production.* Eleven cows have been used in a comparison of white sweet clover with alfalfa hay. The sweet clover was stemmy and of only fair quality. They were fed through three 30-day periods using the reversal method. The feed consisted of a basal ration of sorgo silage

TABLE XXII.—A COMPARISON OF SWEET CLOVER AND ALFALFA HAY FOR MILK PRODUCTION.

PROTEIN SUPPLEMENT.	Average live weight during the feeding period.	Total feed consumption.			Total production.	
		Grain.	Hay.	Silage.	Milk.	Fat.
Alfalfa	Lbs. 1,185	Lbs. 1,186	Lbs. 2,091	Lbs. 8,270	Lbs. 3,283.4	Lbs. 121.02
Sweet clover	1,179	1,230	1,912	8,230	3,194.8	116.94

and a grain ration composed of 4 parts corn chop, 2 parts wheat bran, and 1 part linseed meal. The average results of two trials are shown in Table XXII.

Little difference in body weight was noted while on the different hays. Due to the fact that the sweet-clover hay was less palatable than alfalfa, somewhat less was consumed. The grain consumption on sweet clover was somewhat heavier. The production of both milk and butterfat was lower for the cows receiving sweet clover. The decrease was 2.7 per cent in milk and 3.4 per cent in butterfat. The trial will be repeated when suitable sweet-clover hay can be secured.

3. *The Effect of Feeding Sorgo Seed Upon the Per Cent of Butterfat in Milk.* Eighteen cows have been used in these trials in alternating periods of ten days duration, considering the first three days as preliminary. Samples were taken from each milking for butterfat analysis. The ration was alfalfa hay and cane silage plus a grain ration made up of 1 part of linseed meal and 5 parts either of corn chop or ground Kansas Orange sorgo seed. The feed seemed to make no difference in the per cent of butterfat in the milk, the differences in each of the three trials being only 0.05, 0.03, and 0.02 per cent, respectively.

4. *Ground Kafir and, Ground Sorgo versus Corn Chop for Growing Heifers.* During the past three years considerable attention has been given to a comparison of kafir, sorgo grain, and corn each with alfalfa as a feed for growing heifers. The feeding period has been six months. In experiments during the biennium the feeding period was extended to ten months, but for the last four months the grain ration was reduced one-half and replaced with bran. The average daily gains during this four-month period were 0.59, 0.53, and 0.21 of a pound for the corn, sorgo, and kafir lots, respectively, and at the end of the tenth month, they were 92.4, 85.9, and 90.2 per cent of normal weight, respectively.

During the two months following the experimental period the heifers were supplied according to appetite with alfalfa, silage, a herd grain mixture and some pasture. They responded with an average daily gain of 1.9 pounds. It is evident that the rations during the experiment did not contain sufficient nutrients for adequate growth, but recovery was rapid. There were no harmful effects on reproduction.

5. *Grain Sorghum for Developing Dairy Heifers.* An experiment was started in March, 1927, in which heifers that have been reared to six months of age on a ration containing 50 per cent sorghum grain are continued to first calving on that ration. The sorghum grain for one lot consists of kafir and for another of sorgo seed. There are four heifers in each lot. Just previous to calving linseed oil meal is added to the grain and after one complete lactation the grain feeds are reversed.

To date the kafir lot is 80.8 per cent of normal weight while the

sorgo lot averages 87.1 per cent normal. All individuals appear to be thrifty although somewhat small.

6. *Rations for Wintering Dairy Heifers.* The object of this sub-project is to determine the possibility of wintering heifers on cottonseed meal and sorgo silage.

Beginning in the winter of 1926 two lots of eight heifers each were fed for 180 days on cottonseed meal and silage in one case and alfalfa hay and silage in the other. The gain for the cottonseed meal lot averaged 1.44 pounds per day, and the animals were in much better condition than in the alfalfa hay group with a daily gain of 1.13 pounds per day. The rations were fed according to the Morrison standard, lot 1 receiving 3.6 per cent less total digestible nutrients, but 29.5 per cent more energy than lot 2. The cottonseed meal lot was continued for an additional 90 days with somewhat lower gain. To date practically all the heifers have been bred or calved, and while the breeding efficiency of both lots is low, there is no appreciable difference, lot 1 having been bred an average of 4.3 times and lot 2, 3.5 times.

7. *Atlas versus Kansas Orange Silage for Milk Production.* A group of seven cows were fed through three 30-day periods, considering the first 10 days of each period as preliminary for the purpose of testing the value of Atlas sorgo, a new variety, the merits of which are discussed elsewhere. A basal ration of alfalfa hay and a grain mixture composed of 4 parts of corn chop, 2 parts of bran, and 1 part linseed meal was fed. Body weights were taken for three days at the beginning and at the close of each 20-day experimental period proper, the latter being taken as the weight for the period. Milk weights were kept on each milking and samples taken for butterfat test on the six milkings in the middle of each 20-day period.

The body weight of the animals varied little during the feeding trial, it being only 1.6 per cent higher when Atlas silage was fed. The cows ate 7.5 per cent more grain on the Kansas Orange silage ration, but slightly less hay and silage. The Atlas silage produced 2.1 per cent less milk and 6.75 per cent less butterfat than did the Kansas Orange silage.

8. *Soybean Hay versus Alfalfa Hay for Milk and Butterfat Production.* Eight cows were divided into two groups as evenly as possible and fed by the double reversal method for three 30-day periods, the first 10 days of each period being preliminary. The hay was supplemented by a basal ration of sorgo silage and a grain mixture consisting of 4 parts corn chop, 2 parts of wheat bran, and 1 part of linseed meal.

Alfalfa hay proved to be slightly superior for both milk and butterfat production. However, the difference in the butterfat was negligible. The quality of the soybean hay used was rather poor, being somewhat stemmy, high in crude fiber and low in crude protein. Considering the production per unit of food nutrients, it appears that less digestible crude protein and total digestible nutri-

ents were required with the soybean hay than with the alfalfa hay, except in one instance. For the maintenance of body weight the soybean hay appeared less valuable than the alfalfa hay.

9. A Comparison of Stack-browned versus Green Alfalfa Hay for Dairy Cows. Two groups of four cows each were used in this experiment, the production and body weight of the groups being balanced as nearly as possible. They were fed during two 30-day periods, the first 10 days of each period being preliminary. The basal ration consisted of Kansas Orange sorgo silage and a grain ration composed of 5 parts of corn, 2 parts of bran, and 1 part of linseed oil meal. Group 1 received green cured alfalfa hay the first 30 days and group 2 received brown alfalfa hay for the same period. The feeds were reversed during the second 30-day period.

The body weights of the animals remained about the same or within the limits of experimental error. The production of both milk and butterfat was greatest while the cows were on green cured hay. The per cent of butterfat was practically the same. It was noticed throughout the experiment that the cows did not like the brown alfalfa. Some refused to eat it at first, but later they seemed to relish it. The brown hay used in this experiment was not of the highest quality, being somewhat darker and crisper than good brown hay. It analyzed somewhat higher in crude protein than the green hay, but there was no material difference in true protein. [Project 34; Department of Dairy Husbandry; state funds.]

Kafir Versus Sorgo for Dairy Calves. The active phase of this project consisted of feeding calves to six months of age on a grain ration containing either 50 per cent sorgo or kafir. Milk, alfalfa hay, and silage were fed according to appetite. Growth was compared with that obtained by other calves fed a similar ration except that corn replaced the kafir and sorgo.

During the biennium eight calves have been fed on sorgo and eight on kafir with fairly satisfactory results. Including eight calves from the previous biennium, those on sorgo have averaged 88.5 per cent of normal weight and 98.7 per cent of normal height. Those on kafir averaged 89.4 per cent of normal weight and 99.2 per cent normal height., those fed the corn ration being considered as normal. Thus there is still some question whether sorghum grains are as satisfactory as corn for growth. More calves will be fed as available and two lots of six calves each are just being started on sorgo and corn respectively. They will be fed through one lactation period on the same grain. [Project 154; Department of Dairy Husbandry; state funds.]

Silage Investigations. During the past biennium factors affecting the composition of sorgo silage and silage material have been studied. Two duplicate trials have been conducted, using rather well-matured Kansas Orange sorgo, the principal objectives being to determine the changes in composition and loss in weight of any material going into the silo. This was accomplished by taking

samples of the cut silage at intervals in collapsible cans 1 foot in diameter and 2 feet tall. The cans were then buried in the silo as it was being filled. There were also included samples of material that had been shocked and left in the field for various periods of time previous to filling the silo. As the silage was used, a month or two later, the cans were removed and the contents analyzed.

A very slight loss in weight from siloing was observed, the average being less than 1 per cent. The material removed from the cans had slightly more moisture than the original material as it went into the cans.

There was a noticeable difference in the protein content of green sorgo in 1927 as compared with 1925 and 1926. The 1926 crop had approximately 20 per cent less protein than the 1925 crop and that grown in 1927 had less than in 1926. The protein, ether extract, crude fiber, ash, and nitrogen-free extract contents for the green sorgo and the silage were essentially the same. The most marked changes were observed in the carbohydrate content. There was little difference in the starch content, but the sucrose as well as most of the reducing sugars had almost entirely disappeared from the silage. There was a total loss of carbohydrates amounting to about 2 per cent. [Project 34; Departments of Dairy Husbandry and Chemistry; state funds.]

Normal Growth of Dairy Cattle. As previously reported an attempt is being made to determine the normal growth of dairy cattle by weighing and measuring the height at withers of each female calf dropped in the station herd. Records are made of each female up to 24 months of age and of each male up to 12 months of age at intervals of 30 days from birth to two years of age. The four major dairy breeds are represented in this study.

A total of 117 females and 16 males have been carried through the entire year. It appears that male calves tend to average from four to seven pounds heavier at birth and approximately 100 pounds more at one year of age than females. The project will be continued indefinitely. [Department of Dairy Husbandry; state funds.]

A Study of the Use of Fly Repellents for Dairy Cattle. During the past biennium different commercial fly sprays have been tested. In practically all cases spraying reduced somewhat the number of flies. The cost varied from about 1½ to 2½ cents per cow per day. As an average of three seasons, including five different sprays, 43 cows produced 4.3 pounds, or less than one-tenth of 1 per cent, more milk when sprayed than when not sprayed. This difference is far within the range of experimental error.

A test of a fly salt was also conducted. As high as 6 per cent salt of the grain ration was fed. The results were negative so far as protecting the cows from fly attack or increasing milk flow is concerned. Neither was the flavor of the milk affected. The work will be discontinued. [Department of Dairy Husbandry; state funds.]

A Study of the Cost of Milk Production. This project consists of a study of the feed required to produce a pound of fat at different levels of production in the station dairy herd. The roughage consumed was determined by a two-day estimate each month, while grain consumption was based on actual weights. Feed and production records have been maintained since January, 1920, for every female of milking age in the herd.

The results for the years 1926 and 1927 have been summarized. For this period the average feed cost of 1 pound of butterfat for 135 cows was 9.7 pounds of grain, 20.6 pounds of alfalfa hay, and 38 pounds of silage or equivalent. The results for each year were approximately the same. The proportion of the feeds eaten by the Holstein cows varied but little from that eaten by the average Jersey or Guernsey. When individual records were considered, the feed cost was found to vary widely and inversely with the production. [Department of Dairy Husbandry; state funds.]

Winter Temperature of the Floors of Dairy Barns. A cooperative project, the object of which is to study winter temperatures of the floors of dairy barns as influenced by different materials, has been arranged between the Departments of Dairy Husbandry and Agricultural Engineering. Duplicate standing platforms were constructed with six different types of material as follows: (1) Five inches of concrete laid over one layer of rubberoid roofing; (2) 2-inch planks laid over a 3-inch concrete base; (3) building tile 12 by 12 by 4 inches laid over a 3-inch concrete base, and covered with 2 inches of concrete; (4) 2-inch cork brick laid over a 3-inch concrete base; and (5) 3-inch pine blocks laid over a 3 1/2-inch concrete base. These were compared with the regular concrete floor of the barn.

Electric resistance thermometers were placed in the surface of each floor in a position about even with the cow's udder. Wires were run from the thermometers so that the temperature could be read without disturbing the cows.

Several records of from 10 to 14 days' duration during periods of zero and subzero weather were secured. The temperatures were read hourly, day and night, throughout the test. Other factors which might have a bearing upon the results, such as the cows lying down and getting up and the opening and closing of windows and doors, were noted. While the project has not been completed the following general observations have been made.

1. Solid concrete floors compare favorably with floors constructed of building tile between two layers of concrete. The layer of concrete over the building tile conducts heat away from the cow as rapidly as the solid floor.

2. The 2-inch plank floor warmed up more rapidly than the concrete, the rate being three to four times as fast. This was probably due to the difference in conductivity of the two materials.

3. Cork brick or creosoted pine block maintained about the same temperature as the plank floor.

4. The temperature on the creosoted pine block floor compared very

favorably with that on the cork brick floor. This is important because of the difference in initial cost and the comparative wearing qualities of the two floors.

[Project 162; Department of Dairy Husbandry; state funds.]

Ice Cream Investigations. The work for the biennium has consisted of investigations of some of the methods used in the manufacture of ice cream, such as (1) the common practice of adding sugar to the ice cream mix, (2) testing ice cream for butter fat, (3) the use of egg yolk in ice cream, and (4) the homogenization and aging of ice cream.

The addition of sugar to the ice cream mixes before homogenization increased the viscosity to a greater extent than did the addition of the sugar after homogenization. The butterfat, as indicated by micro-photographs, was more highly dispersed in the mixes homogenized without sugar than with the sugar present. Sugar added to the mix after homogenization increased the overrun. The resistance of the ice cream to melting at room temperature was decreased by the addition of sugar to the mix after homogenization. The method of adding the sugar had practically no effect on the body and texture of the finished ice cream.

Several popular methods of testing ice cream for butterfat have been tried in an attempt to find which test is most satisfactory. Most of them were satisfactory for fresh ice-cream mixes. The glacial acetic sulphuric acid test when made in a milk bottle and read with glymol gave results which approximated the chemical test very closely. The glacial acetic sulphuric nitric test and the ethyl alcohol sulphuric acid test when read without glymol gave good results. Factors other than the method of making the test seem to be responsible for variation in the results. The addition of preservative to the sample, the test bottle, and the composition and flavor of the ice cream appear to be largely responsible for such variations.

A large number of ice cream mixes of varying compositions were prepared which contained powdered egg and fresh eggs in varying amounts. Overrun, incorporation, and the body and texture of the ice cream were observed. The value of egg yolk in improving the texture was greatest in the low solid mixes. In the case of the high solid mixes the texture was smooth regardless of whether egg was present. Egg yolk was found to greatly facilitate the freezing of fresh mixes, irrespective of the composition. In case of high solid mixes it was found that the freezing time was not only reduced but also the ice cream maintained a comparatively firm consistency through the freezing process, whereas, in the absence of egg yolk the ice cream was too soft to draw from the freezer when sufficient overrun had been incorporated. Fresh eggs give just as satisfactory results as dried egg yolk.

Ice cream mixes of varying composition were homogenized at 2,000- and 4,000-pound pressure. Freezing trials were made of the fresh and aged mixes. The time required to secure the desired overrun and the texture of the finished ice cream were observed.

It was concluded that the aged mixes gave a greater amount of swell in a shorter time than did the fresh mixes. Likewise a greater swell was secured in less time from the 2,000-pound pressure mixes than from those processed at 4,000 pounds. By lowering the sugar and serum solid content of the mixes, freezing time and overrun incorporation were greatly accelerated. The finished ice cream from fresh and aged mixes did not show any marked difference in textures. Aging did not produce any great improvement in the texture of high solid mixes, but did materially improve the texture of low solid mixes. [Project 124; Department of Dairy Husbandry; state funds.]

Bacteriological Study of Ice Cream. The work on this project during the past biennium has followed two major lines of investigation: (1) Biological changes during aging of the ice cream mix, and (2) bacteriological study of gelatin in use in ice cream plants.

A study of the types of bacteria in ice cream mix before and after aging indicated that whatever physical changes take place they are not the result of a change in the micro flora of the mix.

In connection with the study of gelatin an attempt was made to adapt the methylene blue reduction test to this product with the hopes of affording a quick and simple method of judging the sanitary quality of gelatin. The results indicate that the test is not applicable because of the low bacterial content of gelatin now manufactured, and also because of the rapid absorption of oxygen by the gelatin.

A comparison of the bacterial counts of gelatins analyzed during the past year with those studied in 1923-'24 indicates a very marked improvement in this respect.

The work also included a study of the effect of the hydrogen-ion concentration on the growth of micoorganisms in gelatin. It was found that none of the samples studied had a sufficiently acid reaction to completely inhibit bacterial development, but many were so acid as to materially retard the growth of inoculated organisms. This fact is significant in interpreting the bacterial count as an index to the sanitary conditions surrounding the production of the gelatin. Of the 34 samples studied, 11.8 per cent had a reaction of pH 6.6, 41.2 per cent were between 6.1 and 6.5, 29.4 per cent between 5.6 and 6, 8.8 per cent between 5.1 and 5.5, and 8.8 per cent between 4.8 and 5.

A study of the keeping quality test, commonly used by ice cream makers in the selection of gelatins, indicates that it does not correlate with the bacterial content. [Project 124; Department of Bacteriology; state funds.]

Inheritance of Down Color and of Down on Toes in Poultry. During the past biennium studies have been made of the inheritance of (1) down color in Single Comb Rhode Island Reds, and (2) down on the toes of Single Comb White Leghorns. Work on the

former has consisted of selection to establish more uniformly breeding "light" and "dark" down strains, crossing the two strains to determine the mode of inheritance of the character, and a study of the relations of down color variations to adult color variations. It was found that down color is heritable and no sexual dimorphism with regard to this character was observed. Thus 1,112 individuals classified as to down color showed the following distributions for the two sexes: Females, 25-114-396-64-2 and males, 36-92-321-60-2, the grades increasing in degree of darkness from left to right. The distribution is practically the same for the two sexes.

Selection over a four-year period has so modified the light and dark strains that there is practically no overlapping of the two. All individuals of the light strain fall within the first two grades and those of the dark strain in the last three grades. The F_1 generation resulting from crossing the two strains shows a distribution practically intermediate between the two. The female offspring of reciprocal crosses show identical distribution, which indicates that no important sex-linked factors are involved. Since the distribution of the F_1 generation overlaps, it is difficult to place down-color inheritance upon a definite factorial basis. Something over 600 individuals have been involved in crosses of the two strains and it appears that all results can be explained on the basis of one pair of factors.

Since one of the standard requirements for Single Comb White Leghorns is feet and shanks free from feathering, the occurrence of down on the toes constitutes a disqualification. The work on this problem for the past two years has consisted of selection to increase the per cent of down in a strain showing this character and mating it with a strain free from the defect. Some difficulties have been encountered due to the lack of vigor of the strains being used. This probably resulted from the inbreeding which was necessary. An epidemic also eliminated a large number of offspring of these matings during the 1927 season, thus making it impossible to obtain adult classification. Although the strain showing down on the toes has been selected for four generations, it does not breed true, about one-third of the offspring failing to show down at hatching. However, about two-thirds of the latter develop down before maturity.

Although the strain selected for the presence of down fails to breed true, the other selected for the absence of the character is entirely free from the defect. Crosses of the two strains show the absence of down to be almost completely dominant, and reciprocal crosses show no evidence of important sex-linked factors. Offspring of additional matings are now being reared and classified. The additional data plus that already accumulated should make the genetic analysis as complete as can be made with our present knowledge of poultry genetics. [Project 77-3; Department of Poultry Husbandry; state funds.]

Inheritance of Certain Characters in Single Comb White Leghorns and Jersey Black Giants. The work on this project has

included the study of inheritance of earlobe color, sex-linkage, and hybrid vigor. In the study of the inheritance of earlobe color a number of white and red earlobe breeds have been crossed, but most of the data have been obtained from crosses of Single Comb White Leghorns and Jersey Black Giants. All crosses produced offspring which were for the most part intermediate, showing a mingling of the white and red. Some of them, however, had all-white or all-red earlobes in the F_1 generation. The overlapping of the F_1 classes upon the parental types has complicated the genetic analysis. It was possible, however, to show that earlobe color is dependent upon at least three genetic factors. Two of these factors are autosomal and the third sex-linked. The linkage relations of the latter with other members of the sex-linked group were also measured.

It was shown that no genetic or physiological linkage exists between white earlobe and white eggshell color. They are associated in most of the better-known breeds, but the association appears to have no genetic basis. This phase of the project has been concluded.

It has been the purpose of the study of sex-linkage to determine the linkage relations of some of the better-known members of the sex-linked group characters. The allelomorphic pairs considered were rapid and slow feathering, slate and yellow shanks, gold and silver plumage, and the barred and nonbarred condition of the plumage. Most of the data were obtained from crosses of the Single Comb White Leghorn by the Jersey Black Giant and the Brown Leghorn by the Silver Penciled Rock. The study includes something over a thousand individuals and by appropriate crosses the linkage relations were calculated between rate of feathering and barring, and between the same factor and shank color. The relations of rate of feathering to the gold-silver factor were also calculated.

The fourth linkage relation to be considered was that between the gold-silver factor and barring. Forty-eight per cent of crossing-over was found between the gene for rate of feathering and barring and 47 per cent for rate of feathering and shank color. Forty-six per cent crossing-over was found between the gold-silver gene and barring. This would indicate that these pairs of genes are widely separated upon the sex-chromosome. Fourteen per cent of crossing-over was found between the genes for rate of feathering and gold-silver. Thus it is suggested that the gold-silver gene and that for rate of feathering are in one end of the chromosome separated by 15 units, while the genes for barring and shank color are in the opposite end. The linkage relations between shank color and barring could not be calculated because of the masking effects of the characters. Since this study has included all of the workable sex-linked characters, it is planned to terminate this phase of the project.

It was found that first-generation hybrids between the Single Comb White Leghorn and the Jersey Black Giant showed exceptional vigor. A study was made comparing these two breeds with their hybrids, utilizing all available criteria of vigor. In most cases

the hybrids were half-brothers and sisters of the pure stock. It was found that the F₁ hybrids were superior to either of the two breeds, as measured by egg production, chick mortality, per cent of hatchability, or rate of growth. In most instances the differences were statistically significant. It is planned to make a more comprehensive study of this subject. [Project 77-4; Department of Poultry Husbandry; state funds.]

The Inheritance of Egg Production in Single Comb Rhode Island Reds. The work on this project has consisted of selection for late and early strains. This has been carried out by mating sons of late-maturing mothers to late-maturing females. The first selection was made in 1926 when two early- and three late-maturity matings were made. There were from three to seven females in each mating. The first year's selection showed but little effect, since the two early-maturing matings produced daughters which matured on an average of 280 and 267 days, while the daughters of the three late-maturing matings had an average age of 265, 269, and 274 days when laying their first egg. In 1927 selection was more effective. Four early-maturing matings gave daughters which had an average age at maturity of 232, 210, 273, and 240 days. The three late-maturing matings produced female offspring which had an average maturity age of 260, 249, and 243 days. Selection is to be continued, using the most desirable offspring of the matings of which the average maturity is most in the direction of the selection. When strains are established which are uniformly late- and early-maturing, the two will be crossed for a genetic analysis. [Project 77-5; Department of Poultry Husbandry; state funds.]

Poultry Flock Management. This project is a continuation of the work begun in the fall of 1923, the object of which is to develop a practical system of managing the farm flock to obtain maximum egg production from pullets during the fall and winter when the price is high, and maximum fertility and hatchability from the hens during the spring. High fall and winter egg yields have been attempted by placing 75 March-hatched pullets in the laying house October 1, leaving them confined until April 15, and feeding for egg production during that period. The pullets are given free range with the hens after April 15.

To obtain good fertility and hatchability 50 hens which have completed one, or more, year's production are given free range throughout the year, and during the early winter months they are fed sparingly on a maintenance ration. Beginning January 1 they are generously fed a laying ration in order to stimulate egg production, and it is from the eggs produced from this group in the early spring that chicks are hatched to place in the pullet pen October 1. In September the 50 best individuals from both groups are selected as the breeding flock for another year, and so the system is repeated. Rhode Island Reds were used the first three years and White Plymouth Rocks have been kept the past two years.

An attempt was made to hopper feed both grain and mash. The

outcome was an overconsumption of grain and very little exercise, which resulted in an overfat condition and a small egg production during the fall and winter. The hopper feeding of scratch grain was discontinued about March 1.

The hatchability at the Poultry Farm for the season of 1927 was generally unsatisfactory. Whether the trouble was due entirely to the operation of the incubator or whether the season was a factor is not definitely known. Hatchability for 1928 was reported very satisfactory from all sections of the state, and the results at the College were better than usual. The project will be continued three more years with Barred Plymouth Rocks, after which the results with the Rhode Island Reds, White Plymouth Rocks, and Barred Plymouth Rocks will be compiled and prepared for publication. [Project 77-6; Department of Poultry Husbandry; state funds.]

A Study of the Dissemination of Bacillary White Diarrhea in Incubators. This project is a continuation of a study started in 1925. At that time *Salmonella pullorum* was artificially introduced into a forced-draft incubator and the spread of the organism to chicks was noted. Whether chicks would contract the disease from hatching eggs from naturally infected hens was the object of the study made in 1927.

Eggs from infected and noninfected hens were set in separate trays in the same incubator. After the eggs were hatched the chicks were taken to separate brooders and reared to two weeks of age. All of those which died from both groups were carefully examined for the *S. pullora* organism. Eight different hatches involving several hundred eggs were made during the season.

In six of the eight hatches there was definite evidence of the transmission of bacillary white diarrhea to the chicks from the reactor hens. This work is being continued as an industrial research project, financially supported by two incubator companies. The object of the present, study is to determine whether or not disinfectants or other agencies can be used to destroy *S. pullora* in forced-draft incubators without injury to the incubating eggs and hatching chicks. [Project 77-10; Department. of Poultry Husbandry; state funds.]

A Study of the Use of Hydrolyzed Feathers as a Feed for Chickens. During the biennium hydrolyzed feathers were fed as a part of the protein concentrate to laying hens, broilers, and baby chicks. Slightly better egg production was obtained from the hens receiving the feather feed the first year, but in the second year there was a slight loss. In both years the feather feed delayed molting about two weeks. There were no significant differences in body weight or feed consumption. In the first experiment with broilers the lot fed feather feed exhibited considerable less cannibalism than the check lot, but there was no difference in gains. In the second case there was no great difference in cannibalism, but the lot given feather feed made much poorer gains in weight.

Baby chicks receiving feather feed as a sole source of animal

protein made much poorer gains than those of the check lot and no difference in rate of feather growth was noticed. The chicks receiving half of their animal protein from feathers and half from the usual source made slightly less gains than the check lot. Again no differences in feather growth were noticed.

This experiment will not be repeated, as the results indicate that hydrolyzed feathers add nothing of importance to the present-day rations for laying hens, chicks, or fattening broilers. The cost of hydrolyzation is too great to expect such a feed to compete commercially with other protein supplements on an equal feeding basis. [Project 77-11; Department of Poultry Husbandry; state funds.]

The Effect of an Inadequate Ration on the Production and Hatchability of Eggs. The work on this project during the past two years has developed along two distinct lines. One has to do with the relation of vitamin A to egg production, hatchability, and vigor of chicks produced and the other with the utilization of calcium for egg production.

In 1927 qualitative studies were made of certain green and succulent feeds as a source of vitamin A to determine the effect upon production and hatchability of eggs and upon the health of the birds. Those studied were alfalfa leaf meal with and without mangel beets, green sprouted oats, and germinated oats. White Leghorns were used and the experiment was conducted from November 1, 1926, to August 1, 1927.

TABLE XXIII.—THE INFLUENCE OF THE RATION ON PRODUCTION AND HATCHABILITY OF EGGS.

Pen No.	RATION.	Average egg production per hen, Nov. 1 to Aug. 1.	Number eggs set.	Per cent fertile.	Number chicks hatched.	Per cent fertile eggs hatched.	Number hens died or removed.
73	White corn meal..... 50	77	939	78	516	70	22
	Meat scraps..... 20						
	Ground oats..... 10						
	Wheat bran..... 10						
	Alfalfa leaf meal..... 10						
74	White corn meal..... 50	73	824	89	551	75	24
	Meat scraps..... 20						
	Ground oats..... 10						
	Wheat bran..... 10						
	Alfalfa leaf meal..... 10						
	Mangel beets, <i>ad libitum</i> ... 10						
75	White corn meal..... 50	64	622	84	298	57	35
	Meat scraps..... 20						
	Wheat bran..... 30						
	Sprouted oats (a).....						
76	White corn meal..... 50	48	320	96	203	66	63
	Meat scraps..... 20						
	Wheat bran..... 30						
	Germinated oats (b).....						

(a) One square inch per bird daily.

(b) Sprouts one-fourth to one-half inch long; 1 square inch per bird daily.

All pens received shelled white corn for scratch grain and grit, oyster shell, and water. The hatchability figures were obtained by setting 10 to 15 fertile eggs from each hen which laid that number during the hatching season. Hens which laid less than 10 eggs were not included in the figures reported here. The rations used and the results obtained are shown in Table XXIII. The mortality, which was high in all pens, was exceedingly heavy in pen 76 due to avitaminosis A.

In the study of the utilization of calcium for egg production, the following work was done: (1) An analysis of the blood of growing chicks, both cockerels and pullets, was made each month from the time they hatched until they matured; (2) analyses were made of the blood of mature hens before, during, and after molting and setting; (3) a comparison was made of the blood of capons and roosters; (4) a complete mineral analysis was made of the blood of laying hens and mature roosters. For this purpose 400 c. c. of blood was collected by drawing 10 c. c. from each of 40 hens from the wing vein by means of a syringe; (5) the relative amount of "vita radiation" (the portion of the sun's rays which enables animals to utilize calcium) was determined each day during the past year.

The calcium content of the blood of normal chickens, except hens during the time they are in egg production, was found to be practically the same as that of other animals. As the pullets matured as shown by the comb development the calcium content of the blood increased. During the time of egg production the calcium content of the blood remained high, being from two to three times the ordinary amount. When production ceased, either from molting or setting, the calcium content dropped to the normal level, then raised to a high level again when egg production began. During egg production the amount of calcium in the blood did not remain constant, as is usually the case, but fluctuated as much as 10 milligrams from

TABLE XXIV.-A MINERAL ANALYSIS OF THE BLOOD OF LAYING HENS AND MATURE ROOSTERS.

Experiment No.	Grams in 1,000 grams of plasma.			
	Composit from 40 laying hens.		Composit from 25 mature roosters.	
	1	2	1	2
ELEMENT.				
Calcium.....	0.241	0.245	0.145	0.150
Magnesium.....	.045	.....	.039	.....
Sodium.....	3.399	3.433	3.555	3.385
Potassium.....	.272	.284	.257	.252
Phosphorus.....	.329	.343	.134	.111
Chlorine.....	3.777	3.752	4.114	4.002
Sulphur.....	.940	.....	.821	.....

week to week. The cause of the fluctuation has not been determined. The results of the complete mineral analysis of the blood of laying hens and mature roosters are given in Table XXIV.

It will be seen from Table XXIV that both the calcium and phosphorus content of the blood are higher for hens than for roosters. The increase in calcium is due to an increase of the inorganic salts of calcium. This is not true for phosphorus, as other determinations show the inorganic phosphorus to be no higher in the blood of laying hens than in the blood of nonlaying hens or roosters. The increase must, therefore, be due to some organic phosphorus compound. It would appear that the increase in calcium is to provide for the inorganic calcium of the eggshell, and the increase of phosphorus provides for the organic phosphorus found in the yolk of the eggs.

The project will be continued for the purpose of making further quantitative studies of vitamin A as found in alfalfa leaf meal when used with kafir, milo, wheat, and corn. An effort will also be made to determine the cause of the fluctuation in the calcium content of the blood during egg production. [Project 127; Departments of Poultry Husbandry and Chemistry; Adams fund.]

The Relation of the Vitamin Content of the Feed to Immunity to Roup. It has been found, as stated in previous reports, that vitamin A is the only vitamin which has any relation to roup-like diseases in poultry. For this reason the work has been confined during the past two years to a study of this vitamin. The condition which is usually called roup, better called avitaminosis A, is characterized by two main types of lesions; one of these has to do with the infections about the head, and the other the deposition of urates throughout the body, mainly in the kidneys and ureter.

To provide material for studies by the Departments of Bacteriology and Chemistry, six pens of ten hens each have been fed experimental feeds each of the past two years. This feed consisted of corn, bran, shorts, tankage, bone ash, and oyster shells. White corn was used in the pens which were to be on a vitamin A-free feed, while yellow corn was used as a source of this vitamin in the check pens. All pens were irradiated each day to provide the vitamin D requirement.

The hens would neither eat nor drink during the advanced stage of the disorder. In order to determine the effect this had on the uric acid content of the blood, one group on the vitamin A-free feed were force fed and watered after they had reached the stage where they would not eat nor drink. Uric acid determinations were made at frequent intervals. In addition, three groups which received a normal feed and were in normal condition were used to study the influence of fasting on the uric acid content of the blood. Of these three, one lot received nothing but water, one received water [and 1 c. c. of cod-liver oil containing vitamin A, and one received water and 1 c. c. of cottonseed oil, which contained no vitamin A.

The results confirm the work of the preceding years. Practically all of the hens receiving the feed low in vitamin A developed eye,

nose, and throat infection, while none of those receiving vitamin A developed this disorder. No doubt many outbreaks of what is commonly called roup results from a lack of vitamin A in the feed.

While the actual cause of the increase of uric acid in the blood has not been determined, the following results were secured.

There is no increase in the uric acid content of the blood until the disease is in an advanced stage. At this time the comb darkens and the hens become drowsy. Neither food nor water is taken. In most cases the tissue around the eyes becomes cedematous, and the eyes water and fill with a white cheesylike material. The ureter becomes congested with urates to such an extent as to stop the flow of urine.

Force feeding did not prevent the increase of uric acid in the blood nor the formation of urate crystals. How much of the feed administered by this force feeding was digested and assimilated was not determined.

Giving water by means of a pipette did not prevent the increase of uric acid in the blood. It did, however, increase the cedematous condition of the eyes.

Fasting of normal hens caused almost as great an increase in the uric acid content of the blood as was caused by the lack of vitamin A. Vitamin A given in the form of cod-liver oil had no effect on the uric acid content of the blood of the fasting hens. [Project 131; Departments of Chemistry, Bacteriology, and Poultry Husbandry; state funds.]

Studies in Animal Reproduction and Inheritance. In the biennial report of 1924-'26, all the experiments in progress were reported in detail. During the past two years many animals have been produced, adding to the data already accumulated, but few new facts have been secured.

In the study of color inheritance in guinea pigs, it has been determined that "black tipping" found in reds and in *Cr* whites is dominant. More data will be necessary in order to ascertain definitely whether or not more than one pair of allelomorphs are involved.

In previous reports the statement was made that guinea pig females 15 months old at parturition produced an excess of males. The original 1913 to 1921 data have been checked over and the ages of the mothers determined in days instead of months. Ten-day classes were then made and for a period extending over a fairly large number of days it was found that the excess of males was still biometrically significant. When compared with the remainder of the population it was found that the difference was 4.2 times its probable error.

The 1922 to 1925 data were examined in a similar manner for females having the same age limits as above, but the ratio of males to females was almost exactly 1:1, thus failing to substantiate the generalization made from the 1913 to 1921 data.

An effort has been made to change the sex ratios in guinea pigs

by mating together animals whose parents produced a large excess of either males or females. As a check, animals were mated having parents producing the two sexes in equal numbers. After two or three generations no differential effect has been noticed. In both cases a slight excess of females has been produced thus far. It will be necessary to carry the experiment further before definite conclusions can be drawn.

The mortality of rabbits has been relatively high. False bottoms, consisting of one-half inch mesh wire cloth, have been put on all the cages, thereby greatly reducing the labor of cleaning and also improving sanitary conditions. In addition, the feed has been improved. The "grain" mixture now consists of approximately 6 per cent high-grade wheat germ (about equal parts of wheat germ and wheat, bran), 3 per cent skimmed milk powder, 1 per cent cod-liver oil, 1/4 per cent table salt, and the remainder rolled oats. Alfalfa meal is fed in addition. This feed seems to increase reproduction and is especially of value during lactation. Large litters have been born and very few animals have died while they were with their mothers. The high mortality has come after the animals were weaned. Many have had cases of diarrhea and die within twenty-four hours. All of these have some coccidia. It is uncertain, however, whether coccidiosis is the actual cause of death.

A number of descendants of animals whose eyes have been needled have been mated together, but none of their offspring have defective eyes. On the other hand, a defective-eyed male was produced by normal-eyed parents from untreated stock and when he was mated to his normal-eyed sister she produced a litter of seven, one of which had very opaque lenses in both eyes. [Project 93; Department of Animal Husbandry; state funds.]

Studies in the Inheritance of the Grouse Locust. The work during the biennium has proceeded along several lines. In October, 1926, a collecting trip was made to southern Texas, where many specimens of the species *Paratettix texanus*, *Apotettix eurycephalus*, and *Tettigidea parvipennis* were secured. Practically all the color characteristics previously studied and a few new ones were included in these collections. These, in addition to the stocks some of which have been on hand for 18 years, have been bred both bisexually and parthenogenetically, records have been made, and many drawings and numerous specimens have been preserved. A new feature has been the inauguration of intensive studies of the chromosomes. The local (Kansas) grouse locust, *Acrydium arenosum*, has been bred rather extensively. They are more difficult to breed than the southern species, but they have some interesting features not possessed by the others.

One new characteristic, an intense black, named O, has been discovered in *A. eurycephalus*, and the place of its factor on the chromosome map approximately located. Many additional data as to the relations of the other characteristics both of *P. texanus* and *A.*

eurycephalus have been recorded. They strengthen and confirm the relative positions already shown for them. These have taken their place among the considerable data in biological literature which are placing quantitative biology close to, if not precisely on, the same basis with quantitative chemistry.

A close correlation has been found between the arrangements of the chromosomes of the parthenogenetic individuals and the inheritance of the characteristics. This work gives much promise of interesting results. A major paper on this subject with excellent illustrations is about ready for publication. Many additional data on parthenogenesis also have been accumulated. [Project 72; Department of Zoölogy; Adams and state funds.]

The Influence of Climate on Inheritance in the Grouse Locust. Celloglass cages have been constructed and preliminary experiments on the effects of ultra-violet rays on the development of grouse locusts compared with controls kept in the glass cages have been conducted. The effects of artificial and natural hibernation on the northern species also have been studied.

The ultra-violet light in the celloglass cages, which is greater in amount than that in the glass cages, seems to be beneficial.

A second generation of the northern species, *Acrydium arenosum*, was reared in the late summer of 1927, after the parents had been hibernated two or three weeks in a specially constructed refrigeration apparatus, the result, it is believed, of artificial hibernation.

Further tests of the effects of ultra-violet rays, both by the use of lamps and celloglass, will be made. Also the effects of x-rays on the inheritance of the factors, and on crossing over and mutations will be determined as far as possible. [Project 104; Department of Zoölogy; Adams funds.]

Bee Investigations. A study of the collection of food by the honeybee was begun in the spring of 1927. Valuable data have been gathered concerning the relation of nectar flow and climatic conditions as well as the identification of pollen-yielding plants. This work is not complete.

Dry substitutes for pollen, such as dried skim milk and dried egg yolk, when fed within the hive have been found not to be beneficial. Wheat flour, when gathered and taken into the hive by the bees, likewise is not beneficial.

Several colonies were divided in the spring of 1927 to provide for an increase without at the same time reducing the output of honey below that of undivided colonies. That is possible in the regions where the honey flow comes from 11 to 15 weeks after brood-rearing normally begins. Colonies treated in this manner during the first two weeks of April produced as large crops as undivided ones. By this method the production of the honey crop may be doubled in a season over that from undivided colonies. In the plains region it is also possible to requeen colonies during the early part of April without impairing the strength of the colony at the time of the honey flow.

During the summer of 1927 experimental work was commenced to determine the best method of field treatment of American foul-brood. With the means usually available, the smoke down, the smoke over, and the chute methods of transferring bees from diseased to disease-free bee equipment proved the best. The shaking method is not recommended unless the colonies are isolated from other bees. Treatment should be made only on warm days during a honey flow. After treatment, queen excluders should be put in the entrance of hives. If all bees, honey and brood in a diseased colony are burned, a thorough clean-up is assured.

Cerelose, when fed in a solution of two parts of sugar and one part water, was found unsatisfactory for a winter food. It solidified in the comb and in the digestive tract.

A study of the habits of different races of bees is in progress. This work was begun in 1927 and will take several years to complete. The races under observation are Italian, Carniolan, and Caucasian. [Project 126; Department of Entomology; state funds.]

DISEASES OF FARM ANIMALS

Some of the more important features of the work of the Agricultural Experiment Station during the past biennium relating to animal diseases and parasites are discussed below.

Miscellaneous Animal Disease Investigations. The work on this project has consisted of routine laboratory examinations, hog cholera investigations in baby pigs, anaplasmosis in cattle, and investigational trips throughout the state in relation to disease outbreaks. A total of 6,514 laboratory examinations have been made. This shows a decided increase in the work over the preceding biennium, the corresponding figure for which was 3,080.

Considerable trouble with baby pigs farrowed by cholera-immune sows has developed in the state. These pigs show a typical picture of hog cholera. In order to prove that hog cholera was the cause of the condition, susceptible pigs were purchased for inoculation. Altogether five susceptible pigs have died of hog cholera as a result of these inoculations while the controls in each instance have remained healthy. These five instances cover but two different outbreaks. Sows that farrowed two lots of the pigs were purchased and hyper-immunized in order to determine whether or not they had been successfully immunized. Five hundred cubic centimeters of potent virus was injected into them and no trouble followed, thus indicating in a general way that the cause was not to be found in a disturbance of the immunity in the sow.

Investigational trips revealed the presence in the state of a disease simulating anaplasmosis in cattle. Specimens were brought to the laboratory for confirmation, and three calves were purchased for experimentation. Two of them were injected subcutaneously and intramuscularly with defibrinated blood from the cases referred to above. The other calf was left as a control, all three animals having been purchased at the same place. Twenty-nine days after inocula-

tion the temperature in one animal went to 104.5°F. and remained high for seven days. During this time anaplasma bodies were found in the blood. The other inoculated animal did not show a distinct rise in temperature at one time, but had slight rises every five to eight days. On the thirty-seventh day anaplasma bodies were found in its blood. The hemoglobin content was materially reduced in both animals, as were also the red blood corpuscles. The red blood corpuscles showed marked crenation, anisocytosis, poikilodytosis, and marginal bodies or anaplasma, and also nucleation. From the above findings a diagnosis of anaplasmosis was made.

In the meantime isolations had been made from the organs. Six different anaërobic bacteria had been isolated (welchii, novyi, septicus, tertius, sporogenes, and an unknown and unidentified non-gas-producing anaërobe). These were subsequently injected into calves alone and in combination with themselves and with anaërobes that had also been isolated. None of these injections proved harmful, but most of them were followed by swelling and slight indisposition.

Three calves were subsequently injected with blood, one with blood from the first case mentioned and the second from artificially cultivated blood containing large numbers of anaplasma bodies. The third animal served as a control. These animals were kept under observation for approximately three months without showing any clinical disturbance. On post-mortem they were shown to be entirely free of any lesions of disease. It is felt that sufficient work has been done to make a diagnosis of anaplasmosis in spite of the fact that no fatal case has been produced. [Project 102; Department of Veterinary Medicine; state funds.]

Abortion Disease Investigations. Further examinations from abortion suspect material have been made during the past biennium, bringing the total now reported to 183 cases. Of this number 35 per cent were positive and 45 per cent were negative for *Bacterium abortus* (Bang), and 30 per cent were sterile bacteriologically. The number of blood samples received from various parts of the state is increasing each month, indicating that the disease is focusing the attention of farmers and dairymen and that they are attempting to control it through the aid of the laboratory tests and the supervision of the abortion research personnel. The objective of this work has been to develop an accurate blood test and to correlate the breeding history with the results obtained by using the blood test.

Some work is being done leading toward the establishment of abortion-free herds in several near-by counties. It is hoped that they will serve as examples of what can be accomplished by following the use of the proper methods of control.

An attempt has been made to determine the causative factor in a recent outbreak of Malta fever in the cavalry dairy herd at Fort Riley in coöperation with the military authorities, particularly Colonel Gussinger. An experiment is now under way to determine whether the intravenous injection of drugs will lower the agglutina-

tion properties of the blood of a positive reacting animal. This experiment has not progressed far enough to be reported on at this date.

Cytost has been prepared from bovine uteri and ovaries and has been used upon experimental animals, both guinea pigs and rabbits, and while it proved toxic for both species it did not cause abortion in small doses. This material will be used on pregnant cows in the near future in an attempt to produce abortion. A circular on "Infectious Abortion of Cattle" has been published. The project will be continued. [Project 135; Department of Veterinary Medicine; state funds.]

Blackleg Investigations. The work on this project during the past biennium has consisted in the production and sale of blackleg filtrate and blackleg aggressin, and in the study of the bacteriological and immunological characteristics of *Clostridium chauvæi* and other related anaerobes. The following points have been considered: (1) The production of toxins by cultures of *Cl. chauvæi*; (2) the production of aggressive substances by cultures of *Cl. chauvæi* grown in media containing various chemical substances; (3) the action of formaldehyde on the aggressive substances and its use as a preservative for blackleg filtrate; (4) the action of disinfectants such as phenol, formaldehyde, and alcohol on aerobic and anaerobic spore-forming organisms; (5) the production of aggressins by *Bacillus anthracis* and a study of a formolized filtrate from anthrax cultures; (6) the occurrence of anaerobic organisms in cases of blackleg; (7) the pathogenicity of these organisms for calves; (8) the immunization of calves by the use of minimal doses of blackleg filtrate; (9) losses following the use of blackleg aggressin, especially when used in the stockyards; (10) the keeping qualities of formolized blackleg filtrate; (11) the cultural characteristics of cultures of *Cl. chauvæi* obtained from England, France, India, Germany, Ireland, South Africa, and Argentina; (12) distribution of cultures of *Cl. chauvæi* to commercial biologic companies and advice concerning improved methods of production; (13) the action of magnesium sulphate and other inorganic salts on the fermentation and cultural reactions of anaerobic organisms; and (14) a comparison of the results obtained by the use of blackleg filtrate, blackleg aggressin, and powder vaccine.

It has been shown in previous reports that *Cl. chauvæi* does not produce toxins in ordinary culture media or in the animal body. Some special media which have been recommended for the production of various bacterial toxins were used and it was found that toxins were not produced in brain liver medium, dextrose meat mash, peptic digest broth, or peptic digest meat medium, or in media containing sodium sulphite, potassium tellurite or glucose in strengths of 5 or 12 per cent. Filtrates of cultures of *Cl. chauvæi* grown in these media were nontoxic for guinea pigs in doses of 10 c.c. subcutaneously, 5 c.c. intraperitoneally, and 2 c.c. intracardially or intravenously.

It was found that certain salts, notably sodium citrate, potassium tellurite, and ammonium phosphate greatly increased the production of aggressive substances of blackleg cultures. Sodium citrate or formaldehyde used alone doubled the strength of blackleg filtrate. When used in the same filtrate the strength was found to be four times as great as that of filtrates made by previous methods. Some of the detailed results with these substances are given in Table XXV.

TABLE XXV.-POTENCY OF BLACKLEG FILTRATE AND AGGRESSIN AS INFLUENCED BY SODIUM CITRATE, PHENOL, AND FORMALDEHYDE .

Number of tests.	Product.	Medium.	Chemicals added.	Preservative 0.5 per cent.	Potency aggressive units.
20	Aggressin	Calf liver pulp and liver brain . . . . .	.....	Phenol	19.39
50	Filtrate	Calf liver pulp and liver brain . . . . .	.....	Phenol	17.72
5	Filtrate	Calf liver pulp and liver brain	A, B, or C	Phenol	28.72
6	Filtrate	Calf liver pulp and liver brain	None	Formaldehyde	32.50
13	Filtrate	Calf liver pulp and liver brain	A, B, or C	Formaldehyde	63.15
2	Bacterin	Calf liver pulp and liver brain	None	Formaldehyde	32.50
1	Bacterin	Calf liver pulp and liver brain	A	Formaldehyde	65.00

A, sodium citrate; B, potassium tellurite; C, ammonium phosphate.

One per cent or 5 per cent of glucose, 1 per cent of sucrose, or sodium and potassium phosphate did not affect the production of aggressive substances. In the biennial report for 1924-'26 it was shown that ferric salts increased the virulence of *Cl chauvæi* but had no effect on the production of aggressive substances.

As a result of these experiments the methods of producing blackleg filtrate have been changed. Sodium citrate and ammonium phosphate are now included in the culture medium, and formaldehyde is used as the preservative. By this modification a filtrate is now available which is four times as strong as filtrates or aggressins previously available.

An attempt to produce an anthrax filtrate was made. *B. anthracis* was grown in liver broth and sterilized by the use of 0.5 per cent. formaldehyde. No aggressive substances were demonstrated in this product before or after filtration. Some slight retardation of the development of anthrax in guinea pigs injected with this product was noted.

Two tests were made to study the immunization of calves by the use of small doses of blackleg filtrate. The first test showed that doses of 6.5 aggressive units would protect calves for 10 days. A second test gave ambiguous results as the control calf proved immune to large doses of blackleg virus and some of the test calves died.

A study of the normal susceptibility of calves to blackleg was made. It was found that 30 per cent of those inoculated for the pro-

duction of blackleg agressin were immune. Since about 20 per cent are normally immune it is probable that a similar number are unusually susceptible to this disease. It is, therefore, evident that immunity tests on cattle are of slight value unless a very large number of animals can be examined. It is concluded that the aggressive action tests which have been used since 1918 are a better indication of the potency of blackleg aggressins than animal immunity tests.

Losses following the vaccination of cattle with blackleg agressin and filtrate have in many cases been found to be due to an association of *Cl. chauvæi* with *Cl. septicus* or *Cl. welchii*. *Cl. welchii* especially has been found following losses of calves vaccinated in the stockyards.

A study of the use of 450,000 doses of blackleg filtrate and 200,000 doses of blackleg agressin during the past 10 years show that these products will protect cattle under all conditions. Losses following the use of these products have been less than 1 to 10,000 head vaccinated.

Losses from the use of powder vaccine show that there are occasional cases of inoculation blackleg, and that the losses following immunization are 1 or 2 per cent or even higher.

Cultures of *Cl. chauvæi* obtained from abroad were found to be identical to those isolated in Kansas. [Department of Veterinary Medicine; state funds.]

Studies in Hog Cholera Immunity. The results obtained in hog cholera immunity studies during the biennium are not especially gratifying. The rather adverse results were not due to any fault in the experiment itself but rather to indirect causes, such as great preponderance of males, lack of lactation of sows, etc. At the beginning of the biennium there were four sows, but only two gave birth to pigs to enable the continuation of the experiment. Of these pigs there were only two sows that produced litters, and none of the individuals in these litters were females. Of 12 pigs that were given the first inoculation 11 were males. The sow died before the second inoculation. At the present time there are only two sows to farrow to supply material for future work. However, the results to date suggest that immunity sufficient to withstand hypering may be produced by giving virus to young pigs from immune sows. The data are too meager to justify a general statement to this effect. [Project 150; Department of Veterinary Medicine; state funds.]

Histo-pathology of Poultry Diseases. The work in this project during the past biennium has consisted of a study of six pullets and six cockerels fed an adequate diet at the Poultry Farm. They were weighed and carefully examined before and after slaughter, and histological slides were made from all the organs. A systematic examination of these slides has been begun. The results of the examination to date show:

1. Considerable variation in the size and number of strands of thymus tissue in individual birds.

2. The microscopical sections of different organs show that in general there is a great similarity of the tissues of mammalian organs. Some striking differences are noted, as in the liver, in which the cells are large and have a very indistinct cell wall, thus giving a more tubular appearance to this organ.

It is proposed to complete the examination of the slides which have been prepared. If this can be done it is hoped that some time can be devoted to an examination of tissues from diseased birds. [Project 168; Department of Veterinary Medicine; state funds.]

Poultry Disease Investigations. The work of this project is divided into three phases as follows: (1) General study of poultry diseases; (2) studies on bacillary white diarrhea; and (3) a study of *Pasteurella avicida*, the causative organism of fowl cholera. The work on each phase is briefly discussed below.

General Study of Poultry Diseases. No change has been made in the general procedure of this phase of the project. The large number of specimens being received makes it impossible to make more than a routine examination except on a very few birds. During the biennium 5,376 birds from 2,271 flocks have been examined. In addition 1,480 birds were examined for experimental purposes.

A few definite problems have been studied more carefully than others in connection with diseases that have been diagnosed. Worm infestations have been carefully recorded to determine the per cent of flocks which are infested with the different kinds of worms. Table XXVI gives a summary of these studies. These data were collected over a period from June 30, 1925, to May 1, 1928. The data are based on birds sent to the Department of Bacteriology for diagnosis. Only those over eight weeks of age have been considered in this investigation.

TABLE XXVI.-SUMMARY OF EXAMINATIONS MADE TO DETERMINE PREVALENCE OF WORMS IN KANSAS POULTRY.

	Total.	Per cent.
Number examined.....	2,141	.....
Infested with cecum worms (<i>H. papillosa</i>).....	873	40.8
Infested with large round worms (<i>A. lineata</i>).....	626	29.2
Infested with tapeworms (all species).....	463	21.6
Infested with gizzard worms.....	56	2.6

Two problems in avian tuberculosis have been studied for the past three years. These are (1) effects of tuberculosis on the weights of various organs, and (2) the distribution of lesions in tuberculous birds. A summary of the study on the distribution of lesions in tuberculosis is given in Table XXVII.

An increasing number of cases of paralysis are being found among adult birds. As a number of probable causes of paralysis (coccidia, tapeworms, and neurotropic viruses) have been mentioned by sev-

TABLE XXVII.-DISTRIBUTION OF LESIONS IN AVIAN TUBERCULOSIS.

ORGANS CONTAINING LESIONS.	Number of cases.	Per cent of total cases.
Liver.....	222	96.1
Spleen.....	206	89.2
Intestines.....	159	68.8
Lungs.....	59	25.5
Peritoncum.....	46	19.9
Bones and joints.....	23	10.0
Kidneys.....	13	5.6
Skin.....	0	0.0
Pericardium.....	0	0.0
Ovary.....	0	0.0
Proventriculus.....	4	1.7
Esophagus.....	0	0.0
Spinal cord.....	1	0.4
Gizzard.....	12	5.2
Pancreas.....	1	0.4
Total number examined.....	231	.....

eral investigators, particular attention has been directed to determining the cause in each case. Examination for coccidia in three paralysis cases was positive. In other cases various kinds of tapeworms have been found in large numbers.

Bacillary White Diarrhea. During 1926-'27 a total of 11,581 tests for bacillary white diarrhea were made on Kansas flocks. The number during 1927-'28 was 7,490. The single-tube dilution test (1 to 25) recommended by the Department of Bacteriology has been used by various testing agencies and has been accepted as standard by the Kansas Poultry Improvement Association. In addition to the above 250 complement fixation tests were made to compare this method of diagnosis with the agglutination test.

Studies conducted during the biennium show that (1) highly complicated methods of preparing antigens from *Salmonella pullorum* suitable for use in the complement fixation tests are unnecessary, (2) the *Salmonella pullorum* organism contains a highly antigenic substance which may be separated from the cell by washing with physiological saline, is soluble in saline, and stable when subjected to high temperatures, (3) the antigenic principle of this organism cannot freely act with a specific antiserum in the complement fixation test unless it is separated from the cell, (4) the complement fixation test and agglutination test have about the same value in testing for carriers of the *Salmonella pullorum* organism, (5) a

combination of the two tests is more accurate than either test alone, (6) with the so-called fatty serum the complement fixation test may be used to advantage and may be recommended for this purpose, and (7) that the complement fixation test is of no value in determining whether birds giving low reaction to the agglutination test are carriers or non-carriers of the *Salmonella pullorum* organism, except in confirming the agglutination reactors.

A careful comparative study has been made during the past four years of various tests for routine work. The two-tube test of 1 to 20 and 1 to 80 solutions of blood serum used in 1924-'25 and 1925-'26 involved much time and material, and investigations to supplant this method with a simpler and shorter one were undertaken in 1926-'27. Previous work showed conclusively that the lower dilutions were more effective in detecting carriers, but that an occasional test would show a prozone to 1 to 20 or 1 to 40 solution. For this reason a two-tube test of a low dilution and a high dilution indicates that there are only a small per cent of reactors left in the flock when only a single tube test of 1 to 20 dilution is used. Therefore for routine testing a single-tube test of 1 to 25 dilution (to conform with the Standard Method advised by the United Live Stock Sanitary Association at its 1926 meeting) was substituted in 1927-'28 as the standard for routine tests.

Studies on the tube test have shown that several probable sources of error must be considered. Most of the difficulties encountered are due to two causes: (1) Precipitates in the presence of too much phenol, and (2) contamination by phenol-fast organisms. The former can largely be overcome by employing as a preservative only 0.3 per cent phenol instead of 0.5 per cent as generally recommended. Incubation at 45° C. has been found effective in preventing the growth of phenol-fast organisms, contaminating organisms, and this incubation temperature is recommended as superior to the usual temperature of 37° C.

In 1926-'27 studies of the pullorin or wattle test for carriers of bacillary white diarrhea were begun. The tube agglutination test was used as a basis of comparison. The tests were made over a several months' period and under various field conditions.

The pullorins used in the work were of two types, (1) those obtained from commercial concerns and other laboratories, and (2) those prepared by ourselves. The pullorins from outside sources were in part suspensions of cellular and other material derived from *S. pullorum*. The ectopollorins used by us were similar to the ecto-antigens described by Bushnell and Hudson.²

Various methods of injecting the material were tested but the best results were obtained by introducing about 0.1 cm. as nearly intracutaneously as possible. The edge of the wattle has been found to be the most satisfactory place of injecting the pullorin. Immediately before making the injection of pullorin into the wattle a sample of blood was taken from the wing vein of each bird for the

2. Jour. Infect. Diseases, 41:383-387.

TABLE XXVIII—COMPARISON OF THE PULLORIN REACTION TO THE AGGLUTINATION TEST.

Flock No.	Number of birds	Per cent reactors agglutination test.	+A		-A		+P		-P		+A	-A	+P	-P	Per cent agreement.	Per cent reactors by pullorin.
			Number.	Per cent.	Number.	Per cent.	Number.	Per cent.	Number.	Per cent.						
1.....	185	0.0	0	0.0	177	95.7	0	0.0	0	0.0	8	4.3	85.7	0.0		
2.....	51	43.1	12	23.5	25	49.1	10	19.6	0	0.0	4	7.8	72.5	19.6		
3.....	70	1.2	1	1.3	76	96.2	0	0.0	0	0.0	2	2.6	97.4	0.0		
4.....	80	1.4	1	1.3	63	78.6	0	0.0	0	0.0	10	20.0	80.0	0.0		
5.....	180	0.5	0	0.0	166	92.2	1	0.5	1	0.5	13	7.3	92.2	0.5		
6.....	43	55.9	13	30.3	19	44.2	11	25.5	11	25.5	0	0.0	74.4	25.5		
7.....	92	43.5	22	23.9	44	47.8	18	19.5	18	19.5	8	8.7	71.7	19.3		
8.....	116	24.1	11	9.5	85	73.3	17	14.6	8	6.9	3	2.5	82.8	14.6		
9.....	161	41.4	23	14.3	100	62.1	25	15.5	25	15.5	13	8.1	76.4	15.5		
10.....	581	21.1	46	7.9	375	64.5	77	13.3	77	13.3	83	14.3	72.5	13.3		
11.....	66	60.6	25	37.8	8	12.1	15	22.8	15	22.8	18	27.2	50.0	22.8		
12.....	121	40.3	18	14.9	48	39.6	38	31.3	38	31.3	17	14.1	54.5	31.3		
13.....	133	1.5	0	0.0	102	76.7	2	1.5	2	1.5	20	21.8	76.7	1.5		
14.....	133	1.5	0	0.0	111	83.5	2	1.5	2	1.5	20	15.0	83.5	1.5		
15.....	143	36.3	18	12.6	69	48.2	34	23.8	34	23.8	22	15.4	60.8	23.4		
16.....	25	16.0	1	4.0	17	68.0	3	12.0	3	12.0	4	16.0	72.0	12.0		
17.....	143	20.3	16	11.2	90	62.9	13	9.1	13	9.1	24	16.8	74.1	9.1		
18.....	121	46.2	51	42.1	12	9.9	5	4.1	5	4.1	53	43.8	52.0	4.1		
19.....	113	26.5	15	13.2	71	62.9	15	13.2	15	13.2	12	10.6	76.1	13.2		
20.....	1,134	8.6	8	0.7	980	86.4	89	7.9	89	7.9	57	5.0	87.1	7.9		
Totals or averages.....	3,700	17.7	281	7.5	2,638	71.3	375	10.1	375	10.1	406	10.9	78.8	10.1		

A, agglutination; P, pullorin. Association coefficient, 0.67.

agglutination test. The tests were made on 3,700 birds in 20 producing flocks on farms near the College. Table XXVIII shows the results obtained by the tube agglutination test and various kinds of pullorin.

For the 3,700 birds with 17.7 per cent reactors there is an association coefficient of 0.67 by the Yule method and 78.8 per cent agreement between the two tests.

From this study we must conclude that the pullorin test in its present state is not so satisfactory in detecting carriers of bacillary white diarrhea as is the agglutination test. The fairly high correlation observed may indicate that a more satisfactory pullorin may be developed. Further work on this problem is being planned.

Studies in Fowl Cholera. During 1926-'27 the work on this phase of the project was directed toward the problem of why the fowl cholera organism kills the susceptible but not the immune birds. From the work done and results obtained we may draw the following conclusions: (1) That the organism of fowl cholera does not produce a soluble toxin in culture media; (2) that the organisms increase very rapidly in the blood of the susceptible birds but disappear rapidly in the blood of immune birds; (3) that the disappearance is apparently due to a bactericidal substance in the blood of immune birds which is absent from the blood of normal birds; (4) phagocytosis does not appear to play a very active part in this process, although it is of some importance. This part of the problem is not complete; (5) that birds immunized by the use of living attenuated cultures are very strongly immune; (6) the use of attenuated living cultures cannot be recommended for field work because the organisms sometimes regain their virulence and cause losses in vaccinated birds; (7) inadequacy of diet plays a role in resistance to this disease. This apparently is due to a lowered bodily resistance rather than to a change in the antibody content of the blood. [Project 85; Department of Bacteriology; state funds.]

Relation of Adequacy of Diet to Disease. During the past few years the project has been confined to a study of purely deficiency diseases. The past two years avitaminosis A was studied from several angles. Plans were made to determine the effect of minerals and the effect of fasting on the production of lesions similar to those seen in avitaminosis A.

An effort also was made to obtain data on the relationship of avitaminosis A to bacterial infection in the eyes of Rhode Island Red pullets. All birds that died from this disease were autopsied and the lesions recorded. The eyes of each bird were ground and emulsified with sterile physiological saline solution and injected into young rabbits weighing three to five pounds. This was done in an attempt to isolate *Pasteurella avicida*. Very little definite information was obtained. Probably the chief reason was that the birds were slow to show symptoms of avitaminosis A and many did not develop visible symptoms of the disease during the course of

the experiments. It is probable that the Rhode Island Red pullets retained enough vitamin A to prevent them from developing the disease until a much later date than has been observed in other years with Single Comb White Leghorns.

The experiment was continued in 1927-'28 with a flock of Single Comb White Leghorn pullets. Each bird was bled for the agglutination test for bacillary white diarrhea and a swab of the nasal cleft was taken for culture of *P. avicida*. The object of this procedure was to detect individuals that harbored normally in the upper respiratory tract the *Pasteurella* organism. Those birds which by cultural examination showed the presence of bacterial flora macroscopically and microscopically resembling the *Pasteurella* were placed together in a separate pen in order that any differences in susceptibility to avitaminosis A or the lesions produced might be noticed. None of the birds of this flock reacted to the agglutination test for bacillary white diarrhea.

The usual procedure of autopsy and recording of lesions was followed. Only a small number of specimens were utilized for inoculating rabbits with eye material. In one case the inoculated rabbit died a short time following inoculation. Cultural examination revealed the presence of *P. avicida* in the tissues and organs.

More care will be exercised in the selection of birds for future experimental purposes. It may be necessary to raise all birds used for such work under very special conditions in order to avoid parasites which cause very irregular results. [Project 131; Department of Bacteriology; state funds.]

Parasitological Investigations. During the past biennium the work of this project has consisted of studies on various phases of the biology of the large roundworm, *Ascaridia lineata* (Schneider), of chickens and of further search for the intermediate hosts of fowl tapeworms.

The results of seven experiments involving 411 birds to ascertain the effects of the large roundworm revealed the following symptoms: Sluggishness, loss of appetite, drooping wings, ruffled feathers, extreme weakness, retarded muscular and osteological development, reduction of body fat, presence of urates in the ureters, loss of blood and of body weight, and mortality of 16.3 per cent among the parasitized groups as compared with 1.9 per cent in the controls. These effects are attributed to injury to the intestinal wall by the parasite, loss of blood, probable bacterial infection, absorption of metabolic wastes from the worms and partial inanition resulting from lost appetite. Other points in this study include the discovery that parasitized chickens develop much resistance against these worms by the time they are three months old; that from the time the young worms hatch in the duodenum there is a continuous elimination of some of them from the intestine until most of them have been lost; and that the effects of parasitism are most severe in chickens two months or less of age and during the period between the tenth and seventeenth days after the embryonated eggs are swallowed. It is

during this period that the young worms may be found with their anterior digestive glands, causing loss of blood and affording opportunity for bacterial infection.

Among the factors which lower the resistance of *A. lineata* is an insufficient amount of vitamin A in the diet. Results of five experiments involving 117 chickens showed that in the absence of vitamin A there was the usual development of xerophthalmia manifested by watery eyes, swollen eyelids, and cheesy exudate in the corners of the eyes. The criteria for determining whether or not the resistance was lowered were the average number and size of the worms that were able to remain in the intestines after three weeks of parasitism resulting from the administration of the same number of worm eggs to each group under comparison. At the close of the experiment it was found that the group whose diet lacked vitamin A had significantly more and larger worms than that whose diet contained this vitamin.

A further search for intermediate hosts of chicken tapeworms was made by collecting invertebrates at a poultry farm where the fowls were heavily infested with tapeworms and feeding the animals so collected to chicks raised in confinement. Considerable numbers of the following invertebrates were fed: Cockroaches (*Parcoblatta* sp.), sow-bugs (*Porcellio* sp.), carabid beetles and larvae, grubs of the common June bug (*Lachnosterna* sp.), and earthworms (probably *Helodrilus* sp.).

At autopsy one month after the last feeding none of the chickens were infested with any tapeworms. But two of them fed earthworms were infested with *A. lineata*, and one fed larvæ of the June bug contained this nematode. These infestations probably resulted from the earthworms and grubs taking up the worm eggs with the humus they had devoured, since the farm chickens were infested with mature *A. lineata*. [Project 79; Department of Zoölogy; Adams and state funds.]

A Study of the Resistance of Chickens to Parasitism. The work of this project which began in February, 1927, has consisted of (1) experiments designed to ascertain if vitamin D, the lack of which causes leg weakness in chickens, is a factor in the resistance to parasitism with *A. lineata*, (2) studies on vitamin B as a factor in the resistance of chickens to this parasite, and (3) tests to determine whether an infestation of these worms tends to make the chicken immune or more resistant to subsequent infestations.

With the high incidence (49 per cent) of the large roundworm in Kansas chickens, and the common occurrence of leg weakness in young chickens, it seemed that a relationship might exist between them. Accordingly four experiments involving 150 growing chickens were carried out to ascertain if the lack of vitamin B lowers the resistance of chickens to this parasite.

Pure-bred chicks from the same hatch were divided into two lots of equal size and weight and placed in similar quarters from which

most of the ultra-violet light was excluded. Both lots were placed on a diet deficient in vitamin D.

The group designated as plus D received ten minutes of daily irradiation with a Cooper-Hewitt mercury vapor lamp. The other lot designated as minus D were not irradiated. When most of the minus D group showed the characteristic symptoms of leg weakness, all chicks of both lots were parasitized by being fed 300 embryonated eggs of *A. lineata*. After three weeks of parasitism both lots were autopsied, and the worms from each chicken counted and measured.

In only one case were the number of worms significantly smaller in the plus D than in the minus D group. This difference was probably due to the increased amount of vitamin A in the cod-liver oil used as a source of vitamin D in this experiment. In all other cases the difference in numbers of worms between the two groups was not significant.

There was no significant difference in the length of the worm between the minus D and the plus D lots in any of the experiments. These data would seem to show that the resistance to *A. lineata* had not been lowered by the lack of vitamin D.

The data from the weekly weights of the chickens, however, showed that during the three-week period of parasitism in each experiment the minus D group suffered more, as evidenced by their significantly smaller gains in weight, than did the plus D group. Thus, while vitamin D did not serve to protect the chickens against the survival and growth of the worms, it did protect them to a considerable extent against the effects of the worms. [Project 169; Department of Zoology; Purnell funds.]

Studies Relating to the Embryology of Parasitic Worms.

During the past biennium the work has consisted of studies relating to (1) the migrations of larval nematodes through the bodies of the host animals, (2) the anatomy and development of *Oxyuris ambigua* a parasite of the rabbit, and (3) the possible effects of larvae of the intestinal worm, *A. lineata*, upon the thyroid glands of chickens, since evidence has been adduced by other workers which seems to show a relation between goitre and intestinal worms. The principal results obtained were:

1. Evidence was secured of a causal relation between the filaria worm, *Onchocerca cervicalis*, and fistulous withers in horses. The parasites have been found in more than 75 per cent of the cases studied, and in the remaining cases it is not certain that they were absent.

2. New anatomical features in the larval and adult stages of the rabbit nematode, *Oxyuris ambigua*, have been found and illustrated.

3. The results of four experiments involving 113 chickens to ascertain if a relation exists between the intestinal worm, *Ascaridia lineata* (Schneider), and pathological thyroid glands failed to show a significant relationship. However, some evidence was afforded to support the idea that the thyroids of females are more sensitive to environmental factors, to nutritional changes, or to pathogenic conditions than are those of the males.

[Project 119; Department of Zoölogy; state funds.]

STUDIES IN HOME ECONOMICS

The welfare of the rural home is the concern of the entire nation. Several lines of investigational work which have for their purpose its development and improvement have been conducted during the past biennium by the Agricultural Experiment Station. Some of the more important features of the work in this field are briefly discussed below.

Factors Affecting the Seasonal Variation in the Growth Curve of Children. The work on this project, originally started at three state institutions, has been limited during the past biennium to one institution, the State School for the Deaf at Olathe.

The plan of the experiment has been practically the same as that reported for the biennium 1924-1926. Healthy children from five to eleven years of age were the subjects. In 1926 to 1927 there were 77 cases, and in 1927 to 1928, 66 cases. The children were divided into three groups as evenly as possible with respect to number, sex, and age. As far as practicable they have been continued from year to year in the group to which they were originally assigned. For all children in the experiment the regular routine of the school has been retained.

One of the three groups, designated as the orange group, received daily the equivalent of two oranges. This was given as orange juice made from Califorange, a concentrated orange juice which was biologically tested and its vitamin C content demonstrated. Another group, known as the light group, received irradiation from an Alpine lamp. The third group were used as controls and had no addition to the regular routine of the school. Due to unavoidable conditions, in neither year was it possible to begin before January. During the second year orange juice was supplied after December 1 and light treatments were given after December 16. At intervals throughout the study the diet of the children was observed and was found to be fairly adequate. A liberal supply of milk, other protein foods, carbohydrate, and fat were given; raw fruits and vegetables were supplied less liberally.

The children were weighed at monthly intervals throughout the school year. During the first year, heights were measured in September, January, and in May; in the second year they were recorded monthly. Table XXIX gives the monthly gain in weight by each group for the season 1927-'28.

The more important observations were as follows:

1. There was a definite seasonal variation in growth in all three groups of children, the growth throughout the fall months being much greater than during the late winter months. There was a spurt in growth between March and April in the treated but not in the control groups.
2. There was a tendency for a greater variation in the growth of boys than of girls.
3. The girls averaged a greater actual gain, during the school year, than the boys.
4. There was a variation in growth during different years.

5. The seasonal variation in growth of children was not affected in these experiments by deficiency of vitamin C in the diet or by lack of ultra-violet light.

TABLE XXIX - AVERAGE MONTHLY GAIN IN POUNDS OF THREE GROUPS OF CHILDREN AT THE STATE SCHOOL FOR THE DEAF AT OLATHE, 1927-'25.

NUMBER IN GROUP.	Sept. and Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	Total.	
Control Group.										
Boys.....	12	3.7	1.3	0.8	0.4	1.0	1.4	-1.3	0.6	7.9
Girls.....	10	2.2	2.0	2.5	0.6	1.3	0.5	-0.1	0.6	9.6
Totals.....	22	3.0	1.6	1.6	0.5	1.1	1.0	-0.8	0.6	8.8
Light Group.										
Boys.....	11	3.0	1.5	0.5	0.4	0.8	2.3	-2.1	1.1	7.5
Girls.....	11	4.4	1.0	1.3	-0.2	0.9	2.4	-1.7	1.0	0.1
Totals.....	22	3.7	1.2	0.9	0.1	0.9	2.3	-1.9	1.0	8.2
Orange Group.										
Boys.....	13	2.7	1.2	0.9	0.3	1.3	1.5	-1.3	1.1	7.7
Girls.....	8	1.9	1.8	0.9	0.4	1.1	1.7	-0.2	0.4	8.0
Totals.....	21	2.4	1.4	0.9	0.3	1.3	1.6	-0.9	0.8	7.8

In considering these data it should be remembered that the orange and light treatments were not begun until the period of accelerated growth was near or at its close. The work will be continued another year and it is hoped that it will be possible to begin the treatments in September. In all other respects the project will be carried on as before [Project 158; Department of Home Economics; Purnell

The Vitamin Content of Some Common Fruits and Vegetables. During the past biennium, the work has consisted of investigations of the vitamins A, B, and C content of peaches and cherries canned by the open-kettle and cold-pack methods and the vitamin C content of Keifer pears, fresh and canned by the two methods. It was found that in early Richmond cherries canned by the open-kettle method the unit of vitamin A falls between one-eighth and one-fourth gram of cherry per rat per day. Cherries are therefore rich in vitamin A. When canned by the cold-pack method the following year they were slightly lower in vitamin A content than those canned by the open-kettle method. This variation may be a seasonal one. Experiments are in progress to determine whether the open-kettle cherries of consecutive years till show the same variation. The unit in fresh yellow Elberta peaches was found to be about one-half gram per rat per day. Experiments in progress indicate that white

peaches are a very much poorer source of vitamin A than yellow peaches.

Raw Keifer pears contain about 12 units of vitamin B per ounce, measured in terms of the requirement of a rat per day. This is about the same as lettuce. Early Richmond cherries canned by the open-kettle method have about nine units per ounce. Canned peaches, Elberta and white, open-kettle and cold-pack, show about six units per ounce in all cases.

Fresh Keifer pears show better than two units per ounce of vitamin C, which is somewhat higher than the figures usually given for fresh apple.

Fruits canned by the methods commonly employed in the home are very poor in vitamin C. Thus Elberta peaches and Keifer pears canned by the cold-pack method contain only about one unit and less than one unit per ounce, respectively. Early Richmond cherries, Elberta peaches, and Keifer pears canned by the open-kettle method had a very low vitamin C content.

The work will be continued next year. The newer concepts of the multiple nature of vitamin B will influence the methods used. Investigations are being planned to learn whether the vitamin content of fruits is influenced by such factors as variety of the fruit, season, or place where grown. Other foods will also be investigated. [Project 158; Department of Home Economics; Purnell funds.]

Utilization of Calcium and Phosphorus from Fresh, Dried, and Canned Milk. During the past biennium studies have been made with four adult subjects, using a carefully planned diet of ground beef, potatoes, prunes, orange juice, butterfat, sugar, and milk. The experiment was divided into three-day periods, two of them being devoted to each of four forms of milk: (1) Pasteurized grade A milk, (2) raw milk from the same source as the pasteurized, (3) evaporated milk, and (4) dried milk. The subjects received no cod-liver oil nor other food rich in vitamin D. Also they were kept indoors as much as possible so as to receive a minimum of ultra-violet light.

Milk, which furnished a constant amount of calcium throughout, was the only variable in the diet and furnished 68 per cent of the total calcium. The diet supplied an adequate amount of protein and sufficient calories for maintaining body weight. The total amount of calcium was planned to be near the minimum requirement suggested by Sherman so that differences in utilization might be apparent. Uniform methods of preparation and serving of foods were followed. All milk was consumed as a beverage without heating.

All foods were weighed and samples taken daily for analyses. All feces and urine were collected and analyzed for calcium and phosphorus. Balances between total intake and total output showed the comparative utilization of the minerals from the various kinds of milk. Since the subjects were all either very near equilibrium or in slight negative balance during the experiment differences should be apparent. Some of the results were as follows:

1. Using the balances obtained with fresh milk as standard, pasteurized milk gave a consistently lower calcium retention than fresh milk. On the other hand, evaporated milk showed a calcium retention at least as good as that obtained with raw milk.

2. Figures for phosphorus are less convincing than those for calcium since the diet was planned primarily for the study of calcium and the milk could not at the same time furnish the bulk of the phosphorus in the diet. In general the trend for phosphorus is the same as that for calcium.

3. The results for dried milk and evaporated milk confirm results previously secured with adult subjects at this station,

Similar experiments with dogs for subjects are now being started. [Project 159; Department of Home Economics; Purnell funds.]

A Study of the Change in the Ash Content of Vegetables During Storage and Cooking. An investigation of the calcium, phosphorus, and iron content of a number of vegetables was undertaken as preliminary to determining changes in ash content during storage and with different methods of cooking. Radishes, carrots, onions, potatoes, turnips, parsnips, and Jerusalem artichokes were used for the investigation. The carbohydrate as well as the ash content of the parsnip was ascertained for different methods and different lengths of time of storage. The results were as follows:

1. There was great variation in the amount of the three ash constituents present in different varieties of the same vegetable grown under different conditions. For example, white onions exceeded red onions by more than 35 per cent in total ash. This difference was largely in the phosphorus and iron content. Mature carrots showed a higher per cent of all three elements than the immature carrots. Texas carrots were lower in ash than Kansas carrots.

2. The alcohol-soluble sugars in parsnips increased during storage, the amount of the increase being governed by the time in storage and by the temperature.

3. The total carbohydrates in parsnips decreased during storage, the amount of the decrease being governed by the time in storage and by the temperature.

[Project 159; Department of Home Economics; state funds.]

The Protective Value of Certain Clothing Fabrics. The work on this project during the past biennium consisted of two phases: (1) A study of the protective value of certain clothing fabrics against heat loss from the body in still air and from air in motion, and (2) a study of the coefficient of protection offered the skin against sunburn by certain textile fabrics. The work was done in coöperation with the Department of Physics.

The method employed in studying heat loss was to compensate electrically the loss from an oil-filled copper cylinder placed in a well-insulated calorimeter. The ratio of energy input in case of the unclothed cylinder to that of the clothed cylinder was taken as the protective ration of the fabric in question. Heat loss was determined in still and moving air.

The fabrics tested were: Denim, Indian head, canton flannel, all cotton underwear (knit), mixed cotton and wool underwear (knit), blue broadcloth, baby shirt, red broadcloth, cotton underwear (fleece lined), outing flannel, canton flannel (nap outside), mixed flannel, Astrakhan (nap outside), and Astrakhan (nap inside). The pro-

tective ration of blue flannel (wool) and canton flannel (cotton) for different air velocities are shown in Table XXX.

TABLE XXX-THE COMPARATIVE PROTECTIVE VALUE OF BLUE FLANNEL (WOOL) AND CANTON FLANNEL (COTTON) IN STILL AND MOVING AIR.

NAME OF FABRIC.	Wind speed, miles per hour.	Potential difference in volts.	Current intensity in amperes.	Joules of energy to maintain body at 36° C.	Protective ratio.	Protection in per cent.
Bare cylinder.	0	3.35	0.603	2.178		
Blue flannel (wool)	0	3.11	0.65	1.875	1.63	14.0
Canton flannel (cotton)	0				1.07	7.7
Bare cylinder.	2.3	3.98	0.87	3.4626		
Blue flannel (wool)	2.3	3.80	0.83	3.1540	1.095	8.9
Canton flannel (cotton)	2.3	3.85	0.83	3.1955	1.086	8.0
Bare cylinder.	3.5	4.30	0.90	3.7800		
Blue flannel (wool)	3.5	3.85	0.83	3.1955	1.15	15.4
Canton flannel (cotton)	3.5	4.00	0.815	3.4200	1.105	9.5
Bare cylinder.	4.6	4.80	1.04	4.993		
Blue flannel (wool)	4.6	3.90	0.84	3.2760	1.52	34.3
Canton flannel (cotton)	4.6	4.12	0.88	3.6256	1.37	27.3
Bare cylinder.	8.6	4.85	1.15	5.5776		
Blue flannel (wool)	8.6	4.19	0.8888	3.6256	1.54	34.9
Canton flannel (cotton)	8.6	4.35	0.93	4.0455	1.37	27.3
Bare cylinder.	11.5	5.35	1.14	6.0900		
Blue flannel (wool)	11.5	4.32	0.90	3.8880	1.56	36.4
Canton flannel (cotton)	11.5	4.49	0.96	4.3104	1.41	29.3
Bare cylinder.	13.2	5.30	1.18	6.4600		
Blue flannel (wool)	13.2	4.30	0.92	4.0112	1.62	38.2
Canton flannel (cotton)	13.2	4.5	0.96	4.3200	1.50	33.4

The study of the protection afforded the skin against sunburn by textile fabrics has been continued following the plans reported for the biennium 1924-1926.

The results tend to prove that the protection depends principally upon the per cent of interspace due to weave. However, the vegetable fibers, cotton and linen, transmit some of the rays that burn and tan, the coefficient of protection being only three for the linen and four for the cotton. The animal fibers, silk and wool, on the other hand, absorb a portion of these, thus affording more protection. The coefficient of protection for these fabrics is 20 in both cases. These conclusions are doubly interesting in view of the fact that most infants when placed out of doors for exposure to the sun are completely or at least partly clothed in silk and wool, thus assuring ample protection from sunburn. [Project 161; Department of Home Economics; Purnell funds.]

BRANCH EXPERIMENT STATIONS

Four branch experiment stations located at Hays, Garden City, Colby, and Tribune are maintained primarily for the purpose of supplementing the work at the central station with special reference to conditions that prevail in the western part of the state. Satis-

factory progress has been made at all of the stations during the biennium. Improvements have been made to the physical equipment, including a new residence for the superintendent, a new greenhouse and service building, and the remodeling of several buildings at Hays; a new barn and an addition to the residence of the superintendent at Garden City; a new machine shed at Colby; and a new office building at Tribune.

The experimental work has been maintained upon a fairly high plane and the results of the work have been effectively presented to the farmers of western Kansas through field days, bulletins, and press reports. A total of nine field meetings have been held at the branch stations during the biennium. Something of the character and extent of the work of each of the branch stations is presented below.

FORT HAYS BRANCH EXPERIMENT STATION

The Fort Hays Branch Experiment Station was established on 3,600 acres of the old Fort Hays military reservation by legislative enactment in 1902. Approximately 2,000 acres are under cultivation, the remainder being pasture, creek bed, experimental feeding yards, campus, and state park. The station is equipped to conduct field experimental work with soils, crops, trees, and live stock. Brief statements regarding the principal projects follow.

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

The work involves a large series of tillage and rotation experiments where various cultural methods are used to determine their respective value. Studies are made of the value of sod crops and green manure crops in rotations and of the value of barnyard manure and commercial fertilizers. A study is also being made of the water-storage capacity of the soil, the relation between crop yields and the amount of moisture stored in the soil at seeding time, and to what extent the crops make use of the stored moisture. Meteorological observations are recorded to study the relation between climatic conditions and crop yields. The results show a marked advantage in having as much moisture as possible stored in the soil at seeding time since there is a close relation between the amount of water stored in the soil and the resulting yield.

The first effort made to harvest plats in such a manner as to leave a tall stubble similar to that left in general farm practice was made in the summer of 1926. A binder was used for this purpose, the platform being raised to its maximum height and the binding apparatus replaced by removable containers 30 by 60 by 24 inches high. In operation these were filled with headed grain, transferred to a low flat-top wagon, and hauled direct to the thresher. Thirty-eight plats were harvested by this method. The method proved

successful but not altogether satisfactory, as it was slow and laborious.

An improvement was made in 1927 by using a small Gleaner combine harvester having an eight-foot cut. This was mounted on a Fordson tractor, the Fordson carrying the entire weight of the machine and in addition supplied the motive power to run the harvester by means of a power take-off. One hundred plats were harvested with this outfit under very favorable conditions.

The success of the experiment during the seasons of 1926 and 1927 proved beyond a doubt the possibility of developing a practical machine for combining one-tenth-acre plats, and as a result a new machine has been constructed and is now ready for the 1928 crop. This machine consists of a Holt Caterpillar tractor, a Gleaner combine, and a Model T Ford motor. The Gleaner has been rebuilt and fitted on the Caterpillar, which carries the weight of the Gleaner and furnishes the tractive power. The Ford motor is mounted on the machine to furnish power to run the combine. The Caterpillar type of tractor distributes the weight of the outfit over enough ground to prevent damage to the surface soil, and makes possible shorter turns, which is an important point in combining small plats. The Ford motor guarantees uniform speed for the thresher. This outfit modernizes harvesting methods on the experimental projects and permits more efficient and effective work. [Fort Hays Experiment Station; state and federal funds.]

Cereal Investigations. Investigations of cereal crops adapted to western Kansas have been conducted at the Hays station since 1902, and in cooperation with the Office of Cereal Crops and Diseases of the United States Department of Agriculture since 1912. The work has consisted of nursery and varietal testing of domestic and foreign introductions and the improvement of crops by selection. Wheat, barley, oats, grain, sorghums, and corn have been the principal crops under investigation. Since hard winter wheat is the most important small grain and cash crop, the experiments with this crop have been the most extensive. Two cultural experiments with winter wheat, namely, time of seeding and pasturing, are reported herewith because of their application to western Kansas agriculture.

The time of seeding wheat is to some extent influenced by the amount of available moisture at seeding time and the kind of seedbed. In general, when moisture is available for germination in September, early seeding usually results in reduced yields, due to excessive fall growth and loss from Hessian fly infestation. The best average seeding date at Hays over a period of years, as shown by Table XXXI, is from September 20 to October 6. Seeded at this time wheat makes sufficient growth to become well established against winter hazards and emerges late enough to escape fly infestation. Seeding later than October 6 may result in weakened plants not able to survive soil blowing in the spring. Late seeding

followed by a cold, wet fall are favorable conditions for smut infection.

TABLE XXXI.—RESULTS OF DATE-OF-SEEDING EXPERIMENT WITH WINTER WHEAT.

DATE OF SEEDING.	Bushel yields per acre, 8-yr. average, 1920-'27 (a).			Per cent culms infested in the fall with Hessian flies (b).	Per cent smut recorded 1926.
	Cropped land.	Fallowed land.	Average. Cropped and fallowed.		
September 8	20.6	22.2	21.4	37	0
September 15	20.7	23.6	22.2	27	0
September 22	24.0	24.5	24.3	16	0
September 29	21.5	27.8	24.7	00.5	Trace
October 6	22.9	22.6	22.8	(c)00.2	Trace
October 13	18.0	16.1	17.1	0	3
October 20	16.1	14.6	15.4	0	5
October 27	15.0	13.7	14.4	0	5

(a) Hail destroyed 1923 crop; (b) 4-yr. average; (c) due to late infestation in fall of 1925 only.

The most practical rate of seeding has been found to be four pecks to the acre. No loss of yield occurs with a five- or six-peck rate of seeding, and such rates may prove slightly beneficial in dry autumns or if severe soil blowing occurs in the spring. With a well-prepared seedbed and abundant fall moisture wheat seeded during

TABLE XXXII.—RESULTS OF PASTURING WINTER WHEAT WITH HORSES. Fort Hays Branch Station.

Seedbed preparation and method of pasturing.	Approximate number acres required per animal.	Time of pasturing.	Yield in bushels.		
			1926.	1927.	2-yr. av.
FALLOW.					
Severe seasonal	1.5	Oct. 15 to Dec. 15; Mar. 1 to May 1.	13.8	11.8	12.8
Moderate seasonal	2.5	Oct. 15 to Dec. 15; Mar. 1 to Apr. 1	22.2	11.0	16.6
Chuck (not pastured)			16.7	14.5	15.6
Fall	3.5	Oct. 15 to Dec. 15	21.0	15.5	18.3
Spring	1.0	Mar. 1 to Apr. 15	21.6	11.1	16.4
Late spring	0.3	Apr. 15 to May 1	13.8	9.6	11.7
Clipped late spring (not pastured)			14.8	7.8	11.3
CROPPED LAND.					
Severe seasonal	2.0	Oct. 15 to Dec. 15; Mar. 1 to May 1	18.4	7.2	12.8
Moderate seasonal	4.0	Oct. 15 to Dec. 15; Mar. 1 to Apr. 1	19.9	0.2	14.6
Chuck			26.7	6.7	16.7
Fall	4.5	Oct. 15 to Dec. 15	19.5	9.5	14.5
Spring	2.0	Apr. 1 to Apr. 15	20.3	9.4	14.9
Late spring	0.6	Apr. 15 to May 1		8.3	

the last week of September at the rate of three pecks per acre may prove satisfactory.

Because of the demand for information on the effect of pasturing winter wheat by live stock, an experiment was begun in 1926 to determine the effect of different methods of pasturing on yield. The amount of pasture available from wheat is largely influenced by the moisture supply of the seedbed and the fall growth.

The data which are presented in Table XXXII indicate that moderate pasturing of wheat with a heavy growth causes no injury and may even prove beneficial, besides providing an appreciable amount of excellent feed for live stock. Where the growth of wheat is limited, pasturing generally results in reduced yields. In seasons of drought and slow fall growth, wheat pasture cannot be depended upon to supply feed for live stock. The experiment is being continued. [Fort Hays Experiment Station; state and federal funds.]

Forage Crop Investigations. Results of this project have been largely cumulative from year to year since its organization April 1, 1913, in cooperation with the Office of Forage Crop Investigations of the United States Department of Agriculture. The work consists of field experiments relating to the culture and improvement of the principal cultivated forage crops adapted to this section. Sorghums, being the heaviest yielding of these crops, have received the most attention. Other crops extensively tested include Sudan grass, millet, alfalfa, sweet clover, cowpeas, and soybeans.

Results for the past biennium have been of particular interest on account of the climatic extremes, the growing season of 1926 being very dry and that of 1927 one of the wettest on record. Table XXXIII, showing yields of several leading sorghums in comparison with corn, illustrates the wide departures from normal that occur

TABLE XXXIII-YIELDS OF SEVERAL SORGHUMS AND CORN AT HAYS, KAN., FOR 1926 AND 1927, AND AVERAGE YIELDS FOR 1914 TO 1927.

VARIETY.	Total crop air dry; tons per acre.			Grain yields; bus. per acre (c).		
	1926.	1927.	Average, 1914-1927.	1926.	1927.	Average, 1914-1927.
Black Amber.....	1.48	4.23	3.15	5.0	32.9	25.3
Early sumac.....	1.38	4.82	(a)3.32	1.6	42.9	(a)21.5
Kansas Orange.....	1.56	6.12	3.83	0.0	48.6	10.8
Pink kafir.....	1.28	4.98	(b)2.94	0.0	59.1	(b)25.7
Dawn kafir.....	1.35	4.52	2.83	0.9	50.7	25.5
Dwarf Yellow milo.....	0.87	3.63	2.62	1.6	39.5	24.5
Feterita.....	1.30	3.67	2.54	6.8	47.3	28.0
Freed.....	1.50	3.54	2.36	12.2	29.8	22.5
Bloody Butcher corn.....	1.04	3.24	2.07	0.0	52.1	16.7

(a) Average for 1926 to 1927; (b) Average for 1915 to 1927; (c) grain yield Calculated at 56 lbs. per bushel.

at Hays under such conditions. Such early maturing hardy varieties as Freed, feterita, and Black Amber, best withstood the adverse conditions of 1926, but responded less than larger varieties to the favorable conditions of 1927. For the 14-year period, the principal sorghums outyielded corn by about 50 per cent.

One of the principal lines of work has had to do with a cross of Early sumac with Dwarf hegari for the purpose of developing a white-seeded smut-resistant sumac. Several white-seeded selections have been obtained and the F₄ generation is being tested in 1928 for smut resistance.

Upland alfalfa plats, both in rows and in close drills, failed rapidly due to the dry conditions of 1926 and of October to January, inclusive, in 1927-'28. For the latter four months the precipitation was lower than ever before recorded during 60 years for which records are available. These experiments, which were begun in 1913 and 1915, show that upland alfalfa can be maintained for 10 to 12 years, yielding one or two cuttings a year, amounting to about a ton per acre. Common Kansas alfalfa lasted as well as Grimm or other expensive hardy northern varieties. [Fort Hays Experiment Station; state and federal funds.]

Beef Cattle Feeding Investigations. The feeding experiments for the biennium as in the past were concerned largely with the utilization of western Kansas feeds for the maintenance of beef cattle.

The 1926-'27 feeding trials were planned to study (1) the relative value of shocked kafir and kafir fodder silage as a winter ration for yearlings and calves, (2) the relative value of alfalfa hay and cottonseed cake as protein supplements for kafir fodder silage as winter rations for yearlings and calves, and (3) the relative value of cottonseed hulls and headed wheat straw as wintering rations for yearlings and calves.

The results of these trials show that an acre of kafir silage produced 71.4 per cent more gain than an acre of shocked kafir when each was supplemented with alfalfa hay and only 22.5 per cent when each was supplemented with cottonseed cake. One pound of cottonseed cake (43 per cent protein) proved to be a little more efficient than 4 pounds of alfalfa hay when fed as a protein supplement for shocked kafir.

Cottonseed hulls proved more satisfactory pound for pound than headed wheat straw for producing gains on yearlings when each was supplemented with 2 pounds of cottonseed cake.

In addition to the feeding experiments, a fly-salt experiment was carried out during the grazing season of 1927. A group of yearling cattle were divided into two groups, one given access to common salt and the other to a new so-called fly salt said to have the property of repelling flies from the animals consuming it. Both lots were grazed on the same kind of pasture. The results of this test are shown in Table XXXIV.

It will be noted that the cattle receiving ordinary salt gained slightly more than the cattle receiving the so-called fly-repellent salt. The common salt cost 40 cents per hundredweight and the so-called fly-repellent salt sold on the local market at \$2.40 per hundredweight.

TABLE XXXIV.-FLY SALT VERSUS ORDINARY SALT FOR GRAZING CATTLE.

Lot No.....	1	2
Kind of salt.....	Fly salt	Ordinary salt
Kind of cattle.....	Yearlings	Yearlings
Time on pasture.....	156 days	156 days
Average initial weight.....	615 lbs.	595 5 lbs.
Average final weight.....	786 lbs.	771 4 lbs.
Average gain per steer.....	171 lbs.	175.9 lbs.
Average daily gain per steer.....	1.09 lbs.	1.12 lbs.

[Fort Hays Experiment Station; state funds.]

Dairy Cattle Pasturing Investigations. The milking herd is supplied with Sudan grass pasture and sweet-clover pasture which are grown on fallow land. In 1926, a very dry season, sweet clover provided pasture from May 12 until June 21. Altogether there were 533 milking days and 163 dry-cow days of grazing. The total production of milk during the period was 15,811.5 pounds, or an average daily production of 29.66 pounds.

A similar experiment was conducted during the early summer of 1927 on the same field which, however, had thickened up considerably from reseeding the previous year. This season only 10 cows were milking. These were turned on the sweet clover May 20 and removed June 25. The pasture provided a total of 370 milking days and 37 dry-cow days. The cows produced 10,961 pounds of milk, or an average daily production per cow of 29.6 pounds.

Sweet clover is especially valuable in providing early pasture. About the time the sweet clover is exhausted the cows can be turned on Sudan grass pasture, thus affording a pasture season of several months without break.

Sudan grass pasture was made available to the dairy cows July 1, 1927. A field of 15.2 acres was divided into two fields. Rains during the summer kept the pasture growing vigorously, permitting heavy pasturing, and produced considerable Sudan hay in addition. The equivalent of 14 head of cows were pastured for 97 days. The average daily milk production was 344.6 pounds per day from 12 cows, or a daily average per cow of 28.7 pounds. The cows were removed October 5. The hay cut from the field amounted to 8.36 tons, or 0.55 of a ton per acre. [Fort Hays Experiment Station; state funds.]

State Forest Nursery. The work in the Forest Nursery has been

a continuation of that of the previous years in experimental planting of new and untried trees and in the propagation and distribution of the hardy types adapted to western Kansas.

The new greenhouse and service building has been completed and is in use, mainly for propagating certain varieties of trees and shrubs. The storage basement which will later carry the packing shed has been extensively used for the winter and spring storage of nursery, and has proved most useful.

The number of orders received were 758 in 1927 and 1,017 in 1928. The distribution of Chinese elms alone in 1928 reached the total of 5,284, these being mostly from 4 to 6 feet in size. Trees were distributed in 79 counties in Kansas in 1928. Through a coöperative arrangement with the Forest Service of the United States Department of Agriculture, the Forest Nursery was able for the first time to distribute forest-tree seedlings for use in planting windbreaks and woodlots. The first year's distribution consisted of 10,572 seedlings of various hardy varieties.

Twenty of the newer hardy types of shrubs were planted for determination as to hardiness and general value for yard plantings. Some hardy varieties of plums from the Dakotas were introduced also. The old orchard which had largely been planted to apples of what are now termed inferior varieties is rapidly being replaced with hardy types of sour cherries. Experiments indicate that the sour cherry is one of the few fruits which can be successfully grown in western Kansas. The station has not failed to grow a cherry crop during the past seven years. Apples produced one partial crop during this period, and two fairly good crops of pears have been obtained. Apricots produced a few small, insignificant fruits one year out of the seven. Plums were obtained two years out of the seven.

Through coöperative arrangement with the Horticultural Division of the Bureau of Plant Industry of the United States Department of Agriculture several varieties of the more promising potato varieties now being developed were sent to the station for trial. Similar work is being done with grapes by arrangement with the Woodward Field Station, at Woodward, Okla. [Fort Hays Experiment Station; state and federal funds.]

Pure Seed Distribution. The growing and distributing of pure seed has become one of the major functions of the station. The growing season of 1926 proved very severe for the sorghums, and only a small amount of seed was produced, all of which was sold. The season of 1927 proved the best year in the history of the station in so far as the production of pure seed was concerned, as over 10,000 bushels of sorghum seed were threshed. A large distribution of this seed was made, reaching 86 counties in Kansas, 12 neighboring states, Mexico, and Canada. The station disposed of 134,539 pounds of sorghum seed, 12,491 pounds of seed barley, 178,490 pounds of seed wheat, and 1,855 pounds of seed corn during the fiscal year ending July 1, 1928. [Fort Hays Experiment Station; state funds.]

GARDEN CITY BRANCH EXPERIMENT STATION

The Garden City Branch Experiment Station consists of 320 acres of upland five miles northeast of Garden City, Finney county. The experimental work is divided into two main projects: Dry-land agriculture and irrigation agriculture. A limited amount of experimental work is also being done with live stock. At the present time the latter consists mainly of a grazing study of different grasses for use in irrigated pastures for dairy cows and of alfalfa as a pasture crop for hogs. Irrigation water is obtained from a deep-well pumping plant. A shallow-water plant is now being installed for use on the lower levels and will materially reduce the cost of irrigation on that part of the farm.

Dry-land Agriculture. The Office of Dry-land Agriculture, United States Department of Agriculture, is coöperating with the station in conducting experiments with crops grown on unirrigated land. The project is a continuation of that started at the time of the establishment of the station in 1907. It consists of approximately 30 acres of land and is divided into one-tenth- and one-twenty-fifth-acre plats. The work consists of tests with rotations, tillage methods, methods of fallow, seedbed preparation, and rates and dates of planting with winter wheat and sorghums.

Some rather definite conclusions have been drawn from the date-of-planting test with sorghums. Eight varieties have been planted on four dates: May 15, May 30, June 15, and June 30. With one exception the May 30 date has proved the best on which to plant. As most farmers had been planting in early May this information is of considerable practical value.

The results of the seedbed test have proved the value of a clean seedbed for the sorghum crops. An average increased yield of 5.2 bushels of grain to the acre was secured as the result of one cultivation in the spring prior to planting.

In addition to the work mentioned above considerable space is given to the testing of different varieties of corn, grain sorghums, forage sorgos, and small grains, and to spacing experiments with Dwarf Yellow milo. Cassel White Dent, Freed White Dent, and Colby Bloody Butcher are the highest yielding varieties of corn. A new variety, Hays Golden, has been included in the test during the past two years and looks promising. Dwarf Yellow milo, Wonder kafir, feterita, Sunrise, Dawn, and Pink kafirs have been the highest-yielding grain sorghums. Standard sumac and Kansas Orange sorgos have been the highest-producing forage varieties. Blackhull and Kanred winter wheats, Kanota oats, and Club Mari-out and Coast barleys have been the most satisfactory small grains.

Two coöperative corn and sorghum tests with farmers on sandy land were started in 1923 in an effort to learn if the varieties that have proved best at the station on heavy soils are also the most satisfactory for use on sandier types of soil. The data available to date indicate that the outstanding varieties for our heavier soils

are also well adapted to those of a sandier nature. [Garden City Experiment Station; state and federal funds.]

Irrigation Agriculture. The work on the irrigation project is a continuation of that outlined in 1920 with a few modifications and additions. It consists of experiments in rate and season of watering alfalfa; stage of growth and frequency of cutting alfalfa; rotations that include alfalfa, forage crops, grain sorghums, sugar beets, and barley as compared with the same crops grown continuously without alfalfa; fertility experiments with alfalfa, Dwarf Yellow milo, winter wheat, and sugar beets; variety tests with corn, sorghums, and small grains; grass mixtures compared with sweet clover alone for dairy-cow pastures; and with alfalfa as a pasture crop for hogs. Corn hybrid, sugar beet variety, and milo disease nurseries were started in the spring of 1928.

From the season-of-watering experiments, it appears that alfalfa makes better use of water that is applied in the early spring than of equal amounts applied late the previous fall. Spring irrigation tends to stimulate an earlier and more vigorous growth, resulting in a heavier first crop. The rate-of-watering experiment shows that alfalfa requires 36 to 42 inches of irrigation water annually for best results. Smaller amounts of water result in materially decreased yields. Heavier applications than 42 inches produced larger yields, but the increase is not sufficient to justify the additional cost of the water,

The stage-of-growth and frequency-of-cutting experiment with alfalfa was started in 1926 for the purpose of learning if alfalfa can be cut before the flower buds have formed, or at the time the first ones appear, for the first two crops each year without weakening the plants to such an extent as to result in loss of stands. A much better quality of hay can be obtained from the first and second crops if early cutting can be practiced. The experiment is so planned that data will be secured on six different harvest practices, and it is hoped that a satisfactory method can be developed which will permit of early cutting.

Increased yields of both grain and forage have resulted when sorghum crops have been grown in rotation with alfalfa. The difference in favor of rotation is increasing from year to year and in the case of grain yields of Dwarf Yellow milo has passed the 50 per cent mark in each of the past two seasons. The average for the seven-year period that the experiment has been conducted is 30 per cent. The favorable results obtained through the use of alfalfa in rotation with nonleguminous crops is especially interesting since barnyard manure and commercial fertilizers have not materially increased yields of Dwarf Yellow milo, winter wheat, or alfalfa. Sugar beets and irrigated pasture grasses, however, have responded to applications of barnyard manure.

Many varieties of farm crops are under experiment each year. Freed White Dent and Colby are the best yielding varieties of corn that have been grown on irrigated land. Two additional varieties,

Cassel White Dent and Hays Golden, were grown in nursery plats in 1926 and 1927 and look very promising. Dwarf Yellow milo, Sunrise, Dawn, Bowers Wonder, and Pink kafirs are the highest-yielding grain sorghums under experiment. Several strains of straight neck milo are being tried out in hopes of securing a crop that will have the yielding ability of Dwarf Yellow milo without also having the objectionable crooked necks so often found in that variety. One strain in particular looks promising. Honey, Standard sumac, and Kansas Orange sorgos are the highest yielding forage crops under test.

Dwarf Yellow milo is not susceptible to diseases that attack most sorghums, but during the past three years an unknown disease has appeared on the station that is very disastrous to milo. A small block of land was planted in the spring of 1928 for use in studying this disease and possible methods of control. This work is being done in coöperation with the Plant Pathology Laboratory of the Bureau of Plant Industry, United States Department of Agriculture.

The work with irrigated pastures is a continuation of experiments started in 1920 and consists of two lots of pigs on alfalfa pasture and of three lots of dairy cows on sweet clover and grass mixtures. One group of pigs is self-fed on ground milo in addition to having access to alfalfa pasture for a period of about 105 days beginning the latter part of June, and the other group is fed a daily ration of 2 pounds ground milo for every 100 pounds live weight. The full-fed pigs make rapid gains throughout the season and carry sufficient flesh by the close of the pasture period to permit of their being shipped direct to market, thus taking advantage of the higher market prices before the drop in prices which usually occurs the latter part of September or the fore part of October. The pigs receiving the limited ration make fair growth, but require a period of dry-lot feeding after the close of the pasture period, and they are not in marketable condition until after the fall break in prices. The pigs from the 1927 full-fed lot sold for \$10.55 per hundred on October 8 while the limited-ration pigs brought but \$7.50 on December 5, after being brought to the same weight and finish as those in the former lot. While the decline in prices in 1927 was somewhat greater than usual, a similar decline is usually a factor in determining profit or loss on spring pigs, fed for the fall or early winter markets.

The average daily gain per pig in the full-fed pen during the five-year period has been 1.29 pounds; grain required to produce 100 pounds of gain, 395.72 pounds; and gross returns per acre above feed costs, \$105.42, which is equivalent to \$17.57 per ton for the alfalfa. The average daily gain per pig in the limited ration pens has been 0.55 of a pound; milo required to produce 100 pounds of gain, 293.11 pounds; gross returns per acre above feed costs, \$72.05, or the equivalent of \$12.01 per ton for the alfalfa. Both lots have paid well for the alfalfa they consumed and have eliminated the usual harvest cost. [Garden City Experiment Station; state funds.]

COLBY BRANCH EXPERIMENT STATION

The Colby Branch Experiment Station contains 274 acres of land and lies immediately southwest of Colby, Thomas county. The work is divided into three major phases: Dry-land agriculture investigations, a study of varietal adaptation of crops, and a dairy herd improvement project. A brief outline of each is given below.

Dry-land Agriculture Investigations. This work in coöperation with the Office of Dry-land Agriculture, United States Department of Agriculture, has continued without material change since its organization in 1914. The project now consists of 180 tenth-acre plats embracing 41 rotations ranging in length from 2 to 4 years. The chief work of the project is a study of the effect of crop rotation and of the effect of different methods of tillage on winter wheat, spring wheat, oats, barley, corn, milo, and kafir. Other harvested crops are feterita and pinto beans.

Some of the rotation results secured with winter wheat are as follows :

	Bushels per acre.
Winter wheat after barley (8-year average)	7.7
Winter wheat after winter wheat (8-year average)	8.3
Winter wheat after pinto beans (8-year average)	13.0

Eleven-year averages with winter wheat on different seedbed preparations are as follows:

	Bushels per acre.
Winter wheat on late fall plowed land, continuously cropped.	11.1
Winter wheat on early fall plowed land, continuous.	7.0
Winter wheat on early fall plowed land in a rotation.	9.5
Winter wheat on summer tilled land (average six plots).	18.9
Winter wheat drilled in corn stubble, ordinary spacing.	8.8
Winter wheat drilled in corn stubble, alternate row corn.	11.2
Winter wheat after rye for green manure, then summer worked.	18.6
Winter wheat drilled in milo stubble.	10.6
Winter wheat stubbled in winter wheat stubble.	9.0

Soil moisture determinations were continued during the biennium on the winter wheat plats sampled by foot-units to a depth of 6 feet. These samples are taken weekly during the spring growing season until the removal of the crop and duplicate samples are taken in the fall at or near the seeding date. Samples are taken on eight seedbed preparation plats for winter wheat. The sampling has been continued for eight years and eventually will prove valuable in a study of tillage operations and moisture studies in relation to winter wheat yields. [Colby Experiment Station; state and federal funds.]

Crop Adaptation. A study of crop adaptation includes variety work with corn, winter wheat, oats, barley, spring wheat, and sorghums; also coöperative nursery work with corn and barley. Two hundred fifty strains of corn and the best of over 1,000 strains and varieties of barley were grown. Additional head selections were made of local barleys which are proving to be the highest yielding types. Four strains of Colby corn were also grown in isolation

plots. The uniform winter-hardiness wheat nursery, and uniform spring-wheat and oats-rust nurseries were continued. Also a leaf rust nursery was seeded each year of the biennium.

Twenty-one varieties of corn have been under test during the biennium. A strain of Colby developed by selection on the station has produced the highest average annual yield.

During the biennium seven varieties were tested in the winter wheat variety test. Nine-year averages for the more important varieties are as follows:

	Bushels per acre.
Kanred	27.1
Kharkof	25.5
Blackhull	25.3
Turkey	22.9

Other variety work during the biennium included the testing of 8 varieties of spring wheat, 7 varieties of oats, 21 varieties of barley, 27 varieties of sorghum, and the introduction of 6 nursery barleys into the 1928 planting.

A small amount of horticultural and forestry variety planting was started during the biennium. This consisted of duplicate plantings of 20 varieties of grapes, 6 varieties of plums, and 3 of cherries. Testing of shrubs and trees consisted of the planting of 10 species of evergreens in duplicate and over 50 different shrubs, trees, plants, and vines. Both variety-testing plats and ornamental plantings were made.

In the fall of 1918 a comparison of the ordinary 8-inch row-spaced wheat drill with a furrow drill which plants the grain in small lister furrows 12 inches apart was begun. These tests have been uniformly conducted on land previously summer tilled. Seeding east and west and north and south and at four different rates of seeding have been included. The average yields of tests classified as to rates of seeding are shown in Table XXXV.

TABLE XXXV.—FURROW VERSUS THE PRESS DRILL IN A RATE-OF-SEEDING TEST.

RATE OF SEEDING PER ACRE.	Yield in bushels per acre.		
	Press drill.	Furrow drill.	Average.
<i>Pks.</i>			
4.....	23.2	25.6	24.4
3.....	23.7	26.9	25.3
2.....	23.9	24.9	24.4
1.....	24.7	22.2	23.4
Average all rates.....	23.9	24.9	.....

These results show the optimum rate of seeding, under the conditions of the experiment, to be from 2 to 4 pecks per acre. The

method of seeding seemed to make no material difference in the optimum rate.

A comparison of the two types of drills shows the furrow drill to be distinctly superior to the press drill at the 3- and 4-peck rates of seeding, and possibly better at the 2-peck rate of seeding. For the very thin rate of 1 peck per acre, the press drill is evidently better than the furrow drill. [Colby Experiment Station; state funds.]

Dairy Improvement. Dairy work was first started in the fall of 1915 at Colby with the purchase of six grade Shorthorn-Ayrshire cows and a pure-bred Ayrshire bull. The object was to develop a good-type daily cow and uniform production from ordinary farm cows by the use of pure-bred sires. A few pure-bred females have been purchased from time to time and a rather careful selection of the grade female stock has been made in recent years. The milking head now consists of nine grade Ayrshire cows and three pure-bred Ayrshires. The grades are all descended from the foundation animals purchased in 1915. All but one of them trace to two foundation cows. Uniform production and reasonable uniform type have been secured in second- and third-cross heifers. For the latter some line breeding has been resorted to for the fixation of type and production. Marked improvement in production has resulted in a number of instances. The dairy is maintained in a manner approaching farm conditions. No official testing has been done but accurate daily milk and monthly butterfat records are kept. [Colby Experiment Station; state funds.]

TRIBUNE BRANCH EXPERIMENT STATION

The Tribune Branch Experiment Station is located midway between the Arkansas and Smoky Hill rivers in Greeley county, 16 miles from the Colorado line. This territory in its native condition was a grazing region and since being brought under cultivation is used chiefly for the production of feed crops, although wheat is sown on about one-third of the cultivated land.

Experiments of the last two years have shown the suitability of sorghums for the production of both grain and forage. In 1926, with the lowest rainfall since the station was established, Freed sorgo, Early sumac, Red Amber, and several others yielded between one-half and three-fourths of a ton of fodder per acre, and Sudan grass on fallow produced 2,300 pounds of hay. Early sumac and Red Amber yielded 3 tons in 1927 and averaged 3 1/2 tons over a longer period. Grain was produced in 1926 by several new strains developed from a cross of Pink kafir and Freed sorgo and Freed sorgo yielded 5.2 bushels per acre. Dwarf Yellow milo has made 22.6 bushels; Sunrise kafir, 17.7 bushels; and Feterita, 16.5 bushels as an average for the last six years.

During the same six-year period Cassel's White Dent made an average yield of 21.1 bushels per acre, Freed White Dent 19.2 bushels, and Colby 18.2 bushels per acre. In 1926 the varieties of

corn produced no grain, as was true also of sorghum, except the earliest varieties, and in 1927, which was also a dry season, these varieties of corn made about one-half as much as adapted varieties of grain sorghums.

Winter wheat yielded well in 1926, but was practically a failure in 1927 due to drought. Kanred and Blackhull both yielded 16 bushels in 1926, making 2 bushels more than Turkey, but for the last six years Kanred has averaged 13.6, Blackhull 8.3, and Turkey 11.1 bushels per acre.

Oats and barley produced about the same number of pounds per acre during the last two years and also for the last six years. Club Mariout, the highest-yielding variety of barley, made 13 pounds per acre less in the two-year period than Kanota, the best variety of oats, and averaged 30 pounds per acre more than Kanota in the six-year period.

Potatoes made about 60 bushels an acre in 1926 and 125 bushels in 1927. Irish Cobbler and Red River Ohio have each averaged 96 bushels per acre over a five-year period.

Garden crops were successfully grown the last two seasons as well as in preceding years where limited irrigation was provided. [Tribune Experiment Station; state funds.]

STATION PUBLICATIONS

The results of investigations by the Agricultural Experiment Station are reported in three series of publications: Bulletins, research or technical bulletins, and circulars.

Bulletins. The reports of specific investigations for popular distribution are published as bulletins. The material is presented in such a manner as to be readily understood by the average reader. Nine new bulletins were printed during the biennium.

Technical Bulletins. Reports of detailed scientific investigations too technical for the average reader but of value to the investigational and technically trained reader are published as technical bulletins. Three such bulletins were issued during the biennium.

Circulars. Brief popular reports of experimental results and popular discussions on various agricultural problems are published as circulars. Fifteen circulars were published during this biennium.

The following are the regular station publications listed by series and showing the title, size of edition, and the number of pages issued during the biennium:

GENERAL BULLETINS			
NO.	Title.	Edition.	Total Pages. pages.
237	Federal Aid as a Part of a Long-time Agricultural Policy..	10,000	5 4 540,000
238	Corn Production in Kansas.....	25,000	4 2 1,050,000
239	Crop Production in Southwestern Kansas	10,000	3 0 300,000
240	Sheep Production in Kansas.....	15,000	7 6 1,140,000
241	Blackhull Wheat in Kansas.....	30,000	2 4 720,000
242	Alfalfa Production in Kansas.....	35,000	4 2 1,470,000
243	Equipment for Swine Production.....	20,000	4 6 920,000
244	The Effects of Shortage of Farm Storage Space and Inability to Get Local Bank Credit on the Movement of Kansas Wheat to Market	7,500	29 217,500
245	A Poultry Survey in Kansas.....	10,000	52 520,000

TECHNICAL BULLETINS

21	Bacillary White Diarrhea in Fowl.....	5,000	85	425,000
22	The Control of Sorghum Kernel Smut and the Effect of Seed Treatments on Vitality of Sorghum Seed.....	5,000	37	185,000
23	The Importance of Vitamin A and Vitamin C in the Ration of Swine	7,500	48	360,000

CIRCULARS

126	Rabies-Hydrophobia-Dog Madness	15,000	6	90,000
127	Fitting and Exhibiting Standard-bred Poultry.....	20,000	39	780,000
128	Cattle Feeding Investigations, 1924-25	15,000	14	210,000
129	Economic Plant Diseases Common in Kansas and Their Control.....	15,000	23	345,000
130	Cattle Feeding Investigation 1925-26.....	15,000	5	75,000
131	Lamb Feeding Investigation 1925-26.....	10,000	4	40,000
132	Year-to-year and Seasonal Fluctuations in Hog Prices.....	20,000	14	280,000
133	Growing Flax in Kansas	5,000	10	50,000
134	Grape Growing in Kansas	15,009	32	480,000
135	Infectious Abortion of Cattle	10,000	11	110,000
136	Killing Field Bindweed with Sodium Chlorate.....	17,500	15	262,500
137	Judging Price Risks in Marketing Hogs.....	15,000	29	435,000
138	Swine Feeding Investigations, 1923 to 1926.....	10,000	14	140,000
139	Filling Silos	15,000	8	120,000
149	Tomato Wilt Disease.....	7,500	5	37,500

SPECIAL PUBLICATION

The Fungous Flora of Kansas.....		2,000	46	92,000
----------------------------------	--	-------	----	--------

DIRECTOR'S REPORT

Director's Report, 1924-1926.....		2,000	162	324,000
-----------------------------------	--	-------	-----	---------

SOME INFORMATION REGARDING EACH PUBLICATION ISSUED

BULLETINS

Bulletin 237: Federal Aid as a Part of a Long-time Agricultural Policy.

This subject is discussed in this bulletin "with special reference to the distribution of tax levies." An analysis is presented of federal aid for agricultural experiment stations, agricultural extension, vocational education, and construction of rural highways, the last three being the principal parts of the "fifty-fifty" system. The main arguments against federal aid are stated and analyzed with respect to each type under four heads: (1) The constitutionality of federal aid; (2) state and local initiative under federal aid; (3) the assertion that federal aid diverts funds to purposes of subordinate local importance; and (4) federal aid from the standpoint of fairness in the distribution of taxes among the states. The author comes to the conclusion that the arguments against federal aid for these purposes are mainly erroneous. Precedents for federal aid and data on its operation and results are presented. (By Eric Englund, Department of Agricultural Economics. 54 pages; 12 figures; 4 tables.)

Bulletin 238: Corn Production in Kansas. This bulletin undertakes to answer most of the questions Kansas farmers ask concerning this important crop. Some of the more important features discussed are: (1) Where corn should be grown. (2) Varieties of corn. (3) Preparing the seedbed. (4) Time, rate, and methods of planting. (5) Cultivating and harvesting corn. (6) Control of insect pests of corn. (By S. C. Salmon, Department of Agronomy. 42 pages; 19 figures; 7 tables.)

Bulletin 239: Crop Production in Southwestern Kansas. This bulletin discusses the production of crops in southwestern Kansas, being based primarily on the results of experiments at the Garden City branch of the Agricultural Experiment Station. The peculiarities of the soil and climate of this section are pointed out and their relations to crop production discussed. The best crops to grow in southwestern Kansas, the need of a balanced agriculture, and the relation of live-stock and crop production receive attention. The two principal crops of this area, winter wheat and the sorghums, receive special attention with respect to varieties, tillage methods, time and rate of seeding, cultivation, etc. The need of trees and lawns to make the farm home more attractive is recognized and methods of securing them are discussed.

(By E. H. Coles, Office of Dry-land Agriculture, United States Department of Agriculture, and F. A. Wagner, superintendent of Garden City Agricultural Experiment Station. 30 pages; 7 tables; 7 figures.)

Bulletin 240: Sheep Production in Kansas. The purpose of this bulletin is to furnish specific information relative to the many problems that confront sheep raisers and feeders in Kansas. The bulletin is divided into six sections: I. Introduction, which discusses the general sheep situation; Kansas as a sheep state; and the part the owner plays in successful sheep production. II. Types and breeds of sheep. Each breed is carefully described and illustrated with pictures of prize winners. III. The farm flock. Establishing and managing is discussed in detail. IV. Pastures for sheep. The importance of pasture and pastures suitable for sheep is presented. V. Shelter and equipment. Suggestions of a practical nature are offered. VI. Feeding western lambs for market. Selection, feeding, and marketing western lambs are discussed in a thorough and practical manner. (By H. E. Reed, Department of Animal Husbandry, 76 pages; 41 illustrations.)

Bulletin 241: Blackhull Wheat in Kansas. Blackhull wheat in Kansas should be of interest to every wheat grower in the state who has considered growing this popular variety. Its strong points and weak points are pointed out in an impartial manner, especially with respect to such qualities as (1) resistance to winter killing, (2) lodging, (3) time of maturity, (4) resistance to Hessian fly, (5) yield, and (6) quality. Mention is also made of Superhard Blackhull. (S. C. Salmon and H. H. Laude, Department of Agronomy, and C. O. Swanson, Department of Milling Industry. 24 pages; 9 tables; 3 figures.)

Bulletin 242: Alfalfa Production in Kansas. This bulletin discusses the factors which have been responsible for the decline in the acreage of alfalfa in Kansas and the importance of this legume to Kansas agriculture. It also describes the methods of alfalfa production and harvesting and discusses the different varieties of alfalfa and their adaptability. The more common alfalfa diseases, insect enemies, and injurious rodents are discussed and methods of control suggested. (By R. I. Throckmorton and S. C. Salmon, Department of Agronomy. 42 pages; 8 tables; 12 figures.)

Bulletin 243: Equipment for Swine Production. This bulletin deals with the equipment that is necessary for successful swine production and gives complete discussions of the various types of hog houses, their advantages, and disadvantages; also details for construction. The equipment necessary for feeding is discussed and illustrated in detail. A few articles of equipment necessary for care and management, such as pig creeps, breeding crates, castrating troughs, loading chutes, and shipping crates are illustrated and discussed in detail: The appendix lists plans for hog houses and equipment that may be obtained for a nominal price. (Prepared in cooperation with the Engineering Experiment Station of K. S. A. C. By B. M. Anderson, Department of Animal Husbandry, and V. R. Hillman, Department of Agricultural Engineering. 46 pages; 32 figures.)

Bulletin 244: The Effects of Shortage of Farm Storage Space and Inability to Get Local Bank Credit on the Movement of Kansas Wheat to Market. Causes and effects of seasonal surpluses of wheat is the theme of this bulletin. (1) The probable influence of a short marketing period for wheat upon wheat prices; (2) the volume of wheat marketed in excess of mill and export demand; (3) the extent to which shortage of farm storage space causes early marketing; and (4) the extent to which inability on the part of farmers to get local bank credit causes movement of wheat to market are the principal problems discussed. (By R. M. Green, Department of Agricultural Economics. 29 pages; 9 tables; 6 figures.)

Bulletin 245: A Poultry Survey in Kansas. A personal house-to-house visit was made in 250 different farms in 10 representative counties in order to obtain an accurate cross section of the poultry industry in Kansas. The subjects upon which information was obtained included housing, incubation, brooding, management, feeding, breeding, diseases, marketing, and miscellaneous items. Tables giving the actual practices as carried out with each of

these different subjects are listed and worked out on a percentage basis for each of five districts and for the entire state. (By Loyal F. Payne and Howard H. Steup, Department of Poultry Husbandry. 52 pages; 13 tables; 9 figures.)

TECHNICAL BULLETINS

Technical Bulletin 21: Bacillary White Diarrhea in Fowl. This bulletin reports the findings on the disease bacillary white diarrhea in the domesticated fowl as determined by various workers in the field and by the members of the staff of the Agricultural Experiment Station. The report includes a study of the physiology and seriology of *S. pullorum* (the organism causing the disease) and the incidence of the disease in adult fowls and chicks. It also discusses symptoms and pathology; sources and modes of infection; influence on fertility and hatchability; treatment of the disease by means of sour-milk therapy; and methods of testing flocks for the presence of reactors. This disease causes heavy losses of chicks and breeding stock and the only method of control is testing all breeding birds; carefully eliminating all reactors; and using strict sanitary precautions in the hatching and brooding of chicks. The method of conducting the agglutination test is described in detail. (By L. D. Bushnell, W. R. Hinshaw, and L. F. Payne. Departments of Bacteriology and Poultry Husbandry. 85 pages; 36 tables; 4 figures.)

Technical Bulletin 22: The Control of Sorghum Kernel Smut and the Effect of Seed Treatment on Vitality of Sorghum Seed. This bulletin presents the results of sorghum seed treatment experiments conducted by the Agricultural Experiment Station at Manhattan over an eight-year period. Data are presented showing the relative effectiveness of various soaking and dust treatments in controlling kernel smut *Sphacelotheca sorghi* Lk.) Clint. The effect of these treatments on the germinability of the seed also is shown. Formaldehyde soaking treatments gave the most complete control but resulted in slight seed injury. Copper carbonate dust treatments gave very satisfactory control and very little seed injury. (By C. O. Johnston and L. E. Melchers, Department of Botany. 37 pages, 10 tables.)

Technical Bulletin 23: The Importance of Vitamin A and Vitamin C in the Ration of Swine. In the experiments discussed in this bulletin young growing pigs were fed a feed deficient in vitamin A until they developed the advanced stages of avitaminosis A. This condition was characterized by striking nervous symptoms such as impaired vision, extreme incoördination, and spasms. Histological examination of the nerves of these pigs showed definite degeneration of some of the nerve bundles. Microphotographs of such degenerated nerves were made. Eye lesions were found to be of minor importance in avitaminosis A in swine. Results of an experiment in which swine were carried through three generations, over a period of 5 1/2 years, without vitamin C are also reported. (By J. S. Hughes, C. E. Aubel, and H. F. Lienhardt, Departments of Chemistry, Animal Husbandry, and Veterinary Medicine. 48 pages, 26 figures, 3 tables.)

CIRCULARS

Circular 126: Rabies-Hydrophobia-Dog Madness. In this circular will be found a description written in popular style of the disease generally known as dog madness. The cause of the disease, animals that are susceptible to it, how they become affected, and the symptoms of the disease in domesticated animals are discussed. A brief description is included of the laboratory methods of diagnosing the trouble, as well as brief statements about the prevention of the disease and the treatment of bitten persons. (By R. R. Dykstra, H. F. Lienhardt, and E. J. Frick, Department of Veterinary Medicine. 6 pages.)

Circular 127: Fitting and Exhibiting Standard-bred Poultry. This circular describes in detail the methods of selecting show birds from the common flocks; how to prepare and train them for show-room competition; and how to

care for them before and after the show. It also includes complete suggestions for the arrangement and management of poultry shows, as well as information on the organization of poultry clubs. The appendix contains a list of the more common defects of popular breeds of poultry and forms a valuable guide in the selection of breeding pens. (By H. H. Steup, Department of Poultry Husbandry. 39 pages; 18 figures.)

Circular 128: Cattle Feeding Investigations, 1924-'25. This circular is divided into three parts. Part I reports the results of a study conducted to determine the extent to which one may depend upon silage as a roughage for baby beef being fattened for market. Part II reports a study of the relative value of cottonseed meal and ground corn as fattening feeds for cattle. Part III gives the results of a study of different methods of wintering yearling steers, preparatory to grazing without grain the first half of the season and full feeding on grain the last half. (By C. W. McCampbell, B. M. Anderson, and H. W. Marston, Department of Animal Husbandry. 14 pages; 9 tables.)

Circular 129: Economic Plant Diseases Common in Kansas and Their Control. This circular describes briefly the nature and cause of plant diseases. The common, economic diseases attacking cereals, forage crops, and orchard and truck crops are described and methods of control or prevention recommended. Seed treatments for grain, and sweet and white potato diseases are described. Sprays and other fungicides and mixtures are discussed. The publication is written for the purpose of helping one identify the disease in question and to suggest how it may be controlled. (By L. E. Melchers, Department of Botany. 23 pages.)

Circular 130: Cattle Feeding Investigations, 1925-'26. This publication gives the results of a test in which an attempt is made to find a means of making silage and prairie hay as good a roughage for baby beefs being fattened for market as silage and alfalfa hay. Additional data relative to the comparative value of cottonseed meal and linseed oil meal as protein supplements for corn are also reported. (By B. M. Anderson and H. W. Marston, Department of Animal Husbandry. 5 pages; 1 table.)

Circular 131: Lamb Feeding Investigations, 1925-'26. The results published in this circular show the minimum efficient utilization of alfalfa hay when corn is fed according to the appetite of lambs. They also show the difference in gain and finish when large quantities of alfalfa hay and small quantities of corn are fed in comparison with small quantities of alfalfa hay and large quantities of corn. (By H. E. Reed and H. W. Marston, Department of Animal Husbandry. 4 pages; 1 table.)

Circular 132: Year-to-year and Seasonal Fluctuations in Hog Prices. This circular discusses fluctuations in hog prices as related to the two farm-marketing problems of (1) when to increase or decrease total production of hogs and (2) at what times during the year to have hogs finished and ready for market. (By R. M. Green and Harold Home, Department of Agricultural Economics. 14 pages; 1 table; 6 figures.)

Circular 133: Growing Flax in Kansas. The methods of growing, harvesting, and marketing flax, adapted varieties, the importance of wilt, and the place of flax in rotation with other crops are discussed in this circular. Information is given as to the area and condition to which flax is adapted, the importance of the crop compared to other crops in this state and to flax in other states, and the effect of tariff on flax prices. (By H. H. Laude, Department of Agronomy, and W. E. Grimes, Department of Agricultural Economics. 10 pages; 3 tables; 1 figure.)

Circular 134: Grape Growing in Kansas. "Grape Growing in Kansas" sets forth those methods of caring for the vineyard of American grapes which many years of practical experience, as well as the application of the results of careful experiments, have shown best adapted to the state. Special emphasis is placed on correct methods of soil management and pruning as applied to this fruit. (By R. J. Barnett, Department of Horticulture. 32 pages; 9 figures.)

Circular 135: Infectious Abortion of Cattle. The nature, cause, symptoms, and treatment of infectious abortion of cattle are presented in this circular in the form of a series of questions and answers. The questions used are those asked daily by persons interested in the practical breeding and handling of cattle. (By C. H. Kitzelman, Department of Veterinary Medicine. 11 pages.)

Circular 136: Killing Field Bindweed with Sodium Chlorate. This circular gives directions for the use of sodium chlorate to control bindweed, together with statement of cost of treatment and precautions to be taken on account of the danger from fire when not properly handled. In addition a brief description of field bindweed and means of spreading are given. Salting and fallow as methods of control are also discussed. (By W. L. Latshaw, Department of Chemistry, and J. W. Zahnley, Department of Agronomy. 15 pages; 11 figures.)

Circular 137: Judging Price Risks in Marketing Hogs. What causes hog prices to follow somewhat similar seasonal trends from year to year and what important market situations cause variations from these more usual seasonal price trends are the principal features of this circular. The frequency with which month-to-month price advances take place under varying conditions is given as a starting point for judging the probability of price changes at different times of the year. (By R. M. Green, Department of Agricultural Economics, and E. A. Stokdyk, Extension Specialist in Marketing, 29 pages; 12 figures; 4 tables.)

Circular 138: Swine Feeding Investigations. 1923 to 1926. This circular is divided into six parts. Part I reports the results of a study conducted to determine the relative value of alfalfa and sweet clover as pasture crops for hogs. Part II reports the results of tankage versus linseed oil meal as supplementary feeds for hogs being fattened on corn and alfalfa hay in the dry lot and corn and alfalfa pasture. Part III gives the results of adding tankage to the ration of corn to hogs being fattened on alfalfa pasture. Part IV gives the results of using corn and tankage versus corn, tankage, and alfalfa hay for hogs being fattened for market. Part V gives the comparative results of corn and kafir as fattening feeds. Part VI gives the results of using corn, tankage, and alfalfa pasture versus kafir, tankage, and Sudan grass pasture for fattening hogs. (By A. D. Weber, B. M. Anderson, and H. W. Marston, Department of Animal Husbandry. 14 pages; 9 tables.)

Circular 139: Filling Silos. This circular is a revision of Circular 95 on the same subject, containing, however, later information on the time to cut silage crops and methods of filling silos. It attempts to answer briefly all the questions that may arise in the mind of silo owners in regard to silage crops; time and methods of cutting these crops; selection and operation of the silage cutter; and filling, refilling, and sealing silos. (By J. B. Fitch, Department of Dairy Husbandry. 8 pages; 1 figure.)

Circular 140: Tomato Wilt Disease. The distribution of the tomato wilt fungus in Kansas and losses from this disease are briefly outlined in this circular. Symptoms of wilt-infected plants are given and control measures are described. The circular closes with practical recommendations for avoiding losses from the tomato wilt disease. (By R. P. White, Department of Botany. 5 pages; 1 figure.)

SPECIAL PUBLICATION

The Fungous Flora of Kansas. This special research bulletin contains a detailed list of the fungous plants of Kansas. The list comprises nearly 1,800 fungi indigenous to the state of Kansas. About 360 of the species enumerated were new to science when first reported from this state. (By Elam Bartholomew, Stockton, Kan. 46 pages.)

DIRECTOR'S REPORT

Director's Report, 1924-1926: For the Biennium, July 1, 1924, to June 30, 1926. This report outlines the scope of the station work for the biennium, makes brief mention of a few outstanding developments affecting the work of

the station, and gives brief summaries of the more important results secured in research work. The annual financial statements and a list of the publications of the station and of contributions to other scientific publications by members of the staff are included. (By L. E. Call, Director, Agricultural Experiment Station of Kansas State Agricultural College. 162 pages, 37 tables.)

PUBLICATIONS BY DEPARTMENTS

The following table contains a list, classified by departments, of the regular publications of the Agricultural Experiment Station and also the technical articles contributed to scientific journals by members of the station staff:

LIST OF PUBLICATIONS BY DEPARTMENTS

Department of Agricultural Economics

Serial No.	Year of Issue	Title, author, and publication.
10	1926	Factors in the Cost of Producing Beef in the Flint Hills Section of Kansas. R. W. Wilcox, W. E. Grimes Morris Evans, and H. J. Henney. U. S. Dept. of Agr. Bul. 1454.
11	1927	The Effects of Shortage of Farm Storage Space and Inability to Get Local Bank Credit on the Movement of Kansas Wheat to Market. R. M. Green. Kan. Agr. Expt. Sta. Bul. 244.
26	1926	Federal Aid as a Part of a Long-time Agricultural Policy. Eric England. Kan. Agr. Expt. Sta. Bul. 237.
28	1928	The Cost of Producing Poultry on Kansas Farms W. E. Grimes and Morris Evans. Poultry in Kansas. Kan. State Bd. Agr. 45 :23-28.
29	1926	Year-to-Year and Seasonal Fluctuations in Hog Prices. R. M. Green and Harold Howe. Kan. Agr. Expt. Sta. Circ. 132.
30	1927	The Influence of Agriculture Upon Industry. W.E. Grimes, Twenty-fifth Bien. Rpt. Kan. Statc Bd. Agr. 30:46-50.
31	1927	Side Lines on the Farm. Harold Howe Twenty-fifth Bien. Rpt. Kan. State Bd. Agr. 30:54-56.
32	1927	The Banker and the Farmer. R. M.Green Twenty-fifth Bien. Rpt. Kan. State Bd. Agr. 30:50-54.
34	1927	Growing Flax in Kansas. H. H. Laude and W. E. Grimes. Kan. Agr. Expt. Sta. Circ 133.
...	1927	Judging Price Risks in Marketing Wheat. R. M. Green and E. A. Stokdyk. Kan. Agr. Ext. Circ. 54.
38	1927	Our Shifting Agriculture. W. E. Grimes. Jour. Farm Econ, 9:333-339.
42	1928	The Effect of Improved Machinery on the Organization of Farms in the Hard Winter Wheat Belt. W. E. Grimes Jour. Farm Econ. 10 :225-231.
43	1928	Judging Price Risks in Marketing Hogs. R.M. Green and E. A. Stokdyk Kan. Agr. Expt. Sta. Circ 137.

Department of Agronomy

163	1926	Viscosity and Winter Hardiness in the Small Grains. S. C. Salmon and H. M. Tysdal. Jour. Amer. Soc. Agron. 18: 1099-1102.
164	1926	Corn Production in Kansas. S. C. Salmon. Km. Agr. Expt. Sta. Bul. 238.
166	1927	Growing Flax in Kansas. H. H. Laude and W. E. Grimes. Kan. Agr. Expt. Sta. Circ 133.
167	1927	Experiments with Sodium Chlorate and Other Chemicals as Herbicides for Field Bindweed W. L. L. WL Latshaw and J. W. Zahnley. Jour. Agr. Res. 35:757-767.
168	1927	Blackhull Wheat in Kansas. S. C. Salmon, C.O. Swanson. and H. H. Laude. Kan. Agr. Exp. Sta. Bull. 241.
169	1927	Factors Affecting the Popping Quality of Pop Corn. A. M. E Brunson J. G. Willier. Jour. Agr. Res. 35:615-624.
171	1927	Alfalfa Production in Kansas. R. I. Throckmorton and S. C. Salmon. Kan. Agr. Expt. Sta. Bul. 242.
172	1927	The Resistance of Certain Varieties of Winter Wheat to Artificially Produced Low Temperatures. D. D. Hill and S. C. Salmon. Jour. Agr. Res. 35 :933-937.

Serial No.	Year of issue.	Title, author, and publication
173	1928	The Effect of Growing Plants on Solubility of Soil Nutrients. W. H. Metzger. Soil Sci. 25 :273-280.
174	1928	Killing Field Bindweed with Sodium Chlorate. W. L. Latshaw and J. W. Zahnley. Kan. Agr. Expt. Sta. Circ. 136.
...	1928	Experiments in Crossing Varieties as Means of Improving Productiveness in Corn. L. H. Smith and A. M. Brunson. Ill. Agr. Expt. Sta. Bul. 306.
...	1926	William Bateson, 1861-1926. John H. Parker. Jour. of Heredity 17:433-449.
Department of Animal Husbandry.		
80	1920	Cattle Feeding Investigations, 1924-'25. C. W. McCampbell, B. M. Anderson, and H. W. Marston. Kan. Agr. Expt. Sta. Circ. 128.
81	1926	Lamb Feeding Investigations, 1925-'26. H. E. Reed and H. W. Marston. Kan. Agr. Expt. Sta. circ. 131.
82	1926	Cattle Feeding Investigations, 1925-'26. B. M. Anderson and H. W. Marston. Kan. Agr. Expt. Sta. Circ. 130.
83	1927	Genetics and the Production of Show type Animals. H. L. Ibsen. Jour. of Heredity, 18:240-243.
84	1927	Equipment for Swine Production. B.M. Anderson and V. R. Hillman. Kan. Agr. Expt. Sta. Bul. 243.
...	1927	Paralysis in Swine. C. W. McCampbell and C. E. Aubel. Record of Proc. Amer. Soc. of An Prod., November, p. 98
85	1927	Sheep Production H. E. Reed. Kan. Agr. Expt. Sta. Bul. 240.
86	1827	Cod-liver Oil for "Snuffles" in Rabbits and Pneumonia in Guinea Pigs. H.L. Ibsen. Science, 66 :509-510.
87	1928	Prenatal Growth in Guinea Pigs with Special Reference to Environmental Factors Affecting Weight at Birth. H.L. Ibsen. Jour. Expt. Zool., 1-91.
88	1928	The Importance of Vitamin A and Vitamin C in the Ration of Swine. J. S. Hughes, C. E. Aubel, and H. F. Lienhardt. Kan. Agr. Expt. Sta. Tech. Bul. 23.
89	1928	Swine Feeding Investigations, 1923 to 1926. A. D. Weber, B. M. Anderson, and H. W. Marston. Kan. Agr. Expt. Sta. Circ. 138.
Department of Bacteriology		
72	1928	Poultry Diseases in Kansas. W. R. Hinshaw and L. D. Bushnell. Poultry in Kansas. Kan. State Bd. Agr., 45:261-314.
77	1920	A Study of the Variation in Number of Blood Cells of Normal Rabbits. L. D. Bushnell and Edna F. Bangs. Jour. Infec. Dis. 39 :291-301.
79	1926	Bacillary White Diarrhea in Fowl L. E. Bushnell, W. R. Hinshaw, and L. F. Payne. Kan. Agr. Expt. Sta. Tech. Bul. 21.
82	1927	Thermo-tolerant organisms as a Cause of Pin-point Colonies. A. C. Fay. Jour. Bact., 13:347-377.
83	1927	The Use of Diseased Fowl in Experimental Investigations. W. R. Hinshaw and L. D. Bushnell. Poultry Sci., 7:17-22.
84	1928	Importance of Ultra-violet Light in the Poultry Industry. J. S. Hughes, L. F. Payne, and W. R. Hinshaw. Proc. World's Poult. Cong., 1927, pp. 214-221.
85	1928	Typhoid and Fowl Cholera. L. D. Bushnell. Proc. World's Poult. Cong., 1927, pp 353-355.
86	1928	Incubator as a Means of Transmitting Bacillary White Diarrhea. W.R. Hinshaw. Proc. World's Poult. Cong., 1927, pp. 372-374.
87	1927	Sanitary Control of Cream. A. C. Fay. Quarterly Rpt., Kan. State Bd. Agr., 46:103-106
88	1927	Seasonal Distribution as an Aid to Diagnosis of Poultry Diseases. W. R. Hinshaw and L. D. Bushnell Jour. Amer. Vet. Med. Assoc., 71 (n. s. 24)764-772.
89	1927	Preparation of Salmonella pullorum Antigens for Complement Fixation Tests. L. D. Bushnell and C. B. Hudson. Jour. Infec. Dis., 41:383-387.
90	1927	Complement Fixation and Agglutination Tests for Salmonella pullorum Infection. L. D. Bushnell and C. B. Hudson: Jour. Infec. Dis., 41:388-394.
91	1928	Sources Energy for Azotobacter With Special Reference to Fatty Acids. P. L. Gainey. Annals of the Mo. Bot. Garden, 15:116-168.

<i>Serial No.</i>	<i>Year of issue.</i>	<i>Title, author, and publication.</i>
92	1928	The Ice Cream Scoring Contest as a Means of Improving the Quality of Ice Cream. A. C. Fay and W. H. Martin. Jour. Dairy Sci., 11:136-142.
93	1928	Atypical <i>Salmonella pullorum</i> Agglutininations Caused by Bacterial Contamination. W. R. Hinshaw and G. L. Dunlap. Jour. Amer. Vet. Med. Assoc., 72:(n. s. 25)694-598.
94	1927	The Effect of Gelatin on the Bacterial Content of Ice Cream Mix. A. C. Fay and N. E. Olson. Jour. Bact., 14 :363-376.
96	1928	Further Studies on Dissemination of <i>Salmonella pullorum</i> Infection in Incubators. W. R. Hinshaw, H. M. Scott, and L. F. Payne. Jour. Amer. Vet. Med. Assoc., 72:(n. s. 25)pp.599-610.
99	1928	Comparison of Mortality in Chicks Suffering from Bacillary White Diarrhea and Normal Chicks. H. M. Scott, W. R. Hinshaw, and L. F. Payne. Jour. Amer. Vet. Med. Assoc., 72:(n. s. 26)756-761.
102	1928	Green Feed Deficiency in the Poultry Ration. C. A. Brandly. Jour. Vet. Med., 23:223-224.
Department of Botany		
228	1927	Studies on Tomato Wilt Caused by <i>Fusarium lycopersici</i> , Sacc. R. P. White. Jour. Agr. Res., 34:197-239.
229	1926	Economic Plant Diseases Common in Kansas and Their Control. L. E. Melchers. Kan. Agr. Expt. Sta. Circ. 129.
...	1926	Crown Wart of Alfalfa in the South. J. L. Weimer. Phytopathology, 16:1012.
240	1927	Effects of Soil Moisture and Temperature and of Dehulling on the Infection of Oats by Loose and Covered Smuts. C. O. Johnston. Phytopathology, 17 :31-36.
...	1927	Potato Seed Treatment. R.P. White. Kan. Agr. Col. Est. X-Form 228.
251	1928	Tomato Wilt Disease. R.P. White. Kan. Agr. Expt. Sta. Circ. 140.
252	1928	The Control of Sorghum Kernel Smut and the Effect of Seed Treatments on the Vitality of Sorghum C. O. Johnston and L. E. Melchers. Kan. Agr. Expt. Sta. Tech. Bul. 22.
256	1926	Copper Dusts and Sprays of Potatoes in Kansas. R. P. White. Amer. Potato Jour., 3:353-355.
257	1926	Inheritance of Resistance to Leaf Rust, <i>Puccinia triticina</i> Erikss, in Crosses of Common Wheat, <i>Triticum vulgare</i> Vill. E. B. Mains, C. E. Leighty, C. O. Johnston. Jour. Agr. Res., 32 :931-972.
259	1927	Observations on Some Alfalfa Root Troubles. J. L. Weimer. U. S. Dept. of Agr. Circ. 425.
260	1926	Sand Flotation in Nature. F. C. Gates. Science, 64:595-596.
262	1927	Fighting Wheat Smut. L. E. Melchers. Twenty-fifth Bien. Rpt. Ken. State Bd. Agr., 30:214-224
263	1926	Induced Dormancy in Seed Potatoes Due to Seed Treatment. R. P. White. Potato Assoc. of Amer. 13th Annual Meeting, pp. 97-99.
264	1926	The Efficiency of Organic Mercury Compounds for the Control of Rhizoctonia on Potato. R. P. White. Potato Assoc. of Amer. Proc., pp. 81-83.
266	1927	A Wilt Disease of Alfalfa Caused by <i>Fusarium Sp.</i> J. L. Weirner. Phytopathology, 17 :337-338.
268	1927	The Fungous Flora of Kansas Elam Bartholomew Ken. Agr. Expt. Sta. Special Publication.
269	1927	Studies on the Control of Millet Smut. L. E. Melchers. Phytopathology, 17:739-741.
271	1927	Establishment of Plant Associations. F. C. Gates. Ecology, 8:339-340.
272	1927	Strains of Smuts of Sorghum <i>Sphacelotheca sorghi</i> and <i>S. Crucnta</i> . W. H. Tisdale, L. E. Melchers, and H. J. Clemmer. Jour. Agr. Res., 34 :825-838.
273	1928	Pathogenicity of Two Strains of the Tomato Wilt Fungus. H. H. Haymaker. Jour. Agr. Res., 36 :675-695.
279	1928	Mutation in <i>Pinus sylvestris</i> . F. C. Gates. Bot.Gaz 85:451-456
280	1928	Relation of Toxic Excretory Products from Two Strains of <i>Fusarium lycopersici</i> Sacc. to Tomato Wilt. H. H. Haymaker. Jour. Agr. Res., 36:697-719.
284	1928	Bacterial Wilt and Winter Injury of Alfalfa F. R. Jones and J. L. Weimer. U. S. Dept. of Agr. Circ. 39.

Department of Chemistry

<i>Serial No.</i>	<i>Year of issue.</i>	<i>Title, author, and publication.</i>
121	1926	Destruction of Vitamin A in Milk by Ultra-violet Light. R. W. Titus, J. S. Hughes., W. R. Hinshaw, and J. B. Fitch. Industrial and Engineering Chemistry, 18:843.
122	1926	Should Leg Weakness in Growing Chicks be Called Rickets? J. S. Hughes and R. W. Titus. Jour. Biol. Chem., 69:289-294.
124	1927	A Dual Purpose Light. J. S. Hughes, R. W. Titus, L. F. Payne, and G. T. Klein. Trans. Illuminating Engineering Soc., 22:412-416.
128	1927	Relation Between the Vitamin C Content of a Cow's Ration and the Vitamin C Content of Its Milk. J. S. Hughes, J. B. Fitch, H. W. Cave. and W. H. Riddell. Jour. Biol. Chem., 71:309-316.
129	1927	The increase in the Calcium of Hens' Blood Accompanying Egg Production. J. S. Hughes, R. W. Titus., and B. L. Smits. Science, 65:264.
130	1928	Importance of Ultra-violet Light in the Poultry Industry. J. S. Hughes, L. F. Payne, W. R. Hinshaw. Proc World's Poul. Cong., 1927, pp. 214-221.
133	1927	Experiments with Sodium Chlorate and Other chemicals as Herbicides for Field Bindweed. W. L. Latshaw and J. W. Zahnley. Jour. Agr. Res, 35:757-767.
139	1928	The Importance of Vitamin A and Vitamin C in the Ration of Swine. J. S. Hughes, C. E. Auber, and H. F. Lienhardt. Kan. Agr. Expt. Sta. Tech. Bul. 23.
140	1928	Killing Field Bindweed with Sodium Chlorate. W. L. Latshaw and J. W. Zahnley. Kan. Agr. Expt. Sta. Circ. 136.

Department of Dairy Husbandry

57	1927	Relation Between the Vitamin C Content of a Cow's Ration and the Vitamin C Content of Its Milk. J. S. Hughes, J. B. Fitch, H. W. Cave, and W. H. Riddell. Jour. Biol. Chem., 71:309-316.
58	1927	A Year's Test of the So-called Fly Spray. L. C. Aicher, R. H. Lush, and R. C. Smith. Jour. Econ. Ent., 20:593-602.
59	1928	Filling Silos. J. B. Fitch. Kan. Agr. Expt. Sta. Circ. 139.
60 ³	1928	The Ice Cream Scoring Contest as a Means of Improving the Quality of Ice Cream. A. C. Fay and W. H. Martin. Jour. Dairy Sci., 11:136-142.

Department of Entomology

327	1926	The Trash-carrying Habit of Certain Lace Wing Larvae. R. C. Smith. The Scientific Monthly, 23:265-267.
335	1928	A List of the Literature of Kansas Arthropoda. J. W. McColloch. Jour. Kan. Ent. Soc., 1:3-19.
353	1928	The Menace of the European Corn Borer. G. A. Dean. Twenty-fifth Bien. Rpt. Kan. State Bd. Agr., 30:224-235.
354	1927	Observations on <i>Euplectrus platyhypenæ</i> How. (Chalcidæ). A Parasite of Noctuid Larvae. R. C. Smith. Bul. of Brooklyn Ent. Soc, 22:128-135.
355	1926	Some Insects Injurious to Nursery Stock in the Nursery Row. G. A. Dean. Tenth Bien. Rpt. Kan. Ent. Comm., pp. 29-34.
356	1928	The Hibernation of Certain Scarabæids and Their Tiphia Parasites. J. W. McColloch, Wm. P. Hayes, and Harry R. Bryson Ecology, 9:34-42.
357	1927	Preliminary Notes on the Depth of Hibernation of Wireworms (Elateridæ, Coleop.). J. W. McColloch, Wm. P. Hayes, and H. R. Bryson. Jour. Econ. Ent, 20:561-564.
359	1927	A Year's Test of the So-called Fly Spray. L. C. Aicher, R. H. Lush, R. C. Smith. Jour. Econ. Ent., 20:593-602.
360	1928	The Courses in Entomology in American Colleges. R. C. Smith. Kan Agr. Col. Bul., 12:1-23.
361	1927	A Plan to Facilitate the Annual Meetings of the Various Sections of the American Association for the Advancement of Science with Special Reference to the Entomological Sections. R. C. Smith. Jour. Econ. Ent., 20:733-738.
...	1928	Spring Increase for the Plains Region. R. L. Parker and C. B. Keck Amer. Bee Jour., 68:66-67.

3. Erroneously marked as No. 59 in the publication.

<i>Serial No.</i>	<i>Year of issue.</i>	<i>Title, author, and publication.</i>
364	1928	Ecological Studies of Kansas White Grubs (Scarabæid Larvæ Coleop.). J. W. McColloch, and Wm. P. Hayes. Jour. Econ Ent. 21:
367	1928	Notes on the Injury to Plant Cells by Chinch Bug Feeding. R. H. Painter. Ann. of the Ent. Soc of Amer., 21:232-242.
368	1928	The Coccinellidæ of Kansas (Coleoptera). Harry L. Gui. Jour. Kan. Ent. Soc., 1, No. 2, pp. 2-13.
369	1928	<i>Lasius interjectus</i> Mayr (Formicidæ) A Household Pest in Kansas. R. C. Smith. Jour. Kan. Ent. Soc. 1:14-18.
Department of Home Economics		
2	1927	Vitamin C Content of Fresh and Canned Pear. Verral J. Craven and Martha M. Kramer. Jour. Agr. Res., 34 :385-392.
4	1927	The Protective Value of Clothing Fabrics. Lilian Baker. Textile World, 71:65-66.
5	1927	Protection Afforded the Skin Against Sunburn by Textile Fibers. Katherine Hess, J. O. Hamilton, and Margaret Justin. Jour. Agr. Res., 35 :251-259.
Department of Horticulture		
...	1926	Greenhouse Soil Sterilization. W.B. Balch. Iowa State Hort. Soc. Proc., 61:150-151.
60	1926	Relation Between Orchard Practices and Apple Grades. George A. Flinger. Bien. Rpt. Kan. State Hort. Soc., 38:17-21.
61	1926	Why the Winners Win. W. F. Pickett. Bien. Rpt. Kan State Hort. Soc. 35:73-80
62	1926	Cover Crops for Kansas Orchards. R. J. Barnett. Bien. Rpt. Kan. State Hort. Soc., 38:21-26.
68	1927	Rate of Seeding Winter Vetch. R. J. Barnett. Fruits and Gardens, No. 8,p. 6.
69	1928	Grape Growing in Kansas. R. J. Barnett. Kan. Agr. Expt. Sta. Circ. 134.
72	1926	A Preliminary Study of the Fruiting Habit of the Worden Grape. W. F. Pickett. Amer. Soc. Hort. Sci. Proc., Twenty-third annual meeting, pp. 135-138.
73	1927	Apple Variety Susceptibility to Disease. R. J. Barnett and W. F. Pickett. Midwest Fruitman, 1:4,p.7.
75	1927	Further Studies on the Fruiting Habit of the Grape. W. F. Pickett. Amer. Soc. Hort. Sci. Proc., Twenty-fourth annual meeting, pp. 151-154.
77	1928	The Twig and Trunk Growth of Winesap Apple Trees; Rate and Duration. R. J. Barnett. Amer. Soc. Hort. Sci. Proc., Twenty-fifth annual meeting, pp. 217-221
Department of Milling Industry		
29	1926	The Mechanical Modification of Dough. C. O. Swanson. Jour. Cereal Chem., 3 :65-83.
31	1927	The Bread Value of Kansas Wheat. C. O. Swanson. Twenty-fifth Bien. Rpt. Kan. State Bd. Agr., 30:104-119.
32	1927	Influence of Variation in the Chemical Composition of Wheat Upon Baking Qualities. C. O. Swanson. The Millers Review, 41:24.
33	1927	Blackhull Wheat in Kansas. S. C. Salmon, C. O. Swanson, and H. H. Laude. Kan. Agr. Expt. Sta. Bul. 241.
34	1928	The Action of Phosphatides in Bread Dough. E. B. Working. Jour. Cereal Chem., 5 :223-234.
...	1927	Possibilities of Knowing the Quality of Wheat Before It is Milled. C. O. Swanson. Amer. Miller. 55: or Bul. Assoc. Oper. Millers. July, pp. 225-229.
...	1928	Grinding Zone and Effects of Varying the Differential. R. O. Pence. National Miller, 33 :16-20 and 82-89.
Department of Poultry Husbandry		
34	1926	Fitting and Exhibiting Standard-bred Poultry. H. H. Steup. Kan. Agr. Expt. Sta. Circ. 127.
35	1927	A Dual Purpose Light. J. S. Hughes, R. W. Titus, L. F. Payne, and G. T. Klein. Trans. Illuminating Engineering Society, 22:412-416.
35-A	1926	Bacillary White Diarrhea in Fowl. L. D. Bushnell, W. R. Hinshaw, and L. F. Payne. Kan. Agr. Expt. Sta. Tech. Bul. 21.
36	1927	The Effect of Freezing the Combs of Breeding Males. L. F. Payne and Clyde Ingram. Poultry Science, 6:99-107.

<i>Serial No.</i>	<i>Year of issue.</i>	<i>Title, author, and publication.</i>
37	1928	Importance of Ultra-violet Light in the Poultry Industry. J. S. Hughes, L. F. Payne, and W. R. Hinshaw. Proc. World's Poultr. Cong., 1927, pp. 214-221.
38	1927	A Study of Various Methods of Preventing Rickets in chicks. G.T. Klein, Poultry Science, 7 :31-40.
39	1928	A Poultry Survey in Kansas. L.F. Payne and H. H. Steup. Kan. Agr. Expt. Sta. Bul. 245.
40	1927	Hybrid Vigor in Poultry. D.C. Warren. Poultry Science, 7:1-8.
...	1927	Coat Color Inheritance in Greyhounds. D. C. Warren. Jour of Heredity, 18:513-522.
41	1925	Further Studies on Dissemination of <i>Salmonella pullorum</i> Infection in Incubators W. R. Himshaw, H. M. Scott, and L. F. Payne. Jour. Amer. Vet. Med. Assoc., 72(n. s. 25):599-610.
42	1928	Comparison of Mortality in Chicks Suffering from Bacillary White Diarrhea and Normal Chicks. H. M. Scott, W. R. Hinshaw, and L. F. Payne. Jour. Amer. Vet. Med. Assoc., 72(n. s. 26):756-761.
Department of Veterinary Medicine		
34	1926	A Method of Increasing the Virulence of Cultures of <i>Clostridium chauvei</i> by the Use of Ferric Salts. J. P. Scott. Jour. Infect. Diseases, 38:511-513.
35	1926	Rabies-Hydrophobia-Dog Madness. R. R. Dyksta, H. F. Lienhardt, and E. J. Frick. Kan. Agr. Expt. Sta. Circ. 126.
36	1928	Infectious Abortion of Cattle. C. H. Kitzelman. Kan. Agr. Expt. Sta. Circ. 135.
37	1927	Bottling by Gravity. J. P. Scott. Jour. Lab. and Clin. Med., 13:80-83.
43	1928	The Importance of Vitamin A and Vitamin C in the Ration of Swine. J. S. Hughes, C. E. AubeI, and H. F. Lienhardt. Kan. Agr. Expt. Sta. Tech. Bul. 23.
Department of Zoölogy		
77	1926	Food Selection of Ground Squirrels F. L. Hisaw and F. E. Emery. Jour. of Mammal., 8:41-43.
79	1926	The Bull Snake-Enemy of Rodents. F. L. Hisaw and Howard K. Gloyd. Jour. of Mammal., 7: 200-205.
80	1926	Effect of Testicular Extract Upon Pregnant Guinea Pigs and Fetus. F. E. Emery. Amer. Micros. Soc. Trans., 45 :44-53.
82	1926	Further Studies on the Fish of an Acid Lake. Harold Brown and Minna E. Jewell. Amer. Micros. Soc. Trans., 45 :20-34.
83	1926	Studies on the Functions of Giant Nerve Fibers of Crustaceans. G. E. Johnson. Jour. Comp. Neur., 42:19-33.
84	1927	Observations on Young Prairie Dogs (<i>Cynomys ludovicianus</i>) Born in the Laboratory. G. E. Johnson. Jour. Mammal., 8:110-115.
85	1926	Number and Behavior of the Chromosomes in <i>Cavia cobaya</i> (The Common Guinea Pig). Mary T. Harman and F. P. Root. Biol. Bul., 51:73-80.
86	1926	Fire Studies in Human Heredity. L. C. Thomas. Eugenical News, 11:150-159.
...	1927	Resistance to Parasitism Affected by the Fat-soluble Vitamin A. J. E. Ackert, Marian L. Fisher, and Naomi B. Zimmerman. Jour. Parasitol., 13 :219-220. (Abs.)
88	1928	Some Intestinal Worms of Chickens and Their Control. J. E. Ackert. Proc. World's Poultr. Cong., 1927, pp. 333-336.
89	1927	Vitamin B. A Factor in the Resistance of Chickens to <i>Ascaridia lineata</i> (Schneider). Naomi B. Zimmerman, Lola B. Vincent, and J. E. Ackert. Jour. of Parasitol., 12:164.
90	1927	Polandry in the Grouse <i>Locust, Paratettix texanus</i> . R. K. Nabours. Amer. Nat., 61:531-538.
91	1927	Helminthiasis and the Thyroid Gland. J. E. Ackert and Gilbert F. Otto. Amer. Jour. Tron. Med., 7 :339-347.
92	1927	Studies on Alkali Reserve of the Blood of <i>Ameriurius nebulosus</i> from Acid and Basic Waters. Minna E. Jewell and F. W. Jobes. Amer. Micros. Soc. Trans., 46:175-186.
93	1927	Hibernation of the Thirteen-lined Ground Squirrel, <i>Citellus tridecemlineatus</i> Mitchell. G. E. Johnson. Jour. Expt. Zoöl., 50:15-30.

Serial No.	Year of issue.	Title, author, and publication.
95	1927	Aquatic Biology of the Prairie. Minna E. Jewell. Ecology, 8:289-298.
96	1928	Inheritance of Color Patterns and Parthenogenesis in the Grouse Louse, <i>Telmattix aztecus Saussure</i> . R. K. Nabours and Bertha Snyder. Genetics, 13:126-132.
98	1928	Insect Food of Kansas. Lizards with Notes on Feeding Habits. C. E. Burt. Jour. Kan. Ent. Soc., 1:50-67.
Director's Office		
33	1926	Director's Report 1924-'26.
34	1927	Crop Production in Southwestern Kansas. E. H. Coles and F. A. Wagner. Kan. Agr. Expt. Sta. Bul. 239.
36	1928	Must We Learn to Live with the European Corn Borer? L. E. Call. Quarterly Rpt. Kan. State Bd. Agr., 47:185-A, pp.18-27

FINANCIAL STATEMENT, 1926-'27

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

	Federal appropriations.	State appropriations and receipts.	Totals.
Main station	\$80,000.00	(a) \$46,465.98	\$126,465.98
Branch Stations, appropriations.....	.....	(b) 60,167.83	60,167.83
Branch stations, sales .....	.....	95,046.52	95,046.52
Totals	\$80,000.00	\$201,680.33	\$281,680.33
Salaries	\$35,000.00	\$28,314.99	\$63,314.99
Labor	17,365.41	67,172.11	84,537.52
Stationery and office supplies.....	37.71	1,652.32	1,690.03
Scientific supplies, consumable.....	1,135.08	4,284.66	5,369.69
Feeding stuffs	679.00	12,728.12	13,407.12
Sundry supplies	483.51	9,592.67	10,076.18
Fertilizers .....	.....	3.00	3.00
Communication service	7.97	1,869.81	1,877.78
Travel expenses	935.78	4,514.00	5,449.78
Transportation of things	44.20	3,883.99	3,928.19
Publications .....	.....	1,181.79	1,181.79
Heat, light, water and power.....	57.43	4,917.68	4,975.11
Furniture, furnishings, fixtures.....	147.48	865.74	1,013.22
Library	17.30	22.12	39.42
Scientific equipment	534.44	509.94	1,044.38
Live stock	2,105.40	14,754.16	16,859.56
Tools, machinery, and appliances.....	596.03	8,139.66	8,735.69
Buildings and land	849.91	20,390.02	21,239.93
Contingent expenses	3.40	637.59	640.99
Balance, June 30, 1927.....	.....	16,295.96	16,295.96
Totals	\$80,000.00	\$201,680.33	\$281,680.33

(a) Includes a balance on hand June 30, 1926, of \$2,475.98.

(b) Includes a balance on hand June 30, 1926, of \$4,467.83.

FINANCIAL STATEMENT, 1927-'28

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

	Federal appropriations.	State appropriations and receipts.	Totals.
Main station	\$70,000.00	(a) \$47,427.12	\$117,427.12
Branch stations, appropriations.....		(b) 74,452.08	74,452.08
Branch stations, sales		76,206.44	76,206.44
Totals	\$70,000.00	\$198,085.64	\$268,085.64
Salaries	\$42,499.93	\$31,256.67	\$73,756.60
Labor	20,120.28	63,069.73	83,190.01
Stationery and office supplies.....	66.50	1,910.57	1,977.07
Scientific supplies, consumable.....	869.31	3,744.80	4,614.11
Feeding stuffs	878.23	14,247.64	15,125.92
Sundry supplies	301.33	11,708.33	12,010.16
Fertilizers			
Communication service	2.00	2,069.26	2,071.26
Travel expenses	688.08	6,073.88	6,761.96
Transportation of things.....	171.34	2,499.56	2,670.90
Publications		713.69	713.69
Heat, light, water, and power	158.48	3,694.06	3,852.54
Furniture, furnishings, fixtures.....	11.89	1,442.59	1,454.48
Library		32.49	32.49
Scientific equipment	1,175.13	1,871.08	3,046.21
Live stock	2,385.92	14,070.94	16,456.86
Tools, machinery, and appliances.....	628.29	13,456.20	14,084.49
Buildings and land	38.09	9,777.90	9,815.99
Contingent expenses	4.65	3,609.36	3,614.01
Balance, June 30, 1928.....		12,836.89	12,836.89
Totals	\$70,000.00	\$198,085.64	\$268,085.64

(a) Includes a balance on hand June 30, 1927, of \$3,437.12.

(b) Includes a balance on hand June 30, 1928, of \$12,752.08.

