

# AGRICULTURAL EXPERIMENT STATION

KANSAS STATE COLLEGE OF AGRICULTURE  
AND APPLIED SCIENCE  
MANHATTAN, KANSAS

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## TENTH BIENNIAL REPORT OF THE DIRECTOR

1938-1940



PRINTED BY KANSAS STATE PRINTING PLANT  
W. C. AUSTIN, STATE PRINTER  
TOPEKA 1940  
18-6404



**KANSAS AGRICULTURAL EXPERIMENT STATION**  
Manhattan, Kansas

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H. E. MYERS, Soils.  
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CLARE R. PORTER, Assistant in charge of South Central Kansas Experiment Fields.  
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†C. O. GRANDFIELD, Alfalfa Investigations.  
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†M. L. PETERSON, Assistant in Agronomy.  
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†CHARLES L. STUMBO, Soil Microbiology Investigations.

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†HURLEY FELLOWS, Plant Pathology (Wheat footrot).  
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†C. H. FICKE, Plant Pathology (Wheat footrot).

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J. W. GREENE, Industrial Chemistry.

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J. L. HALL, Meat Investigations.  
C. H. WHITNAH, Dairy Chemistry.  
RALPH M. CONRAD, Poultry Chemistry.  
H. N. BARHAM, Industrial Chemistry.  
W. J. PETERSON, Nutrition.  
J. F. MERRILL, Analytical Work.  
B. W. BEADLE, Analytical Work (On leave).  
ALBERT HANKE, Analytical Work.

**DAIRY HUSBANDRY**

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W. H. MARTIN, Dairy Manufacturing.  
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R. C. SMITH, Staple Crop Insects.  
R. L. PARKER, Fruit Insect and Bee Investigations (State Apiarist).  
R. H. PAINTER, Staple Crop Insects.  
D. A. WILBUR, Staple Crop Insects.  
H. R. BRYSON, Staple Crop Insects.  
P. G. LAMERSON, Northeastern Kansas Experiment Fields Entomologist.  
ROY F. FRITZ, Assistant in Entomology.  
†R. T. COTTON, in charge Federal Laboratory.  
†G. B. WAGNER, Flour Mill Insect Investigations.  
†N. E. GOOD, Flour Mill Insect Investigations.  
†J. C. FRANKENFELD, Cereal and Forage Insect Investigations.  
†E. T. JONES, Cereal and Forage Insect Investigations.  
†H. H. WALKDEN, Cereal and Forage Insect Investigations.  
†W. T. EMERY, Cereal and Forage Insect Investigations.  
†T. F. WINBURN, Cereal and Forage Insect Investigations.  
†H. D. YOUNG, Investigations in Fumigants.

**HOME ECONOMICS**

MARGARET M. JUSTIN, in charge.  
MARTHA S. PITTMAN, Foods and Nutrition.  
BERNICE L. KUNERTH, Foods and Nutrition.  
PAULINE NUTTER, Foods and Nutrition.

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† Employee of the United States Department of Agriculture cooperating with the Station.

AGRICULTURAL EXPERIMENT STATION

KATHARINE HESS, Clothing and Textiles.  
 HAZEL FLETCHER, Clothing and Textiles.  
 MYRTLE GUNSELMAN, Household Economics.

HORTICULTURE

W. F. PICKETT, Pomology, in charge.  
 R. J. BARNETT, Pomology.  
 L. R. QUINLAN, Landscape Gardening.  
 G. A. FILINGER, Pomology.  
 L. F. SMITH, Forestry (State Forester).  
 S. W. DECKER, Floriculture and Vegetable Gardening.  
 ERWIN ABMEYER, Assistant in charge, Northeastern Kansas Experiment  
 Fields.  
 CHARLES J. BIRKELAND, Research Assistant.

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 C. O. SWANSON, Wheat and Flour Investigations.  
 E. B. WORKING, Wheat and Flour Investigations.  
 R. O. PENCE, Milling Technology.  
 J. E. ANDERSON, Milling Investigations.  
 †MARK A. BARMORE, Regional Hard Winter Wheat Quality Laboratory.  
 †KARL F. FINNEY, Regional Hard Winter Wheat Quality Laboratory.  
 †MAX E. McCLUGGAGE, Regional Hard Winter Wheat Quality Labora-  
 tory.

POULTRY HUSBANDRY

L. F. PAYNE, Poultry Management, in charge.  
 D. C. WARREN, Genetics.  
 HAROLD M. SCOTT, Physiology.  
 B. B. BOHREN, Assistant.  
 C. L. GISH, Farm Foreman.

VETERINARY MEDICINE

R. R. DYKSTRA, in charge.  
 L. M. RODERICK, Animal Pathology.  
 C. H. KITSELMAN, Bang's Disease Investigations.  
 \*HERMAN FARLEY, Anaplasmosis Investigations.  
 W. W. THOMPSON, Feeder Cattle Investigations.  
 ALICE D. KIMBALL, Technician.

ZOOLOGY

R. K. NABOURS, Genetics, in charge.  
 J. E. ACKERT, Parasitology.  
 E. H. HERRICK, Injurious Mammals.  
 ALLEN EDGAR, Technician.  
 FLORENCE STEBBINS, Genetics.  
 MARY T. HARMAN, Embryology.

\* In cooperation with the United States Department of Agriculture.

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**FORT HAYS BRANCH STATION**

- \*L. C. AICHER, Superintendent.
- F. P. ESHBAUGH, Forest Nurseryman.
- \*L. E. WENGER, Forage Crops and Diseases.
- LAWRENCE REED, Assistant to Superintendent.
- †A. F. SWANSON, Cereal Crops and Diseases.
- †F. L. TIMMONS, Bindweed Investigations.
- †A. L. HALLSTED, Dry Land Agriculture.

**COLBY BRANCH STATION**

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**GARDEN CITY BRANCH STATION**

- L. M. SLOAN, Superintendent.
- \*ALVIN E. LOWE, Assistant in Agronomy.
- †H. J. HAAS, Dry Land Agriculture.

**TRIBUNE BRANCH STATION**

- T. B. STINSON, Superintendent.

## LETTER OF TRANSMITTAL

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OFFICE OF DIRECTOR, June 30, 1940.

*To His Excellency, Payne H. Ratner, Governor of Kansas:*

I have the honor to submit herewith the report of the Agricultural Experiment Station of the Kansas State College of Agriculture and Applied Science for the biennium ending June 30, 1940. The report contains brief descriptions of the work in progress during the past biennium, summaries of some of the more significant results, changes in the personnel of the station staff, a list of the publications of the station and of the published scientific contributions of the station staff, and a statement of receipts and expenditures during the biennium.

L. E. CALL, *Director.*

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

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### INTRODUCTION

This report contains a brief statement of the work of the Kansas Agricultural Experiment Station for the biennium ending June 30, 1940. The station is both a state and federal agency. It was authorized by act of congress and was organized following the acceptance of this act by the Kansas legislature on March 4, 1887. It is supported by both state and federal funds which were about equal in amount during the biennium. The work is conducted at the central station at Manhattan, at four branch stations in western Kansas located at Hays, Colby, Garden City, and Tribune, and on numerous outlying farms and experiment fields. All of the work of the station is conducted upon a project basis and is presented in this report under five distinct fields of activity as follows: Agricultural Economics, Soil Conservation, the Plant Industries, the Animal Industries, and Home Economics. Brief mention is made in the report of the objectives of each of the more important projects, the source of funds for the support of the project, the names of the workers most actively engaged upon the work of the project, and summaries of the more important results secured upon each project during the biennium.

### COÖPERATION WITH OTHER AGENCIES

The station has coöperated actively during the biennium with a number of agencies working in the same or closely related fields. This coöperative work has been upon the whole highly advantageous to this station and has made possible much greater service to the agricultural and rural life interests of Kansas than would have been possible without this coöperation. Agencies with whom coöperative relations have been maintained include other state agricultural experiment stations, the United States Department of Agriculture, other institutions and departments of the state of Kansas, other research agencies and farmers. These relationships have been pleasant, satisfactory, and helpful and have resulted in an increase in the efficiency of the work conducted.

Much progress has been made during the biennium in coöperative attack on a regional basis by the state experiment stations upon research problems that transcend state lines and are common for a region. The experiment stations of the thirteen north central states have recognized that these states have many mutual problems and have perfected a loose organization of these states for coöperative

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1. Contribution No. 70, from office of the Director.

attack upon some of them. Special attention has been given to the problems of marketing of agricultural products. Projects are now being formulated to study coöperatively some of the more acute problems in the marketing of livestock and poultry products in this region. The Kansas station has recognized the need of such coöperative attack and has made arrangements to coöperate with the other twelve state stations of the region in these studies.

The coöperative work with the United States Department of Agriculture during the past biennium has included studies with the following bureaus, divisions, and services: (1) The Bureau of Plant Industry relating to (*a*) production and breeding of small grains and corn, the control of cereal diseases, bindweed control, and problems pertaining to the milling quality of wheat in coöperation with the Division of Cereal Crops and Diseases; (*b*) alfalfa improvement, the control of alfalfa diseases, and forage crop production in coöperation with the Division of Forage Crops and Diseases; and (*c*) studies of crop production and soil management in the drier sections of the state in coöperation with the Division of Dry Land Agriculture. (2) The Bureau of Agricultural Chemistry and Engineering in the study of the storage of wheat and the sorghums and in an advisory capacity in connection with the regional laboratories. (3) The Bureau of Animal Industry in a study of anaplasmosis, quality of meat, and in advisory capacity relative to the improvement in viability of poultry and swine breeding. (4) The Bureau of Entomology and Plant Quarantine in a study of insects attacking staple crop plants, grain storage insects, and pests. (5) The Bureau of Agricultural Economics in studies of farm organization, cost of producing farm products, land-use planning, taxation, tenancy, farm population, and marketing of farm products. (6) The Agricultural Marketing Service in the marketing of farm products and in a pre-harvest wheat survey. (7) Soil Conservation Service in studies of soil erosion, water conservation, and evaporation. (8) The Forest Service in the propagation and distribution of forest trees. (9) The Bureau of Home Economics in the vitamin content of food in relation to human nutrition.

The station has coöperated with the Farm Security Administration in the study of land utilization, with the Farm Credit Administration in the analysis of the potato industry in Kansas in relation to the coöperative marketing of potatoes; and members of the station staff have given assistance and advice in connection with many problems pertaining to tenant purchase of farms, wind-erosion control, shelterbelt planting, land-use planning, agricultural adjustment, taxation, and rural credit.

The station has continued to coöperate with the Kansas State Board of Agriculture by providing personnel and facilities for the chemical determination of feeding stuffs, livestock remedies, and dairy products, and has maintained in coöperation with the board a state seed-testing laboratory. Coöperation has been continued also

with the State Livestock Sanitary Commissioner in a study of livestock diseases. Coöperative relationships have been established with the Kansas Industrial Development Commission, and, as a result of a special appropriation by the legislature of \$5,000 annually to this institution for the establishment of industrial fellowships, research has been more active in this field in coöperation with the station. The station has also provided personnel and assistance to the Kansas Tax Commission for the study of the taxation problems of the state. Farmers throughout the state have coöperated with the station in studies upon problems of mutual interest.

#### THE BANKHEAD-JONES ACT

The Bankhead-Jones act, as reported in detail in the Eighth Biennial Report of the station, authorized increased federal appropriations for agricultural research. Under this act, based upon the rural population as determined by the 1930 census, the Kansas station received \$12,512.62 for the biennium 1935-'36. The act provided for increments of the same amount for each succeeding year for a five-year period until for the biennium, 1939-'40, the station should have received slightly more than \$62,500. Due to the failure of congress to appropriate for the stations the entire amount authorized by the act, this station received for the first year of this biennium \$43,794.59 and for the second year, \$50,050.96. The station is, therefore, receiving but four-fifths of the amount originally authorized. This is the first instance in the history of the country where congress has failed to appropriate in full the amounts authorized by acts for the support of the work of the Agricultural Experiment Stations.

#### BUILDING, EQUIPMENT, AND LAND

Extensive improvements to the physical plant of the institution have been completed during the biennium which have increased greatly the facilities of the station. A new science building has been finished replacing a building burned in 1934. The new building is named Willard Hall in honor of Dr. J. T. Willard, who for many years was head of the Department of Chemistry and who served as Director of the Agricultural Experiment Station from 1900 to 1906.

Willard Hall is built of native limestone, thus harmonizing with all other major buildings on the campus. It is a four-story building, 305 feet long and 65 feet wide with wings at each end which measure 92 by 66 feet. The interior of the building is steel and reinforced concrete construction. The cost of the building with equipment was slightly over \$723,000.

The building provides facilities for the Departments of Chemistry and Physics, the Chemical Laboratories of the Agricultural Experiment Station with service rooms occupying much of the first floor. Eighteen chemical laboratories are used chiefly for station work and provide separate facilities for research in poultry, meat, food, nutrition, dairy, soils, and other types of chemical work. Five constant

temperature rooms with a temperature range from  $-30$  to  $120$  degrees Fahrenheit, each separately controlled, and with controlled humidity are also available. Station facilities also include a well-equipped shop, grinding and storage rooms, and a small-animal laboratory. The laboratories are provided with all facilities, such as gas, water, compressed air, vacuum, distilled water running through aluminum pipes, and D. C. current controlled so as to be set to meet any requirement desired up to 110 volts.

A fully equipped weather station under the direction of the Department of Physics is housed on the top floor of the building with instruments located on the roof. Meteorological data for the station are available from this laboratory.



FIG. 1.—The swine nutrition laboratory constructed during the biennium.

A plant research laboratory building has been constructed during the biennium. This building consists of a two-story head house, 126 feet long and 20 feet wide, of stone construction, to which are attached four greenhouse sections, each section being approximately 100 by 29 feet. Two sections of the greenhouse were constructed during this biennium and two are of older construction, having been in use by the station for several years. The cost of the new construction, consisting of the head house and two sections of greenhouse, was slightly more than \$20,000 with somewhat more than \$7,000 worth of equipment, bringing the total cost of the building and equipment to about \$28,000.

The head house is divided into offices, laboratories, service rooms for the greenhouses and caretaker's quarters. It is equipped with facilities for controlled high and low temperature work with crop

plants. The building provides laboratories, offices, and greenhouse space for the Departments of Agronomy and Botany for experimental work with cereal and forage crops and in addition furnishes a small amount of storage space for the Department of Horticulture.

A swine nutrition laboratory was constructed during the biennium at a cost of \$2,500, including equipment and a scale for weighing.

The building is a shed roof, one-story frame structure, 109 by 22 feet with the high part to the south. The structure is well ventilated, well lighted, and provided with 18 individual feeding pens 6 by 8 feet, which are paved with concrete and divided by steel gates. Along the north end of the pens is a feed alley  $4\frac{1}{2}$  feet wide extending the length of the barn, which stands in an east-and-west direc-



FIG. 2.—The cattle-feeding equipment at the Hays Branch Station, used in cattle-feeding tests conducted there.

tion. Each pen has an outside area to the south, 6 by 8 feet, paved with concrete and fenced with wire.

In the center of the building extending to the north is a feed and equipment room, 16 by 20 feet, with a five-ton Howe scale for weighing. This room has a loft for storing feed which extends out over the tops of the pens to the south.

This laboratory will provide modern and complete facilities to carry on this type of study. It was designed for use in conjunction with technical studies of the mineral requirements of growing pigs. These studies have involved carefully controlled feeding trials, determining the calcium and phosphorus requirements of growing pigs.

New buildings constructed at the branch stations consist of the following:

1. A new seedhouse at the Colby station, 30 by 40 feet, of frame construction, concrete floors, and two stories in height, built at a cost of \$2,500.

2. A seed and feed house at the Garden City station of frame construction, 76 by 36 feet, with a fireproof vault, two workrooms, a large ground-floor room for grinding and storing feed and a second story reached by both stairs and elevator. The building cost approximately \$5,000.

3. The superintendent's residence at the Tribune station was remodeled at a cost of approximately \$750.

New refrigeration equipment for the meats laboratory, including a complete new refrigeration unit, was purchased during the biennium at a cost of approximately \$2,500.

The legislature of 1937 appropriated \$5,000 for the purchase of land at the Garden City branch station. In June, 1937, a tract consisting of 99.26 acres adjoining the station on the west was purchased from Mr. George Gano, of Hutchinson, at a cost of \$2,000. In April, 1939, a tract adjoining the station on the south, consisting of 136 acres, was purchased from Mr. and Mrs. Pete Meekma at a cost of \$2,922. The greater part of both tracts of land can be irrigated from the station irrigation plant.

### PERSONNEL CHANGES

Two major changes in administrative personnel were made during the biennium. On July 1, 1938, Dr. W. F. Pickett, a member of the staff of the Department of Horticulture since 1917, succeeded Prof. R. J. Barnett as head of that department. Professor Barnett had been a member of the staff since 1920 and head of the Department of Horticulture since 1930. Professor Barnett continues as professor of horticulture and chairman of the Editorial Committee of the station.

Dr. C. O. Swanson who, since 1906, has been a member of the staff of the station and since 1923 head of the Department of Milling Industry, retired July 1, 1939, as head of the Department of Milling Industry. He was succeeded by Dr. E. G. Bayfield. Doctor Swanson continues as a member of the staff, devoting his time chiefly to research and writing.

The station lost two efficient and conscientious workers by death during the biennium. Prof. Hugh Durham, assistant dean of agriculture and editorial assistant of the station since 1915, died on October 15, 1938.

Mrs. Elisabeth Harling, seed analyst in the Department of Agronomy and the State Seed Laboratory since 1917, died November 30, 1938.

**Resignations.**—Nine of the staff resigned during the biennium. Those resigning were:

- L. F. Miller, agricultural economics.**
- J. H. Parker, plant breeding.**
- \*M. L. Fierke, bacteriology.**
- D. B. Creager, plant pathology.**
- H. W. Cave, dairy production.**
- W. H. Riddell, dairy production.**

**Martha Kramer, food economics and nutrition.**  
**R. K. Larmour, milling industry.**  
**George Cauthen, zoölogy technician.**

*Appointments.*--The average number of persons regularly employed on the scientific staff of the station during the biennium was 145. Eighteen appointments were made during the biennium as follows:

**Paul L. Dittmore, editorial assistant.**  
**R. J. Eggert, livestock marketing.**  
**Merton L. Otto, land-use planning.**  
**L. P. Reitz, plant breeding.**  
**\*E. G. Heyne, crop improvement.**  
**K. L. Anderson, pasture management.**  
**R. F. Sloan, assistant in pasture management.**  
**Elva Norris, seed analyst.**  
**\*Chas. R. Stumbo, bacteriology.**  
**Earl D. Hansing, plant pathology.**  
**H. E. Bechtel, dairy production.**  
**A. O. Shaw, dairy production.**  
**Roy Fritz, assistant in entomology.**  
**Pauline Nutter, food economics and nutrition.**  
**Charles J. Birkeland, assistant in horticulture.**  
**E. G. Bayfield, milling industry.**  
**B. B. Bohren, assistant in poultry husbandry.**  
**Allen Edgar, zoölogy technician.**

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\* In cooperation with the United States Department of Agriculture.

**SCOPE OF THE STATION WORK, JULY 1, 1938, TO JUNE 30, 1940**

A list of the principal active projects carried during the biennium ending June 30, 1940, is given below, together with statements of the source of financial support, project leaders, and reference to the discussion included in this report.

NAME	Project No.	Department	Leader	Funds	Discussed on page—
Studies of Factors Affecting the Organization and Operation of Kansas Farms.	95	Agricultural Economics...	W. E. Grimes..... J. A. Hodges W. H. Pine R. J. Doll	Purnell and State....	28
The Development of an Agricultural Land-Use Program for the State of Kansas.	215	Agricultural Economics...  Agronomy.....	W. E. Grimes..... W. H. Pine Harold Howe J. A. Hodges M. L. Otto W. H. Metzger	Bankhead-Jones.....	27
Investigations in Land Tenure and Other Related Problems..	132	Agricultural Economics...	Harold Howe.....	Purnell.....	27
The Marketing of Kansas Grain.....	143	Agricultural Economics...	Geo. Montgomery.....	Purnell.....	28
The Marketing of Kansas Livestock and Livestock Products..	149	Agricultural Economics...	R. J. Eggert.....	Purnell.....	28
The Marketing of Kansas Fruits and Vegetables.....	177	Agricultural Economics...	F. L. Parsons.....	Purnell.....	29
Production and Marketing of Kansas Potatoes.....	214	Horticulture..... Agricultural Economics...	S. W. Decker..... F. L. Parsons	Bankhead-Jones.....	29
A Study of Factors Governing the Marketing of Dairy Products in Kansas.	185	Agricultural Economics...	F. L. Parsons.....	Purnell.....	30
The Economics of the Poultry Industry in Kansas.....	144	Agricultural Economics...	C. Peairs Wilson.....	Purnell.....	31
A Study of Factors Affecting the Social Well-Being of Rural People in Kansas.	195	Agricultural Economics...	R. C. Hill.....	Purnell.....	31
Soil Fertility Investigations.....	17	Agronomy.....	W. H. Metzger.....	Hatch.....	32



SCOPE OF THE STATION WORK, JULY 1, 1933, TO JUNE 30, 1940—CONTINUED

NAME	Project No.	Department	Leader	Funds	Discussed on page
Influence of the Absolute Reaction of the Soil Solution Upon the Growth and Activity of Azotobacter.	128	Bacteriology.....	P. L. Gainey.....	Adams.....	32
Influence of Legumes and Free-Living Nitrogen Organisms on the Growth of Plants and on the Nitrogen Balance.	172	Agronomy.....	H. E. Myers.....	Purnell.....	33
The Storage, Utilization, and Evaporation of Soil Moisture...	210	Agronomy.....	J. C. Hide.....	Bankhead-Jones....	34
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### STUDIES IN THE ECONOMICS OF AGRICULTURE

Studies in the economics of agriculture have been pursued during the biennium along ten major lines, each of which is discussed briefly in the following pages.

***Studies of Factors Affecting the Organization and Operation of Kansas Farms.***--This project was expanded at the beginning of the past biennium to include seven phases of work as follows:

1. *Type of Farming and Land-Use Planning.*--The study of recent trends in Kansas agriculture has been given special attention, bringing up to date a former study that extended over 50 years or more for selected series. The data obtained are useful for type-of-farming studies, land-use planning, and for other purposes.

2. *Factors Affecting the Farm Income.*--A total of 942 farm account books were analyzed in the past biennium, through the cooperation of the Division of College Extension, Department of Dairy Husbandry, and several Kansas Dairy Herd Improvement Associations. Multiple correlation analyses were made on several bases such as differences in income, size of business, distribution of farm acreage, and crop acreage. An analysis of the data shows that the average pay for management was consistently higher on farms obtaining a major portion of income from livestock and with an above average of number of acres under cultivation which included legumes in the crop rotation. Low incomes tended to be associated with farms having a smaller percentage of land in legumes and a low percentage of receipts from livestock.

3. *Effectiveness of Federal Agricultural Programs.*--In cooperation with the Bureau of Agricultural Economics of the U. S. Department of Agriculture, analyses were made of the farm survey of the AAA Western Regional program and the Thomas county experimental program; the Nemaha county ACP; and a resurvey of supervised records in southwestern Kansas. Complying farms in Nemaha county generally showed higher incomes for labor and management than noncomplying farms, even if the ACP payments were excluded from the income of complying farms. In a study of the degree of readjustments of farm programs in order to comply with the Nemaha county ACP program, it may be stated generally that farms that did not comply would have had to make more drastic readjustments than those required of farms that did participate in the program.

It may also be stated that the effects of weather and other factors were greater on organization of the farm business and trends of crop acreages and number of livestock than the AAA or ACP programs. This does not imply that the federal programs were ineffective, but these effects are extremely difficult to isolate. As an example, the trend of legumes in central and eastern Kansas was generally downward as a result of drought and grasshoppers, but the downtrend on complying farms was less marked than the downtrend on noncomplying farms.

A report recently released by the Bureau of Agricultural Economics of the U. S. Department of Agriculture reflects the heavy dependence of farmers in southwestern Kansas upon AAA payments and the general prejudice in that section with small or average-size farms against large operating units.

4. *Relative Adequacy of Four Types of Sample-Surveys.*--Tests were made in Marion county of the adequacy of four types of sample-surveys for use in obtaining data for this project. The types tested were: Four-section blocks, random one-section blocks, random farms, and judgment routes. A preliminary report was prepared from the results of this test. The work was done in cooperation with the Division of Crop and Livestock Estimates, Bureau of Agricultural Economics, U. S. Department of Agriculture.

5. *Farm Organization in Type-of-Farming Area No. 5.*--Comparative budgets were made for five systems of farming each for 320- and 480-acre



farms in Area No. 5. Since this area embraces the Blue Stem Region of Kansas, special attention was given to methods of handling cattle, and organization, income, expenses and net returns were calculated for each of the five systems in the two sizes of the farms. A manuscript giving the results of this study has been prepared for publication.

6. *Changes in Farm Practices.*--A survey of farm practices was planned to obtain information needed to revise standards for budget making. The most immediate needs appear to be concerned with practices with beef cattle and the requirements for operations with small tractors and small combines. Survey records in Chase, Lyon, and Jackson counties were taken in June, 1939. Standards for recent practices will be compared with records formerly taken in Chase and Jackson counties, and the extent of change in practices during the last 10 to 15 years will noted.

7. *Study of Hail Insurance for Central Kansas.*--The principal phase of this study was a comparison of loss ratios and premium rates by counties and by years. While loss ratios appeared to be the chief factor affecting rates, they did not entirely account for the great variation of rates, and on this basis some equalization of rates appears desirable.

(Project 95, Department of Agricultural Economics. Leaders, W. E. Grimes, J. A. Hodges, W. H. Pine, R. J. Doll; Purnell and state funds.)

***The Development of an Agricultural Land-Use Program for the State of Kansas.***--This project was started on July 1, 1939, and is coöperative between the Kansas Agricultural Experiment Station and the Bureau of Agricultural Economics, the Soil Conservation Service, and the Division of Soil Survey, Bureau of Plant Industry, all of the United States Department of Agriculture. Emphasis for the first year's work was placed upon the development of a technique for land-use planning.

Nemaha county was selected as a trial area and a land-use map, showing 24 land-use areas, was prepared of the county and a productivity rating for the soils mapped was established. Soil types are not being mapped in this survey, but instead similar types have been grouped and soil groups only are shown. The map also shows the predominating slope for each soil group, the nature of the parent material and the degree of erosion. Maps so prepared are intended to serve as a basis for county planning and planning for larger areas. They are not adequate for individual farm planning. A large-scale reconnaissance survey covering 80 counties is now under way. Detailed surveys will be made as rapidly as possible.

With land classification as the basis of any land-use program, farm plans and budgets are being prepared for seven types of farms in Nemaha county, suggesting desirable farm organizations for the specific conditions in each area.

Plans have been made to develop a land-use program for Chase county, for which a type-of-farming study has been started.

(Project 215, Departments of Agricultural Economics and Agronomy. Leaders, W. E. Grimes, W. H. Pine, Harold Howe, J. A. Hodges, M. L. Otto, W. H. Metzger; Bankhead-Jones fund.)

***Investigations in Land Tenure and Other Related Problems.***--The work during the past biennium has been directed principally toward furthering a study of farm tenure, in coöperation with the Bureau of Agricultural Economics of the U. S. Department of Agriculture. The main phases of the work are as follows:

1. *Summarizing Available Data on Tenancy.*--Data available in the Census and in farm account records have been summarized, and include the percentage of tenancy by counties and townships, the trend in tenancy by counties, and comparison of type of farming followed by owners and tenants.

2. *Summarizing Mail Questionnaire Returns.*--Replies from approximately 4,000 tenants were received during the biennium, representing all counties of the state. In addition, two men collected approximately 200 schedules by personal interviews in four counties.

3. *Preparation of Tenancy Report.*--During the closing months of the biennium, work has been done in shaping materials from primary and secondary sources into a manuscript designed to give a general picture of farm tenancy in Kansas. Data from the 1940 census and additional information to be gathered during the next year will complete the manuscript.

(Project 132, Department of Agricultural Economics. Leader, Harold Howe; Purnell funds.)

***The Marketing of Kansas Grain***--A major part of the research on this project during the biennium has consisted of studies of seasonal price movements of Kansas grain. These investigations have included :

1. *Seasonal Movements in Corn Prices.*--An analysis was made of the seasonal movements of corn prices from June to December in periods preceding the harvest of large corn crops and small corn crops for the period, 1892 to 1939.

2. *Monthly Price Movements of Oats.*--A study of the monthly price movements of oats for the period 1910 to 1939, inclusive, was made. Deflated monthly top prices of No. 2 white oats at Kansas City were used in the study.

3. *Seasonal Movements in Wheat Prices.*--This phase of the work is an expansion of the study of seasonal wheat prices and concerns the seasonal movement of wheat prices preceding the harvest of large crops and preceding the harvest of small-crops.

4. *Analysis of Elevator Records.*--Changes in the financial and operating conditions of 35 elevators included in a study began in 1930 are being analyzed.

5. *Relation between Fall Precipitation and Wheat Yields in Western Kansas.*

--Information gained from the rainfall-wheat-yield study indicates that fall precipitation is a more reliable index of wheat production in western Kansas than is observation of the condition of the crop.

(Project 143; Department of Agricultural Economics. Leader, George Montgomery; Purnell funds.)

***The Marketing of Kansas Livestock and Livestock Products.***--Work on this project during the past biennium has been carried on along four main phases, as follows:

1. *Economics of Cold-storage Locker Operation.*--An analysis was made of the organization and operation of 94 Kansas cold-storage locker plants, in co-operation with the Farm Credit Administration and with F. L. Parsons, leader of Project 177. Locker plant numbers in Kansas have increased from 11 in 1935 to 120 in 1940, and the survey showed that on January 1, 1940, one-half of the available storage space was rented. It was significant to observe that one town in the state has three plants and 20 towns have at least two plants. This fact indicates that current interest in the cold-storage locker enterprise may easily result in the establishment of plants where there would be inadequate volume of business for efficient operation. In the survey conducted among locker patrons, 43 percent of them stated that products do not keep satisfactorily in lockers. This objection arises probably from the fact that the

survey conducted among operators showed that only 5 percent of the plants maintain a locker room temperature range (0 degrees to 5 degrees F.) recommended by authorities on meat and fruit, and vegetable refrigeration.

2. *A Study of Seasonal Variations of Livestock Prices.*--Percentage price changes from one month to the next are of assistance in presenting the usual seasonal price trends in livestock. Price series by ten-day and monthly averages for 12 classes and grades of cattle, five classes of hogs, and four classes of sheep and lambs have been computed for the period, 1921-1939, and average seasonal price trends have been calculated for 19 of these.

3. *Purchases and Sales of Livestock by Farmers.*--This phase is a part of the "Effective Selling of Livestock" study as outlined by the North Central States Land-Grant College Committee on Livestock Marketing Research. Plans have been completed for conducting a survey among approximately 10,000 Kansas farmers to obtain information on livestock purchases and sales by them.

4. *Current Market Reports.*--Considerable time was spent in preparing weekly, monthly and annual reports and forecasts on marketing livestock in Kansas. Direct assistance has been given to stockmen in planning a profitable livestock enterprise and in presenting demand and supply information relative to desirable periods to buy or sell livestock.

(Project, No. 149 ; Department of Agricultural Economics. Leader, R. J. Eggert; Purnell funds.)

*The Marketing of Kansas Fruits and Vegetables.*--Work on this project during the past biennium was directed mainly toward a study of the marketing of Kaw Valley potatoes on local markets. Tests were conducted to determine the efficiency of the commercial mechanical method of cooling potatoes before shipment. Questionnaires were sent to 500 cold-storage locker patrons of five plants in eastern and central Kansas to determine the extent to which the lockers were used in storing of fruits and vegetables. Some of the more important findings of these investigations are as follows:

(A) Kansas potatoes constituted approximately one-half of all potato sales in July by 18 representative grocery stores in Topeka, Lawrence and Kansas City, Kan. This compares with about 6.5 percent in October and approximately 2 percent, in January and April. Kaw Valley potatoes in July sold for about 1.3 cents per pound less than competitive potatoes from Idaho, Colorado, and California. About one-half the Kaw Valley potatoes on these markets were washed. All shipped-in potatoes were washed and graded.

(B) Only a small percentage of cold-storage locker users store fruits and vegetables, it was found in a survey of 263 families using storage lockers. The quality of stored fruits was reported as being better than the quality of the stored vegetables, but if prepared and packaged properly, vegetables kept satisfactorily.

(Project 177; Department of Agricultural Economics. Leader, F. L. Parsons; Purnell funds.)

*Production and Marketing of Kansas Potatoes.*--Experiments were conducted and studies were made of production, grading, washing, storing and loading of Kansas potatoes by the Departments of Agricultural Economics and Horticulture. During the past biennium, most of the work has been directed toward a study of the factors of marketing.

In coöperation with the coöperative division of the Farm Credit Administration, a study is being made of the Kaw Valley Potato Growers' Association to determine what factors were responsible for its successes and failures during the period of its operation, 1930 to 1936. This survey has not been completed.

Some of the more important facts gathered in the study of the phases of potato marketing are :

A. Loss of weight due to desiccation was greatest in washed potatoes in storage, amounting to about 15 percent during the six-months period as compared to a shrinkage of 10.2 percent in the unwashed lot for the same period.

B. Decayed and spoiled potatoes averaged 19.6 pounds per sack in washed lots at the end of the test period, as compared to 9.4 pounds per sack in the unwashed lot. Under normal conditions, low-grade potatoes should not be stored; and if they are stored, they should not be washed.

C. During the 1930-1939 period, 32 percent of federally inspected potatoes graded U. S. No. 1, 51.4 percent were U. S. commercial grade, 12.7 percent U. S. No. 2 grade, and 3.1 percent unclassified grade. Decay has been the principal cause for putting potatoes in the unclassified grade, as 88.8 percent of the potatoes in this grade had more than 1 percent decay. Nearly 75 percent of U. S. No. 1 potatoes were classified as clean, compared with only 46 percent for U. S. commercial grade and 26.9 percent for U. S. No. 2 grade.

D. The pyramid style of loading potatoes for shipment, introduced in 1939, rapidly is replacing the summer style of loading in cars, chiefly because cars loaded pyramid style reach their destination with fewer sacks of potatoes shifted while in transit.

E. For the two-year period, 1935-1936, more than 90 percent of potatoes produced by the members of the Kaw Valley Potato Growers' Association were sold either through a commission man at the shipping point or through a commission man at the shipping point plus a terminal broker. Wholesale receivers purchased 47.6 percent of all potatoes produced. Wholesale grocers purchased 9.3 percent, jobbers purchasers 12.7 percent, retail grocers 1.5 percent, shippers purchased 15.4 percent, and all other sales amounted to 13.5 percent.

F. Of the potatoes marketed in 1938, 25 percent were graded U. S. No. 1, and 14.5 percent failed to be graded U. S. No. 1 because of dirt only. A study of the grade defects in the carloads failing to grade U. S. No. 1 for reasons other than dirt shows that approximately 40 percent were composed of grade defects over which man might exercise control, chiefly mechanical injury, sunscald, sunburn, bruises, cuts and caked dirt. The remaining 60 percent of the cars failing to grade U. S. No. 1 were damaged by insects, disease, and weather factors over which man may have little control.

G. Potatoes produced in Missouri, California, and Idaho are the chief competitors with Kaw Valley potatoes on the Chicago market during July.

H. The potato acreage in Kansas from 1880 to 1936 has declined gradually and today the acreage averages less than 40 percent of the 1885-1894 acreage. The acreage of the leading six Kaw Valley potato-producing counties has fluctuated greatly, but has not shown any definite decline over a period of years. The acreage in the six counties for the 1935-1936 period was 10,502 acres.

(Project 214; Departments of Agricultural Economics and Horticulture. Leaders, F. L. Parsons and S. W. Decker; Bankhead-Jones funds.)

***A Study of Factors Governing the Marketing of Dairy Products in Kansas.***--During the biennium work consisted principally of (1) investigating butter storage in community cold-storage lockers; (2) collection of data showing production and value of dairy products by Kansas counties for the period of 1926 to 1938, inclusive; (3) maintaining Kansas price series on butterfat, used principally in preparation of periodic market reports and forecasts

concerning marketing of dairy products. Some of the more important findings of these investigations are:

1. Only 15.6 percent of 263 families over Kansas using cold-storage lockers made a practice of storing butter. The average quantity stored was 32 pounds a year. Ninety percent of the patrons reported that butter kept in good or excellent condition.

2. Dairying in 1939 in Kansas was slightly unfavorable in comparison with most major farm enterprises, an analysis of butterfat, feed and livestock prices showed.

3. Cold-storage costs for butter at terminal markets were estimated on the basis of handling, storage, insurance and interest costs. These charges average \$0.00359 per pound for the first month and \$0.00244 per pound for each succeeding month.

(Project No. 185; Department of Agricultural Economics. Leader, F. L. Parsons; Purnell funds.)

***The Economics of the Poultry Industry in Kansas.***--For the past biennium the marketing of poultry and poultry products in Kansas has been given major attention in this project. A survey of Kansas coöperatives handling poultry and eggs was made in coöperation with the Farm Credit Administration, Washington, D. C., and included 28 associations. It was found that poultry and eggs account for only a small part of the total business of the associations and that the associations lacked facilities for handling poultry and eggs. Three of 22 associations handling eggs operated on a graded basis. Only three associations had refrigeration facilities.

Gross margins on eggs averaged 6.5 percent and on poultry 8.8 percent. Of the 27 associations handling poultry, 23 operated on a graded basis. Six turkey pools used government grades.

It was found that little effort has been made by coöperative associations to promote a quality improvement program among producers.

Farm management studies were made of 75 member farms in Farm Bureau-Farm and Home Management Associations, these studies dealing with receipts from sales and home use of poultry. Receipts per hen tended to increase with size of flock and the heavy breeds showed slightly higher receipts per hen than the light breeds in spite of the fact that the heavy breed flocks were somewhat smaller in size. This appeared to be due to the relatively better poultry or meat situation compared with the egg situation in 1937.

(Project, 144; Department of Agricultural Economics. Leader, C. Peairs Wilson; Purnell funds.)

***Studies of Factors Affecting the Social Well-Being of Rural People in Kansas.***--A summary statement of population changes in Kansas during 1938 was prepared, in coöperation with the Division of Farm Population and Rural Welfare, Bureau of Agricultural Economics, United States Department of Agriculture.

The report was based on 2,500 returned questionnaires out of approximately 7,000 sent to farm women in Kansas. The report indicates, among other things, a decline in farm population in Kansas of 5,000 persons in 1938 compared with a decline of 14,000 persons in 1937, over twice as many births as deaths, and a net movement from farms to villages, towns and cities of 11,000 persons. The survey will be repeated to obtain the population movement during 1939.

Tabulations of data are being made in connection with the work on composition and trends of population for all counties of Kansas for each year from 1887 to 1938.

A summary of the study "Public and Private Relief in Rural Kansas" was mimeographed and distributed to social welfare workers and other persons interested in rural social welfare research data.

Data concerning rural youth in three Kansas villages are being put into tabular form for analysis. These data were obtained a few years ago under the plan of Coöperative Research, which terminated August 31, 1939.

(Project No. 195; Department of Agricultural Economics. Leader, R. C. Hill; Purnell funds.)

### SOIL CONSERVATION

The problems associated with soil management from the standpoint of soil conservation have continued to receive the careful attention of the station during the past biennium. A brief description of the work under way is given in the following pages.

**Soil-Fertility Investigations.**--Research work on this project during the past biennium has been conducted in three phases:

1. *Effects of Rotations and Fertilizers upon Crop Yields and Soil Composition.*--The twenty-ninth year of this phase recently was completed and the results have shown a continued deterioration of soil with an increase in the length of the cropping period, particularly where all crop growth is removed and no manure returned to the soil. Nitrogen has become a limiting factor in the soil under rotations without a legume and phosphorus gives consistently favorable response with wheat and alfalfa. A recent summarization shows that liming produced twice as great an increase in alfalfa hay yield over no treatment during the second 14-year period than during the first 14-year period.

2. *A Study of Some Factors Influencing Soil Aggregation.*--Good structure was maintained on fallowed soil in a greenhouse study, adding only sufficient water to keep the soil under optimum moisture condition. Maintenance of a good structure under such fallow conditions is presumably due to the accumulation of electrolytes. When similar soil had sufficient water added to produce some leaching, an appreciable destruction of aggregates took place. Organic matter in the amount of 5 tons of straw per 1,000 tons of soil prevented this deterioration. Liming also prevented destruction of aggregates. Soil under wheat, soybeans and sweet clover was better aggregated where lime was applied than where no lime was applied.

3. *Phosphorus Fixation Studies.*--This phase is a continuation of previous studies. The results, consistent with those presented in the preceding biennial report, indicate that accumulated products of soil weathering, not identified, but other than oxides of aluminum and iron and exchange material, play an important role in phosphorus fixation. It was concluded from the results of the work of the last three years that chemical precipitation in the various forms may largely account for phosphorus fixation in acid soils and that fixation on the surfaces of the particles in a replaceable form (adsorption) may be of small practical significance.

(Project 17; Department of Agronomy. Leader, W. H. Metzger; Hatch funds.)

**Influence of the Absolute Reaction of the Soil Solution Upon the Growth and Activity of Azotobacter.**--The relative growth of *Azotobacter* in the presence or absence of combined nitrogen at pH values below 6.0 has been the principal research on this

project during the past biennium. In contrast with the findings of Burk, the results of these studies indicate:

(a) The majority of locally isolated cultures show little or no tendency to grow at pH values below 5.9-6.0 in either the presence or absence of combined nitrogen. A few cultures will grow, but not satisfactorily, at pH values of 5.6-5.7.

(b) In many instances growth takes place somewhat more rapidly at lower pH values in the presence of combined nitrogen ( $KNO_3$ ) and this may result in an elevation of pH, followed in turn by more abundant growth, thereby giving the appearance of a greater tolerance of acidity in the presence of combined nitrogen.

Prolonged growth of *Azotobacter* in the presence of high concentrations of nitrate nitrogen will cause many strains, possibly all, to lose their nitrogen-fixing ability. Also, high concentrations of nitrate nitrogen are toxic to *Azotobacter*. These two facts explain the oft-noted low *Azotobacter* population in soils relatively high in available (nitrate) nitrogen.

Approximately 250 locally isolated strains of *Rhizobium meliloti* have been tested for their nitrogen-fixing efficiency. About one-fourth appear to be exceptionally good and one-fourth poor.

A study of rhizobial strain adaptation to varieties of alfalfa revealed a host plant specificity, but efforts to correlate this with resistance and susceptibility to alfalfa wilt failed.

The 32 soil cylinders previously inoculated with *Azotobacter* have been continued as in previous years, and were planted to oats in 1939 and 1940. *Azotobacter* have remained in the soil of limed cylinders, but repeated inoculations in unlimed soil have failed to establish an *Azotobacter* flora. No evident effect of *Azotobacter* upon plant growth has been observed.

(Project 128; Department of Bacteriology. Leader, P. L. Gainey; Adams funds.)

***Influence of Legumes and Nitrogen-fixing Organisms on the Growth of Plants and on the Nitrogen Balance.***—Work during the past biennium has been conducted in the field and laboratory. The field work has been a continuation of the rotations already in progress. The major emphasis has been to determine the influence of soybeans, sweet clover and alfalfa on the yield and quality of the succeeding crops and to study the comparative effect of corn and kafir in these same rotations on the yield of succeeding crops.

The laboratory studies have been made in an effort to determine the cause or causes of the differential influence of the various rotations. The nitrate nitrogen and moisture content of the soil following the various legumes and following corn and sorghums have been determined. The possible influence of the sugar content of sorghum residue and the nitrate content of the soil solution on the differential influence of crops on soil aggregation has also been investigated.

The field results indicate that where a strong legume such as alfalfa or sweet clover is grown in the rotation, the so-called harmful effect of sorghums is not evident where the land is fall-plowed following the sorghum harvest and planted to a spring crop. The average yields of oats and wheat in the row crop, oats, wheat rotations are as follows:

PREVIOUS LEGUME	Average yield of oats, 1935-1939		Average yield of wheat, 1936-1939	
	After kafir	After corn	After kafir	After corn
1 year soybeans.....	31.8	33.1	19.0	19.4
1 year sweet clover.....	36.7	34.8	20.0	20.2
2 years sweet clover.....	39.7	38.1	22.2	21.6
2 years alfalfa.....	38.7	38.3	20.5	20.5
Average.....	36.7	36.2	20.4	20.4

The laboratory studies show that the nitrate nitrogen content of soils following kafir in a rotation with alfalfa and sweet clover is higher at oat-seeding time than it is in soils following corn in a nonlegume rotation. The nitrate nitrogen content of the kafir soils in the legume rotations is lower than the nitrate nitrogen content of the corn soils in the same rotation, but for the yield levels obtained the lower nitrate content does not appear to limit the yield.

Laboratory studies indicate that a shortage of moisture, either directly or indirectly, is the principal cause of corn failures following legumes.

(Project 172; Department of Agronomy. Leader, H. E. Myers; Purnell fund.)

***The Storage, Utilization and Evaporation of Soil Moisture.***

--This project in coöperation with the Soil Conservation Service, United States Department of Agriculture, was started during the biennium.

Physical equipment was assembled consisting of 30 metal lysimeters 18" in diameter by 72" deep, together with equipment for weighing. From November, 1938, weights were taken at as frequent intervals as found necessary to determine moisture changes.

The work to date has been largely exploratory but is valuable in developing a satisfactory procedure. Good stands of wheat and alfalfa were secured in the fall of 1939. The wheat seeded on October 2, 1939, made good growth and had used 0.75 inch of water for growth purposes by the end of the month. Moisture use during the winter months was slight, but the April growth used about 0.70 inch of water. The use of moisture by fall seeded alfalfa up to May 1 was not great enough to exceed distinctly the evaporation loss. From 12 rains of 0.50 inch or over which were succeeded by at least 3 rainless days, the average loss by evaporation from fallow soil was 0.51 inch. Ten of the values fell between 0.33 and 0.65 inch.

In coöperation with Doctor Metzger the greenhouse study on the influence of various crops and soil treatments on soil aggregations was continued. The high degree of aggregation previously found in fallowed pots in the greenhouse was not encountered when pots were subjected to a moderate amount of leaching. Application of organic matter or the use of lime in conjunction with a growing crop increased the degree of aggregation.

In the laboratory a comparison of a well aggregated fraction with a poorly aggregated fraction from several soils showed the well aggregated material to be relatively high in organic carbon and total nitrogen. It also possessed a larger quantity of difficultly oxidizable organic carbon and a wider carbon nitrogen ratio than the poorly aggregated material. Preliminary fractionation of the organic matter indicates further differences. The well aggregated ma-



terial was relatively high in total sand and clay but low in silt. Difference in base exchange capacity appears to be due to differences in clay content.

A few observations made during the biennium indicate that temperature differences at various depths in the soil profile may account for movement of considerable amounts of water in the soil by vaporization and condensation.

The study will be continued mostly in its present form with increased emphasis on moisture movement in the vapor form and on the qualitative nature of soil organic matter associated with aggregation in soils.

(Project 210; Department of Agronomy. Leader, J. C. Hide; Bankhead-Jones fund.)

***A Study of Soil Solution as Governed by H-ion Concentration and Other Factors.***—Considerable work has been done with limed soils from Ohio, New Jersey and Kansas in a study of soil minerals, which determine the soil solution. New equipment has made possible the carrying on of studies with finer particles and under constant temperatures. In an intensive study of Kansas soils, soil material is being treated with solutions of different H-ion concentrations and mineralogical separations are then being made from the treated material. Some of the results of these studies are:

1. Results obtained from field soils indicate that liming decreases the amount of fine particles in comparison to the coarse particles and decreases the amount of light particles in comparison to the heavy particles. It is significant that the fine particles, as well as the light particles, are most desirable from the viewpoint of plant nutrients.

2. Data obtained indicate that a nearly neutral soil has a larger percentage (by weight) of larger particles than of small particles, and that the finer particles belong to the light mineral group.

The work next biennium will be largely a continuation of the work of the past several years, but with much greater emphasis being placed on soils treated in the laboratory. Some soil samples which have been treated with volumes of solutions, equivalent to 50 years' rainfall, at different pH values, are now ready for mineralogical separations, and other soil samples which have been treated with volumes of solutions nearly equivalent to 100 years' rainfall with different acids are nearly ready for mineralogical separations.

(Project 155; Department of Chemistry. Leader, A. T. Perkins; Purnell fund.)

***A Study of Some Replaceable Cations and Anions in Some Kansas Soils.***—Work during the past biennium has been directed toward a determination of the phosphorus adsorbing and fixing ability of some Kansas soils. Soil material has been separated and fractionated into several divisions. Some of the results of this study are :

1. Phosphate fixation varies directly with the time the phosphate is in contact with a soil, although in some cases a double reversion takes place and more phosphate might become soluble in time.

2. Phosphate fixation varies indirectly with the size of soil particles. The coarse particles of a Wabash soil fixed 6 percent of the phosphorus added at the rate of 2,000 pounds per acre of  $\text{CaH}_2(\text{PO})_2 \cdot \text{H}_2\text{O}$  per 2,000,000 pounds of soil, but the colloidal particles fixed over 99 percent of a similar application.

3. The light mineral group is more active in fixing phosphates than the heavy mineral group. Among the coarse particles, under standard conditions,

the light minerals fixed 93.63 percent of added phosphorus while a similar weight of the heavy mineral group fixed 77.70 percent of added phosphorus.

4. Chemical analyses show that the light minerals are much richer in aluminum than the entire soil or the heavy minerals, and results of separations confirmed by comparative analyses indicate that the heavy mineral group does not exist among the fine separates.

(Project 179; Department of Chemistry. Leader, A. T. Perkins; Purnell fund.)

**Soil and Crop Experimental Fields.**--Experiments in soil management and crop production were continued on four groups of outlying experiment fields in eastern and southern Kansas. The work conducted on each of these groups of fields is briefly discussed below.

*Southeastern Kansas Experiment Fields.*--Work has been continued as in the past on the Columbus and Moran fields and a third field has been started during this biennium at Thayer. Since soil fertility is the principal agronomic problem in the section of the state where these fields are located, soil fertility experiments received major emphasis during the biennium, as has been the case in the past. A number of rotation and crop sequence experiments, which are really a part of the soil fertility program, also have been tried out. Variety tests of all principal farm crops have been conducted on at least two of the three fields. The soft wheat nursery which was abandoned in 1933, due to lack of funds, was reestablished in 1938. Also, a flax improvement nursery was started in 1938 at the Thayer experiment field.

With the establishment of the Thayer field, the flax nursery and the re-establishment of the soft wheat nursery, the amount of research work in Southeast Kansas has been increased about two and one-half times during the biennium.

The results obtained from the fertility experiments at the Columbus and Moran fields during the past two years substantiate previous work. Although there are no data previous to this biennium to compare with the Thayer results, they are much as were expected and tend to bear out the information obtained at other fields in Southeast Kansas.

In general, the application of lime is necessary to establish and maintain good stands of alfalfa and of the clovers. Since lime does insure better stands of these crops, somewhat better yields are obtained. Lime probably has very little or no direct effect upon the yields of grain crops, but does increase the yields of these crops indirectly through its effect on the legumes that precede them. Phosphorus is necessary for the most economical production of wheat, oats, alfalfa and clove. Sorghums, corn, flax and soybeans give some response to phosphorus in some cases, but whether it is profitable to use it on these crops is more or less doubtful. Potash has failed to give enough response to warrant its use on soils in Southeast Kansas.

The yields at the Columbus field during the biennium were very similar to those of the past except that they were somewhat higher than the average. Because of army worm injury, the wheat crop of 1938 was poor. The increase from the use of superphosphate was a little lower than usual and there is a rather large decrease from the use of legumes whereas the long-time average shows a small increase.

At the Moran field, the yields and increases from fertility treatments run true to form on alfalfa, clover, hay, soybean hay, and oats, but on corn, soybean seed and Atlas, the results were erratic. In 1938 the extremely dry late summer and fall resulted in small differences between various treatments on late crops and in 1939 the entire season was so dry that no moisture was stored in the subsoil. Because of this condition the late crop had to depend upon the moisture reserve that was not used the previous summer. Therefore, on those plats that produced heaviest in 1938, the reserve subsoil moisture

was lowest and consequently low yields were obtained in 1939. This resulted in an almost complete reversal of normal yields.

As 1939 was the first year of results at the Thayer field, no comparisons can be made with previous years. The methods of seedbed preparation and crop rotations continue to have a decided influence on the yield of flax at the Columbus field. A yield of eleven bushels of flax an acre was obtained on both spring-disked and winter-plowed soybean ground as compared to about six bushels from kafir ground prepared in the same manner.

Alfalfa variety tests were carried on all fields during the past two years and in every case Ladak has led in yield. Grimm and Kansas Common were close together in the yields produced. Several other varieties have been tested, but none was outstanding in any respect.

In 1938, 15 commercial corn hybrids were tested with eight open-pollinated varieties and in 1939 about 50 commercial and experiment station hybrids were tested on the Moran and Thayer experiment fields. Of this entire group, there is no evidence that any of the commercial hybrids tested are any better than the best open-pollinated varieties. There are, however, several experiment station hybrids that yielded considerably more in 1939 than any of the open-pollinated varieties.

Flax variety work was carried on at Thayer and Moran, both in 1938 and 1939. Linota continued to produce the best yields at Moran, but Bison was the highest yielding variety at Thayer both years.

Oat variety tests were conducted at Moran and Thayer both years. There continued to be very little difference between Kanota, Columbia and Fulton when they were planted in early March, but when planted in late March or early April the Kanota variety was inferior.

Sorghum variety tests were conducted at all fields. The largest test at Thayer in 1939 included 17 varieties and three dates of seeding. H. C. No. 312, Blackhull kafir, and Club produced the highest grain yield. Kansas Orange and Atlas lead the other varieties in forage yields with the former having a slight advantage. In 1939 several combine types of kafir were tested and showed much promise.

Eight varieties of soybeans and two of cowpeas have been tested at all fields for the past two years. Of the soybean varieties I. P. No. 6, Hongkong, and A. K. were the highest in grain yield. Laredo and Hongkong were highest in hay yields. New Era cowpeas made higher yields in both seed and hay than did Whipoorwill.

Clarkan continued to hold some slight advantage in yield over Kawvale in the wheat variety tests at Columbus and Thayer. The quality of Clarkan was also better than that of Kawvale. Loose smut has increased steadily in Clarkan while Kawvale continues to be almost entirely free from this disease.

Reno winter barley has made a good record for the past two years. It has ranked high both years at Columbus and was second to South Central Kansas barley at Thayer in 1939. Missouri Early Beardless has been the lowest yielding variety during each of the two years.

(Department of Agronomy. Leaders, R. I. Throckmorton and F. E. Davidson; state fund.)

**South Central Kansas Experiment Fields**—The experimental work on the South Central Kansas Experiment Fields is conducted on the Wichita, Kingman, and Hutchinson fields.

The experimental work on the Wichita and Kingman fields is divided into two phases, namely, soil fertility studies and crop variety studies. The former consist of various rotations, crop sequence, application of commercial fertilizers and manure and different tillage methods. The latter deals with wheat, winter barley, spring barley, oats, alfalfa, sweet clover, cowpeas, corn, sorghum, and tame and native grasses. At the Hutchinson field, the work is limited to crop variety testing.

The response of crops to the application of superphosphate has been more

or less erratic. During some years there has been a significant positive response. There has been more response from the application of superphosphate on continuous wheat than on wheat grown in a rotation with alfalfa, sorghum, and oats. Wheat grown in a rotation with alfalfa has yielded six bushels per acre more than continuous wheat.

A four-year rotation involving methods of handling sweet clover in rotation with wheat, kafir and oats has given significant results for the two years it has been in effect. The rotation previous to 1937 included sweet clover, oats, kafir, and corn, but to make the rotation more practical wheat was inserted in place of corn. Wheat yields for the two-year period in this rotation have been as follows:

Plot Treatment Preceding Wheat	Ave. Wheat Yields, 1938-'39: Bushels per acre.
No sweet clover	24.4
Sweet clover seeded in oats and turned under second year for green manure	31.9
Fall-seeded sweet clover for seed	29.3
Spring-seeded sweet clover for seed	28.1
Spring-seeded sweet clover taken off for hay	31.3
Spring-seeded sweet clover, hay first year, green manure second year.	29.5

It should be noted that there has been a significant response from sweet clover in every case. However, since this rotation has been in effect only two years, these figures serve only as an indication of what may be expected over a longer period.

On the Wichita field, good stands of sweet clover have been secured by seeding in the spring on disked sorghum land. Practically as good results have been secured by seeding oats at the rate of one bushel to the acre and then seeding clover in the oats about the time the oats are sprouting as when sweet clover is seeded alone. When the clover was seeded alone in the spring, there has been slightly more first-year growth on the clover than where the clover was seeded with the oats as a nurse crop.

During the last two years, fall-seeded clover following a small grain crop has failed. This has been due mainly to a lack of rainfall during the latter part of the summer.

Date-of-seeding tests of oats during the past biennium as well as over a longer period of years have shown rather conclusively that best yields of oats may be obtained from early March seeding as compared to later seedings.

Fulton oats, which were approved for certification in 1939, has outyielded Kanota oats for the period they have been in the tests. Fulton is somewhat earlier, resistant to smut, and makes more early spring growth than Kanota.

Yields of alfalfa have been relatively low during the past two years. However, fair stands have been maintained. There has not been a large difference in yields of Ladak, Kansas Common, and Grimm.

Corn has yielded less than one-half the amount of grain obtained from sorghums. Hays Golden has continued to be the leading open-pollinated variety of corn. Twenty-three hybrids were tested in 1939. Five of these produced a higher yield than Hays Golden and 18 produced less than Hays Golden.

The application of superphosphate at the Kingman field has given only slight response as far as wheat is concerned. There has been a one- to two-bushel increase from phosphate on wheat in a rotation with very little carry-over effect the second year. Phosphate on continuous wheat has not given any increase in yield over a period of years.

The application of sodium nitrate has increased yields approximately two bushels per acre where wheat is grown continuously.

Top-dressing wheat in alternate years with manure (two and one-half tons per acre) has not increased the yield over a period of years. Increase from manure has been secured by plowing it under previous to seeding.

Wheat variety yields at Kingman have been good during the past two years. Tenmarq, Cheyenne, and Nebred, have been the outstanding varieties.

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Two new wheats, Oro X Tenmarq C. I. 11673 and Kawvale X Tenmarq C. I. 11669 have produced high yields during this period.

Oats varieties yielded well in 1938, but yields were low in 1939 due to a lack of moisture and damage from green bugs. Date tests of oats show conclusively that early March seeding, at Kingman as at Wichita, is more desirable than later seedings.

Fulton oats has yielded from four to five bushels more than Kanota on normal seeding dates. Fulton is two to three days earlier than Kanota, exhibits more early spring growth, and is resistant to smut. It lodges as badly as Kanota.

Ladak alfalfa shows much promise on the Kingman field. It has the ability to hold its stand over a longer period of time than other varieties. It produces heavy first crops, it is resistant to wilt, resistant to low temperatures, and more resistant to leaf and stem diseases than is Kansas Common.

Brome grass has been the outstanding tame grass on the Kingman field. It has the ability to maintain its stand once it is established. Crested wheat grass may do well for two or three years, but does not have the ability to withstand adverse conditions as well as Brome grass.

At the Hutchinson field, four strains of White Darso selections which showed the most promising characteristics in 1938 were placed in plots in 1939. In 1939 two of these four selections did well but the other two were discarded because of their tendency to crook-neck, to have heavy black glumes, and to have poor threshability. Yields secured in 1939 of the two promising strains exceeded common Darso by about 10 percent.

Sorghum yields on the Hutchinson field were good in 1938 and exceptionally good in 1939. Pink kafir, Club kafir, Red kafir, Darso, Pierce kafir, and Finney milo all have yielded well.

(Department of Agronomy. Leaders, R. I. Throckmorton and C. R. Porter; state fund.)

**Southwest Kansas Experiment Fields.**--Two experiment fields have been operated in Southwest Kansas during the biennium--the Dodge field in Ford county and the Meade field in Meade county. The fields are devoted to tests of varieties, seedbed preparations, methods of summer fallowing, rates and dates of seeding, crop rotations and methods of seeding of all farm crops grown in the area. Experiments are conducted with native varieties and introduced species and varieties of grasses.

Adverse weather conditions during the biennium at the Meade field resulted in very low yields and much of the work failed to produce comparable results. The total rainfall in 1939 was 8.93 inches, the lowest on record. Only crops on summer fallowed land produced harvestable yields.

In the barley variety test on fallow, Flynn produced an average yield of 19.8 bushels per acre during the biennium while Common 6-row produced an average yield of 16.4 and Vaughn 19.2 bushels per acre.

Only the Kanota and Brunker varieties of oats were included in the test during both years of the biennium. The average yield of the former on fallow was 15.0 bushels per acre and that of the latter was 11.8. Fulton was included in the test in 1939 and produced 11.0 bushels per acre, while the yield of Kanota was 6.6 bushels.

The average yields from the wheat variety tests on fallow during the biennium were as follows: Chiefkan 13.7, Local Blackhull 13.4, Blackhull 11.7, Tenmarq 10.9, Nebred 10.9, Kanred 10.6, Early Blackhull 10.4, Cheyenne 10.1, and Turkey 8.2 bushels per acre.

In the method-of-fallow project, the highest yield in 1939 and for three years 12.6 bushels per acre was obtained by one-waying early in the spring and then basin listing when weed growth started. Early one-waying followed by listing was a close second. The lowest average yield for the three years was received when the land was cultivated with the spring tooth early and was one-wayed during the remainder of the season.

The average yield of wheat on the good summer fallowed plots during the biennium was 10.3 bushels per acre. The average yield of wheat the second year after fallow was 3.9 bushels per acre while the average yield under continuous wheat production was 2.5.

In the method of fallow test at the Dodge field the highest yield of wheat, 25.1 bushels per acre, was obtained from early one-wayed followed by listing about June 1. The lowest yield on fallow, 13.8 bushels per acre, was obtained from land that was cultivated with the spring tooth immediately after harvest. The lowest yield, 2.9 bushels per acre, was obtained on continuous wheat land that was one-wayed a few weeks before seeding.

The average yield of wheat on all fallowed plots was 19.3 bushels per acre as compared with 3.3 bushels for wheat after wheat.

On land having an average slope of only 0.21 percent the yield of wheat on contoured fallow was 18.5 bushels per acre while on the noncontoured fallow the yield was 16.0 bushels per acre.

In testing the influence of wind erosion control methods on the yield of wheat--that is, listing and chiseling in the winter or early spring--the following yields per acre were obtained on fallow land: No treatment for control of wind erosion, 17.8 bushels; listing one furrow every 20 feet, 17.1 bushels; listing every 10 feet, 17.1 bushels; and chiseling, 13.2 bushels. On cropped land the yields were increased to some extent by listing and chiseling.

The average yield of all varieties of sorghums on fallowed land was 14.7 bushels of grain and 3,244 pounds of dry forage per acre. The average yield of all sorghums following wheat in the rotation was 1.1 bushels of grain and 1,162 pounds of forage per acre. Colby produced 26.4 bushels of grain per acre on fallow and 6.0 bushels on wheat stubble land while Wheatland produced 18.5 bushels on fallow and no grain on wheat stubble land. Sudan grass produced 1,471 pounds of hay on fallow and only 204 pounds on cropped land. Early sumac produced 4,044 pounds of forage on fallow and 1,021 pounds on cropped land.

The early date, May 15, of planting the sorghums has been definitely inferior to the later dates. The kafirs and the forage types have produced the highest yields from the June 1 plantings while the milos and milo derivatives have responded best when planted on June 15.

(Department of Agronomy. Leaders, R. I. Throckmorton and A. B. Erhart; state fund.)

**Northeast Kansas Experiment Fields.**--The Northeast Kansas Experiment Fields are located near Newman, McLouth, Atchison, Blair, and Wathena. The work was conducted on all fields during the biennium, according to the plans as previously reported.

Emphasis on the Newman field has been placed on potato experimental work, including practically all phases of potato production. The results secured during the biennium were not consistent or in line with previous results because of excessively high temperatures and a lack of precipitation. In the rotation work the lowest yield of No. 1 potatoes, 127 bushels per acre, was obtained when the crop followed alfalfa; while the highest yield, 171 bushels of No. 1 potatoes per acre, was secured when potatoes followed potatoes the second year after alfalfa.

The use of commercial fertilizers containing nitrogen and phosphorus resulted in satisfactory increases in the yield of No. 1 potatoes in 1938, but because of adverse climatic conditions had practically no influence in 1939.

In the rate of planting experiment the highest yield of No. 1 potatoes, 178 bushels per acre, was obtained when 25 bushels of seed was planted per acre. The use of 12, 16, and 20 bushels of seed per acre resulted in average yields of 120, 147, and 168 bushels of No. 1 potatoes per acre, respectively.

Plantings made during the latter part of March resulted in higher yields of No. 1 potatoes than did plantings made about the middle of March or the tenth of April.

The size of seed piece used influenced the number of tubers produced and the yield per bushel of seed planted. The average number of tubers per plant increased with increase in the size of the seed pieces, but the yield per bushel of seed planted decreased with an increase in the size of seed piece, being 13.2 bushels for the 0.5 ounce seed pieces and 5.6 for the 2.0 ounce pieces.

Plots that were mulched with straw produced 188 bushels of No. 1 potatoes per acre, while the nonmulched plot produced an average yield of 174 bushels per acre. The addition of 500 pounds of ammonium sulphate to the mulched plot resulted in a decided increase in the yield of potatoes in 1938 and a corresponding decrease in 1939.

Because funds have been insufficient to handle the work satisfactorily on all five fields in northeastern Kansas, the Newman field was discontinued, following the crop season of 1939.

The work on the McLouth field consists primarily of soil fertility and crop adaptation tests. Because of adverse climatic conditions corn failed in 1939 and yields of alfalfa were extremely low.

In a five-year rotation of alfalfa two years and corn, oats, and wheat each one year, the average yield of oats where no fertilizer was applied was 32.0 bushels per acre while with the use of lime, manure, and superphosphate in the rotation the average yield was 53.0 bushels per acre. The average yield from the use of superphosphate alone was 44.1 bushels per acre. In the same rotation the average yield of wheat was 18.2 bushels per acre when no fertilizer was applied and 31.6 bushels where the lime, manure, and superphosphate treatment was given. The average yield of wheat from the use of superphosphate alone was 29.0 bushels per acre. In the two-year rotation, with and without legumes, soil treatments had little or no influence on the yield of crops.

During the biennium Fulton produced an average yield of 61.7 bushels of oats per acre; while Columbia, Kanota, and Red Texas produced average yields of 59.9, 54.9, and 46.5 bushels per acre, respectively.

In the wheat variety tests, two new Kawvale X Tenmarq strains produced the highest yields. Of the varieties that are being grown by farmers, Clarkan produced the highest yield, 32.9 bushels per acre, and Kamvale was second with an average yield of 32.0 bushels per acre. Missouri Early Premium was included in the test in 1939 and was the lowest yielding variety for the year.

Winter barleys were severely injured by low temperatures during the winter of 1937-'38 and the southeast Kansas strain was the only one that produced grain. In 1939 the highest yield, 38.6 bushels per acre, was produced by Reno and the lowest, 29.2 bushels per acre by Missouri Early Beardless.

Pink kafir was the highest yielding variety of the grain sorghums during the biennium. It produced an average of 48.4 bushels of grain per acre. Western Blackhull ranked second with an average yield of 46.3 bushels per acre. The average yield of Club was about five bushels less than that of Pink. Atlas sorgo ranked first in forage production with an average yield of 30,469 pounds per acre. Kansas Orange was a close second with a yield of 29,601 pounds of forage per acre.

In the soil management studies in the Atchison apple orchard, trees growing under straw made the largest average annual growth, 3.48 inches, as measured by increase in trunk circumference. The lowest average annual growth, 2.50 inches, was made under red clover. Differences in average annual growth increases were not great under Korean lespedeza, cowpeas, corn, and vetch, and varied from 2.62 inches to 2.85 inches.

The Atchison orchard produced its first relatively uniform crop in 1939 and the highest yields of all varieties were secured under the straw mulch as is indicated by the following table:

SOIL MANAGEMENT	Average yield in pounds per tree of-			
	Winesap	Jonathan	Richared	Grimes
Straw mulch.....	212.6	203.1	101.4	136.7
Korean lespedeza.....	116.6	176.3	85.3	81.0
Corn.....	150.7	116.3	87.5	29.3
Cowpeas.....	124.9	102.0	37.2	36.1
Winter vetch.....	88.0	49.8	46.8	8.5
Red clover.....	71.1	73.1	26.0	12.9

Fruit produced by the trees on the straw mulch blocks averaged larger in size than the fruit produced by trees under the other types of soil management. The trees in this orchard were severely damaged by rabbits during the winter of 1939-40, when snow drifted several feet high around the trees.

Severe climatic conditions during 1939 resulted in a heavy loss of apples by dropping during the latter part of the season at the Blair orchard.

Soil moisture in the Blair orchard averaged slightly higher under the straw mulch than under the other systems in 1938, but in 1939 the moisture content of the soil was practically the same under all methods of management.

In the type of pruning test with the Winesap variety the average yield of apples per tree for the two years was 429 pounds for light pruning, 333 pounds for moderate, and 236 pounds for heavy. Size and color of fruit increased slightly as the severity of pruning increased.

Liquid and dry lime sulfur caused injury to the foliage of trees when applied as late as the first and second cover sprays. When these materials were supplied in the pre-bloom sprays and followed by wettable sulfur in after-bloom sprays, the injury was largely avoided. Bordeaux spray applied early in the season caused severe russetting of the fruit. All materials gave good control of apple scab in 1938 and no scab occurred in 1939.

Since the trees in this orchard are in a weakened condition as a result of several successive years of adverse climatic conditions, an effort will be made during the next two years to increase the vigor of the trees rather than to continue the experiments as originally outlined.

Yields of strawberries and raspberries at the Wathena field were so low during each year of the biennium due to adverse climatic conditions that differences were not significant. White grubs caused serious injury to newly set strawberry plants on manured land.

(Departments of Agronomy, Horticulture, Botany and Entomology. Leaders, R. I. Throckmorton, W. F. Pickett, L. E. Melchers, G. A. Dean, and Erwin Abmeyer; state fund.)



**INVESTIGATIONS IN THE PLANT INDUSTRIES**

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

*Temperature Relations of Crop Plants*—Studies during the biennium dealt principally with the resistance of wheat and corn to high temperature. Varieties of wheat, including both winter and spring types, were tested for resistance to heat when the plants were about 3 weeks old. The winter wheats as a class were more resistant to high temperature than the spring wheats, which agrees with previous work. The percentage injury of different varieties of wheat as an average of six experiments is given in the following table:

<i>Variety</i>	<i>Average injury, percent</i>	<i>Variety</i>	<i>Average injury, percent</i>
Nebred .....	23	Munhardi .....	52
Clarkan .....	30	Thatcher .....	56
Blackhull .....	34	Comet .....	59
Lutescens .....	34	H-44 .....	61
Oro .....	34	Reward .....	67
Chiefkan .....	36	Marquillo .....	69
Kawvale .....	42	Hope .....	72
Kanred .....	43	Baart .....	77
Tenmarq .....	49	Kubanka .....	85

In the further study of the diurnal cycle of heat resistance in plants it was found that wheat about 3 weeks old made significant gains in resistance to heat during a 10-minute exposure to light after having been in darkness overnight. Further gains in resistance were observed at intervals of 10 minutes during the first hour of exposure to light. Most of the daily resistance appeared to have been gained during the first 2 hours that the plants were exposed to light.

Limited evidence indicated that the rate of gain of daily resistance of heat was positively associated with intensity of light.

Work contemplated for next year includes (a) a study of the relation of heat resistance and cold resistance, (b) a comparison of the laboratory test of heat resistance of corn with drought resistance in the field, and (c) limited study of the nature and cause of resistance in the daily cycle.

(Project 157; Department of Agronomy. Leader, H. H. Laude; Purnell fund.)

*Crop-weather Studies*--A principal objective of the crop-weather research project which is conducted in cooperation with the Bureau of Plant Industry and Weather Bureau of the United States Department of Agriculture, is the study of the relation between the environment of a crop and its growth and yield.

The physical environment that prevailed throughout the season in the field was measured with respect to temperature, moisture and air movement. Continuous graph records were obtained of air temperature, relative humidity of the air, precipitation, and soil temperature at 3 positions. The rate and character of growth of wheat was measured in the fall and at weekly intervals during the spring.

The height and dry weight per plant were greater for the crop of 1939 than for corresponding dates of 1938. The yield promised to be considerably more in 1939 than in 1938, but because of severe damage by hail on June 8, irregular and low yields were harvested.

Apparently no simple analysis of the data that were recorded explains why the two crops grew differently. Records for more seasons will materially aid in pointing out the particular weather complexes that are favorable and unfavorable for wheat and may afford a basis for estimating the degree to which the conditions will influence the physiological processes of the plant and thus the final outcome in terms of yield.

The results so far suggest that the condition of the plant at the beginning of winter with respect to size (dry weight), number of tillers and weight per tiller may indicate what the plant can accomplish during the remainder of the season and how it will respond to environmental conditions, particularly favorable and unfavorable extremes.

The study is being extended to the hard winter wheat region through cooperation with the experiment stations at Lawton, Oklahoma; Amarillo, Texas; Hays, Kansas; Lincoln, Nebraska, and Akron, Colorado.

(Department of Agronomy. Leader, H. H. Laude; state fund.)

*Small Grain and Sorghum Improvement.*--Winter wheat, flax, oats and sorghums were included in this project, conducted in cooperation with the Departments of Botany, Entomology, and Milling Industry, and with the Division of Cereal Crops and Diseases, Bureau of Plant Industry, United States Department of Agriculture.

*Winter Wheat.*--The work of breeding for superior types of wheat for Kansas conditions was hampered because of a hailstorm at Manhattan in 1939, but considerable progress was possible in that discards could be made, based on shattering, lack of winter hardiness, leaf rust infestation, extremely low yield and a few other characters. In a study of varietal reaction to hail, broken straw was least in the Marquillo X Oro hybrids, Cheyenne, Nebred and Turkey and most in Tenmarq, Kamvale and its hybrids lost most grain in hail-shattering, with the least loss from this cause in the Marquillo X Oro hybrids. Two strains of Cheyenne X Tenmarq were advanced to the United States Department of Agriculture Uniform Yield nursery and two Marquillo X Oro strains were advanced to single plots at the agronomy farm. Several promising hybrid strains which appear to have soft grain were developed at the Columbus nursery. Over a period of years Kawvale has been the highest yielding variety at Columbus, although Clarkan is a close competitor.

*Flax.*--Seven varieties of flax in a nursery, including 29 strains or varieties grown at a uniform regional nursery at Thayer, yielded as much or more than Linota, the standard variety for southeastern Kansas. Thirteen varieties out-yielded Bison. Studies were begun on the resistance of flax to low temperatures, especially late spring freezes, but few results have been obtained.

*Oats.*--A severe hailstorm in June, 1939, shattered from 35 to 75 percent of the grain from the heads. Yields were low, Fulton and Kanota each yielding about 8 bushels per acre. Test weights were also low, Fulton averaging 27.6 pounds and Kanota 23.8 pounds per bushel. Breeding for smut resistance was continued with rod row plots of 56 selections of Fulton made in 1936. Smut spores were applied to these selections by the vacuum method, the composite of smut being made up of one-half of the race that attacks Fulton and the other half of smut collected over Kansas. Fulton averaged 13.9 percent, Kanota 36.4 percent, and the selections varied from 3.5 to 21.1 percent smutted panicles. Thirty of the most uniform selections with low smut infection were bulked and this bulk is being tested in field plots in 1940.

Selections of Richland X Fulghum are the most promising strains in a nursery including 77 strains, grown in rod rows. These strains are as early as or earlier than Kanota and are resistant to stem rust and smut. Several Fulghum X Victoria selections are promising, being resistant to crown rust and smut. A few strains of compound crosses involving stem rust, smut and crown rust appear promising.

*Sorghum.*--Chinch bugs and drought damaged the sorghums in 1939 with

all milo types being killed or severely damaged principally by the chinch bugs. The cross Atlas X (Red Amber X Feterita) was more susceptible to chinch bugs than (Blackhull kafir X Spur Feterita) X Blackhull kafir. In breeding to obtain a chinch bug-resistant, kafir-combine type of sorghum for eastern Kansas, Blackhull kafir X Dwarf White Milo selections were found to be too susceptible to chinch bug injury.

Breeding work with sorghums was directed mainly to development of both grain types and forage types possessing smut resistance. Many of the Atlas x (Red Amber X Feterita) lines were smut free, but none of them appeared to equal Atlas in this character. Three rows of Atlas averaged 27 percent smutted plants, Red Amber X Feterita had no smutted plants, and 117 rows of the cross averaged 6.5 percent, ranging from 0 to 33 percent. In breeding for a smut-resistant kafir-type grain sorghum, 65 rows of the F<sub>4</sub> generation of (Blackhull kafir X Spur Feterita) X Blackhull kafir had no smut and 113 rows averaged 5.4 percent smut, giving promise of smut-resistant kafir-type sorghums. Blackhull kafir averaged 14.2 percent smutted heads in four rows.

Feterita hybrids were the most drought resistant.

Selections of Blackhull kafir X Dwarf White milo grown at the Kingman experimental field appeared promising. Of 96 heads rows of combine sorghum grown at that station, most of the selections were discarded. Nearly all of the 100 heads rows of Darso hybrids and Weskan selections grown at the Hutchinson experiment field were discarded because of susceptibility to Pythium milo disease.

Selections are being made at the Tribune branch of the experiment station in the cross Greeley X Weskan (in the F<sub>5</sub> generation in 1939) to obtain a drought-resistant, good yielding and clean threshing kafir type sorghum for the high plains of western Kansas.

(Project 67; Department of Agronomy. Leaders, L. P. Reitz, E. G. Heyne; Hatch fund.)

*Inheritance of Factors Affecting Quality in Wheat.*—During the biennium further tests were made on promising methods of evaluating new strains of wheat and many new strains were tested by either old or new methods or both.

Wheat meal time fermentation tests were conducted on about 200 strains of wheat grown at Manhattan and Columbus in 1938. Most of the Marquillo hybrids had a long "time," an indication of strength and mixing tolerance. Soft wheats had a low time in contrast to the long time for hard wheats.

Complete data on milling and baking qualities of nine strains grown in 1938 were secured. Two strains of Oro X Tenmarq (C. I. 11672, 11673), two strains of Kawvale X Tenmarq (C. I. 11669, 11750), Kanred-Hard Federation X Tenmarq, Early Blackhull hybrid and Cheyenne X Tenmarq all gave better results than Tenmarq or Turkey.

Pearling tests, made in the United States Department of Agriculture Hard Wheat Quality Laboratory, were used to determine kernel hardness for strains of wheat in 1938 and 1939. Observed texture and pearling results were highly correlated, but the pearler more nearly eliminates the human element in gauging hardness and often makes a separation possible between strains which to the eye appear equal in hardness. It is to be hoped that this test will prove of great value for future work.

Many hybrids involving Marquillo as one parent are being tested. Marquillo is known to contain objectionable quantities of carotene in the grain, but the variety is of value for transmitting resistance to Hessian fly to desirable winter wheats. Carotene tests were made on 93 strains in 1939 and it was encouraging to find that only 20 contained more carotene than Kharkov. This test warranted discarding a number of strains and that permits more thorough testing of those remaining.

(Project 178; Departments of Agronomy and Milling Industry. Leaders, L. P. Reitz and C. O. Swanson; Purnell fund.)

*Variety Tests of Small Grains and Sorghums.*—Variety experiments with wheat, barley, oats, flax and sorghums were conducted during the past biennium. Time of planting experiments with wheat and a study of natural selection in varietal mixtures of wheat were also studied. In a study of the relative palatability of different varieties of sorghum, it was found that varieties differed widely in moisture retention in the stem while stored in the shock and that the palatability of sorghum forage apparently is associated with juiciness and sweetness of stalk.

Several new varieties of wheat have shown superior adaptation and have averaged higher in yields than older standard varieties. A selection from the cross Oro X Tenmarq (Kans. No. 2729) averaged slightly higher in yield than either parent in the three years it has been grown. The selection possesses bunt resistance similar to Oro and flour quality similar to Tenmarq, and in winter hardiness it is equal to Tenmarq, but less hardy than Oro. Susceptibility to leaf rust in the new selection is less than in Tenmarq. A selection from the cross Kawvale X Tenmarq (Kans. No. 2723) has yielded slightly better than Oro X Tenmarq (Kans. No. 2729) in each of the three years tested. Its vigor of growth, which may be attributed to the Kawvale parent, possibly accounts in part for the higher yield. This cross appears to have more winter hardiness than Tenmarq and to be about as resistant to leaf rust as Kawvale. Kawvale X Tenmarq (Kans. 2723) seems to have good milling characteristics but to possess less desirable baking quality.

Fulton oats, a selection of Fulghum X Markton, developed at this station, has continued to yield about the same as Kanota oats, with the added advantage of being resistant to present forms of smut.

The study of natural elimination of nonwinter hardy varieties of wheat from a mixture of winter hardy and nonwinter hardy varieties, started in 1931, has been continued and in 1939 only 10 percent of the Kanred + Harvest Queen mixture was Harvest Queen. In the Kanred + Currell mixture, only 1 percent was Currell. In 1931 the mixtures were composed of equal numbers of kernels of each variety. A part of the crop harvested each year has been used to plant the test the following season.

It appears likely that the marked superiority of sorgo forage over kafir forage and more so over feterita forage is due in part to the ability of the sorgo forage to retain a much higher percentage of the moisture in the stalk when stored in shocks. In the following table the percentage of moisture in the stalk is reported for several varieties at harvest time in October and after storage in the shock until January, three months later:

TYPE	Variety	Percent moisture in stalk	
		October	January
Kafir.....	Blackhull.....	81	45
	Red.....	81	47
	Pink.....	81	47
	Western Blackhull.....	81	44
Feterita.....	Ajax.....	75	23
Sorgo.....	Atlas.....	76	76
	Kansas Orange.....	73	65
	Leoti Red.....	73	66

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

*Varietal and Cultural Tests of Soybeans and Cowpeas—*

The work of this project for the biennium has consisted of testing varieties, introductions and selections of soybeans and cowpeas and methods and rates of planting soybeans. The work with soybeans included the testing of 17 varieties, 12 Kansas selections, 24 introductions, six rates-of-planting with (a) a grain drill in close rows, (b) a corn planter in 38-inch rows and 19-inch rows. Fifteen varieties of cowpeas, two varieties of tepary beans and two varieties of mung beans were also tested for yields of hay and yields of seeds.

Grasshoppers and rabbits did considerable damage to the test plots in 1938 in spite of the use of poisoned bran mash and poisoned salt as control measures. A hailstorm destroyed the entire planting in 1939 soon after emergence and all plantings were repeated. Drought and high temperatures during late August and all of September reduced the yields, especially in the later-maturing varieties. Seed yields of soybeans for 1938 ranged from 11.0 to 21.5 bushels per acre and in 1939 the yields varied from 6.1 to 15.5 bushels per acre. The A.K. and Hongkong varieties of soybeans, usually among the highest producing varieties, yielded about 16 bushels in 1938 and 8 bushels in 1939.

Arlington ranked first in 1938 and second in 1939 among the varieties of cowpeas tested for yield of hay. Hay yields were low for both years, no variety producing as much as 1.5 tons per acre. Seed yields in 1938 were exceptionally high, ranging from 12.76 to 17.23 bushels per acre, but in 1939 the yields were near normal for this region and ranged from 1.0 to 5.2 bushels per acre.

Tepary beans continue to produce high yields of both hay and seed, ranking above soybeans and cowpeas in hay, and the Redfield white variety was at the top of all varieties in seed production for both years of the past biennium. Tepary beans seem to be more resistant to drought and high temperatures than either soybeans or cowpeas.

Highest yields of hay with soybeans have been obtained by planting with a grain drill, and in 1938, a more favorable year, this method of planting also produced the highest yield of seed. In 1939, an unfavorable season, it was found that more seed was produced when planted in rows 38 inches apart. Results with rates of planting were slightly in favor of the 32-pounds-per-acre rate when planted with a corn planter and approximately 100 pounds per acre when planted with a grain drill. Somewhat lighter rates of seeding have previously given fully as high yields.

(Project 129-3; Department of Agronomy. Leader, J. W. Zahn-Icy; Hatch fund.)

*Miscellaneous Legumes for Forage*—The work of this project for the past biennium has consisted mainly of tests of a number of varieties of sweet clover. A study of the effect of a nurse crop upon the establishment of a stand of clover was conducted with seven varieties. Miscellaneous crops tested included three varieties of lupines, low-hop clover, coumarin free sweet clover (*Melilotus dentata*), four varieties of castor beans, and eight varieties of foxtail millets.

Evergreen sweet clover, a late, white-blossom variety obtained from the Ohio Agricultural Experiment Station, produced the highest yield of forage in 1937 and in 1939. It was omitted from the 1938 tests because of a shortage

of seed. This variety, if it proves to be consistent in seed production in this climate, may have outstanding value for pasture where a longer season of sweet clover pasture is desired.

Madrid Yellow sweet clover, No. 27474, has been officially named Madrid and application for registration with the American Society of Agronomy will be presented this year. Seed was distributed in the fall of 1939 to a number of Kansas farmers for the production of certified seed.

Seven varieties of sweet clover were planted in March, 1937, and March, 1938, with and without a nurse crop. These crops were harvested in 1938 and 1939. Counts in the 1937 plantings, made July 13, 1937, showed a loss of 10.4 percent of the plants where planted without a nurse crop and 49.7 percent loss where planted with oats as a nurse crop. In April, 1938, the 1937 planting showed an average survival in all varieties of 57 percent where planted alone and a survival of 24.3 percent where planted with oats. Similar counts on the 1938 plantings showed 62 percent survival where planted alone and 29 percent survival where planted with a nurse crop. In 1939 the plants averaged 31/2 inches higher and the total yield of forage showed an increase of 1.04 tons (55 percent) on plots seeded without a nurse crop.

Of the miscellaneous legume crops planted, three varieties of lupines, low-hop clover and coumarin free sweet clover (*Melilotus dentata*) failed. Castor beans grew well but matured so unevenly that harvesting by hand would be required in commercial production. Among the eight varieties of foxtail millets tested, only one or two appear to be superior to the German millet.

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

**Corn Production and Improvement.**—Work on this project during the past biennium consisted mainly of the development of inbred lines for the production of superior dent and popcorn hybrids. These investigations are conducted cooperatively by the Division of Cereal Crops and Diseases, Bureau of Plant Industry, United States Department of Agriculture, and the Department of Agronomy. Nearly 400 unrelated dent and popcorn lines were grown and about 20,000 hand pollinations were made. The testing program was expanded during the biennium to include 2,250 entries which were compared in over 9,000 plots scattered over various parts of Kansas in 1939. In preliminary tests conducted at Manhattan, Perry, and Horton, 203 top crosses, 318 single crosses, and 380 double crosses were included. In the 1939 Corn Performance Tests, 640 entries from commercial producers, other experiment stations, and other sources were tested. Two fields, one on upland and one on bottom land, were located in each of five districts.

Yields in 1938 varied from 15 to 70 bushels per acre and differences in other characteristics were fully as striking. A comparison of some of the more promising hybrids with standard open-pollinated varieties is given in the following table :

**TWO-YEAR AVERAGE, 1938-1939**

ENTRY	Two-year average, 1938-1939				
	Acre yield, bushels	Lodged plants, percent	Firing, percent	Dropped ears, percent	Ears per cwt.
<b>YELLOW DENT</b>					
Pride of Saline.....	46.6	42	50	13	219
Kansas Hybrid 1104.....	59.3	25	32	12	190
Kansas Hybrid 1138.....	55.8	15	42	6	172
Mean of 48 hybrids.....	47.9	31	42	14	200
<b>WHITE DENT</b>					
Pride of Saline.....	53.9	32	37	17	219
Kansas Hybrid 2015.....	62.0	35	40	0	181
Kansas Hybrid 2004.....	56.2	19	40	3	188
Mean 4 varieties.....	50.5	42	44	15	207
Mean 12 hybrids.....	53.6	32	40	3	197

Drought resistance must be incorporated in hybrids for Kansas since drought appears to be the major limiting factor for corn production in the state. Breeding for drought resistance is given major attention and significant results are being obtained. A drought susceptible cross yielded 27.5 bushels per acre while a drought-resistant cross grown alongside it yielded 65.5 bushels per acre. Field observations are being supplemented with heat chamber data on corn seedlings.

Studies in disease resistance were conducted during the biennium. Diplodia rot and corn smut are two of the most serious diseases of corn in Kansas. A positive interannual correlation indicated that resistance to both diseases is a strain characteristic and is inherited. A highly significant correlation of +0.88 between inoculated and check plots indicated that inoculation with *Diplodia Zeae* was a satisfactory method of differentiating between resistant and susceptible material. It was found that stalk inoculation and differential Diplodia infection caused a 12 percent decrease in yield and considerable stalk-breaking, but did affect smut infection, premature dying of stalks or leaves, or ear rotting.

Breeding for smut resistance also was carried on during the biennium since this appears to be the most promising means of control. Preventing ear development increased smut infection, while clipping the leaves decreased smut infection. These results suggest a possible reason why there is a positive relation between relatively dry conditions and heavy corn smut infection. Hot, dry conditions result in poor pollination of the corn plant. Total sugars accumulate in the stalk when they cannot be translocated to the ear and these sugar accumulations stimulate axillary bud growth, which in turn stimulates growth of the smut fungus.

Studies during the biennium have demonstrated outstanding differences among lines and hybrids for resistance to chinch bugs, grasshoppers, corn ear worms and grub worms.

(Project 156; Department of Agronomy. Leader, R. W. Jugenheimer; Purnell fund.)

*Alfalfa Investigations.*—During 1938 and 1939 alfalfa investigations were carried in five phases, as follows:

1. *Environmental Factors Affecting Seed Production in Alfalfa.*—Results thus far obtained on the environmental factors such as soil moisture, temperature and humidity show that soil moisture is an important factor and from these experiments plants grown in pots with the soil moisture at 10 percent of the soil moisture holding capacity 29.7 percent of the flowers tripped set pods, whereas in pots with 25 percent soil moisture 13.1 percent of the flowers tripped set pods, indicating the lower moisture was conducive to better seed setting.

Temperature is apparently a more important factor than humidity in seed setting. The maximum set of seed pods was obtained at temperatures ranging from 70 degrees to 95 degrees F. As the temperatures increased above 100 degrees the number of seed pods decreased rapidly. Little differences were obtained at relative humidities ranging from 5 to 70 percent, regardless of the temperature.

The number of seeds per pod was not affected by either the temperature or humidity within the temperature range for good seed set.

2. *Time of Cutting as Related to Root Reserves.*—In alfalfa the bud development for the crop of the next year starts in the fall and increases in number rather rapidly from early fall until growth is retarded by freezing. Therefore, their development may be likened to a winter annual. From the physiological studies made, it was found that total water and bound water show a direct negative correlation. The bound water increases from early fall until late fall and the total water decreases throughout the same period. This change causes a lowering of the amount of free water or easily freezable water in the tissue which is a definite hardening process. Bound water is closely associated with the hydrophylic colloids which are largely found in the hemicelluloses stored as food reserves.

The electrical conductivity determinations showed a definite trend from high conductivity in the early fall to low in late fall. This correlates with the amounts of sugar found by the carbohydrate determinations.

The carbohydrate analysis consisted of determinations for starch, dextrans and hemicelluloses, total sugars, reducing sugars and nonreducing sugars. From these data are shown the relation of the stored reserves in the roots, their translocation to the crown buds and their correlation with the hardening processes mentioned above. The hydrophylic properties of the hemicelluloses have a direct relation to bound water, and the simultaneous reduction of free water. The sugar concentration of the cell sap is directly associated with the lowering of the freezing point of the cell sap and the protection of the colloidal proteins, both of which are reflected in the electrical conductivity determinations.

The significance of these determinations are that they give a clearer understanding of the hardening process of the alfalfa plant and place the responsibility of this process on the stored food reserves which are greatly influenced in their quantity by the fall cutting practices.

3. *Adaptation of Alfalfa from Different Foreign and Domestic Origins.*—Variety tests have been conducted at this station for many years and to the present time, no variety has been introduced that has proved as satisfactory as Kansas Common for Kansas soil and climate. Ladak, an imported alfalfa, is satisfactory and should be equal to or better than Kansas Common on the uplands in central Kansas, and in western Kansas where alfalfa can be grown without irrigation. Ladak has been slow in becoming generally used in these areas because of the high price of seed.

4. *Breeding for Combined Disease Resistance.*—Selection for disease resistance, particularly bacterial wilt, shows that some Kansas Common lines are showing definite improvement over Kansas Common. Several lines are showing more resistance than the Hardistan checks. Several of these improved



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lines are being increased for further testing, and two seem particularly well adapted to the territory where Kansas Common is adapted. Information from comparable tests show them to carry a high degree of wilt resistance and to yield only slightly less than Kansas Common.

During the biennium a study has been made on some of the leaf and stem disease in cooperation with the Department of Botany. A special study was made on black-stem (*Aschochyta imperfecta*). From these studies a method of artificial inoculation by spraying spore suspensions onto vigorous growing plants was used successfully. The plants were inoculated and immediately placed in a moist chamber for five days at approximately 22 degrees C. The plants were then taken out of the chamber and placed in the greenhouse where the disease was allowed to develop.

Disease readings of the artificially inoculated plants were made by a method developed for these studies. The readings were made by giving equal consideration to the leaves and stems. Stems were grouped into classes numbered from one to five according to the severity of the infestation. Similar scores were made on the leaves. The leaf and stem scores were then added together, giving a plant score ranging from 0 to 10.

From the artificial inoculation studies it was determined that it is possible to select plants showing black-stem resistance.

5. *Range in Adaptation of Improved Alfalfa Strains.*—Reports of the uniform alfalfa nursery show data from nursery tests in 39 states. From these data it is evident some of the Kansas selections are very good in the territory where Kansas Common is adapted. Kansas Selection A-8 and A-11 were compared with 15 of the top-ranking lines as reported from all stations and from these data A-8 ranks first, A-11 fourth, and Kansas Common thirteenth in the Kansas Common territory.

In the reports nine different factors were considered, such as yield, vigor, wilt, recovery, etc. By ranking the varieties for each of these factors A-8 ranked first, three times and A-11 four times. No other of the 15 lines used ranked first more than once.

(Project, 183; Department of Agronomy. Leader, C. O. Grandfield; Purnell fund.)

**Pasture Improvement Investigations**—During the past biennium investigations were conducted on six phases of this project:

1. *Management of Livestock on Bluestem Pastures.*—Deferred grazing is being compared with season-long grazing on 1,400 acres of bluestem pasture. The following results have been obtained:

	Deferred grazing	Season-long*
Stocking rate (acres per animal unit, while grazed). (12-year average) . .	1.50	3.30
Grazing days per acre per year (12-year average) . . . . .	55	38.7
Gains on livestock, pounds per acre per year (10-year average) . . . . .	55	40

\* Average of 2 season-long grazed pastures.

Studies of the vegetative cover have shown that the deferred pasture, in spite of having been grazed more intensely, has the best cover of desirable pasture grasses and fewer weeds.

2. *Effect of Burning on Bluestem Pastures.*—This phase of the investigations was discontinued four years ago, due to the drought, and the plots have been burned only twice since. No conclusive results can be obtained on the effects of recent burnings since there has not been sufficient time periods to

study trends. Preliminary data obtained indicate that the conclusions of earlier investigations will be substantiated.

3. *Effect of Fertilizer on Native Bluestem Pastures.*--While bluestem pastures responded to both commercial fertilizer and manure, results obtained in this phase of the investigation indicate that the application of fertilizers to pastures is not practical. Manure gave greater increases in yield than any of the commercial fertilizers. A combination of nitrogen and phosphorus gave greater increases in yield than either fertilizer alone.

4. *Palatability Tests of Tame Grasses.*--Unfavorable climatic conditions have made establishing satisfactory stands of grasses difficult for carrying on this phase of the project. Fairly good stands were obtained in the fall of 1939 and it remains for these stands to become established before the tests can be started.

5. *Effects of Time and Method of Seeding Upon Stands of Native Grasses.*--Various species of native prairie grasses are being seeded at various dates and by various methods, each species being planted in duplicate plots. The dates of planting have been: Early, medium and late in the fall and in the spring, respectively, and one date in the winter. Methods of seeding have been: Drill, broadcast, broadcast and mulch with straw, scattering hay with mature seed and pressing into the soil with a disk harrow. The fall seedings all germinated in the following spring and there has been no appreciable difference in stands obtained among the various dates of spring seeding. An average of 10 percent better stand at the end of the first growing season has been obtained by the "hay method." The straw mulch method ranked second, drilling ranked third and the broadcast method ranked fourth.

6. *Breeding and Selection.*--Three lines of work are included in this phase of the project and are: (a) Testing of new grasses for adaptability; (b) selection in open-pollinated lines, and (c) breeding. New materials from several sources are being grown for observation. *Agropyron semicostatum* and *Elymus junceus* appear to be well adapted and have now been included in grazing tests. Selection in open-pollinated lines has increased uniformity in leafiness, height, seed production, yield and forage quality. Improved lines are now ready to be increased for grazing tests. Inbreeding is being employed to study breeding behavior and to concentrate characters. Some lines are now ready to be crossed to study their cross-compatibility and their ability to "throw" good offspring in crosses. Those which do this are to be blended into strains and subjected to grazing tests.

(Project 96; Department of Agronomy. Leader, K. L. Anderson; Bankhead-Jones and Purnell funds.)

**Weed Eradication.**--The work on this project during the past biennium has been principally a continuation of the work reported for the previous biennium.

Sodium chlorate spray, repeated three times, has been the most effective method of killing field bindweed, but the greater cost of application and the danger of fire have made the spray method less popular than the use of dry material. Low point in root reserves of field bindweed usually occurs in spring and late summer, but because of the difficulty of determining the low point by appearance of growth, it is questionable whether this factor can be used as a guide in determining when chemical treatment or cultivation should begin.

Atlacide continued to be somewhat less effective than sodium chlorate on field bindweed where equal quantities of the two chemicals were used.

Two other chemicals, marketed under the trade names of Chemicote and Pentox, were found to be more effective than other commercial products, but inferior to sodium chlorate in bindweed eradication. The two chemicals mentioned above, to obtain maximum effectiveness, must be applied under conditions of dry soil and high humidity, which often necessitates spraying at night.

Full cooperation has existed between this department and the state bindweed supervisor in supplying information on bindweed control.

(Project 166; Department of Agronomy. Leader, J. W. Zahnley; state fund.)

*Co-operative Experiments with Farmers.*—During the last biennium, 1,607 experiments were located in cooperation with county agents, vocational teachers, and farmers in 100 counties. The character and number of tests for each of the two years of the biennium were as follows:

KIND OF TEST	1938		1939		Total No. of tests
	No. of tests	No. of counties	No. of tests	No. of counties	
Wheat variety.....	87	74	87	79	174
Wheat fertility.....	210	39	72	30	282
Wheat date of seeding.....	1	1			1
Wheat on terraced land.....	4	1			4
Wheat date of plowing.....	1	1			1
Wheat rate of seeding and type of drill.....	1	1			1
Winter barley variety.....			1	1	1
Oat variety.....	9	8	27	27	36
Oat fertility.....	50	21	30	15	80
Oat seed treatment.....	6	3	12	3	18
Oat rotation.....	1	1	1	1	2
Spring barley variety.....	20	20	34	32	54
Barley fertility.....	7	5	7	4	14
Barley seed treatment.....	3	1	1	1	4
Rye fertility.....	1	1			1
Flax variety.....			1	1	1
Flax fertility.....	5	3	4	3	9
Effect of bindweed on yield of.....					
Wheat.....	92	14	107	31	199
Oats.....	8	4	17	12	25
Barley.....			8	8	8
Rye.....			1	1	1
Flax.....	3	1	1	1	4
Effect of knapweed on yield of wheat.....			2	2	2
Corn variety.....	47	29	88	52	135
Corn performance tests.....			10	10	10
Soy, tepary and pinto bean variety.....	12	11	6	6	18
Sorghum variety.....	69	65	93	80	162
Alfalfa variety.....	46	34	49	37	95
Alfalfa soil treatment.....	44	19	40	17	84
Pasture crops.....	17	17	1	1	18
Sweet clover variety.....	9	8	11	11	20
Sweet clover fertility.....	13	3	4	1	17
Red clover variety.....	4	4	3	3	7
Red clover fertility.....	2	1	5	2	7
Brass variety.....	33	27	62	43	95
Brass fertility.....			9	9	9
Potato variety and fertility.....	2	2	1	1	3
Sugar-beet fertility.....			2	2	2
Melon fertility.....	1	1			1
Artichoke variety.....	1	1			1
Bindweed eradication by cultivation.....	1	1			1
Totals.....	810	97	797	100	1,607

The number of wheat variety tests conducted during the past biennium was about the same as in the last biennium. The number of fertility tests with wheat, oats and barley was greater than in previous years, and were located in the eastern half of the state. The oat variety testing program was increased during the last two years in order to obtain more information on Fulton oats which has been distributed recently.

The greatest changes in emphasis during the biennium were an increase in the number of tests studying the effect of bindweed on small grains, increase in the amount of corn variety and hybrid testing, and reduction in number of sorghum variety tests. During the 1936-1938 biennium, yields were obtained from 46 tests studying the effect of bindweed on the yields of small grains. This number was increased to 237 during the biennium 1938-1940. This increase was made possible by cooperation with the Weed Control Division of the Kansas State Board of Agriculture.

The number of corn variety and hybrid tests was increased from 108 to 135, because of the greater interest in corn hybrids and was made possible by the cooperation of County Farm Bureau organizations in financing the seed purchases. The corn testing program on farms was also greatly increased by the Kansas Corn Performance Tests, located on farms. These tests are financed by entry fees paid by commercial companies, and are supervised by the Agronomy Department in cooperation with members of the Division of Cereal Crops and Diseases, Bureau of Plant Industry, United States Department of Agriculture, who are located at Kansas State College. In 1938, two hand-planted, replicated tests each containing 20 entries were conducted. In 1939, the program was increased to ten such tests, including from 60 to 70 entries each.

*Wheat Varieties*.—The three high-yielding varieties of wheat in eastern Kansas during the biennium were Kawvale, a semihard variety; Clarkan, a soft wheat variety; and Tenmarq, a hard wheat variety. These three varieties interchanged places in different years, but are rarely exceeded by any other variety now in general use. Chiefkan, a new beardless variety, has ranked high in yield in eastern Kansas and has made the highest yield in north-central Kansas in each year of the biennium. In the south-central section, Tenmarq made the highest yield in 1938, as it has for many years. In 1939, Chiefkan made a higher yield than Tenmarq in this section. Chiefkan has also made the highest yield in western Kansas in both years of the biennium. Chiefkan is a good wheat variety agronomically, but the flour made from this variety does not make satisfactory bread and the variety is more susceptible to both bunt and loose smut than the commonly grown varieties.

*Wheat Fertility*.—Soil fertility tests for wheat established during the biennium had two objectives: Location of areas where phosphate can be used profitably, and the most economical rate of phosphate application. The results obtained to date indicate that phosphate can profitably be used in the production of wheat and oats on most soil that is below average in fertility, east of the west line of Republic and Sumner counties. Fifty pounds per acre of 45 percent  $P_2O_5$ , or its equivalent, appears to be the most profitable rate of application on small grains.

*Oat Varieties*.—Fulton, the new variety of smut resistant oats selected from a Fulghum X Markton cross, demonstrated superiority in the oat variety tests conducted in 1938 and 1939.

*Effect of Bindweed on Yield of Small Grains*.—This study was started in 1934 and has been continued each year since that time. Yields were obtained from farmers in central Kansas only until 1938 when the work was made statewide with the assistance of the Kansas State Board of Agriculture. An average of 190 tests conducted over the state in 1938 and 1939 show a reduction of 50 percent in wheat yield.

Bindweed causes the greatest percentage reduction in yield in the areas where there is the greatest competition for moisture. The influence of bindweed on the yield of oats, flax and barley was also studied but on a less extensive scale. The reduction in yield of these crops was usually greater than

for wheat. The reduction in the yield of oats in eastern Kansas was 41 percent in 1938 and 47.4 percent in 1939.

*Sorghum Varieties.*—Three new sorghum varieties, Club, Early Kalo, and Colby milo, first distributed in the spring of 1938, have all continued to produce high yields in their areas of adaptation. The seed stock of Early Kalo that was distributed in 1938 was withdrawn from certification in 1939 because of impurities. A new supply of seed will be increased at the Fort Hays Branch of the Agricultural Experiment Station in 1940. Finney, a selection from Dwarf Yellow milo which is resistant to the Pythium root rot disease, has consistently outyielded Dwarf Yellow milo in the southwestern part of the state. Dwarf Yellow milo is to be eliminated from the tests in 1940. Highland kafir and Improved Coes, two new, early-maturing, grain sorghums which originated in Colorado were included in the tests in the northwestern section in 1939. They ranked high in these tests.

*Corn Varieties and Hybrids.*—Corn hybrids became of great interest in Kansas during 1938 and 1939. Because of this fact, the testing of corn hybrids was greatly increased. In 1938, none of the hybrids included in the tests proved significantly superior to the best open pollinated variety. In all tests conducted in northeastern Kansas, the first four entries ranked as follows: Missouri 8, 65.0 bushels per acre; Pride of Saline, 61.3; Funk 207, 60.2; and U. S. 44, 57.6. In southeastern Kansas, the highest yielding four entries were Pride of Saline, 46.7 bushels per acre; Missouri 8, 45.5; Pioneer 307, 44.8; and U. S. 44, 43.8.

The hybrids greatly outyielded the open-pollinated varieties in 1939. Sufficient data have not been obtained to serve as a basis for definite recommendations. Some of the hybrids which show promise in eastern Kansas from the 1939 results are U. S. 44, U. S. 35, U. S. 13, Missouri 8, Missouri 47, Funk G-244 and G-94, National 132, Jewett 11, and some of the Kansas hybrids. In central Kansas, the most promising are Kansas topcrosses, Kansas hybrids, U. S. 13, Illinois 200, U. S. 35, Nebraska 238, Pioneer 307, and Missouri 8 in the southern part.

(Department of Agronomy. Leader, A. L. Clapp; state fund.)

*A Study of the Efficiency of the Combined Harvester-Thresher for Harvesting Grain Sorghums.*—Storage studies constituted a major portion of the work on this project during the biennium, since the storage is considered one of the main problems connected with successful growing of grain sorghums. Because of the dry season and the failure of grain sorghums on the Fort Hays station, no work has been done on the harvesting phase of this project during the biennium.

In March, 1939, 2,200 bushels of grain sorghums were placed in storage in different types of ventilated bins at the Fort Hays Branch Station. Due to the dryness of the previous season, moisture was added to rather dry grain sorghums in order to create a storage problem. In November, 1939, about 2,000 additional bushels of grain sorghums were stored in different types of ventilated bins. Again it was necessary to temper the grain in order to secure moisture contents that would create a problem.

The tests have shown: (1) That dry grain sorghum around 12 percent moisture content will keep throughout the spring and summer season in any type of bin; (2) that ventilated bins are much better for the storage of moderately damp sorghums; and (3) methods of ventilation in the order of their effectiveness were: (a) power-driven fans, (b) wind pressure cowls, and (c) wind suction cupolas. Power-driven fans may be needed to dry grain sorghums to a safe storage point during the winter season.

Grain sorghum will go out of condition when the warm spring weather arrives unless it has been dried down to a safe moisture content.

A series of tests were carried on to determine the effect of the temperature of the grain and the temperature of the air used in ventilation. The results show that it is important that the air temperature be lower or equal to the temperature of the grain. When warm air is blown through a mass of grain there is a tendency for the moisture to be picked up and added to grain farther on in the path of travel.

(Project 181; Department of Agricultural Engineering. Leader, F. C. Fenton; Purnell fund.)

*Factors Influencing the Quality of Wheat During Farm Storage.*—Work on this project during the past biennium has been carried on at the Fort Hays Branch Station in cooperation with the Bureaus of Agricultural Engineering and Agricultural Economics of the United States Department of Agriculture, and at Manhattan. The study of methods of ventilating farm bins has been continued at the Fort Hays station, as well as observations of wheat in long-time storage and the storage of wheat in underground bins.

The quality tests made on the samples from the storage bins at Hays did not give information of value on the effect of storage mostly because of other variations in the wheats stored in these bins.

The small scale experiments performed at Manhattan included: wheat treating under adiabatically controlled conditions and a study of the influence of time, temperature, moisture, and air supply on the quality changes in wheat.

Heating due to respiration of wheat increased the temperature to 45° C. in six days, after which there was no further increase. The rate was slower at 16 than at 20 percent moisture, but the same amount of CO<sub>2</sub> was evolved in heating to a given temperature. The heating was more rapid in the spring than in the fall at the same moisture content.

Wheats were stored in gallon bottles for three, six, and nine months at moisture contents varying from 12 to 20 percent. Identical lots were stored at 41° F. and laboratory temperature. Half of the samples were sealed and half partially closed. The tests on the samples made at the end of the storage periods showed :

Mold or mustiness was retarded at 41° F. but not entirely prevented when the moisture contents were 18 and 20 percent and when air was not entirely excluded. When air was excluded sourness developed, and at the longest time of storage the sourness developed at 15 and higher percentages of the samples stored at 41° F. Only one sample, the one having 20 percent moisture and sealed, had a baking score lower than the check samples.

Of the samples stored in the laboratory seven had a lower baking score than the check sample. Several samples which had an odor both in the grain and in the dough had a baking score equal to or higher than the check samples. A few samples which had poor viability had as good baking score as the checks. Thus odor and viability seem to be delicate tests for damage in stored wheats.

The test weights taken on the wet samples decreased with the increase in moisture and this decrease persisted after the samples had been dried, but was only about one-half as much. Calculations on the basis of specific gravity showed that the air space in the test kettle varies from 62 percent in low test weight wheat to about 40 percent in high test weight wheat.

Tests conducted at the Fort Hays station on wheat in storage in bins have shown that power ventilating fans were effective for drying extremely moist wheat when conditions were normal; that underground storage has proved to

be unsatisfactory under the conditions tried in these tests. It is believed that the difficulty has been that the bins were not placed deep enough in the ground to be unaffected by surface temperatures. Condensation has occurred on the cold wall surface near the top of the bin during the winter months and this moisture has caused the grain to become musty at these points.

It has been found that high humidities in the air above a bin of wheat do not penetrate rapidly into the lower depths unless there is some air movement in the grain. Grain at a depth of 11 feet with the surface exposed to high humidities was unaffected except on the top one foot of grain. The deeper parts of the bin neither gained nor lost moisture during a three months' period.

Experimental work has been done on the design of a portable grain dryer. Results show that by heating the grain to 150° F. and then cooling it by rapid movement of air through the grain, drying can be accomplished at a reasonable rate and at a cost that would not be prohibitive. Two to four percent moisture can be removed by one operation. No baking tests have been made on these heat-treated samples.

It is believed that except for observation of wheat in long-time storage, the tests on ventilation at the Fort Hays station need not be continued.

(Project 204; Departments of Agricultural Engineering and Milling Industry. Leaders, F. C. Fenton and C. O. Swanson; state funds. )

*Chemical Factors Influencing the Quality of Wheat and Flour.*—The work during the biennium has been a physico-chemical study of substances responsible for the unique physical behavior of gluten, dough, and bread from wheat flour, with special attention to the effect of phosphatides on the physical characteristics of the protein.

Further work on the precipitation of lecithin sols by fatty acids indicates that the failure to precipitate under certain conditions is not due to failure of the lecithin to dehydrate, but to the fact, that very small flocs are formed which remain in suspension. In any case if the water is evaporated after the addition of the fatty acid, the lecithin cannot be dispersed again in water until the fatty acid is removed by precipitating the lecithin with acetone. The fact that precipitation with acetone restores the lecithin proves that the lecithin-fatty acid complex is not identical with the lecithin-like substance extracted from old flour, which will not disperse in water even after reprecipitating many times with acetone.

Theoretically the action of lecithin in regulating the physical properties of gluten is due to its distribution over interphase boundaries. This action favors the theory of carbohydrate groups in the protein structure, and sugars have been found in crystalline gliadin as well as in other highly purified proteins. However, the preparation of gliadin by 70 percent alcohol introduces the possibility of the disintegration of the original gluten protein. To avoid such possibility, wheat gluten was dispersed in dilute acetic acid, and then precipitated by electro dialysis. Dispersion and reprecipitation could be repeated several times before the quantity of protein recovered was reduced too seriously. The protein collects at the negative membrane, while if a lecithin sol is electro dialyzed, the lecithin collects at the positive membrane. Thus, electro dialysis should free the protein of phosphatide as well as of sugars which are not actually combined. A very interesting observation which may be of importance is that the protein prepared from Chiefkan wheat by this method is strikingly different in physical character from that prepared from Tenmarq wheat.

Preliminary studies have been made of a method of measuring the direct linear swelling of bread in distilled water as a means of studying the freshness

and rate of staling in bread. The swelling varies from about 28 percent for bread two hours old to some 8 or 10 percent for bread four or five days old.

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

***Varietal Factors Influencing the Milling and Baking Quality of Wheat.***—Quality studies during the biennium have been largely restricted to samples of established varieties grown by the Department of Agronomy in cooperative tests over the state. These samples have been composited so that a series of samples of various protein levels have been available for each variety. These samples have been subjected to milling, baking, and other laboratory determinations. Micro-mixer curves were obtained for each variety series. An intensive study of the action of bleaching agents and bromate was also made upon Turkey, Tenmarq, and Chiefkan flours.

The series of samples obtained in each year were not strictly comparable, but certain general conclusions may be drawn from the results obtained. In both years it was evident that both variety and protein content materially influence type of micro-mixer curve. Baking tests in both years showed a good correlation between loaf volume and protein content. It is becoming evident that all varieties do not behave similarly, some being relatively poorer or better than others at either the high or low protein levels. Differences between varieties are most sharply brought out at the higher protein levels. In both years two varieties are worthy of note because of their unfavorable quality. These were Kamvale, off-quality as a soft winter wheat, and Chiefkan, which bakes unsatisfactorily as a hard winter wheat.

The studies dealing with the action of bleaching agents and potassium bromate in baking showed definitely that these agents are not identical in their effects. Superior baking results were obtained from potassium bromate although no way so far has been discovered whereby Chiefkan flours equal Tenmarq or Turkey flours (of equivalent protein contents) in baking strength. Similar conclusions were reached irrespective of whether milk was used in the baking formula. Beta Chloral, Agene, and Novadelox were used as representative commercial bleaching agents. In these baking tests the latter two proved superior to the first named.

(Project 60-B; Department of Milling Industry. Leader, E. G. Bayfield [R. K. Larmour in 1938-'39]; state funds.)

***Tempering Factors Affecting the Quantity and Quality of Wheat Flour.***—Five phases of work on this project have been conducted during the biennium. The designing of a small gravity type continuous flow experimental mill adapted to the grinding of 100-gram or larger wheat samples constituted a major portion of the work during the second half of the biennium.

1. *Effects of Moisture Content and Time in the Tempering of Hard Winter Wheat.*—Inexplicable variations are found in the results obtained by varying the moisture content and time in tempering Chiefkan, Turkey and Tenmarq wheats. These variations probably were due in part to atmospheric changes in the experimental mill room. The tests should be repeated under the controlled atmospheric conditions now available. The results show that the method of tempering definitely affects the curves obtained with the recording dough mixer. The differences produced in the curves may indicate variations which would be found in the baking characteristics of the flour, especially in mechanical development and plasticity of the dough.



2. *Measurement of Dough Plasticity.*—High correlations were secured between plasticity and absorption. In studying the effects of grain temperature during tempering, flours milled from wheat tempered at 25 degrees C. showed a plasticity value much different from those tempered at temperatures above or below 25 degrees C.

3. *Effects of Atmospheric Conditions on Experimental Milling.*—Air temperature and relative humidity in the experimental mill have definite effects on flour yield, flour moisture and flour ash. Higher percentage flour yields were obtained at the lower temperature range. Percentages of flour obtained were lower at the higher humidities. The flour moisture contents were in most cases increased by milling under higher humidities. Flour ash varies directly with yield, but the degree of correlation between ash and yield was low.

4. *Temperature Rise in Tempered Wheat.*—Measurement of hydration temperatures when water is added to wheat shows that for each gram of water held by hydrational forces approximately 34 calories of heat are liberated. Hydrational forces are satisfied or saturated in wheat containing 26 to 28 percent moisture, after which free water begins to exist. These results are in agreement with results obtained from vapor pressure measurements. Equilibrium humidities are near saturation of 100 percent for wheat containing 28 percent moisture. It is evident that in wheat tempered to 14-16 percent moisture all water or moisture is bound or held by some force which lowers the vapor pressure. In the range of moisture content used in tempering, the amount of heat liberated by the addition of water may serve as a measure of the degree of hydration.

5. *Study of Millstreams.*—The study of millstreams showed: (a) flours from the purer middlings streams were more alike in quality than were flours from break stocks or more impure middlings; (b) second and third break flours were outstanding in respect to good curve characteristics, loaf volume, total bread score, and protein content; (c) second tailings flour was poor in the above respects, whereas middlings, sizings flour, and first tailings flour were intermediate. Chiefkan flour streams were poorer in baking quality and handling properties than were the streams from Turkey or Tenmarq.

(Project 170; Department of Milling Industry. Leader, J. E. Anderson; Purnell fund.)

*Factors Which Influence the Colloidal Properties of Dough.*—The principal lines of work during the biennium were: Factors which influence the results in the wheat-meal-time-fermentation test; the influence on quality tests of various protein levels in the same variety; and factors which influence the physical properties of doughs, especially those revealed by the micro-recording dough mixer. Studies were also made on the variations caused by changed conditions in using the micro-recording dough mixer; on the possibilities of using the micro-recording dough mixer in charting the blending characteristics of different wheats; and in following the changes in physical properties which take place during fermentation.

Several factors besides the varietal factors influence the "time" in the wheat-meal-fermentation test. By adding proteases or protease activators, the time of a long time wheat can be made as short as a short time wheat. Also, by adding protease inhibitors, the time of a short time wheat can be made as long or longer than a long time wheat. wheat germ contains constituents which may be made to influence the time, but these are not the cause of long or short time for wheats, neither are the substances in the bran. When flour is used instead of meal, the differences among long and short time wheats disappear, and this cannot be remedied by adding the bran. While the test does

reveal quality differences, it must be used with caution because of the other factors which may influence the time.

Protein content has great influence on the curve characteristics of the same variety throughout the entire protein range. The Blackhull group of wheats give curves of striking resemblance and the effect of the various protein levels were not as great as in the Turkey and related wheats. The curve characteristics are primarily influenced by inherent qualities of the gluten. The heights of the curves are influenced mainly by protein content and somewhat by absorption. The curves from high protein flours of the different varieties differ more in characteristics than the curves from low protein flours in the same varieties. A curve from a low protein Tenmarq is similar to a curve from a low protein Michigan Wonder.

The study of the factors which influence the physical properties of doughs showed that the curve characteristics are greatly influenced by autolysis or merely incubating the dough at 30° C. for varying periods of time. The characteristics greatly resembled the curves obtained when proteases had been added. Thus protease action may be a probable explanation of the softening of doughs during fermentation. The changes in curve characteristics obtained on doughs to which enzymes pepsin, trypsin and papain had been added took place in a much shorter time than when autolysis alone was used. The change was most rapid with the protease activator cysteine. The presence of the diastases produced no change in curve characteristics.

The micro-recording dough mixer showed very good possibilities of its use in blending wheats of different characteristics and also in following the changes in physical properties which take place during dough fermentation.

(Project 200; Department of Milling Industry. Leader, C.O. Swanson; Bankhead-Jones fund.)

*A Physiological Study of the Winter Wheat Plant.*—Artificial defoliation is similar to leaf rust infection in its effects upon the yield of the wheat plant, and in some respects similar to the effects of hail. The knowledge gained by artificial defoliation may be of some value in understanding the reductions in yield caused by these two factors. It was believed advisable to study the effect of partial and complete defoliation at four stages of development upon the yield of the wheat plant.

Eight varieties of red winter wheat were used in these experiments. They were: Kanred, Turkey, Kanred X Hard Federation, Kawvale, Early Blackhull, Chiefkan, and Fulcaster. Three sets of plants were selected one week before flowering, at flowering, one week after flowering, and two weeks after flowering, and each set treated as follows: (a) The entire blade was removed from all the leaves; (b) the blades of the basal leaves were removed; and (c) one-half the length of each leaf was removed. For each group of treated plants a similar number of intact plants served as controls.

The basal defoliation removed approximately 50 percent of the leaf blade area at the first clipping, but since the basal leaves die as the plant becomes older, this percentage was reduced so that at the last two clippings the removal caused no effect on the photosynthetically active leaf area. The half-leaf clipping removed only 41 percent of the total area of the active leaf blade at all stages because the length of the leaves increased slightly from the first to the last period of defoliation.

The number of grains per 100 control and 100 experimental spikes was determined, and the actual decrease and percentage decrease resulting from the various types of defoliation were calculated. Defoliation a week before flowering resulted in the greatest percentage reductions in the number of grains produced. Total defoliation at this stage caused an average reduction in the number of grains of 19.53 percent; basal defoliation, 10.32 percent; and

half-leaf defoliation, 9.77 percent. Later clippings, however, had little effect on the number of grains. Total defoliation produced the largest reductions in the number of grains, varying from 19.53 percent at the early boot stage to 3.16 percent at the final clipping, while basal defoliation caused one to two percent greater reductions in the number of grains than did the half-leaf clippings.

The decrease in the number of grains due to the increase in the number of sterile spikelets accounted for approximately 75 percent of the actual reduction in yield at the early stages of leaf removal, but for only a small percentage of the decrease in the number of grains at the later stages of defoliation. The remaining difference in the decrease in the number of grains was due to an increase in the number of sterile florets in the intermediate spikelets and to an increase in the number of sterile terminal spikelets.

The effect of the three degrees of defoliation on the weight of the grain was determined on the weight of the grain from 100 spikes and the weight of 1,000 grains. The greatest reductions in weight were caused by the earliest defoliations. These reductions ranged under the different degrees of leaf removal from 15.63 to 34.01 percent in the weight of the grain per 100 spikes and from 6.00 to 18.03 percent in the weight of 1,000 grains. The reductions in the weight of the grain gradually diminished with later clippings. Total defoliation caused the largest reductions in the weight of grain produced. In the weight of the grain from 100 spikes, these reductions ranged progressively from an average of 34.01 to 6.25 percent. In the weight of 1,000 grains these reductions diminished from an average of 18.03 to 3.43 percent. Half-leaf clippings had a more pronounced effect on the weight of the grains than the removal of the basal leaves.

Since the basal defoliations caused a greater decrease in the number of grains produced, and the half-leaf clippings had a greater effect on the weight of the individual grains produced, it seems probable that the basal leaves play an important role in the setting of the grain, but that the tip portions of all leaves play a more important part in the later development of the grain.

The various types of defoliation caused an increase in the percentage of ash in the grain as calculated on a dry weight basis. This increase in percentage of ash diminished progressively from its maximum, caused by defoliation at the early boot stage, to its minimum, caused by defoliation at the last stage. The average maximal percentage increases in ash for the various degrees of defoliation at the early boot stage were total defoliation, 5.63 percent; basal defoliation, 4.43 percent; and half-leaf defoliation, 2.76 percent. The percentage increase of ash at the last stages of defoliation was negligible.

The increase in the percentage of ash in the grains was apparently caused by a decrease in the amount of carbohydrates and proteins stored in the grain. The organic constituents of the grain were thus reduced on account of the decrease in photosynthetic area caused by the removal of the leaves.

The effect of the removal of the leaves at the various stages on the actual amount of ash in the individual grain was calculated on the basis of the ash in the grain from 100 spikes and as the amount in 1,000 grains. Both of these determinations showed a definite decrease in the actual amount of ash in the individual grain. Total defoliation produced the greatest decreases in the actual amount of ash in the grain, ranging from approximately 6.5 to 30 percent in case of the weight of the ash in the grains from 100 spikes, and from approximately 4 to 13 percent in case of the weight of ash in 1,000 grains. Half-leaf clippings gave reductions as much as 5 percent greater than the basal treatments.

Although there was an increase in the percentage of ash in the grains at all stages of defoliation as calculated on a dry weight basis, there was a decrease in the weight of the actual amount deposited. The different results obtained from the two methods of expressing the amount of ash were caused by the decreased weight of the individual grains.

The results of the four years' work on the physiological study of the winter wheat plant at different stages of its development were published in Technical Bulletin 47 by the Kansas Agricultural Experiment Station.

A paper entitled "Influence of the awns upon the rate of transpiration from the heads of wheat" has been prepared. This paper has been accepted by the Journal of Agricultural Research and is now in press.

A paper entitled "The modification of diurnal transpiration in wheat by infections of *Puccinia triticina* Eriks.," by C. O. Johnston and E. C. Miller is in press in the Journal of Agricultural Research.

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

***A Physiological Study of Field Bindweed in Relation to Its Control.***—During the past biennium, the work on this project has consisted of studies on (1) seed viability and the effect of different depths of planting; (2) the effect of loss of tops on seedling survival; (3) on the botanical nature of the plant; (4) the effectiveness of sodium chlorate as an herbicide; and (5) the seasonal trends in the amount and distribution of food reserves.

1. *Seed Viability Studies.*—During 1939 seed planted at varying depths, and at the rate of 50 seeds per square yard, showed a viability of 9.71 percent, as compared with 12.54 percent on similar plantings in 1938. As in that experiment, germination was highest in the upper two inches. Seeds were planted at one-half inch intervals from one-half inch to four inches deep.

2. *Age of Seedlings Surviving Loss of Tops.*—All seedlings severed either at the ground line or one-half inch below the ground line within the first three weeks after emergence died. There was a 10 percent survival of seedlings severed at the ground line the fourth week after emergence, and this survival increased to 40 percent when severed at the ground line five weeks after emergence. Beginning with the sixth week after emergence, high survival values were obtained, with 80 percent survival when severed at the ground line and 40 percent when cut one-half inch below the ground line. The seedlings which survived regenerated their tops from a shoot bud which forms just back of the point of severance of the root. Survival values of 80 percent were obtained for both types of treatment when the plants were severed six weeks after emergence.

3. *Studies on the Botanical Nature of the Plant.*—Plants that had emerged as seedlings in April, 1937, were excavated in late July, 1939, and many roots were found to reach a depth of 10 to 14 feet and one root reached 23 feet. The vertical roots which were formed as vertical extensions of lateral roots grew deeper than the vertical root formed at the site of seed germination.

It has been determined that all shoot development of the plant, other than that formed from the plumule of the seedling, arises from shoot buds on the lateral and secondary vertical roots. Specific observations show that after the plant is four months old the crown of shoots above the primary vertical root is composed largely of shoots which arise from buds formed in the upper portion of this root. Cultivation treatments bring about a division of the underground parts of the plant into two main categories: (1) The vertical roots which are undamaged except for the severance of their aerial portions, and (2), the severed growth superficially located in the soil which is readily destroyed by cultivation or by chemicals, and if not destroyed any portion of which, except the shoot, may form roots and later shoots.

4. *Studies Dealing with Sodium Chlorate as an Herbicide.*—A slightly better kill was obtained when a high relative humidity was maintained in a field experiment by uniformly wetting a small area with one-fourth inch of water and covering with a tar paper house.

Applications of sodium chlorate sprays were made in three ways in a greenhouse study: (1) Directly on the shoots; (2) directly on the soil, and (3) the conventional method of spraying both shoots and soil. No significant

differences in effectiveness were observed, except that in the treatment applied directly to the soil there was little damage observed in the shoots for the first 36 to 40 hours after the treatment.

5. *Studies of Seasonal Trends in Extent and Distribution of Food Reserves.*—In an analysis of ten portions of the bindweed plant at 14 periods of sampling (April 1 to November 1, 1937), it was found that all fractions in practically all portions reach their low point in late April or during the first half of May. The total sugars attain high percentages in June and in late August or early September in the vertical roots. In the lateral roots the maximum is attained late in the fall. The starch-dextrin fraction attains a maximum about the middle of June in the lateral roots and about the middle of August in the vertical roots. The readily available carbohydrates attain a maximum about the middle of June in the lateral roots and about the middle of August in the vertical roots. The reserve fractions of the rhizomes, regardless of the point on the plant where they were formed, attain a high percentage about July 1 and again on October 1, after an early season minimum on May 1.

(Project 202; Department of Botany. Leaders, E. C. Miller and J. C. Frazier; Bankhead-Jones fund.)

*Orchard Investigations.*—Work on this project was hampered considerably by the dry weather and high temperatures of the past two years, which caused the death of a large number of fruit trees in the station orchard. No work was done on one phase of the project—soil management experiments—because of the death of most of the apple trees. Phases of the project upon which work was done are:

1. *Spraying.*—The recommended Kansas schedule was followed during 1938. Following the hailstorm of June 7, 1939, the remaining apples were so badly damaged that they were picked and spraying was discontinued for the season.

A dormant spray of liquid lime-sulfur 1-10 followed by an application of liquid lime-sulfur 1 1/2-50 when the new canes were about six inches high gave commercial control of anthracnose on raspberries and blackberries.

A study was made of the effects of spraying nursery wax on newly transplanted nursery stock on the survival and growth. The purpose of the wax is to decrease the loss of water from the plants while new root systems are developing following transplanting. The results of one season's work with nursery wax (Dowax) indicate that the wax does not benefit deciduous trees very much and causes serious damage to some species of conifers. Twelve species of conifers and 20 species of deciduous trees and shrubs were given two applications of the nursery wax, one part to three parts of water. The second application was made immediately after the first application was dry. The trees and shrubs were all newly transplanted in the spring of 1939. A survival of 90 percent was obtained with the sprayed deciduous trees, as compared with a survival of 85 percent for those not sprayed. The deciduous trees were not damaged by the wax spray. With conifers, a survival of only 52 percent was obtained with the sprayed trees, compared with a survival of 57 percent for the unsprayed trees. Many of the surviving conifers showed considerable damage due to burning by the nursery wax.

Since a combination of high temperatures and wax sprays seemed most likely to cause damage to plants, one plot of seedling arborvitae was sprayed on April 8, another plot, on May 24, and a third plot was left unsprayed. The seedling arborvitae were not transplanted. The plants sprayed on April 8, when the weather was cool, were damaged the most, having a survival of 68.3 percent as compared with a survival of 71.3 percent for the plants sprayed on May 24. Highest survival was on the unsprayed plants, 87.5 percent. Surviving unsprayed plants were damaged the least by the hot, dry weather.

Observations were made in May, 1940, on the effects of spraying on seven

species of conifers that had been planted the preceding October. The seedlings, 8 to 12 inches tall, had been sprayed twice, using the usual 1-3 mixture. Colorado Blue Spruce was undamaged and there was slight damage to Black Hills Spruce and Red Cedar. *Juniperus pfitzeriana*, *J. tamarixifolia* and *J. sabina* were badly damaged and the tops were dead, and 18 percent of the *J. sabina* were dead. Slight damage was noted on the tops of *J. scopulorum*. The unsprayed check seedlings are all growing nicely and show no winter injury.

Small Chinese arborvitae and Pfitzer junipers were used in an experiment designed to study the effects of nursery wax on plants. One-half the number of each species used was sprayed with wax and the remainder left unsprayed as checks. Chlorophyll determinations were made at the end of two weeks and at the end of four weeks on trees kept in the greenhouse under temperatures ranging from 50 degrees to 100 degrees F. The increase in chlorophyll was less in the waxed trees for both periods in the Pfitzer junipers, while in the arborvitae, the chlorophyll content decreased in both the waxed and unwaxed, but less in the unwaxed. Both species showed losses in chlorophyll content for both the waxed and unwaxed trees in a heat chamber at 98° to 102° F. The sprayed Pfitzer junipers were dead at the end of four weeks and had no chlorophyll.

Transpiration records were variable. Data seem to indicate that at first nursery wax reduces transpiration, but as injury develops the rate of transpiration increases.

Some recent work indicates that naphthalene acetic acid delays the growth of sprouts on potatoes; this was verified by tests at this station. The delay of development of vegetative tissue led to a test of the material (naphthalene acetic acid) sprayed on fruit trees early in the spring hoping to delay growth enough to escape spring frosts, but no noticeable difference in time of blossoming was observed.

*Methods of Pruning Fruit Trees.*—Work on this subproject during the past biennium was handicapped because of loss of many trees in the Station orchard. A careful study was made each year of the cherry trees that had been pruned according to three methods: Open center, modified leader with moderate pruning of laterals, and modified leader with severe heading of laterals. These trees were planted in 1930 and pruned according to the three systems that spring.

The trees were judged with special reference to the strength of the crotches at the head of each tree and of the main scaffold branches. In 1939, observations were made by two persons and in 1940 by three persons. The modified leader with severe heading of laterals method was scored the best method on both Montmorency and Early Richmond. Moderate heading of laterals only produced the weakest tree with the open center method of pruning ranking intermediate.

It was noted that the variety had a more important influence than did the treatment on the strength or weakness of the trees. The Early Richmond trees are somewhat smaller, but are stronger on the average than the Montmorency.

During the ten-year period 17 Montmorency trees (9.1 percent) are missing or have been replanted out of 178 trees planted, and 4 (8.7 percent) out of 46 Early Richmond trees planted. Further observations will be made in the future to determine the longevity of the trees in the various plots.

*Testing New and Promising Varieties of Tree Fruits.*—Studies of the varieties under test were continued as noted in previous reports: (1) Vegetative behavior of the plants; (2) blooming data and yields of those which have reached blooming age; (3) pest relations.

Varieties of the various tree fruits now under test on the Experiment Station horticultural farm number: Apple, 30; apricot, 4; sour cherry, 1; jujube, 2; pear, 3; peach, 3; plum, 15; quince, 1; total, 59.

New varieties planted during the biennium were: Apricot, Moorpark (as a check against the Hansen varieties) ; nectarine, Garden State; peach, Hardee,

Goldeneast, and Ede, 1939, and Halehaven and South Haven in 1940. Belle of Georgia and Champion were also planted as check varieties.

Climatic conditions affecting the vegetative development of the trees under test were about average during the growing seasons of 1938 and 1939. Medium to strong growth was made by these trees. Poor soil conditions and pests were the causes of death of 15 trees.

Seventeen own-rooted apple trees survive and may prove of experimental value. They are starting their third year of growth in the orchard.

Detailed records of the varieties under test for both years of the biennium are on file.

*Frost Penetration as Affected by Ground Cover.*—Injury to the roots of the fruit plants by low winter temperatures is an important factor in fruit growing. The extent of this injury is related to the depth of penetration into the soil by the frost. Six blocks representing various soil conditions in the orchard are prepared each fall and measurements are made of the penetration and the withdrawal of the frost each year.

The winter of 1938-'39 was characterized by mild temperatures and absence of snow. The minimum temperature reached, was on February 11, when  $-7^{\circ}$  F. was recorded. There was no period of long continued cold, the most potent factor in frost penetration. Maximum depth was on the bare, compact block which froze to a depth of 10 inches. Soil beneath a 3-inch layer of straw remained unfrozen throughout the winter. There was no effective snow mantel during the cold period.

During the winter of 1938-'40, there were periods of 20 days and of 11 days when the maximum reading failed to reach  $32^{\circ}$ ; 14 days of  $0^{\circ}$  or lower minimum, and a season low of  $-15^{\circ}$  on January 17. The snow cover averaged about 7 inches in depth and persisted for 46 days.

Maximum frost penetration under the varying conditions of the test blocks were: Block 1--soil compact and bare (snow removed after each fall), 26 inches; block 2--soil compact and snow covered, 15 inches; block 3--soil rough, snow removed, 25 inches; block 4--soil rough and snow covered, 12 inches; block 5--soil fall cultivated and rye cover crop under snow, 10 inches; block 6--soil covered by a 3-inch straw-mulch and snow,  $7\frac{1}{2}$  inches. Block 6 was practically free from frost until January 22, but still showed a thin frozen layer on February 29, when the last measurement was made. Twenty-six diggings were made during the 61-day period.

It is becoming evident that although frost penetration in the soil is governed primarily by the temperature-time relation, it is also profoundly affected by the condition of the surface soil and the ground cover.

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

*Small-Fruit Investigations*—This project was expanded during the biennium to include a study of the more desirable varieties of small fruits and vegetables suitable for preservation in cold storage lockers. The weather conditions during the two seasons were unfavorable for normal yields, but did offer an opportunity to study drought resistance among the several varieties of each class of fruit grown. The project included grapes, strawberries, brambles and groselles.

*Grapes.*—The grape crop harvested in 1938 was extremely light and the varieties ripened irregularly. The hailstorm of June 7, 1939, so badly damaged the grape plants and fruit that the remaining bunches were removed to save the plants. The plants made only a fair growth during the summer of 1939.

*Strawberries, Brambles and Groselles.*—Strawberry yields were low both years due to poor sets of plants and short harvest seasons because of hot, dry weather. Yield records were taken to determine the effects of the following

cultural practices as well as the varietal differences: (1) Renovation of plots getting more than one crop from a planting; (2) hill system versus matted row; and (3) application of mulch early, before heavy frosts, and late, after ground freezes.

The yields were slightly higher under early mulching than late mulching and also the berries were larger. The larger yields and larger berries were especially noticeable in the early part of the season, indicating winter damage to fruit buds in cases of late mulching.

In a study of the effects of different systems of training brambles, the low trellis, summer topped system obtained the highest yields with summer topping having a greater effect than the type of support given the bramble.

Results obtained in bramble winter protection experiments conducted during the preceding biennium were verified in a repetition of the experiment. Two varieties of red raspberries, Chief and Latham, were used in the study. The percentage of cane survival of the two varieties under the different protection methods were:

	Treatment			
	Covered with soil	Sprayed with dowax	Covered with fodder	Check
Chief.....	76.3	8.24	1.66	0.64
L a t h a m.....	87.96	3.43	6.22	0.56

Severe winter-killing during the past few winters undoubtedly has been a contributing factor in low yields of the brambles. The unprotected red raspberry canes of both varieties killed to the ground each winter. Some plots were sprayed with liquid lime-sulfur, 1 to 10, in the fall of 1939, before other treatments were applied and those sprayed survived better than the unsprayed, where both were soil-covered.

Youngberry canes sprayed with liquid lime-sulfur 1-10 in the fall and covered with straw survived 85 percent, while unsprayed canes survived only 53 percent. The Boysenberry canes that were sprayed survived 30 percent while the unsprayed survived 39 percent.

High temperatures during 1938, and the hailstorm of June 7, 1939, damaged gooseberry crops. The currants were damaged by hot weather, hail and grasshoppers.

A study was made of the various methods of preserving small fruits by freezing. Among the factors which were studied were varieties suitable for preservation by freezing, containers, various packing methods, freezing temperatures, and a cooperative study with the Home Economics Department as to the use of the frozen fruits and vegetables.

Considerable difference was found in the results from the tests of the common Kansas varieties of strawberries. Howard and Blakemore were most desirable. Aroma and Dunlap were fair but quite soft.

Of the black raspberries, Black Pearl was fair; red raspberries, Latham and Chief were both good, but soft; blackberries, Eldorado was the only one tried and it was quite good; gooseberries, Houghton and Glendale were both good.

Containers which were practically airtight and economical of space were the most desirable. Among these were glass jars, paraffin coated cartons, and cellophane-lined cartons. In most cases fruit packed with sugar or covered with a heavy syrup were more desirable than those with no treatment. Temperatures from 0° F. to 10° above were very satisfactory.

(Project 26; Department of Horticulture. Leader, G. A. Filing; state fund.)



*Flower and Vegetable Investigations.*—The drought years have caused many of our recommended varieties of vegetables to fail to produce satisfactorily. Variety testing has been continued in an endeavor to find varieties best able to produce under adverse conditions.

*Beets.*—In 1938 four of the leading varieties of beets were tested and in 1939 thirteen varieties were tested. Early Wonder and Landreth's Best produced the highest yield, being much superior to Ohio Canner or Detroit Dark Red. Cooking tests by the Department of Home Economics based on color, appearance, flavor, tenderness, and odor placed Landreth's Best among the best and Early Wonder in class three of the four classes.

*Peas.*—Four varieties of early peas, Little Marvel, Alaska, Early Perfectah and Mardelah, have been outstandingly higher yielding than other varieties tested. Nott's Excelsior and Hundredfold produced poorly as compared to the above varieties.

*Spinach* variety tests have not been extensive. The results for the past two seasons show length of harvest season to be about equal for the varieties tested, but varied 20 days in time of first harvest.

*Beans*, like tomatoes, have produced poorly and with varying results during the period of this test Seventeen varieties have been tested each year but with varied results.

*Cabbage* as a spring crop has been studied and in coöperation with the Division of Extension, variety plots were established throughout the state in 1938. Cold weather greatly reduced the yield. In 1939 twelve varieties were tested.

Test plots of tomatoes as with cabbage have been established throughout the state. Twenty-eight selected varieties of tomatoes were planted in the college test plot with yield ranging from less than a pound per plant to 4 pounds of marketable fruit. All varieties produced less than 50 percent good fruit.

A cloth house was erected in 1938 in order to study the effects of shade upon the growth and yield of flowers and garden vegetables. Asters, snapdragons, dahlias, zinnias and chrysanthemums made a much more vigorous growth in the cloth house than when grown in the open. The blooms were larger and on stems of greater length. In 1939 the early crop of snapdragons had below normal keeping quality because of the very soft growth.

Tomatoes in the cloth house failed to produce a profitable crop in 1938. Varieties were tested in 1939 with yields of less than 2 pounds per plant to 6.5 pounds of marketable fruit per plant. The plants were set 18 inches by 36 inches and grown to six feet in height. A yield of 6.5 pounds is a fair yield. The fruit was superior in quality, color, firmness, and with fewer cracks than on tomatoes grown in the open.

A complete farm irrigation garden has been grown on each of four plots in a coöperative experiment, with the Department of Agricultural Engineering and the Kansas Committee on the Relation of Electricity to Agriculture. Three systems of irrigation—overhead, furrow, and subirrigation—are being studied. The fourth plot has no irrigation. Preliminary results are not sufficiently complete to warrant recommendations regarding the more economical type of irrigation. It has been observed that beans may be planted throughout the season and made to mature fair crops. Fall crops of winter radishes, turnips spinach and celery cabbage have been grown successfully under irrigation but with poor success without irrigation.

(Project 27; Department of Horticulture. Leader, S. W. Decker; state fund.)

*Relation of Leaf Structure to Rate of Photosynthesis in Fruit Plants.*—During 1938 and 1939 three varieties of apple trees were grown in the greenhouse for the purpose of attempting to correlate the chlorophyll content of the leaves and their internal structure with the photosynthetic activity. As a measure of the photosynthetic activity of the trees, the dry weight increment of each entire tree was determined. York, Jonathan, and Wealthy were the varieties used. Quantitative chlorophyll determinations were made from the foliage of each tree at the close of the experiments.

Nine two-year-old apple trees of each of the three varieties were weighed and planted in twelve-inch clay pots and plunged in a ground bed. In order to estimate the content of water, ash, total acid hydrolyzable carbohydrates, and total nitrogen, three additional representative trees were taken from the same lot and killed by dry heat. These analyses of the three trees of each variety were judged to represent the composition of the trees which were planted in the pots.

The increase in total dry matter accumulated by each tree was used as a measure of the photosynthetic activity of the foliage.

The content of chlorophyll was estimated by colorimetric comparisons of saponified aqueous solution of pure crystalline chlorophyll and extracts from the apple leaves.

The York variety accumulated the least amount of total dry matter per square meter of leaf area, Jonathan was intermediate in rank, and Wealthy ranked highest.

There were no great differences between varieties in the composition of any portion of the trees at either the beginning or the conclusion of the experiment. This finding probably justified using the gain in total dry matter per tree as an index or function or photosynthetic activity of the period between planting time, January, and digging time, June, 1938. All the trees were entirely dormant when they were planted and all used for this report started growth at about the same time. No insecticides or fungicides were used.

In order to measure the differences in leaf structure the ratio of the amount of the internally exposed surface to the external surface was determined for each of the three varieties. Microscopic slides were prepared from the leaves of each tree and 100 pages of camera lucida drawings were made from a composite sample of leaves from all the trees within a variety.

The measurements needed for the computation of the ratio of the internally exposed surface to the external surface, R, were made by means of a chartometer and a planimeter.

The following observations were made:

1. The value of R for the York leaves was 10.09, for Jonathan 12.60, and for Wealthy 15.31. A mean difference of 0.68 was significant.
2. The palisade mesophyll contained from 70 to 85 percent or more of the total internally exposed surface of apple leaves.
3. The first layer of palisade mesophyll contained a larger percent of the total internally exposed surface than the second layer; the second layer more than the third.
4. From the first to the third layer of the palisade mesophyll the diameter of the cells increased.
5. The length of the palisade cells decreased from the first to the third layers of the palisade mesophyll.
6. There was a correlation between R and the total depth of the palisade mesophyll.

Multiple correlation coefficients were calculated between the three variables in the greenhouse experiment: Chlorophyll content per square meter of leaf area, the ratio of the internally exposed surface to the external surface of the leaves, and the gain in total dry matter per square meter of leaf area. The coefficient of correlation between the chlorophyll content per square meter of

leaf area and the ratio between the internally exposed and the externally exposed surfaces is +.52, which is significant. Evidently an increase in internally exposed surface and the chlorophyll content have a fairly close relationship.

The coefficients of correlation between the ratio of the internally exposed surface to the external surface of apple leaves of these varieties and their photosynthetic activity is +.70 while between the chlorophyll content and photosynthetic activity it is +.24.

From this relationship it may be deduced that the extent of the internally exposed surface of apple leaves is an important factor partially governing photosynthetic activity.

During 1939 Jonathan and Wealthy trees were grown in the greenhouse and the procedure was essentially the same as for 1938.

The 1939 data substantiate the 1938 results, namely that variations in the extent of internally exposed leaf surface influence the rate of photosynthesis of apple leaves.

(Project 199; Department of Horticulture. Leader, W. F. Pickett; Bankhead-Jones fund.)

**Investigations with Ornamental Plants.**—The work of the past biennium covers four phases: (1) The effect of the drought on campus trees; (2) testing of the adaptability of trees and shrubs in the Campus Trial Nursery; (3) control of dandelions by the use of kerosene; and (4) study of bearded irises and their adaptability.

1. *Effect of Drought on Campus Trees.*—From 1934 to 1939, inclusive, 695 of the 3,771 trees on the College campus died, due principally to drought injury. Approximately 500 of the total number lost died during the first three years of that period.

2. *Testing Adaptability of Trees and Shrubs.*—Seventy-two species of trees and shrubs were planted in the trial nursery in the spring of 1939. These plants were furnished by the United States Soil Conservation Service. Five plants of each species were planted.

Forty-three species of trees and shrubs were planted in the spring of 1940. These plants were from the same source, but ten plants of each species were planted.

3. *Use of Kerosene in the Control of Dandelions.*—Three brands of kerosene and one tractor oil were used. All four oils showed over 90 percent dandelion mortality where dandelions were growing in bluegrass. The plots were sprayed at the rate of 200 gallons per acre. Where dandelions were growing in Bermuda grass only 0.7 percent to 22.3 percent were killed. No explanation can be made for this difference.

4. *Study of Bearded Irises.*—There are 385 varieties of bearded irises under investigation. Twelve varieties have died since 1935.

(Project 213; Department, of Horticulture, Leader, L. R. Quinlan; state fund.)

**The Chemical Utilization of Plant Materials.**—Studies on this project have been carried on for one biennium and emphasis during that time has been placed on a study of the methods and uses of materials extractable from sorghum grain.

The engineering phase of the project has been confined to a study of the production of starch by the wet milling of sorghum grain. The method employed for the separation of the corn germ from the endosperm cannot be used with sorghum because of the greater specific gravity of the sorghum germ. A 40 percent starch suspension would be required for floating off sorghum germ.

while a 12 percent suspension will float the corn germ. A counter current washing process has solved this difficulty. Sorghum starch of a purity equal to that of commercial corn starch has been prepared by a series of batch washings. This process, while commercially inefficient, has shown the possibility of using a continuous counter current separator for the purification of crude sorghum starch.

The most significant result of the work in the chemical phase of the project has been the successful introduction of chlorine into the starch molecule. Moreover, the same process is applicable to the chlorination of carbohydrates in general, carbohydrate derivatives (esters and ethers), higher alcohols, wood, kojic acid, saturated fatty acids, saturated fats and coal. The chlorine content of these products range from 35 to 77 percent and the products are, in general, soluble in organic solvents. In general chemical and physical properties, the products show typical behavior of organic chlorides. Starch esters might prove to be of value in themselves if methods could be devised wherein they could be prepared with less difficulty and at lower cost. The organic esters of starch are easily prepared and some of them may prove to be industrially important.

(Project 208; Departments of Chemistry and Chemical Engineering. Leaders, H. N. Barham and J. W. Greene; Bankhead-Jones fund.)

### INVESTIGATIONS IN THE ANIMAL INDUSTRIES

The following pages contain brief reports of the work that has been done during the past biennium in problems relating to the animal industries.

*Nutritive Requirements of Swine.*—In the years preceding the present biennium, the study has been confined to a determination of the phosphorus requirements of hogs when the calcium of the feed was kept constant and the phosphorus and vitamin D varied. In this biennium the emphasis has been on the requirements for calcium when the phosphorus was kept constant at a level of 0.3 percent, and adequate vitamin D was present.

In the first year, three lots of five hogs each received a ration with calcium levels of 0.6, 0.8, and 1.0 percent calcium, respectively. Since normal results were obtained in the first experiment, this year the calcium levels were lowered in four lots to 0.1, 0.25, 0.40, and 0.55 percent, respectively. Three hogs were placed in the low lot, while the other three lots contained five animals each. Calcium and phosphorus analyses of feeds and feed ingredients and bones were made and blood analyses were conducted at monthly intervals for all lots.

The first year with levels of 0.6, 0.8, and 1.0 percent calcium, no differences were observed in the pigs of the different lots. The pigs of all groups grew and developed normally and had about the same utilization of feed and daily gain.

The analysis of the blood showed a calcium percentage about the same in all lots; the blood phosphorus was about the same in all lots.

The breaking strength and ash analysis of the femur and humerus bones showed no differences.

These results would indicate that the different levels of calcium as fed in this experiment made no difference in the normal development of pigs.

The second year showed different influences.

The pigs of Group 1, 0.10 percent calcium, about three weeks after the experiment began, became unthrifty and lost appetite. These pigs continued to be in bad condition until after the fourth month of feeding. Two became

better and continued to do better until the close of the experiment. One pig was still unthrifty with more or less indifferent appetite throughout the experiment and showed some difficulty in the control of its hind legs.

In Group 2, 0.25 percent calcium, two of the three pigs acted in the same manner as described for the three in Group 1. They were, however, more unthrifty and one of the pigs lost complete control of his hindquarters and was destroyed at the end of five months. No clinical lesions were observed to account for the posterior paralysis. Bones were taken for chemical and breaking tests. The remaining three pigs in this group seemed normal, ate well, and gained normally. Leg bones were obtained on which ash and breaking test analyses will be made.

In Group 3, 0.40 percent calcium, one pig, about three weeks after the beginning of the experiment, was unthrifty and had a poor appetite. This pig was killed, but no lesions were observed to account for the condition. The remaining four pigs ate well and grew normally throughout, the experiment.

In Group 4, 0.55 percent calcium, the reaction of the pigs was similar to those in Group 3. One pig also in this lot was unthrifty after about three weeks of feeding and was posted, but no lesions to account for the unthriftiness were observed.

The chemical and breaking tests of the bones have not been completed. The blood analysis shows no significant lot differences as regards the calcium and phosphorus content.

(Project 38; Departments of Animal Husbandry, Chemistry, and Veterinary Medicine. Leaders, C. E. Aubel, J. S. Hughes, and L. M. Roderick; Adams and Bankhead-Jones funds.)

**Swine-feeding Investigations.**—The relative advantages of different protein supplements in the swine-feeding ration were studied in this project during the biennium. Three phases of the project were: (1) tankage versus soybeans and soybean oil meal as protein supplements to grain for fattening pigs on alfalfa pasture; (2) the comparative value of tankage, fish meal, soybean oil meal, and mixtures of these feeds as protein supplements for pigs self-fed corn on alfalfa pasture; and (3) the comparative value of certain protein feed mixtures as supplements to corn in swine feeding rations in the dry lot.

1. *Tankage versus Soybeans and Soybean Oil Meal.*—Five lots of pigs were self-fed shelled corn for 112 days in the dry lot. The lots were fed various protein supplements as follows: Lot 1 received tankage as the protein supplement; Lot 2 received whole soybeans; Lot 3 received expeller process soybean oil meal and minerals; Lot 4 received solvent process soybean oil meal and minerals; Lot 5 received solvent process soybean oil meal without minerals.

The pigs in Lot 4 made the largest daily gains, 1.43 pounds; Lot 1 made 1.38 pounds; Lot 3, 1.36 pounds; while the soybean-fed lot made only 0.84 pounds and the soybean-meal lot without minerals only 0.82 pound gain per day per pig.

The lowest feed consumption and the cheapest gains were made in Lot 4 which received the solvent process soybean meal and minerals. The pigs in Lot 3 receiving the expeller process soybean oil meal and minerals made cheap and efficient gains also, while the tankage-fed pigs in Lot 1 made about as good a showing.

The results show the necessity of feeding minerals with the soybeans and soybean oil meal for the animals receiving no minerals were very slow gainers, and gains were very expensive.

2. *Comparison of Tankage, Fish Meal, Soybean Oil Meal, and Mixtures of These Feeds.*—Six lots of spring pigs were self-fed shelled corn for 109 days on alfalfa pasture. The lots were self-fed various protein supplements as follows: Lot 1 received tankage; Lot 2, fish meal; Lot 3, soybean oil meal and minerals; Lot 4, a mixture of soybean oil meal 1 part, tankage 2 parts; Lot 5, a mixture of soybean oil meal 5 parts, tankage 2 parts, fish meal 2 parts, cottonseed meal 1 part; and Lot 6 received soybean oil meal 5 parts, tankage 4 parts, cottonseed meal 1 part.

The pigs in Lot 5 made the largest daily gains, 1.46 pounds; Lot, 3 gained 1.45 pounds; Lot 2 gained 1.44 pounds; Lot 6 gained 1.40 pounds; Lot 1, 1.38; and Lot. 4, 1.33 pounds.

The largest amount of total feed per 100 pounds gain was consumed in Lot 3; it also had the most expensive gains. Lot 6 had the lowest total feed consumption and the lowest costing gains.

The feed consumed and the cost of the gains were very close in the three lots having the largest daily gains—Lots 5, 3, and 2.

The efficiency and cost of gains were no more favorable in lots that received mixtures of protein supplements than in those lots that received single protein supplements, as fish meal and soybean oil meal alone were practically as efficient as was the mixed supplement fed in Lot 5.

3. *Comparison of Certain Protein Feed Mixtures as Supplements to Corn.*—Five lots of fall pigs were self-fed shelled corn for 120 days in the dry lot. The lots were self-fed various protein supplements as follows: Lot 1 received tankage and alfalfa hay; Lot 2, a protein mixture of tankage 50 percent., soybean oil meal 25 percent, and alfalfa meal 25 percent; Lot 3 received a mixture of soybean oil meal 40 percent, tankage 20 percent, fish meal 20 percent, cottonseed meal 10 percent, and alfalfa meal 10 percent; Lot 4 received a mixture of soybean oil meal 50 percent, tankage 20 percent, fish meal 20 percent, alfalfa meal 10 percent; Lot 5 received soybean oil meal 50 percent, tankage 40 percent, and alfalfa meal 10 percent. All lots received a mineral mixture of 5 parts steamed bone meal, 5 parts ground limestone, and 1 part salt.

The pigs in Lot 3 made the largest daily gain of 1.66 pounds. The gains in Lot 5 were next with 1.60 pounds; Lot 4, 1.54 pounds; Lot 2, 1.41 pounds; and Lot 1, 1.38 pounds.

Lot 3 receiving the most complex mixture made the best showing in efficiency of feed and cost of gains. Lot 4 was next. The lot receiving the single supplement with alfalfa hay was the most inefficient lot of all, being excelled by those lots that received more complex supplemental mixtures.

(Project 110; Department of Animal Husbandry. Leader, C. E. Aubel; state fund.)

*Investigations in the Use of Silage for Fattening Beef Cattle.*—During the past biennium study has been made of (1) a comparison of ordinary Atlas sorgo silage, Atlas sorgo silage in which the grain in the silage was ground, and Atlas sorgo stover silage as the basal ration in calf-wintering rations; (2) effect of the addition of powdered limestone to a calf-fattening ration in which silage was the roughage portion; (3) cottonseed meal versus soybean oil meal as protein supplements in the calf-fattening rations; (4) comparison of daily gains, cost of gains, and net returns from lightweight calves versus heavyweight yearlings.

1. *Comparison of Atlas Sorgo Silages.*—Over a period of 150 days the calves fed ordinary silage gained 1.28 pounds per head daily; those fed special silage 1.43 pounds; and those fed stover silage 0.95 pounds. The yield of ordinary silage was 12.3 tons per acre and it consisted of 86.1 percent stalk and 13.9 percent heads by weight as it went into the silo. The grain yield was 30.6 bushels per acre.

2. *Powdered Limestone in the calf-fattening Ration.*—The calves fed ground shelled corn self-fed; Atlas sorgo silage full-fed; cottonseed meal 1 1/2 pounds per head daily; and one-tenth of a pound of powdered limestone per head daily gained 2.23 pounds per head daily, whereas those fed the same ration except that no powdered limestone was included gained only 1.86 pounds per head daily.

3. *Comparison of Soybean Oil Meal and Cottonseed Meal as Protein Supplements in the Calf-fattening Ration.*—Feed consumption was practically the same in all lots for the 218 days feeding period. The lot fed cottonseed meal as a protein supplement gained 2.14 pounds per head daily, was appraised at \$10.25 per hundredweight, and returned \$8.92 per head over calf cost, feed cost, and marketing cost. The lot fed soybean oil meal gained 2.11 pounds per head daily, was appraised at \$10 per hundredweight, and returned \$6.80 per head. The lot fed cottonseed meal and soybean oil meal half and half gained 2.08 pounds per head daily, was appraised at \$9.75 per hundredweight, and returned \$3.54 per head.

4. *Lightweight Calves Versus Heavyweight Yearlings.*—Both groups were fed the same ration. The calves—fed 218 days—gained 2.14 pounds per head daily; gains cost \$7.16 per hundredweight; were appraised at \$10.25 per hundredweight, and returned \$8.92 per head over calf cost, feed cost and marketing cost. The yearling—fed 162 days—gained 2.63 pounds per head daily; gains cost \$9.26 per hundredweight; were appraised at \$10.50 per hundredweight, and returned \$8.37 per head. It is significant that the yearlings which cost \$1 per hundredweight less, gained approximately one-half pound more per head daily; and were appraised at \$0.25 a hundredweight more at the completion of the test, did not return as much per head as the calves.

Phase 1 will be repeated for the third time next year; phases 2, 3, and 4 will not be repeated.

(Project No. 78; Department of Animal Husbandry. Leaders, A. D. Weber, C. W. McCampbell, and R. B. Cathcart; state fund.)

*Method of Utilizing Native Pasture in Beef-cattle Feeding.*—The work on this project during the past biennium consisted of a study of what modifications, if any, need be made in the Kansas Deferred System of utilizing bluestem grass in the fattening of young heifers, instead of steers, for market. Results of the tests indicate that wintering heifer calves on all the good silage they will eat, plus one pound of cottonseed meal, plus one-tenth of a pound of powdered limestone, then grazing the first half of the grazing season, then full-feeding 100 days in a dry lot is an excellent way to utilize grass in fattening yearling heifers for market.

Two lots of heifer calves wintered on a ration consisting of 24.7 pounds of silage, 4.82 pounds of corn, and 1 pound of cottonseed meal, and one-tenth of a pound of powdered limestone gained 236.7 pounds per head in 136 days. One lot of steer calves wintered on the same ration gained 252.7 pounds. However, at the end of the wintering period the heifers showed considerably more finish (fatness) than the steers; in fact, so much finish it did not seem practical to turn the heifers on pasture without other feed as had been previously done with steer calves similarly wintered. It was, therefore, decided to full feed one group of these heifer calves in a dry lot until they reached a marketable finish for heifers of this age. This proved to be 50 days. The other lot of heifers fed grain during the winter were full-fed the same length of time (50 days) on bluestem pasture.

The heifers full-fed 50 days in a dry lot consumed 12.36 pounds of corn per head daily; gained 67.7 pounds, sold for \$9.75 per hundredweight, and returned a margin of \$5.69 per head over heifer cost plus feed cost.

The heifers full-fed 50 days on pasture consumed 7.25 pounds of corn per head daily; gained 18.94 pounds per head; sold for \$9.25 per hundredweight, and returned a loss of \$1.35 per head over heifer cost plus feed cost.

A third lot of heifer calves was fed 32.5 pounds of silage, 1 pound of cottonseed meal, and one-tenth of a pound of powdered limestone (no grain) per head daily. These heifers gained 190 pounds during the wintering period, but showed nearly as much finish as the steer calves which had gained 252.7 pounds per head. They were grazed 90 days with the steer calves (both now yearlings) and then each group was full-fed 100 days in a dry lot. The yearling steers returned a net margin of \$25.25 per head. The yearling heifers returned a net margin of \$22.72 per head.

The work of 1938-'39 was repeated during 1939-'40 with relatively the same results. The heifers full-fed 50 days in a dry lot immediately following the winter period in which 5 pounds of grain was fed per head daily, returned a margin of \$6.16 per head above heifer cost plus feed cost; the heifers similarly wintered and then full-fed 50 days on grass returned \$3.72 per head; whereas the heifers wintered without grain, grazed the first half of the grazing season and then full-fed 100 days in a dry lot, returned a margin of \$24.10.

The steer calves whose winter ration included 5 pounds of grain, grazed the first half of the grazing season, then full-fed 100 days in a dry lot, returned a margin of \$24.30 per head.

(Project 151; Department of Animal Husbandry. Leaders, C. W. McCampbell and A. D. Weber; state fund.)

**Lamb-Feeding Investigations.**—During the past biennium, two phases of this work have been studied: (1) A comparison of silage with and without ground limestone, and prairie hay as roughages in the lamb-fattening ration and a comparison of corn and Atlas sorgo grain for fattening lambs; (2) a comparison of soybean oil meal and cottonseed meal as protein supplements in the lamb-fattening ration.

1. *Effect of Addition of Limestone to Silage.*—(a) The lambs fed ground limestone with silage made larger gains, stayed on feed better and showed a more desirable finish than those not receiving ground limestone. (b) The lambs fed prairie hay gained more than those fed silage and stayed on feed better. (c) There was no appreciable difference in the gains and finish produced on lambs fed corn and Atlas grain. There was a slight difference in favor of the corn-fed lambs. (d) The lambs in both silage feed lots went badly "off feed" after the feeding period had progressed about 70 days. Their silage consumption dropped from nearly 5 pounds per head to slightly less than 2 pounds per head daily. The grain consumption dropped from one and one-third pounds per lamb daily to three-fifths of a pound per head daily. Nervousness was apparent in the lambs in these lots.

2. *Soybean Oil Meal versus Cottonseed Meal.*—(a) The cottonseed meal fed lambs made considerably more gain, and stayed on feed much better than those fed soybean oil meal. (b) The consumption of all feeds, per hundred-weight of gain, was considerably lower for the lambs fed cottonseed meal than for those fed soybean oil meal. (c) After approximately 70 days of feeding, the lambs in the soybean oil meal lots showed a strong tendency to go "off feed". They showed many symptoms of digestive disturbances, such as refusal of both concentrates and roughages, scouring stiffness of legs and joints and soreness of the feet, and finally severe emaciation. Only one death occurred in the experiment, but numerous cases of digestive troubles were noted, and significantly, every such case was in one of the two soybean oil meal lots and no symptoms were in evidence among the cottonseed meal fed lots.

(Project 111; Department of Animal Husbandry. Leader, R. F. Cox; state fund.)



*Cooperative Studies in Lamb-Feeding.*—During the past biennium the lamb feeding work at the Garden City Branch Station has consisted of studies and comparisons of various methods of harvesting, preparing and feeding both the grain and forage of different sorghum crops; studies of different methods of utilizing wheat pasture for fattening lambs; and the use of alfalfa hay, alfalfa straw, beet, pulp, and beet molasses in combination with sorghum grain and roughage.

The following are the principal results obtained:

#### 1938-1939

1. The lambs fed by the deferred grain method went on feed more satisfactorily and experienced less digestive trouble than the lambs full-fed on grain from the start. The cost of gains was a little lower for the deferred lots.
2. Lambs fed chopped milo heads made slightly more rapid gains than those fed ground heads. It was observed that they chew the grain in the chopped heads more thoroughly.
3. Ground milo roughage was more palatable and produced more gain than chopped milo roughage. There was considerably more chopped roughage refused and wasted than ground roughage.
4. There was no apparent difference in the palatability of ground and chopped sumac roughage and they produced equal gain in weight.

#### 1939-1940

1. In comparing alfalfa versus alfalfa two-thirds and ground fodder one-third, and ground fodder two-thirds versus alfalfa straw as lamb-fattening roughages, the feeds ranked in the following order in rate and amount of gain produced: Alfalfa, first; alfalfa two-thirds, fodder one-third, second; alfalfa straw, third; and alfalfa one-third, fodder two-thirds, fourth. The feed cost per hundredweight gain for the above feeds was lowest for the lambs fed alfalfa straw, followed closely by those fed alfalfa two-thirds and ground fodder one-third.
2. Four lots of 56 lambs each were run on wheat pasture for 45 days, after which heavy snows forced their removal from the pasture. Various feeds were used to supplement wheat, pasture in all but one of the lots. The lambs receiving only wheat pasture made slightly more gain than those receiving either ground limestone, one-half feed milo grain, or ground sorghum roughage in addition to wheat pasture. The feed cost per hundredweight of gain was lowest for lambs receiving only wheat pasture, second for those fed sorghum roughage in addition to wheat pasture, and highest for those receiving milo grain and wheat pasture. This substantiates observations to the effect that if wheat pasture is plentiful and if no digestive trouble is encountered, it is inadvisable to feed lambs any supplemental feeds in addition to pasture.
3. This year's results indicate that the carrying capacity of good wheat pasture for an entire fattening period would be approximately five lambs per acre.
4. Replacing one-fourth the milo grain in the ration with beet molasses resulted in a slight increase in gain, but when one-half the grain was replaced with molasses the gain was reduced.
5. Dried beet pulp and milo grain, equal parts, produced larger gains than milo grain alone or milo grain and molasses.
6. When dried beet pulp and molasses are approximately the same price per pound as grain, either can be used as a part of the concentrate ration for lambs with a reduction in feed costs.

(Department of Animal Husbandry and Garden City Branch Experiment Station. Leaders, R. F. Cox and L. M. Sloan; state fund.)

***The effects of Inbreeding and Line Breeding on Body Type, Rate of Growth, Breeding Performance, and Other Characteristics of Sheep.***—Three years of work have been completed under this project, which, in the main, has consisted of carefully selecting breeding stock of the Shropshire and Rambouillet breeds, taking 26 body measurements on each, and after mating in various ways, measuring results in the offspring by several methods.

Measurements have been taken on 168 animals, but no attempt has been made as yet to analyze and summarize the data collected. Many animals have been discarded from the experiment; some through necessity of reducing numbers of breeding animals and others because of the development of unsatisfactory traits so far as the experiment is concerned.

The tests thus far have been with Shropshires and Rambouillets. Later other breeds may be used to check results. Similar results obtained with several breeds may be construed to be due to systems of breeding rather than to variation in individual characteristics.

A few animals of outstanding quality have been produced among the inbred individuals. Some of these have been retained in the breeding flocks and a few have produced offspring which have been added to the experiment.

(Project 205; Department of Animal Husbandry. Leaders, R. F. Cox and H. L. Ibsen; state fund.)

***A Study of Factors Which Influence the Quality and Palatability of Meat.***—A study to determine the influence of the level of phosphorus intake upon the keeping qualities and palatability of meat was begun in 1936. During 1938-'39 season, the experiment was repeated under more carefully controlled conditions, one member of each pair of three pairs of steers receiving six to seven grams of phosphorus per day, the other receiving 15 grams daily. In 1939-'40, two lots of six steers each were fed the same basic ration by the paired feeding method, Lot 1 receiving in addition one-tenth of a pound of ground limestone per head per day.

Some of the significant observations are as follows:

***Color of Muscle Tissue.***—Although the rib eye of the low phosphorus steers averaged 10 percent more muscle hemoglobin the result is hardly significant since there was an almost equal distribution of cross variations.

The oxidation potential of the rib eye of the low phosphorus steers was more positive in four of the six pairs and averaged higher for the lot, indicating the tissue more permeable to oxygen. A similar result was obtained in 1936-'37.

Determinations were made in 1939-'40 for muscle hemoglobin, oxidation potential, pH, glutathione, and dextrose. In five of the six pairs, dextrose was higher in the limestone lot. There was no significant difference between lots in the other determinations.

***Character of Fatty Tissue.***—No color difference was apparent in fat samples. All were pure white. Determinations of melting point and refractive index on rendered fat, and ether extract, moisture, and phosphorus on back fat (adipose tissue), were done, but no significant differences appeared in either season.

***Tenderness.***—Cross variation in collagen and elastin was evenly distributed between lots, and differences were small for both series of experiments. Electrical resistance of raw rib eye and mechanical shear of cooked rib eye both likewise showed evenly distributed cross variation.

The collagen and elastin technic was modified to separate the rib eye proteins into five fractions. The trypsin digestible coagulated fraction showed

similar quantitative trend to the collagen fraction. Electrical resistance measurements made on the 1939-'40 lots showed no significant differences between lots. Separation of rib eye protein into five fractions including collagen and elastin showed no significant difference between lots.

*Keeping Quality.*—After a 28-day ripening period, collagen decreased in all but one, electrical resistance decreased, pH increased, oxidation potential decreased in all but two. No difference in the ripening performance of the two lots was evident. No significant difference between lots in regard to keeping quality was observed in the 1939-'40 lots.

*Degree of Finish.*—Ether extract of rib eye averaged higher for the low phosphorus animals in 1938-'39, but cross variation was almost evenly distributed. Determinations were made on the 1939-'40 lots on rib eye for ether extract, protein, moisture, and ash. No significant differences between lots appeared.

*Juiciness.*—Five of the high phosphorus rib eye samples (raw) yielded more press fluid than their pair mates. Volume of press fluid from raw rib eye was slightly greater for the limestone lot in five of the six pairs, in the 1939-'40 trials.

*Permeability and Water-holding Capacity.*—Very slight turbidity was noted on all rib eye extracts except a moderate amount in one high phosphorus sample and a considerable amount in one low phosphorus sample. Inorganic P/Ca ratios in the press fluids of all samples varied only slightly, indicating uniform state of mineralization.

Shrinkage losses were practically the same for both lots, indicating nearly equal permeability. In 1939-'40, the aqueous rib eye extract was slightly turbid for only one sample; the others were nonturbid. Water imbibition was practically zero. By comparison, a sample of dark beef exhibited extreme turbidity and imbibed 1 c.c. water per gram muscle tissue.

Determinations were made for protein, moisture, ether extract, ash, phosphorus, and calcium on whole rib eye tissue; inorganic and total phosphorus and calcium in press fluid; inorganic phosphorus in aqueous extract; ether extractable phosphorus in rib eye. No significant differences in mineral relationships were observed between the two lots.

By artificially altering the pH of a series of portions of the same sample of lean meat, it was found the imbibition of water varied from 30 percent at pH 4.92 to 87 percent at pH 6.80. Since the pH of black beef is about one unit higher than that of bright beef, the abnormally high water-holding capacity of black beef may be largely accounted for by its abnormally low acidity. Since there is a deficiency of dextrose in black beef, it is probable that insufficient lactic acid is produced from it to maintain normal acidity.

In addition to the station project outlined above, work was done on samples of dark cutters furnished by the National Livestock and Meat Board and by Wilson and Company of Kansas City. Inorganic phosphorus was about twice normal in rib eye aqueous extract and press fluid, and calcium about half normal in press fluid.

Observations relating to the method of processing pork for storage in freezer lockers, made during the past year, indicate: (1) Double wrapping with the papers used reduced the shrinkage during storage; (2) the treated paper used did not reduce the peroxide number or acid number of the pork fat; (3) dusting out flour over the outside of the package did not retard rancidity; (4) pork roasts rolled in oat flour before wrapping definitely reduced the peroxide number but did not influence the acid number; this treatment also reduced the shrinkage during storage; (5) under similar conditions it is recommended that pork sausage should not be stored in a frozen condition for a longer period of time than 90 to 100 days. Fresh pork loin roasts should not be stored in the frozen condition for a period in excess of 120 days.

(Project 165; Departments of Animal Husbandry, Chemistry, and Home Economics. Leaders, D. L. Mackintosh, J. L. Hall, and Gladys Vail; Purnell fund.)

*The Mineral Requirements of Fattening Cattle.*—The effect of added calcium to a ration of corn, silage, and cottonseed meal in the fattening ration was studied during the first year of the past biennium. The second phase of the work has been a study of the effect of low phosphorus rations on the meat produced.

*Effect of Added Calcium to the Fattening Ration.*—Six pairs of steer calves were fed individually 190 days to determine the effects of adding ground limestone to a calf-fattening ration of ground shelled corn, Atlas sorgo silage and cottonseed meal. Three pairs of calves were used in digestion and balance trials at the conclusion of the feeding experiment. Both members of each pair received the same amounts of basal feeds. Each pair was regarded as a unit and no attempt was made to keep the feed consumption of the various pairs the same. In addition to the basal ration, one member of each pair received one-tenth pound of finely ground limestone daily.

Where no ground limestone was fed in the 190 days feeding experiment, the average daily calcium intake was 7.2 grams, which amounted to only 0.17 percent of the dry ration. The addition of one-tenth pound ground limestone to the daily basal ration increased the calcium intake 17.6 grams. This brought the calcium intake up to 0.57 percent of the dry ration. The average phosphorus intake was 20 grams per calf daily irrespective of the calcium level of the ration. This amounted to 0.47 percent of the dry ration.

The addition of ground limestone to this basal ration had no significant effect on (1) appetite; (2) thirst; (3) digestibility of nutrients; (4) dressing percentage; (5) carcass grades; (6) weights of heart, liver, and spleen; and (7) calcium, phosphorus, and hemoglobin content of the blood.

The significant effects of adding ground limestone to this basal ration were: (1) increased gains in weight; (2) more efficient utilization of feed; (3) increased retention of calcium and phosphorus; (4) higher grades on foot; (5) heavier bones of higher specific gravity, greater breaking strength, and higher ash content.

*Effect of Low Phosphorus Rations on the Meat Produced.*—Six pairs of calves have been used in a study to determine the effect of low phosphorus rations on the meat produced. In previous experiments the methods used did not produce typical phosphorus deficient steers. This was partly due to the fact that the calves had a good store of phosphorus when the experiments were begun. In the present experiment the calves were started on December 1, 1939, and will continue on experiment until September, 1940. The feed has a low phosphorus content, and the animals will be kept on experiment for a longer period than formerly so that a marked phosphorus deficiency may be produced.

Six calves receive a ration consisting of beet pulp (1/2 lb.), grain mixture (5 lbs.), blood meal (1/2 lb.), and prairie hay (2 lbs.). This ration contains 0.158 percent phosphorus. One member of each pair receives, in addition sufficient calcium phosphate to provide an ample phosphorus intake. Blood analyses for calcium, inorganic phosphorus, hemoglobin, and phosphatase are made periodically.

At this time the results show that blood inorganic phosphorus values of the animals on the phosphorus deficient ration are very low, and the animals are beginning to show the typical symptoms of phosphorus deficiency. Other blood values are quite normal with the possible exception of phosphatase, in which case the animals which show the most severe symptoms show somewhat higher values, but these values are not as high as would be expected from rickets resulting from vitamin D deficiency.

(Project 203; Departments of Animal Husbandry and Chemistry. Leaders, A. D. Weber, D. L. Mackintosh, and J. S. Hughes; Bankhead-Jones fund.)

***Deficiencies of Sorghum Crops as Feed for Dairy Cows.***—

This project was initiated in November, 1938. Its objectives are, (1) to study the nutritive value of dairy rations derived principally from the Atlas sorgho plant, and (2) to study any nutritive deficiencies of this plant by comparing the relative value of several feed-stuffs when incorporated as supplements in the sorgho ration.

The principal part of the project comprises three groups of cows receiving rations as follows:

Lot 1. —Chopped dried sorghum stover ad libitum. Two pounds sorghum silage per 100 pounds body weight. Sufficient grain mix, of the following composition: to meet energy requirements for maintenance and lactation: 100 parts ground Atlas sorgho grain, 1 part stock salt, pressed salt, and water.

Lot 2. —Same as Lot 1 except using a grain mix formulated as follows: 150 parts ground Atlas sorgho grain, 100 parts cottonseed meal, 5 parts steamed bone meal, 2½ parts stock salt.

Lot 3 —Chopped alfalfa hay ad libitum; sorghum silage as in Lots 1 and 2; grain mix, fed as in Lots 1 and 2, but formulated as follows: 400 parts ground Atlas sorgho grain, 200 parts wheat bran, 50 parts cottonseed meal, 6½ parts steamed bone meal, 6½ parts stock salt, pressed salt and water.

Six cows are receiving the exclusive sorghum ration in Lot 1. Five cows are in Lot 2 which was designed to correct the more apparent protein and mineral deficiencies of the preceding lot. Lot 3 consists of five cows receiving a normal herd ration. All cows completed one or more lactations under normal herd conditions prior to entering this project.

In addition to the above comparisons in progress with cows, calf-feeding trials have been completed with four animals fed Atlas stover and grain plus a limited amount of milk. These studies now include nine additional calves which are receiving rations designed to show the value of fish liver oil and urea as supplements to the sorghum ration.

Striking differences began to appear between the cows by groups long before the expiration of the first year of the project. Certain of these differences—concerned with milk production, body weight, and condition, and depraved appetite—are becoming even more exaggerated as the cows advance in their second lactation under this project. Lactation records for the nine cows which have completed at least one full year on the project are compared in the accompanying table, with the amount of milk produced by the same cows during the year immediately preceding entry on this project. This table shows that pronounced decreases in milk production occurred in Lots 1 and 2 and that these changes were accompanied by decreased persistency of milk production together with a possible trend toward a lower percent of fat in the milk. Failure of the bone meal and cottonseed meal in Lot 2 to overcome the deficiencies of the Lot 1 ration takes an added significance because of the trend in recent months for the Lot 2 cows to resemble more and more closely the thin, rough-coated, unthrifty appearance of the Lot 1 cows. The Lot 3 cows receiving alfalfa hay have continued to equal or exceed their previous milk production records and have remained in good body finish. On the other hand, it has been impossible to put the cows in Lots 1 and 2 in their former condition of fleshing even when fed large quantities of grain during a two-month dry period preceding each freshening date. Feces voided by the cows, especially in Lot 1, appeared to contain appreciable quantities of Atlas grain particles.

***Results with Calves.***—Calves in this project thus far also have developed a thin, rough-coated appearance most noticeable after milk was withdrawn from the ration. The growth rate also declined following the withdrawal of milk from the ration.

***Field Survey Results.***—During February and March, 1939, 115 blood samples were collected from dairy cattle on 36 farms in eastern Kansas and the

analytical data correlated with the use of restricted rations. The results showed low blood phosphorus values in animals with depraved appetite and revealed further that feeding sorghum fodders and other low-quality roughages contributed to low blood carotene values, unthriftiness, low milk production, and breeding difficulties.

This project will be continued during the coming year. Additional calves and at least two additional cows will be placed on test as animals become available. Plans are being made to conduct digestion and metabolism trials with typical cows from the project. The growth stimulating value of several supplements will be studied by additions to the calf rations after milk feeding has been discontinued. Supplements will also be considered for some of the cows about to complete their second lactations on this project.

**SUMMARY OF LACTATION RESULTS OBTAINED IN PROJECT 206  
 (MAY, 1940)**

	Lot 1	Lot 2	Lot 3
Number of comparisons . . . . .	4	2	3
Average production per cow* lbs.:			
Last lactation prior to project . . . . .	3,258	9,628	7,713
First lactation on project . . . . .	4,044	6,156	8,218
Difference . . . . .	-1,214	-3,472	+505
Percent difference . . . . .	-51	-36	+7
Average fat test of milk, percent:			
Last lactation prior to project . . . . .	3.91	3.98	4.27
First lactation on project . . . . .	3.78	3.83	4.49
Difference . . . . .	-0.13	-0.15	+0.22
Average length of lactation, days:			
Last lactation prior to project . . . . .	297	305	280
First lactation on project . . . . .	259	273	305
Difference . . . . .	-38	-32	+25

\* Records computed to a mature, 305-day, two-time daily milking basis and expressed in terms of 4 percent fat-corrected milk. All calving intervals 365 days or longer.

(Project 206; Departments of Dairy Husbandry and Chemistry. Leaders, F. W. Atkeson, H. E. Bechtel, A. O. Shaw, and J. S. Hughes; Bankhead-Jones fund.)

**Dairy Production Investigations.**—Ten phases of this project were conducted during the past biennium, as follows:

1. *Carrying Capacity of Temporary Pasture.*—This project was conducted for measuring the carrying capacity of temporary pastures sowed to various crops, such as Balbo rye, common rye, Turkey wheat, Clarkan wheat, and Reno barley.

Rye greatly excelled barley in days of pasture furnished. Sweet clover and the mixed cereals probably will furnish more pasture than the rye.

2. *Silage Investigations.*—Of principal interest are the data on carotene distribution in freshly-cut Atlas sorgo. Approximately 87 percent of the total carotene in Atlas sorgo occurred in the leaves when the plant was in the early dough stage of maturity. The percentage of total carotene in the leaves was practically the same in Atlas sorgo containing about 60 percent as much total carotene and harvested when slightly past the dough stage of maturity. However, only 72 percent of the total carotene occurred in the leaves when the grain was hard at harvesting time and when most of the leaves were either dry or turning dry, due to chinch bug infestations; this sample contained only 43 percent as much total carotene as the greenest sample of Atlas sorgo.

Analyses of burned silages showed that, except for a complete absence of carotene, the chemical composition approximated that of typical unburned silage. The degree of nutrient loss probably varies directly with the maximum temperature reached during burning.

Preserving agents in making silage studied included salt, A. I. V. acid, molasses, dicalcium phosphate plus molasses, calcium hydroxide, trisodium phosphate, ammonium bicarbonate, sodium silicate, and trisodium phosphate plus calcium hydroxide. Atlas sorgo, sweet clover, alfalfa or Balbo rye was used. Data were recorded on taste, intensity of green color, pH, moisture content, carotene content, palatability trials with cows, and temperature changes during ensiling.

Palatability studies with Atlas sorgo silage made in drums indicated that cows preferred untreated silage to silage treated with A. I. V. acid and/or salt, and to silage treated with molasses used in combination with A.I.V. acid or dicalcium phosphate. Carotene and pH differences appeared to be within normal limits of variation except for a high concentration of carotene found in one sample of silage preserved with A. I. V. acid plus salt.

Alkaline preservative agents were suggested by the pH of fresh green plant tissues and by the fact that carotene is comparatively stable in alkaline solutions under laboratory conditions. Young sweet clover containing 2 percent of hydrated lime retained, for a period of several weeks at least, an odor and a green color resembling the freshly cut crop. The green color and odor were preserved equally well in fresh green alfalfa by treatment with 5 percent of hydrated lime, but most of the cows used in a limited series of comparisons refused to eat this type of silage; alfalfa preserved with 2 percent of hydrated lime was somewhat more palatable than the silage containing 5 percent of hydrated lime.

In December, 1939, somewhat larger quantities of young Balbo rye were ensiled in drums in order to compare untreated grass silage with A. I. V. acid, 2 percent hydrated lime, and 2 percent trisodium phosphate as preservative agents. A parallel series of jars filled at the same time also included other levels of hydrated lime and trisodium phosphate in addition to molasses and several levels of ammonium bicarbonate. In general, the silages made in drums were superior in quality to those prepared in quart jars. The drums of silage were opened after a four-month interval and subjected to a limited number of studies with results as follows:

Silage No.	PRESERVATIVE USED	Green color <sup>1</sup>	Percent moisture	pH.	Carotene content <sup>2</sup>	Palatability rating <sup>3</sup>
1	None.....	5	78.0	4.85	2.24	3
2	A. I. V. acid.....	1	81.5	3.83	2.07	2
3	2 percent hydrated lime.....	15	77.5	4.85	3.51	4
4	2 percent trisodium phosphate,	10	76.5	4.79	3.79	1

1. Arbitrary values directly correlated with intensity of green color.
2. Expressed as milligrams of carotene per 100 grams of silage.
3. Order of palatability preference shown by cows.

Each of the above silages was eaten readily when fed separately to cows receiving an alfalfa hay-silage ration. However, when an ample supply of each of the four silages was equally accessible at the same time, a consistent preference was shown for silage number 4. Silages 1 and 2 seemed to be about equally superior to number 3. Some evidence was obtained to show that Atlas

sorgo silage was preferred by the cows to all of the above grass silages. These results show that hydrated lime preserved the most green color whereas the trisodium phosphate silage was superior in palatability and carotene content in addition to ranking second in green color. From the standpoint of practical application the trisodium phosphate silage would offer the advantage of supplying additional phosphorus in the dairy ration.

3. *Factors Affecting Food Intake.*—Two cows from each of the four breeds in the college dairy herd were fed through three experimental periods as follows:

Period 1. While dry.

Period 2. While at peak production (about thirty days after freshening).

Period 3. While in low production (about eight months after freshening).

Each experimental period was divided into five consecutive subperiods of seven days each as follows:

Subperiod 1. Check period. Grain, silage, and hay as being fed in the regular herd.

Subperiod 2. Grain the same, silage one-third more than subperiod 1, and hay ad libitum.

Subperiod 3. Grain the same, silage one-third less than subperiod 1, and hay ad libitum.

Subperiod 4. Silage the same, grain one-third less than subperiod 1, and hay ad libitum.

Subperiod 5. Silage the same, grain one-third more than subperiod 1, and hay ad libitum.

Two cows have completed all three periods and the other six cows have completed the first two periods. The results so far obtained may be summarized as follows:

1. Dry matter intake remains relatively constant regardless of whether most of the nutrients come from grain, silage, or hay.

2. Hay intake can be increased one-third to one-half by decreasing the silage or the grain one-third.

3. Body weight increased during the first and last periods, but remained the same while the cows were at peak production.

4. Digestible crude protein intake was higher than recommended requirements regardless of how the feeds were varied.

5. Total digestible nutrient intake was higher than recommended requirements during the first and last periods. During the high production period in which the cows were averaging about 1.5 pounds of fat per head, daily T. D. N. intake was slightly below the recommended level in each subperiod excepting when the grain intake was increased one-third.

6. Milk production was affected very little by varying the amounts of silage and hay consumed. There was a considerable increase in production during the heavy grain feeding period.

4. *A Comparison of the Feeding Value of Sorgo and Sudan Silage.*—A feeding trial in which Atlas sorgo silage was compared with Sudan grass silage was conducted and included 10 cows fed by the double reversal method through two 20-day and one 10-day periods. The Atlas sorgo was ensiled in the late dough stage. The Sudan grass was cut after it had lost some greenness and when ensiled, 100 pounds of a mixture of equal parts water and molasses per ton of silage was added.

Some facts that were observed during the feeding trial are: (1) Although the Sudan silage did not have an unpleasant odor it was not nearly as palatable as the sorgo silage. (2) In the analysis for butyric acid in the Sudan silage 41 ml. of 0.1 normal NaOH to neutralize the butyric acid from 100 grams of silage was required, while the sorgo silage contained no butyric acid. (3) Analysis for moisture showed the silages to contain approximately the same percentage of dry matter. (4) Although there was a difference in flavor of the sorgo silage if judged on the basis of the amount of fat corrected milk pro-



duced, it should not be concluded that the Sudan silage cannot be successfully used.

5. *Palatability Trials.*—Stacked and new crop sorghum stover was fed to heifers of breeding age and results so far obtained indicate that consumption of dry matter is even greater after the stover has aged in the stack for a year. The heifers show a distinct preference for the leaves, always cleaning the leaves off completely before starting on the stalk. Chemical analyses of leaves and stalks has shown that for stovers with rather small stalks, the leaves furnish 50 percent of the dry matter of the plant. The leaves are about twice as high in protein and slightly higher in carbohydrates.

In a study of palatability of cereal plants, it was found that cows in the station herd preferred Balbo rye over common rye, winter barley, or winter wheat. In a five-acre field sowed to equal areas of the four cereals, the cows grazed the Balbo rye more than twice as much as any other cereal. Their order of preference was Balbo rye, common rye, winter wheat, winter barley. All cereals were planted at the rate of 8 pecks per acre.

6. *Studies of Farm Dairy Herds Receiving Apparently Inadequate Rations.*—Blood inorganic phosphorus values as low as 0.5 milligrams per 100 c.c. of serum were encountered in a dairy herd in which prairie hay, cane hay, salt and limestone were the principal constituents of the ration during a preceding period of 18 to 20 months. Total blood serum calcium was subnormal in several of these cows. General health and condition, and milk production was subnormal.

Supplemental feeding trials in another dairy herd are of interest primarily because the feeding of 4 ounces of wheat germ oil daily per cow over a period of 7 to 23 days was followed by the appearance of estrum in each of four cows, within 7 to 24 days after starting to feed the oil supplement, which had not been in heat and bred during the approximately 15-month period which had elapsed since the date of last previous calving. Two control cows with similar breeding histories and maintained under the same herd conditions without the use of wheat germ oil supplement (except for a one-day dose of 4 ounces administered to one cow) failed to show signs of estrum during the period of investigation.

*Essentiality of Nicotinic Acid in Dairy Rations.*—One cow which developed stiff legs and a hitch in her gait in addition to a hair condition suggestive of a deficiency disease showed alleviation of symptoms following the use of nicotinic acid in her ration over a 4-day period.

Plans are under way to determine the essentiality of nicotinic acid in certain dairy rations.

7. *Physiology of Udder Congestion at Freshening Time.*—Two of 17 cows studied were fitted prior to freshening on a ration containing a heavy carbonaceous grain mixture and liberal portions of sorgo silage in order to induce extreme congestion. The resultant congestion was accompanied by considerable edema on the belly. No correlation could be established between fluctuations of various milk constituents with udder congestion. The limited amount of data collected to date seem to indicate that there is a relationship between state of nutrition and degree of congestion after freshening.

8. *Control of Sterility and Disease.*—Thirty-eight cows in the herd have been treated with ovarian extract to stimulate estrum and fertility. Of the treated cows, 30 conceived, two were sold as nonbreeders and six have been bred four times and are still open. A complete history of the reaction of each cow in the herd to the agglutination test for contagious abortion is kept and all suspicious reacting cows are isolated. During the biennium three positive reacting cows were sold for beef.

The Department of Bacteriology and the Department of Veterinary Medicine cooperate in control of mastitis in the station herd. Control methods include isolation of the cows after calving until they are classified, and hand milking after freshening until congestion leaves the udder. All cows, with the

exception of one heifer, have started their lactation periods as class A, signifying clean on the basis of tests used by the cooperating departments.

9. *Artificial Insemination of Dairy Cattle.*—During the period from December 21, 1938, to February 29, 1940, a total of 77 cows were conceived by artificial breeding. The average number of services required per conception was 1.73 and 48.1 percent conceived on first service. During the same period 35 cows conceived from natural breeding, requiring 1.6 services per conception, and of this number 71.4 percent conceived on the first service.

The most effective time during the heat period to breed a cow apparently is from 10-19 hours after beginning estrum.

10. *Utilization of Ground and Unground Atlas Sorgo Grain.*—Results of feeding trials show that about 42 percent of Atlas sorgo grain is voided in the feces when fed whole with alfalfa hay to dairy cows. Only 5 percent was voided when the grain was coarsely ground and 1.2 percent when finely ground. The difference in utilization of the coarse ground and fine ground grain is not enough to warrant the added expense of fine grinding.

Studies on this phase of the project were conducted on some cows used in Project 206, and results also show that cows in a poor condition utilize their grain less efficiently than do cows in a normal condition.

(Project 34; Department of Dairy Husbandry. Leaders, F. W. Atkeson, H. E. Bechtel, A. O. Shaw, and G. H. Beck; state fund.)

*Calf-Feeding Investigations.*—Work on this project during the biennium was carried on in two phases: (1) The value of dehydrated cereal grass in the ration of dairy calves; and (2) an investigation of the merits of fat-substituted milk.

*Dehydrated Cereal Grass for Calf-raising.*—This phase of the project, started during the biennium, is devoted to study of the value of dehydrated cereal grass in the ration of dairy calves. Control calves were fed according to standard procedure and in addition received 10 ml. of Nopco XX cod-liver oil concentrate (3,000 units "A" per gram). The experimental calves were handled in the same manner as the control calves except that they received enough dehydrated cereal grass to furnish the same number of vitamin A units as was furnished the control calf in the cod-liver oil concentrate.

Weights and measurements were obtained monthly and blood samples were taken at regular intervals for calcium, phosphorus, and hemoglobin determinations.

To date one control calf and six grass-fed calves have completed the six months' feeding period.

Weight and height data, general well-being and blood analyses, when used as a criterion, indicate that dehydrated cereal grass failed to supply any nutritive substance not already found in the diet of calves fed according to recommended practice.

*Raising Calves on Fat-substituted Milk.*—Two male calves, one Holstein and one Ayrshire, have been raised from two weeks of age to six months of age, using skim milk reconstituted with vegetable oleomargarine. This work has been done preliminary to an investigation of the merits of various fat substitutes for calf feeding.

Both calves received whole milk until two weeks of age and were then changed over to reconstituted milk. By the end of the fourth week both calves were consuming a constant level of 12 pounds each daily of the reconstituted milk and were continued at this level until the end of the sixth month. In addition to the milk the Holstein calf was fed alfalfa hay ad libitum and all the grain he would clean up. The Ayrshire calf was fed prairie hay ad libitum, but did not receive any grain.

Ordinary vegetable oleomargarine was mixed with skim milk by homogenizing. The reconstituted product was standardized to test 3.5 percent fat. In

order to fortify the oleo with vitamins A and D, 15 c.c. of Nopco XX cod-liver oil was fed to each calf daily.

The rate of growth for both calves was slightly below normal. The Holstein calf weighed 87 pounds at birth and increased up to 313 pounds at six months while the Ayrshire calf weighed 81 pounds at birth and 300 pounds at six months. This represents a gain in weight of 76 and 90 percent, respectively, of the Kansas state normal growth rate for Holstein and Ayrshire calves. The Holstein calf became sick with pneumonia at two months of age, probably accounting for his lower rate of growth. Neither calf seemed to suffer any ill effects from their feed.

It appears that calves can be grown satisfactorily on oleo reconstituted milk when it is fortified with vitamins A and D, and when they received a good start on whole milk. Apparently this source of fat has no toxic effect on calves. The grain consumption was low, averaging about 0.5 of a pound daily, indicating that the oleomargarine was used to replace some of the fat and carbohydrates ordinarily furnished by grain.

(Project 154; Department of Dairy Husbandry. Leaders, A. O. Shaw and G. H. Beck; state fund.)

*Factors Affecting the Composition of Milk.*—Work on this project has been continued since September, 1936. To date, a total of 2,353 three-day composite milk samples obtained from 149 different cows have been analyzed for fat and total solids by the Department of Dairy Husbandry and for certain other constituents by the Department of Chemistry.

Summarization of the data relating to the total solids, solids-not-fat, and fat content of milk is in progress at the present time. A summary of the data pertaining to the milk obtained from the Ayrshire breed has been completed.

A total of 529 Ayrshire milk samples from 31 different cows have been analyzed to date. The data show a definite decline for the solids-not-fat, butterfat, and total solids content of milk during the summer months, particularly in July. The average values observed during July, based upon the examination of 43 Ayrshire milk samples analyzed during that month, were: 12.35 percent total solids, 4.01 percent butterfat, and 8.34 percent solids-not-fat. These values are from 6 to 6.5 percent below the breed averages as determined in this study. Nearly half of the samples (21 out of 43) analyzed during July were below 8.5 percent solids-not-fat which is a common legal standard.

A total of 23 lactation records of 10 months duration on 19 different Ayrshire cows have been completed. The average butterfat content of the milk was highest during the first month of the lactation period, after which it declined, reaching the low point during the third month and then gradually increased through the remainder of the 10 months' period.

The trend in solids-not-fat content of the milk throughout the lactation period was not so apparent from the data. Seasonal variations and other factors apparently exert a greater effect on the solids-not-fat content of the milk than does the period of lactation.

Wider variations in the fat and solids-not-fat content of the milk secreted by different cows within the Ayrshire breed were observed. The butterfat varied from 2.40 to 6.4 percent and the solids-not-fat from 6.76 percent to 11.06 percent.

(Project 209; Departments of Dairy Husbandry and Chemistry. Leaders, W. J. Caulfield, F. W. Atkeson, and C. H. Whitnah; Bankhead-Jones fund.)

*Dairy Manufacturing Investigations.*—Seven phases of this project were studied during the biennium:

1. *The Effect of Various Feeds and Feeding Practices on the Flavors of Milk.*—Two groups of three cows each were used in this study to determine the effect of the following pasture crops and weeds on the flavor of milk: Abruzzi rye, Balbo rye, common rye, winter barley, sweet clover, winter wheat, mixed cereals, brome grass, Shepherd's purse, fan weed. Each trial feeding period consisted of six two-day periods. The following results were obtained:

Cows pastured on rye produced milk with a characteristic off-flavor. The variety of rye did not seem to make any great difference in the intensity of the off-flavor. The flavor-score of the milk declined as the time of removal of the cows from pasture before milking was reduced.

The pasturing of winter wheat, barley, and mixed cereals produced essentially the same results as the pasturing of rye.

The pasturing of sweet clover and brome grass did not produce as pronounced an off-flavor as the cereal grasses, although a number of samples in both groups were criticized as being slightly "feedy." The length of time of removing cows before milking had little effect on the flavor of the milk.

The feeding of Shepherd's purse produced a noticeable off-flavor in the milk; however, the milk from the cows fed fan weed had no serious flavor defects.

The intensity of the off-flavor of milk from cows grazed continuously on winter barley was about the same throughout the 13 days of the trial.

The removal of the cows from the cereal pasture at least four hours before milking greatly reduced or eliminated the off-flavor from the milk. The feeding of hay and silage prior to placing the cows on pasture seems to minimize the production of off-flavor in the milk. Aeration of the milk did not result in any noticeable improvement in the flavor. Through all these feeding trials considerable variation was noted in the intensity of the off-flavor in the milk from different cows handled in the same manner:

2. *The Effect of Feeding Vitamin A and Carotene to Cows on the Flavor and Color of Their Milk.*—Previous investigations at this station have suggested that carotene in the feed, or something associated with carotene, has a beneficial effect on milk flavor. The question arises whether the improved flavor of milk which results is due to the vitamin A potency of the carotene or to some other influence.

Selected cows were fed varying amounts of vitamin A and carotene and observations made on the effect of these products upon the flavor and color of their milk.

The results obtained in two trials may be summarized as follows:

1. The feeding of vitamin A at 30,000 to 90,000 I.U. for ten days or 300,000 units for 20 days to cows on winter rations failed to produce any marked improvement in flavor score of fresh or three-day-old milk. It reduced the incidence of oxidized flavor and improved somewhat the score of the copper-treated milk.

2. The feeding of one-sixth to one-third gram daily of carotene equivalent to 267,000 and 533,000 I. U. of vitamin A for 10 days immediately after vitamin A feeding, caused some improvement in the flavor scores of stored milk and reduced the intensity of oxidized flavor in copper-treated milk.

3. Seven days of pasture improved the flavor of stored milk and in most instances eliminated the copper induced oxidized flavor in stored pasteurized milk.

4. Storage of milk samples in partially-filled bottles strongly favored the development of rancid flavors.

5. In the second trial, during 20 days of feeding vitamin A at the rate of 300,000 I.U. daily the color of the milk fat decreased from 6.52 units to 4.90 units. The color of the milk fat increased to 10.08 after 15 days of carotene feeding at the rate of 533,000 I.U. daily and to 19.83 units after 7 days of pasturing.

3. *A Study of Certain Factors Affecting the Accuracy of the Babcock Test when Applied to Milk and Cream.*—This phase has been a part of a study being conducted by a subcommittee on testing milk and cream of the American Dairy Science Association. The possible effect of each of the following factors on the results of the Babcock test has been studied during the past year: (1) Variations in the density of butterfat; (2) variations in the temperature at which Babcock tests are read, and (3) reading whole milk tests with and without glymol.

The density at 60° C. of churned butterfat, purified with acetone, filtered and dried, was not affected to any extent by breed, season of year, or feed. The average density at 60° C. of 69 purified butterfat samples obtained from the four principal dairy breeds was 0.8896.

Fat extracted in the Babcock test on either whole milk or cream showed a greater density at 60° C. than did purified fat from the same lot of milk.

The results indicate that to bring the density of the fat extracted in the Babcock test to an average value of 0.9000 the tests should be read at a temperature somewhat lower than 60° C.

No significant differences could be observed in the results of whole milk and cream tests when read at 120°, 140°, and 160° F., respectively. The average of 201 Babcock tests on whole milk was 4.56 percent fat when read at 120° F., 4.58 percent fat when read at 140° F., and 4.60 at 160° F. The average of 144 tests (288 readings) on cream was 30.28 percent fat when the tests were read at 120° F., 30.33 percent, when read at 140° F., and 30.49 percent when read at 160° F. These differences were not statistically significant.

The addition of glymol to whole milk tests reduced the reading approximately 0.15 percent. When read with glymol, the Babcock test on whole milk yielded results which averaged from 0.1084 to 0.1123 percent lower than the Mojonnier test results. On the other hand, when read without glymol the Babcock test results on whole milk averaged from 0.038 to 0.048 percent higher than the Mojonnier results.

4. *An Evaluation of Several Laboratory Procedures for Measuring the Sanitary Quality of Market Cream.*—A total of 63 pasteurized commercial market cream samples were obtained from 28 different plants located in six Kansas cities for the study. The following analyses were made on each of the samples: (1) phosphatase test; (2) total plate count; (3) direct microscopic count; (4) *Escherichia-Aerobacter* count; (5) titratable acidity, and (6) pH.

An evaluation of the results obtained by these different tests reveals that no single test can be used as a satisfactory criterion for determining the sanitary quality of market cream. Each test has its own particular significance. Much can be gained by using several methods to permit a more complete interpretation of laboratory data. The information revealed by the laboratory data obtained in this study was found to be of inestimable value in detecting faulty plant practices.

The phosphatase test revealed faulty pasteurization in 16 of the 63 samples examined. Only two of these 16 samples would have been regarded as unsatisfactory on the basis of the standard plate count.

The standard plate count was a useful index of the bacteriological condition of the finished product. Fifty-two of the 63 cream samples were below the maximum of 60,000 per ml. permitted for grade A pasteurized cream under the provisions of the U. S. Public Health Service Milk ordinance.

The direct microscopic count proved a very useful index to the quality of raw material used in the production of grade A pasteurized cream. It was observed that 18 of the 63 samples were unsatisfactory for the production of grade A cream on the basis of the direct microscopic counts.

Although there was an apparent relationship between the standard plate count and direct microscopic counts, the relationship was not absolute because of a very high pasteurization efficiency obtained on some samples of cream with high initial bacterial population as shown by the direct microscopic count.

The *Escherichia-Aerobacter* count when used in conjunction with the phos-

phatase test proved to be a valuable index to contamination of the product by poor sanitary condition of the equipment.

The acidity and pH values proved valuable in indicating samples to which a neutralizing agent had been added.

5. *Ingredients Used in Kansas Ice Cream.*—In a survey conducted in April, 1939, all of the 330 licensed ice cream manufacturers were included. Data were obtained showing the ingredients used in approximately 50 percent of the total gallonage of the state.

This survey showed that about 90 percent of the frozen product manufactured in Kansas was ice cream containing 10 percent or more butterfat. The average fat content was 12.0 to 12.5 percent.

Of the manufacturers who replied, 95 percent were using sweet cream as the major source of fat. Cream supplied over 75 percent of all the butterfat used in ice cream, butter supplied 1.0 percent.

Whole milk and condensed whole milk each supplied over 25 percent of the total milk solids-not-fat, and condensed skim and skim-milk powder each furnished about 15 percent of this constituent.

The overrun standard for the greater share of ice cream manufactured in Kansas was between 85 and 100 percent.

Over 75 percent of the manufacturers were using either pure or fortified vanilla extracts, while less than 20 percent were using imitation vanilla.

Eggs in some form were used by approximately 50 percent of the Kansas manufacturers.

In the manufacture of ice cream, gelatin was used almost exclusively as the stabilizer. Gelatin and pectin were equally widely used as the stabilizer for sherbet.

Corn sugar was used in ice cream by about one-fourth of the manufacturers, and in sherbet by one-third of them.

6. *A Study of Homogenized Milk.*—The purpose of this investigation was to determine the effects of certain factors in the flavor, amount of sediment, and bacterial count of homogenized milk.

Factors studied were homogenization pressure, method of pasteurization, manner of removing sediment, and the flavor and acidity of the milk before treatment.

Results obtained in these studies may be summarized as follows:

1. A homogenization pressure of 1,500 to 3,500 pounds per square inch is satisfactory. The optimum pressure is probably about 2,500 pounds.

2. Pasteurization of homogenized milk can be accomplished satisfactorily at a higher temperature than that used for unhomogenized milk. Pasteurization following homogenization gave lower bacterial counts.

3. The method used for the removal of foreign material from milk is unimportant as far as flavor is concerned. Centrifugal clarification is the only sure method of preventing sediment formation in some samples of homogenized milk.

4. The quality of milk used for homogenization is the most important factor involved. It must have a high flavor score if the flavor of the finished product is to be good. It must be handled so as to be low in acidity and free of excessive amounts of foreign material if the bottles of homogenized milk are to be free of sediment.

7. *Problems Relating to the Cold Storage of Butter.*—The extent to which Kansas creameries store butter and other information relative to storage practices were determined by means of a questionnaire. Statistical information was also used to determine the quantity of butter stored, the into- and out-of-storage movements, factors affecting the quantity stored, storage costs, storage risks and profits from storage and hedging.

From information supplied by the Kansas creameries it was concluded that during the past ten years the storage of butter has not been extensively practiced.

The amount of butter in storage in the United States varied from a low in April of 0.5 percent of the annual production to a high of 8.5 percent between

August and October. The cost of storing butter in a Chicago warehouse for six months was found to be approximately 1.58 cents per pound and this was increased to 1.86 cents per pound when hedging costs were added. Hedging may be used advantageously when a definite profit can be realized at the time of placing the hedge and when indications point to a declining market during the out-of-storage season. The establishment of a profitable butter storage policy depends upon a knowledge of the factors which affect price changes in butter.

(Projec, 124; Departments of Dairy Husbandry, Bacteriology Chemistry, and Agricultural Economics. Leaders, W. H. Martin, W. J. Caulfield, G. H. Beck, F. E. Nelson, V. D. Foltz, C. H. Whitnah, and F. L. Parsons; state fund.)

**Bacteriological Study of Ice Cream.**—Eight phases of work under this project have been active, as follows:

1. *Studies on Resazurin and Methylene Blue as Indicators of the Quality of Milk.*—Complete results have been obtained on 94 samples and further data are being collected. Reading the test after three hours of incubation was found to be the best procedure for detecting samples having high bacterial counts, as determined by either the standard plate method or the direct microscopic method. The procedure, based on the time required for the reduction of the dye to a definite pink, was somewhat less sensitive than the three-hour incubation procedure for detecting the samples with high bacterial counts, but appreciably more sensitive than the method requiring but one hour of incubation. The usual test made with a one-hour incubation period apparently is hardly adequate for accurate grouping of samples according to bacterial count. Contrary to the results obtained using aseptically drawn milk, the rate of resazurin reduction in market milk apparently was not correlated with the number of leucocytes present in the sample.

Studies on the use of various chemical agents for increasing the rate of reduction of the dyes employed in the reduction tests are now in progress, but the data are not sufficient to permit the drawing of any definite conclusions. At least two of the agents studied show promise of reducing the time required for reduction without disrupting seriously the relationship between numbers of organisms present in the milk or other dairy product being tested and the time required for the characteristic color change to take place. Further studies on this subject are planned for the purpose of determining whether the modified tests are consistently more rapid and at least equally as differential as the tests now used.

2. *Survey of Kansas Ice Cream.*—Practically all of the ice cream manufactured in the state was represented in a survey of Kansas ice cream in 1938, which included 318 samples. Standard plate count, coliform count, phosphatase test, butterfat test, weight per gallon, and the flavor, body and texture, color and package scores were determined.

Standard plate counts of 100,000 or less per ml. were obtained on 59.8 percent of all samples. A slightly larger percentage of the ice cream samples from counter-freezer operators than from wholesale manufacturers was in the lower count ranges.

Only 26 samples were found to contain less than 10 percent butterfat. A tendency for samples of high butterfat content to have a high total score minus bacterial score was established.

A weight of 4.50 to 5.49 pounds per gallon was most frequently associated with high body and texture score; both lighter and heavier samples tended to be less desirable from this standpoint.

In June, 1939, samples were collected again, 319 being obtained at that time. The counts and tests used in the 1938 survey were made again and direct microscopic count, titratable acidity and pH also were determined. The co-

operating State Dairy Inspector furnished data on the annual gallonage as of 1938 represented by each sample.

Standard plate counts of 100,000 or less per ml. were obtained on 73.9 percent of the samples, the increased percentage over 1938 of such samples undoubtedly being a reflection of the cool weather enjoyed in this area during the period of the survey. Again a slightly larger percentage of the ice cream samples from counter-freezer operators than from wholesale manufacturers was in the lower ranges of count.

The data on gallonage indicate that the 86 wholesale manufacturers produced about 83 percent of the 3,383,000 gallons of ice cream made in the state in 1938 and 14 of these manufacturers accounted for 49 percent of the total for the industry. The 201 counter-freezer manufacturers made about 17 percent of the total output and no single operator in this group made more than 15,000 gallons.

3. *The Application of the Phosphatase Test to Certain Milk Products.*— During the biennium studies have been conducted in cooperation with the Department of Dairy Husbandry to determine: (1) the applicability of the phosphatase test as well as its limitations for measuring the efficiency of pasteurization of ice cream and market cream; (2) the relative heat resistance of the phosphatase enzyme and cultures of the *Escherichia-Aerobacter* group of micro-organisms selected for maximum heat resistance in ice cream and market cream.

The work with ice cream has been completed and the results published. Results obtained with the New York field and the Gilcreas and Davis phosphatase tests on cream separated from pre-pasteurized milk indicate that an exposure of 143 degrees F. for 30 minutes is not adequate to insure negative phosphatase tests on the cream samples in all cases.

When the milk was pasteurized at 143 degrees F. for 30 minutes, positive reactions, indicative of under-pasteurization, were obtained in four out of the 15 samples of 20 percent cream and in eight of the 15 samples of 35 percent cream studied.

When the milk was pasteurized at 150 degrees or 160 degrees F. for 30 minutes, all 15 lots of 20 and 35 percent cream obtained by separation following pasteurization were negative to both phosphatase tests. These data suggest the desirability of using somewhat higher pasteurization temperatures for milk that is to be subsequently separated for the production of market cream if the phosphatase test is to be used as a measure of efficiency of pasteurization.

To study the relationship of the relative heat-resistance of the *Escherichia-Aerobacter* group of micro-organisms and the phosphatase enzyme in market cream, 24-hour litmus milk cultures of selected heat resistant strains of the organism were inoculated into samples of 20 and 35 percent of raw cream in such quantities that from 50,000 to 100,000 per ml. of the organisms were present in the unpasteurized cream. The cream was then pasteurized at a series of different exposures under controlled laboratory conditions. The exposures used were 143.5 degrees F., 145 degrees F., and 150 degrees F. for 20 and 30 minutes, respectively, at each temperature. The phosphatase enzyme was found to be more heat resistant than were the strains of *Escherichia-Aerobacter* organisms studied. In the 104 trials, only one showed any survival of *Escherichia-Aerobacter* organisms. On the other hand, all of the cream samples pasteurized at 143.5 degrees F. for 20 minutes were positive to both the New York field and Gilcreas and Davis phosphatase tests. An exposure of 143.5 degrees F. for 30 minutes was not sufficient to give negative phosphatase tests in all samples. No positive results were observed in any of the samples pasteurized at 145 degrees F. for 30 minutes, 150 degrees F. for 20 minutes, or at 150 degrees F. for 30 minutes. The data seem to justify the conclusion that a sample of market cream which has been pasteurized sufficiently to yield a negative phosphatase test has also been heated sufficiently to destroy the *Escherichia-Aerobacter* organisms ordinarily present. The presence of these organisms in a sample of cream negative to the phosphatase test.



would, therefore, be considered the result of contamination after pasteurization rather than of inadequate pasteurization.

4. *Media for the Determination of Numbers of Bacteria in Dairy Products.*—A new medium for use in making the standard plate count of milk, cream, and ice cream was adopted by the Laboratory Section of the American Public Health Association, effective July 1, 1939. So far as could be determined, no results of comparisons of the new medium with media already in use were published prior to the adoption of the new medium. During the last few months of 1938 and the first few months of 1939 this laboratory made comparisons of the counts obtained using the old standard milk agar, the new standard milk agar and Tryptone-glucose-skim-milk agar, using both 32 degrees and 37 degrees C. incubation temperatures.

The ratio of the counts obtained in the new and old standard milk agars at 37 degrees C. was 1.355 for 38 samples of raw milk, 1.816 for 27 samples of pasteurized milk and seven samples of pasteurized cream and 1.345 for 32 samples of ice cream. These figures would indicate that appreciable increases in counts may be expected in many instances from the use of the new agar. The ratios between the counts obtained on the new standard milk agar, and on Tryptone-glucose-skim-milk agar at 37 degrees C. were 1.005, 1.055 and 0.998 respectively, for raw milk, pasteurized milk and cream, and ice cream indicating no significant difference between the counts obtained on the two improved agars. Except in the case of raw milk, the use of the improved agars tended to lessen the increase in count commonly observed when an incubation temperature of 32 degrees C. is used instead of 37 degrees C.

5. *A Study of Homemade Ice Cream.*—In cooperation with the Department of Dairy Husbandry, a study of 100 samples of homemade ice cream was made. The absence of information on practically all of the points studied suggested the need of this study. Information on a number of points was collected, a brief summary of which is presented.

1. The reasons and number of times mentioned for making homemade ice cream were economy (55), taste (34), convenience (25), and safety (15).

2. Milk and cream were the principal milk products used, with raw products predominating over pasteurized products.

3. The two methods of freezing homemade ice cream were: (1) the tub method; (2) freezing in a mechanical refrigerator with or without agitation.

4. The butterfat and total solids content of 100 samples of homemade ice cream examined varies within wide limits, ranging from a low of 1.4 percent fat to a high of 35.4 percent, and a low of 17.84 percent total solid to a high of 53.36 percent.

5. The bacteriological quality of homemade ice cream averaged lower than that of commercial ice cream collected in a survey somewhat earlier. This was undoubtedly due, in part, to the use of unpasteurized dairy products in some samples.

6. In comparing all samples, refrigerator frozen samples were bacteriologically superior to tub frozen.

7. Samples of ice cream made from pasteurized milk and cream and frozen in the refrigerator were lower in bacteria than those frozen in the tub.

8. Samples made with raw milk and cream were lower in bacteria, if pan frozen, than those which were tub frozen.

6. *Effect of salt on the Keeping Quality of Cream.*—A study of the effect of salt on the keeping quality of cream was made to determine the merits of this procedure. In each of a series of four trials, four samples of 30 percent cream to which salt in quantities equal to 0, 7, 10, 13, and 16 percent of the weight of the fat-free serum was added were held at 60°, 70°, 82°, and 90° F. for 10-day periods. Changes in acidity, formol titration, and grade were followed, observations being made at 1-, 2-, 3-, 4-, 5-, 6- 8-, and 10-day periods and changes in bacterial flora of two samples were followed by direct microscopic observations. All control samples to which no salt had been added deteriorated rapidly and when stored at 82° and 90° F., became unlawful within five days. At 60° F., 7 percent salt kept all samples sweet for a five-

day period and prevented any of the samples from going below first grade in 10 days. At higher temperatures, this salt concentration was less effective.

Further trials, using larger quantities of salt with variable storage temperatures indicate that the deterioration of cream held without benefit of adequate cooling may be definitely retarded by the addition of salt. The amount of salt necessary depends upon the time and temperature of storage. To be effective in retarding deterioration, the salt must be added immediately to the fresh cream before any appreciable deterioration has occurred.

No deleterious effects were noted in butter churned from salted cream. The fresh butter made from the cream scored 92, 92, and 92.5 points, respectively, in three trials, while butter samples from control lots of unsalted cream scored 87, 90, and 90, respectively. No change in score occurred after storage at 0° to -10 F. for 60 days.

At the present time, the Federal Food and Drug Administration has not given its approval to the addition of salt to cream, holding that such addition may be classified as adulteration. It is believed that if the merits of this procedure of improving the keeping quality of cream can be clearly demonstrated, the legal restrictions surrounding its use may be lifted. The procedure is covered by a United States patent, granted to a worker in the United States Department of Agriculture, who has dedicated the procedure to the free use of the people of this country.

7. *Methods of Estimating Escherichia-Aerobacter Organisms in Ice Cream.*—In this study brilliant green lactose peptone bile 2 percent broth, desoxycholate agar and violet red bile agar were each used in determining the prevalence of *Escherichia-Aerobacter* organisms in 318 samples of ice cream. Duplicate tubes containing 1.0, 0.1, 0.01, and usually 0.001 ml. of sample were used with the broth procedure, and the positive tests were confirmed by isolation of a gram-negative, lactose-fermenting organism from an eosin-methylene blue agar plate streaked from the positive broth culture. Seven of the 288 positive presumptive tests were not confirmable. Single plates containing 1.0 and 0.1 ml. of sample were poured with each agar. The results are presented in the following table:

MEDIUM	Number of samples containing E. A. organisms.	Negative	Not run
Brilliant green broth. . . . .	281	37	0
Desoxycholate agar. . . . .	249	56	13
Violet red bile agar. . . . .	274	44	0

Under conditions approximating those which would be found in a commercial laboratory, the broth medium detected the greatest number of samples of ice cream containing the test organisms; the desoxycholate agar was the least sensitive of the three media. Almost all of the discrepancies were found among samples containing fewer than 10 test organisms per ml., and many of these samples contained only one or two test organisms per ml. The differences were not consistently in favor of any one medium, apparently because of the laws of change operating when only a few organisms were present.

8. *An Evaluation of Several Laboratory Procedures for Measuring the Sanitary Quality of Market Cream.*—The principal objectives of this investigation were to determine the relative merits as well as the limitations of several laboratory procedures for evaluating the sanitary quality of cream, and secondly, to observe the relationship between the results obtained with the laboratory tests used.

The results of this study may be summarized briefly as follows:

1. Of the 63 samples of commercial pasteurized cream studied, 75 percent were negative to both the New York field and Gilcreas and Davis phosphatase tests. Of the 16 samples with a positive reaction, 12 were positive to both tests, three were positive to the New York field test only and one sample was positive to the Gilcreas and Davis test only. The positive samples were divided equally between whipping and coffee cream. The degree of under-pasteurization as indicated by the quantitative phosphatase test results, however, was generally greater for the coffee cream samples than it was for the whipping cream samples. This is possibly due in some instances to contamination of the coffee cream with raw or improperly pasteurized milk during standardization.

2. Fifty-two of the sixty-three cream samples had standard plate counts of 60,000 per ml. or less. Samples of cream from milks pasteurized before separation had appreciably lower average counts than did those samples pasteurized after separation.

3. The bacteriological quality, as shown by the direct microscopic count, of the raw materials used for cream pasteurized before separation, whether coffee or whipping cream, was much better than for the cream pasteurized after separation.

4. Contamination following pasteurization as revealed by the presence of numbers of *Escherichia-Aerobacter* organisms appeared to be a major problem in quite a large number of plants whose products were examined in this study. In approximately 50 percent of the samples examined the number of *Escherichia-Aerobacter* organisms was above 10 per ml., indicating extensive contamination. This was found to be particularly true of those samples separated after pasteurization indicating poor sanitary condition of the separator. Only about one-third of the samples examined contained one organism or less of this group per milliliter.

5. No excessive acid development was apparent in any of the samples studied. On the other hand, abnormally low acidities indicative of neutralization were observed in three samples of whipping cream and one of coffee cream. The possible usefulness of the acidity and pH determinations for detecting neutralization in market cream was indicated by the data obtained in this study.

6. As compared with the milk from which the cream was separated the cream samples were found to show an increase in the number of phosphatase positive samples, an increase in the plate count, and a marked increase in the numbers of *Escherichia-Aerobacter* organisms.

7. The results of the laboratory determinations used in this study indicate that no single test can be used as a satisfactory criterion for determining the sanitary quality of market cream.

(Project 124; Department of Bacteriology. Leaders, F. E. Nelson and V. D. Foltz; state fund.)

**Improvement and Conservation of Farm Poultry.**—Four phases of this project, all dealing with chickens, have been carried on during the biennium.

1. *The Relative Value of Alfalfa and Young Cultivated Cereal Grasses in Poultry Nutrition.*—Twelve hundred White Leghorn chicks were divided into four equal lots and placed in four 10-by-12-foot colony brooder houses. Each house was equipped with a 54-inch electric hover the first eight weeks. A range consisting of one-third acre surrounded each colony house. Lots 1 and 2 consisted of a good stand of alfalfa, Lot 3 was seeded to oats for early pasture and Sudan for summer and fall pasture, while Lot 4 was bare ground.

In addition to the above forage crops Lot 1 received fresh chopped alfalfa and Lots 2 and 3 fresh chopped cereal grasses (oats and Sudan) after the first

week. An amount the chicks would consume in about one hour was fed early each morning.

In all other respects the lots received the same care and management and the Kansas all-purpose mash was kept in hoppers before the chicks at all times.

Scratch grain consisting of equal parts of cracked yellow corn and whole wheat was hopper fed in addition to the mash beginning with the fifth week. Records were kept of body weight and feed consumption by four-week periods. Individual weights of birds in grams were taken the 8th, 16th and 24th weeks of age, group weights were taken at the other weighings. All males were removed at eight weeks of age.

The most desirable 100 pullets were selected from each lot when 22 weeks of age and placed in their respective 20-by-20-foot laying quarters where the laying period began two weeks later on October 7, 1938. Here they remained for 50 weeks, continuing on the same ration. They were confined until April 8, 1939, at which time each group was given limited range on wheat pasture. After early July, Sudan pasture was available for all lots. The pullets were trap-nested and all eggs were sold on a graded basis. Hatchability records were kept during the hatching season.

A summary of essential facts regarding the four lots is presented in the following table:

SUMMARY FOR GROWING CHICKS, 1938-'39

Comparison.....	Lot Nos.			
	1	2	3	4
Range crop.....	Alfalfa	Alfalfa +grass	Grass +grass	Bare yard
Average weight 24 weeks (grams).....	1,416.0	1,392.0	1,408.0	1,456.0
Mortality 24 weeks (percent).....	11.7	10.7	11.3	9.7
Pounds feed consumed per chick.....	17.6	17.1	18.7	18.5
Cost of feed per chick.....	\$0.23	\$0.22	\$0.25	\$0.26

SUMMARY FOR LAYING HENS (50 WEEKS)

Mean egg production for hens living through year.....	185.2	189.7	188.6	163.2
Mean egg size (grams).....	56.0	56.4	57.0	57.2
Percentage of eggs in top grade.....	42.0	45.5	53.1	51.0
Mean body weight, 74 weeks.....	1,749.0	1,675.0	1,696.0	1,712.0
Hatchability, fertile eggs.....	63.7	72.3	75.2	68.0
Feed consumed per hen, lbs.....	73.3	74.0	73.5	71.8
Percentage mortality.....	38.0	42.0	35.0	31.0
Egg receipts per hen (graded).....	\$2.14	\$2.20	\$2.20	\$1.87
Feed cost per hen.....	.89	.91	.90	.88
Income above feed cost.....	\$1.25	\$1.29	\$1.30	\$0.99

2. *Grass Silage for Poultry.*—This phase is a continuation of studies on the composition and keeping qualities of oat grass silage. Oat grass grown on the station poultry farm was ensiled at different dates and with the use of different preservatives and methods of storing in steel and wooden barrels holding approximately 300 pounds of silage each. In 1938, the oats were cut six weeks after planting and two barrels were preserved with 8 percent of a mixture containing equal parts of molasses and water. The remaining two barrels were preserved with hydrochloric and sulfuric acid. The moisture content at cutting time was 84 percent and the carotene content was 8.58 milligrams per 100 grams (calculated on a wet basis), a decline from a maximum of 14.00 on April 18 11 days before cutting. On November 30, 1938, the silage was analyzed chemically. The following results were obtained:

KIND OF SILAGE	pH	Moisture	Protein	Fat	Fiber	Ash	N-free extract
Molasses .....	Wet 5.1	80.2	4.63	1.16	2.86	5.64	5.51
	Dry	0.0	23.39	4.87	14.43	28.49	27.82
Acid.....	Wet 6.3	85.4	2.86	0.95	3.05	3.32	4.42
	Dry	0.0	19.59	6.52	20.92	22.76	30.24

The molasses silage was slightly superior, but neither qualified as good silage, with a pH value of above 5. Thirteen percent of all eggs produced by hens that were fed this silage had a greenish cast when candled. Oats were planted again in 1939 and a portion of the field was harvested while the oats were in the first and second joint stage. The remainder was harvested when the grain was in the milk stage in order to compare the keeping qualities of oats plants at different stages. Water, molasses and phosphoric acid were used as preservatives.

Lor No.	pH	Percent ammonia	Moisture
1 .....	4.5	.094	81.0
2 .....	4.9	.188	83.5
3 .....	4.2	.079	79.5
4 .....	4.0	.047	71.0
5 .....	3.7	.041	71.5
6 .....	3.7	.040	72.5

The silage was fed to laying pullets and they seemed to relish it as they would fresh grass. Laying hens that received green feed for several weeks from three different sources produced eggs with olive-colored yolks, or "grass eggs," as follows:

	Percent
Silage made at jointing stage.....	1.91
Silage made at heading stage.....	0.22
Wheat and henbit pasture.....	1.26

These results were a marked improvement over those obtained in the 1938 trials reported above.

The tests were repeated in 1940. The carotene content of the 1940 oats grass was slightly more than one-half that of the 1938 samples when ensiled, due to the extremely rank growth in 1940. The carotene content was 2.76 milligrams per 100 grams. A complete analysis of the 1940 oat grass is as follows:

	Moisture	Protein	Fat	Fiber	Ash	N-free extract
Wet .....	86.74	3.29	0.70	2.85	2.08	4.34
Dry .....	0.00	24.79	5.31	21.53	15.72	32.65

The silage will be used this fall in a critical experiment in comparison with alfalfa and milk in the ration of laying pullets.

3. *Relationship Between Shell Porosity, Egg Weight and Hatchability.*— "Over-all" porosity indices, i.e., the loss in weight per unit of shell area per unit of time under standard incubation conditions (Mg/cm<sup>2</sup>/24 hours), were calculated for representative eggs laid by each hen in a flock of 174 White Leghorns. Hatchability records were obtained for these hens in three hatches conducted in March and April.

No correlation was found to exist between porosity and either (1) weight of egg or (2) percentage of hatchability. Porosity indices ranged from 3.52 to 13.99 mg./cm<sup>2</sup>. with an average of 7.28 mg./cm<sup>2</sup>/24 hours.

4. *Possibilities of the Use of Artificial Insemination for Developing a More Critical Progeny Test.*—Eleven cockerels and eighty-six White Leghorn hens and pullets were used in a test to determine the practicability of artificial insemination on a large scale. It was found that weekly inseminations produced high fertility when using the semen of one male on eight females. Semen was collected at 9 a.m. and 2 p.m. on the day of insemination. The morning semen was held at 40 degrees to 60 degrees F. until being mixed with the afternoon semen of the same male. The entire operation of collecting semen, catching the females, and insemination required about an hour for three persons.

In order to determine how sharply the change would occur in offering when substituting one male for another in artificial insemination, Barred Plymouth Rock females were alternately inseminated with White Leghorn and Barred Plymouth Rock semen. Paternity of chicks could be determined by color. Preliminary results indicate that more than 95 percent of the chicks can be accurately identified as to their sires, except in those chicks produced by eggs laid on the second and third day after insemination.

(Project 77-26-28-29; Department of Poultry Husbandry. Leaders, L. F. Payne, D. C. Warren, and H. M. Scott; state fund.)

**Turkey Production.**—Two phases of this project have been conducted during the biennium.

1. *The Effect of Restricted Food Intake on Reproduction.*—The reproductive performance of turkeys on full feed from fall to late spring has been compared with that of a second group where the level of food intake from fall to date of first egg was just sufficient to maintain a constant body weight. In the second group full feeding was initiated simultaneously with the onset of egg production.

A summary of the results for the breeding season of 1938-'39 and a partial summary of the 1939-'40 season are given in the following table:

FOOD INTAKE	Mean egg production	Percentage hatchability		Percentage fertility	
		Range	Mean	Range	Mean
Nonrestricted (1939).....	33.97	8.3-84.1	53.07	50-100	89.0
Restricted (1939).....	27.98	0-84.6	59.97	17.9-100	77.5
Nonrestricted (1940).....	29.80	.....	.....	.....	.....
Restricted (1940).....	29.00	.....	.....	.....	.....

2. *Effect of Grass Pasture in the Growing Turkey's Rations.*—In the spring of 1938, 25 six-week-old Bronze turkey poults were placed in each of two yards of equal size (.3 acre). Those in Lot 1 had access to a luxurious growth of oat and Sudan grass from 6 to 28 weeks of age. They also received finely chopped fresh grass early each morning. The poults in Lot 2 ranged in a bare yard with no herbage available. Both lots received the Kansas State College all-purpose ration together with uniform care.

During the spring of 1939 a number of Bronze turkey poults were hatched May 12 and reared under electric hovers until four weeks of age. At that time they were divided into three groups of 31 each and placed in three colony brooder houses each of which was surrounded by a lot 1/3 acre in size.

Lot 1 was covered with Sudan grass, Lot 2 was without vegetation, being summer fallowed, and Lot 3 was well covered with alfalfa. The Kansas State College all-purpose ration was fed to each group throughout the experiment, the only variable being the difference in forage crops available.

The results for 1938 and 1939 are given below for growing turkeys:

1938	Lots		
	1	2	Difference
Kind of forage.....	Grass	None	.....
No. poult's started 6 weeks old.....	25	25	.....
No. left at 28 weeks of age.....	23	19	.....
Mortality.....	2	6	4
Average weight lbs., 28 weeks, male and female average.....	19.04	17.19	1.85
Feed consumed per bird, lbs., 6-28 weeks.....	71.76	83.85	12.09
Cost of feed per bird.....	\$0.98	\$1.19	\$0.21
Cost of feed per lb. gain, cents.....	5.14	6.92	1.78
1939			
Kind of forage.....	1 Grass	2 None	3 Alfalfa
No. poult's started 4 weeks old.....	31	31	31
No. left at 28 weeks of age.....	30	24	27
Mortality.....	1	7	4
Average weight lbs., 28 weeks of age, male and female average.....	19.2	19.8	17.6
Feed consumed per bird, 4-28 weeks.....	70.6	\$0.2	65.8
Cost of feed per bird.....	\$0.99	\$1.13	\$0.89
Cost per lb. gain, cents.....	5.2	5.7	5.1

During the first year's work the grass pasture was in excellent condition throughout the summer and it proved to be a good supplement to the grain ration. The birds on grass range not only lived better and gained more on less feed, but there was a saving of 21 cents per bird on feed cost. This made a difference of cost of gain of 34.6 percent in favor of Lot 1.

In repeating and enlarging the experiment in 1939, there was no hand feeding of grass or alfalfa. The birds gathered what they wanted by foraging. The Sudan grass in Lot 1 was killed by chinch bugs about six weeks before the project ended, hence this lot was deficient in green feed during the period when the turkeys made their greatest gains.

(Project 77-17-27; Department of Poultry Husbandry. Leaders, H. M. Scott, L. F. Payne; state fund.)

**Factors Influencing the Color of Yolks of Eggs.**—Three phases of the problem were studied during the biennium.

1. *Olive-colored Yolks.*—An oat-grass silage made in the spring of 1937 from immatured oats that had not yet reached the jointing stage had been found to produce a high percentage of olive-colored yolks when fed at the rate of four pounds a day to 100 hens. (This silage had been prepared by mixing equal parts of water and molasses with the grass at the rate of 80 pounds of molasses per ton of grass.)

The alcohol-phasic carotenoids of olive yolks and of normal-colored yolks obtained from hens in the same flock were analyzed by the chromatographic technique of Strain. The oat-grass silage was similarly analyzed.

Large quantities of the oat-grass silage were also exhaustively extracted with alcohol. The alcohol extract was separated into ether soluble, petroleum soluble, and 90 percent methanol fractions. All extracts and residues were fed to determine whether they would produce olive-colored yolks. In some cases, fractions suspended in an aqueous emulsion of 20 percent egg oil were injected into the wing vein. Hot and cold water extracts of silage were also similarly studied.

DISTRIBUTION OF THE XANTHOPHYLLS (ALCOHOL SOLUBLE) IN OLIVE AND NORMAL COLORED EGG YOLKS AND OAT GRASS SILAGE.

PIGMENT	Olive egg yolks		Normal egg yolks		Silage	
	Distribution on columns in percent		Distribution on columns in percent		Distribution on columns in percent	
	Range	Average	Range	Average	Range	Average
Strongly adsorbed pigments.....	10.43-15.65	13.63	1.83- 4.12	2.98	18.38-23.28	20.83*
Zeaxanthin.....	25.35-38.76	34.26	30.06-33.92	31.99	13.72-30.92	22.32
Isolutein.....	7.24-18.03	12.63	16.78	16.78	10.58-24.65	17.62
Lutein†.....	32.78-51.75	39.47	45.18-51.32	48.25	38.35-40.12	39.23

\* This percentage was composed of two fractions, a very strongly adsorbed zone and a less strongly adsorbed fraction whose percentages were respectively, 2.23 and 18.60.  
 † Contains small amounts of cryptoxanthin.

It was also found that olive-colored yolks contained 61.2 percent more xanthophyll than normal yolks. An all-mash ration containing 10 percent lobster shell was fed to hens, orange-red yolks containing astacin were produced. No olive-colored yolks were obtained on this ration.

When fed at the rate of an equivalent of 0.3 pound oat-grass silage per bird per day, three extracts of the silage—alcohol, ether, 90 percent methanol—each produced marked olive yolks. In contrast to the group feeding experiment of the original silage where only a fraction of the birds produced olive yolks, all birds fed these extracts produced olive yolks.

The factor producing olive yolks apparently is a modified chlorophyll, soluble in 95 percent alcohol, ether, and 90 percent methanol, insoluble in water and slightly soluble in petroleum ether. The substance is not stable to alkali.

2. *The Role of Xanthophylls in Poultry Nutrition.*—A series of experiments have been initiated in an effort to develop a ration free of carotenoid pigments and adequate in all known essential factors that could be used to test the essentiality of xanthophyll for growth of the chicken.

In a preliminary experiment it was shown that a diet free from carotenoid pigments by itself or supplemented with 10 percent alfalfa failed to promote satisfactory growth.

Apparently it will not be possible to determine the role of xanthophyll in poultry nutrition, until a diet can be devised which is free from pigments, and which will maintain the birds in a normal condition when the xanthophyll is added.

3. *Effect of Ingested Pigments on the Color of Retinal Droplets.*—To determine what effect specific carotenoids would have on coloring of retinal droplets, one milligram quantities per bird per day were fed for 5 days and the droplets studied. Alpha-carotene, beta-carotene, astacin, lutein, and zeaxanthin were the pigments used.

Alpha-carotene, beta-carotene, and astacin had slight if any effect on the color of the retinal droplets.

The retinal droplets of birds receiving lutein, zeaxanthin, or a normal feed were colored.

(Project 193; Departments of Poultry Husbandry and Chemistry. Leaders, H. M. Scott, J. S. Hughes, W. J. Peterson, L. F. Payne; Adams fund.)



*The Mechanism of Egg Formation.*—Four phases of this project were carried during the biennium. Studies with pigment deposition demonstrated that the pigment is deposited while the egg is in the uterus and not in the vagina, as had been previously suggested.

1. *Formation of Egg White.*—The accumulation of protein in the oviduct of the laying bird was studied by killing hens at different stages of egg formation, and examining the magnum by both chemical and histological means. The protein of the oviduct soluble in dilute acetic acid was determined. This does not include only egg white protein, but is rather an arbitrary fraction of protein which should include any preformed egg white proteins except mucin, and probably any of their precursors. Histologically, the apparent engorgement of the glands forming egg white proteins was observed. Both methods indicate that protein accumulates continuously in the magnum at a fairly steady rate, and is discharged when an egg passes through the oviduct. This, agrees with the observation that an egg laid following a pause in production contains more white than eggs which follow another egg by a shorter interval.

Studies on chalazal formation have been extended by obtaining eggs from more anterior regions of the oviduct than had previously been reported upon. Evidence indicates that the region of the oviduct situated between the magnum and the infundibulum and designated by some as the chalaziferous region definitely contributes to the formation of the chalaziferous layer of the white and to chalazae formation.

2. *Physical Properties of the Egg.*—The causal factor involved in the production of a specific abnormality in egg shape designated as "flatsiders" has been shown to be the simultaneous presence of two eggs in the shell gland.

3. *Development of Pigment in Brown-shelled Eggs.*—Forty-two Rhode Island Red hens were chosen for this study because they produced from medium to deep brown eggs. Three control eggs were obtained during the week previous by artificially expelling the uterine egg. By the use of an anesthetic, eggs were expelled at periods varying from 1 1/2 to 14 hours previous to the time the egg should have been laid. The amount of pigment in the shell was determined chemically and expressed in percentage of that found in the mean of the eggs laid by the same hen. Photographic records were also made comparing the laid and prematurely expelled eggs.

Pigment formation is not so nearly a straight-line function as is shell formation. It covers a period of several hours, but the initial rate is somewhat retarded when compared with shell formation. The rate of deposition is accelerated toward the end of the period of shell formation. Deep and medium brown eggs seemed to accumulate pigment at the same percentage rate. The results demonstrate that all the shell pigment is deposited while the egg is in the uterus and not in the vagina as had been previously suggested.

4. *Movements of the Hen's Egg While in the Uterus.*—The egg spends the last 20 to 24 hours before being laid in the uterus where the shell is formed. It has been recorded that eggs may be laid either blunt or pointed end first. Also the rotation of the egg on its long axis during this period probably contributes to chalazal formation. In view of these facts any technique which records the movements of the egg while in the uterus would be of interest.

The position and movement of the uterine eggs were observed by the use of a fluoroscope. In 15 hens studied for varying short periods after shell formation had started all showed the pointed end of the egg to be toward the vent. One hen was observed constantly for 17 hours, and another for 5 hours. These observations demonstrate that the egg seldom turns end for end while in the uterus. It seems probable that if any reversal of the egg is made, it occurs during oviposition.

An attempt was made to record the rate of rotation of the egg on its long axis without much success, although the few records obtained indicated that the rate of rotation was approximately once in ten to fifteen minutes.

(Project 198; Department of Poultry Husbandry. Leaders, D. C. Warren, H. M. Scott, R. M. Conrad; Bankhead-Jones fund.)

*The Chemistry of Egg Formation.*—Three phases of this project were conducted during the biennium.

1. *Egg Quality.*—Two groups of birds, consisting of 24 and 26 individuals and having an average fresh egg white quality of 94 and 69 Haugh units, respectively, were selected for use in this study. Fresh eggs laid by these hens were broken, the quality determined, the mucin content of the white determined, and a protein free filtrate of the white analyzed for calcium, magnesium, potassium, and sodium. At the conclusion of the experiment, the birds were killed, and the height of the goblet cells of the magnum determined histologically. The average results of the two groups in which quality is expressed in Haugh units, cell height in microns, mucin in percent of total nitrogen of the white present as mucin, and mineral elements as milligrams present in 100 ml. of egg white, are given.

QUALITY	Cell height	Mucin	pH	Calcium	Magnesium	Potassium	Sodium
94.....	20.7	1.78	7.63	15.76	10.87	156.2	192.2
69.....	19.9	1.48	7.67	16.38	10.47	165.0	178.4

Quality probably is related to mucin content although many individual exceptions were noted. Of the other factors studied, only sodium and potassium seem to have any relation to quality.

2. *Calcium Metabolism.*—Calcium balance studies have been performed with pullets just starting to lay, when fed diets containing 0.5, 1.0, 2.0, and 3.0 percent calcium. A similar study was made of pullets which had been laying steadily for several months on a diet containing 2.28 percent calcium and were fed experimental diets of 1.0 and 3.0 percent calcium content. The average results for groups of 4 to 6 birds for a 30-day period are shown in the following table:

PERCENT CALCIUM IN DIET	Original calcium of skeleton, grams	Calcium withdrawn, grams	Eggs laid
<b>JUST STARTING:</b>			
0.5.....	19.616	7.469	12.00
1.0.....	17.136	5.763	21.25
2.0.....	13.583	—1.776*	21.00
3.0.....	15.721	—2.942*	15.00
<b>OLDER BIRDS:</b>			
1.0.....	**.....	5.600	14.16
3.0.....	**.....	—1.640	20.83

\* Indicates storage.  
 \*\* Data not yet available.

The influence of mammalian parathyroid extract, the female sex hormones theelin and estradiol, and a group of avian preparations made from (1) sexually active females and (2) young cockerels in the blood calcium level of immature stock and adult sexually inactive females has been studied. The

avian preparations administered consisted of pituitaries, adrenals, thyroids, parathyroids, whole blood, blood plasma, and cells. Negative results were obtained with all preparations with the exception of massive doses of theelin and estradiol. No increase was observed in the blood calcium level of immature pullets (0.8 Kg.) when as much as 1,750 rat units of theelin per kilogram were injected over a 15-day period. On the other hand, 1,000 R. U./kg/day for 31 days caused a transitory increase on the seventh day with a return to normal, while twice this dosage caused a continual rise from 8 to 40 milligrams calcium per 100 ml. blood.

In another experiment, 4,000 R. U./kg/day of estradiol benzoate caused an increase from 9 to 18 mg. calcium in 100 ml. blood, while a simultaneous balance study failed to show any abnormal calcium storage. Inspection of the bones indicated an abnormal calcification of the femur in the injected birds, but the analysis of these bones and similar controls show no striking abnormality.

The injection of a group of avian preparations from immature birds into sexually active hens with a high blood calcium level, has shown that the adrenal gland contains a principle capable of depressing the blood calcium level of the laying hen. Neither 1 c.c. of commercial cortin (Eschatin) nor 1 c.c. of adrenalin duplicates this effect, indicating that an unknown hormone is present.

3. *Lipid Metabolism.*—Pullets which had been hatched from “carotenoid free” eggs and fed on a “carotenoid free” diet were fed or injected intravenously with an emulsion of egg fat in water, which contained known and equal amounts of xanthophyll and carotene. The birds were killed at various lengths of time after the administration of colored fat, and the blood, liver, ovary, gastro-intestinal tract, and its contents all analyzed for the pigments administered. It was found that carotene was absorbed from the intestine much more slowly than xanthophyll. When the fat is injected directly into the blood stream, the carotene is removed more rapidly, is deposited in the liver, and apparently destroyed there, presumably by conversion to vitamin A. Six hours after 1 mg. of each pigment had been injected, half the xanthophyll could still be found in the blood and liver, while only five percent of the carotene could be found. No carotene was found in the ovary.

(Project 198; Department of Chemistry. Leaders, R. M. Conrad, H. M. Scott; Bankhead-Jones fund.)

*Influence of Hybridization upon Vigor in Poultry.*—Work on this project has included two different tests. One involved reciprocal crosses of New Hampshires and White Leghorns and the other matings of White Leghorns and Barred Plymouth Rocks to the same strain of Rhode Island Reds. In each case proper pure-breeds were carried for comparison with the different types of hybrids.

As usual the measures of vigor in the comparisons were chick mortality, eight-weeks weight, adult weight, egg weight and egg production. In the New Hampshire-White Leghorn crosses each of the purebred strains was rather poor egg producers and hybridization seemed to do little to improve it. Chick mortality was improved in the hybrids over the purebreds. The sex-linked nature of age at sexual maturity was well shown.

The mating of Rhode Island Red, Barred Plymouth Rock and White Leghorn males to the same group of Rhode Island Red females produced the birds for comparison in the second phase. There was definite improvement in chick mortality, rate of growth and age at sexual maturity. The Leghorn-Rhode Island Red hybrids had very excellent egg production, averaging 232 eggs per year.

The final phase of this project is now in progress and the data will be completed when the pullets under test finish the year's egg record next fall, after which the project will be terminated.

(Project 173; Department of Poultry Husbandry. Leader, D. C. Warren; Purnell fund.)

***Chromosome Mapping of the Genes of the Fowl.***—One phase of this study is the accumulation of data on the mode of inheritance of new characters in the fowl. A better knowledge of these characters indicates whether they have value in the mapping of the genes of the fowl. Work was continued in obtaining additional tests of linkage among known characters and additional data on established linkage groups.

Considerable data were accumulated on the mode of inheritance of a number of characters in the fowl. These include defective flights, pink eye, duplicate, brachydactyly, syndactyly. Special emphasis has been placed on the study of various types of polydactyly in the fowl. Data have been obtained which indicate that at least three types exist in the experiment station flock.

New data have been obtained on fray and naked neck confirming the proposed location of them in known linkage groups. New tests for linkage were between duplicate and rumplessness, pink eye and crest, and pink eye and white skin. Brachydactyly was also tested with frizzling, muff and rose. No evidence was found for linkage in any of the foregoing tests.

Additional data were accumulated on the crest-dominant white-frizzling and silkie-flightless linkage groups with special emphasis on differential crossing over in the two sexes.

(Project 197; Department of Poultry Husbandry. Leader, D. C. Warren; Bankhead-Jones fund.)

***Development of Strains of General Purpose Breeds Possessing High Egg Producing and Early Feathering Tendencies.***—

It is the object of this project, which was started the past year, to develop strains of some of the more popular heavier breeds of chickens possessing early feathering tendencies and desirable egg-laying qualities. Most of the larger breeds are poorly feathered at the stage when the surplus males are to be marketed.

The initial mating of the project was that of an early-feathering New Hampshire male to late-feathering White Plymouth Rock females. F<sub>1</sub> generation males from this cross were backcrossed to White Plymouth Rock females for the production of early feather recessive white females.

The resulting early feathering females are then being mated to F<sub>1</sub> generation males from crosses of White Plymouth Rock males to early feathering high egg producing Rhode Island Reds. From this mating there should result early feathering, recessive white individuals of both sexes. A few such individuals are now at hand from which an early feathering strain of White Plymouth Rocks is to be developed.

It is planned to outcross the resulting early feathering strain of White Plymouth Rocks to both early feathering Rhode Island Reds and late feathering White Plymouth Rocks with the hope of extracting the early feathering and high producing tendencies of the former and the color and body characteristics of the latter. Due to the nature of the project, some time will be required for its completion.

(Project 212; Department of Poultry Husbandry. Leader, D. C. Warren; Bankhead-Jones fund.)

***Inheritance and Physiology of Reproduction in Mammals.***—

Additional data are being accumulated in the conformation and size inheritance experiment with guinea pigs. All of the animals involved are still being tested in regard to their feed requirements. One of the newer departures has been to test the maintenance requirements of a large number of animals. In addition, about 22 animals varying in size, age, and conformation have been tested in regard to their fat and water percentages. These have been found to vary within very wide limits, much wider than was expected.

White-spotting in guinea pigs is due to a recessive gene, but there are many specific modifiers of this gene. One of these is a dominant, which when present with other modifiers of white-spotting, produces an animal that is almost entirely white. One female has been found that is homozygous for this gene. There is also fairly satisfactory evidence that the same result can be obtained by an entirely different gene, in this case a recessive.

A new theory has been built up in regard to the inheritance of horns in sheep, particularly in the Rambouillet breed. The evidence has been obtained to a large extent from data already published elsewhere. These facts indicate that the Rambouillet breed is homozygous for the gene for horns, but in addition is homozygous for a recessive gene (*hm*, horn modifier) which causes the female to be hornless. Evidence obtained at this station shows that many of the hornless breeds such as the Southdown carry a dominant horn inhibiting gene. As a result, when a Southdown is crossed with either a Rambouillet or a Dorset, most of the offspring of either sex are hornless.

(Project 93; Department of Animal Husbandry. Leader, H. L. Ibsen; state fund.)

***Studies in the Inheritance of the Grouse Locust.***—It was found that the application of whitewash to the greenhouse windows seriously affected conditions for breeding. In the spring of 1939, sunshine was admitted to a greater extent and what is believed to be a lethal fungus largely disappeared. The whitewash was applied from 1936 to 1939 in order to reduce the excessive heat of those years.

The shading in the greenhouse which resulted seriously for *Apottetix eurycephalus* and *Paratettix texanus* favored *T. parv. penn.* It had been long observed that the first-named species were found out in the open, hot margins of ponds, etc., while the latter were collected in the shade of grasses, weeds, shrubs and trees. A laboratory experiment correlated and confirmed those field or ecological observations.

A fine collection of new specimens was made near Mitchell Lake, near San Antonio, Texas, in June, 1939. Nearly all the former color patterns were thus restored to the greenhouses and have done well.

The color patterns, long and short pronota wings, conspicuously veined pronotum and a few teratological features, such as deformed pronota and wings, abnormal abdomen and stubby pronota have been studied and data have been recorded.

It was discovered that long and short, pronota wings made a pair of Mendelian characteristics with short dominant. This condition seems to correlate with work done in South Africa with the destructive grasshoppers.

(Project 72; Department of Zoölogy. Leaders, R. K. Nabours and Florence M. Stebbins; Adams fund.)

**Effect of Climate on Inheritance of the Grouse Locust.**—During the biennium, effort has been successfully devoted to building up complexes of genes in lines to be devoted to X-ray studies and other experimentation. Three genes in a line on each of the pairs of chromosomes are now in the breeding nursery.

A number of specimens of *Apotettix eurycephalus*, *Paratettix texanus*, and *Tettigidea parvipennis pennata* have recently been X-rayed and offsprings have hatched and are now growing. Others will be X-rayed during the year.

(Project 104; Department of Zoölogy. Leaders, R. K. Nabours and Florence M. Stebbins; Adams fund.)

**Bee Investigations.**—Weather conditions during the past biennium generally were more favorable for honey production than during the preceding biennium. During the spring of 1940 the weather was more favorable than at any time during the past eight years. Colonies on scales in 1939 made net gains of from 27 to 106 pounds for the season. Investigations were continued in three phases, as follows:

1. **Feeding Substitutes for Pollen.**—Experimental colonies were fed sugar sirup as the carbohydrate food. Substitutes used for pollen, in three combinations, were: 4 parts cottonseed meal, 1 part dry skim milk; 4 parts soybean flour, 1 part dry skim milk; 3 parts soybean flour, 1 part dry egg yolk, 1 part dry skim milk.

The experimental colonies were confined in a wire screen cage and did not have free access to pollen in the field, and were confined two or three weeks before actual feeding of substitutes began in order to exhaust the available protein in the bodies of the bees to avoid false data and conclusions being obtained.

The colony fed cottonseed meal and skim milk produced three frames of brood in two and a partial third generation. There were 150 square inches of capped brood that emerged. The colony fed soybean flour and skim milk produced three frames of brood in two generations. There were 287 square inches of capped brood that emerged. The colony fed soybean flour, egg yolk and skim milk produced three frames of brood in two generations. There were 211 square inches of capped brood that emerged.

In all cases the number of adult bees reared was not sufficient to maintain or increase colony population. Such pollen substitute combinations would be valuable in the continuation of brood rearing in spring or summer pollen droughts.

2. **Management of Two-queen Colonies.**—The management of two-queen colonies for greater honey production with fewer colonies was begun in May, 1938. This work has been carried on during the biennium and such colonies produce twice the amount of honey as do one-queen colonies. After the honeyflow is finished the older queen is removed and the colony equipment reduced in preparation for winter. More pollen stores are gathered by such colonies in the fall, which is an aid in colony build-up in the spring. These colonies have large populations and thus go into the winter in a strong and better condition. These colonies, when protection is given, such as "overcoat" cases, are strong in the following spring and rapidly build up large colony populations.

3. **Testing Queens of Superior Strains.**—Late in the summer of 1939 the testing of queens of superior strains in regard to supercedure, vitality, ability to produce strong colonies and honey production was begun. The work has not progressed far enough to report results.

(Project 126; Department of Entomology. Leader, R. L. Parker; state fund.)

**DISEASES, INSECTS AND OTHER PESTS INJURIOUS TO PLANTS**

The results of some of the more important work in the control of disease, insects and other pests injurious to plants are reported in the following pages.

**Cereal and Forage Crop Disease Investigations.**—The development of varieties and strains of cereal and forage crops that are resistant to the different diseases attacking those crops is an important part of the work of this station. Coöperation in these investigations has been given by the Division of Cereal Crops and Diseases, Bureau of Plant Industry, United States Department of Agriculture. The investigations during the biennium were conducted in five phases:

1. *Sorghum Disease Investigations.*—It has been learned that the fungus, *Pythium arrhenomanes*, alone may not be the sole cause of Pythium root rot of milo. It appears that some other organisms in addition to *P. arrhenomanes* and certain environmental conditions or extenuating factors may be concerned in the problem. Resistant strains of Colby and Sooner milos have been made and selection for agronomic type is under way.

Limited studies were begun on the weak-neck disease of sorghum. Isolations from infected tissue gave *Fusarium* sp. Inoculations with this and other fungi did not give typical symptoms of the disease. The cause of this disease remains unknown.

Studies on growth reactions in soils between *Pythium arrhenomanes* plus *Trichoderma lignorum* show that under certain environmental conditions the latter fungus dominates the former. In cultures on agar plates *Pythium arrhenomanes* is easily killed by *Trichoderma lignorum*. Increasing the amount of *Trichoderma* in naturally milo-disease-infested soils decreased considerably the amount of milo disease symptoms on susceptible milo plants.

2. *Wheat Disease Investigations.*—Physiological race studies of *Tilletia laevis* indicate that at least six distinct races are present in Kansas, one capable of producing 12 percent bunt on Oro, 25 percent on Hussar, and 63 percent on Berkeley Rock. It has been learned that winter wheat plants infected with bunt are less winter hardy than noninfected plants. Susceptible varieties showed very marked reductions in yield due to bunt-infected heads. Resistant varieties also showed some reduction due to the presence of the smut fungus in the plant, even though smutted heads did not occur. Yellow oxide of mercury, used as a preplanting dust, gave satisfactory control of bunt.

A large number of hard, red winter wheat hybrids in the F<sub>4</sub> involving Oro as one parent are bunt resistant. In the F<sub>7</sub> certain lines of Oro X Tenmarq and Marquillo X Oro gave zero readings for bunt. Certain of these in the uniform wheat nursery inoculated with bunt, and planted in 10 different states show marked resistance. Certain Marquillo X Oro and Marquillo X Tenmarq are especially promising, as they combine in one cross disease and insect resistance. Besides bunt resistance, certain of these hybrids are resistant to stem rust, leaf rust, and Hessian fly as well. Members of the Departments of Botany, Entomology, and Agronomy are coöperating in these studies.

Inoculation tests with *Septoria nodorum* indicate that this fungus is capable of causing nodal lesions on wheat resembling those associated with crinkling of joints and breaking over of straw so prevalent in the 1938 Kansas wheat crop. A species of *Macrosporium* was found to be associated with a head-rot of wheat following drought injury in central Kansas.

There is additional evidence that phosphorus is rather effective in controlling take-all disease of wheat. Yields have been increased from 4.7 to 22.2 bushels per acre by the use of this fertilizer.

The control of take-all by chicken manure is due to its effect on *Ophiobolus graminis* rather than on the wheat plant.

With respect to seasonal behavior of the dry-land foot-rot, it was found that midseason rains greatly increase the occurrence and severity of the lesions and these become more numerous and severe throughout the spring and summer growing season. Kawvale X Tenmarq (C. I. 11669) has been found somewhat resistant to dry-land foot-rot.

Studies on biological control of take-all disease continue and about 20 common soil fungi have been selected from the 143 isolated and these have been specifically identified. A method of culturing these in sterile soil and in soil previously inoculated with *Ophiobolus graminis* has been worked out and used in determining the antibiotic effects of these fungi on *O. graminis*.

Thirty-four strains of *O. graminis* have been isolated from various points in central Kansas, and found to vary widely in pathogenicity. Tests with antagonistic soil fungi in artificially infested take-all soil, indicate that the antibiotic or protective effect is much more marked against a moderately pathogenic strain than against a virulent strain of *O. graminis*.

3. *Oat Disease Investigations.*—Using seven differential oat varieties, two distinct races of *Ustilago laevis* and six distinct races of *U. avenae* have been identified. A race or races of *U. avenae* are known to attack Fulton oats severely. How widely such races are distributed in Kansas is not known, but it explains how a resistant oat as Fulton may appear to "lose" its resistance over a period of years. Fulton has made a satisfactory record in the uniform oat nursery when inoculated with smut from various sources and planted in 15 different regions of the United States.

4. *Alfalfa Disease Investigations.*—A bacterial leaf and stem disease of alfalfa, new in Kansas, occurred in plantings in the greenhouse where it did extensive damage. It was identified as due to *Pseudomonas alfalfae*. The cause of the black stem disease as it occurs in Kansas has been determined. The technique for selecting resistant strains of alfalfa to this disease has been developed.

Work on obtaining selection with combined resistance to bacterial wilt and black stem is planned. The life history of alfalfa rust, *Uromyces striatus*, and methods of infections and control of the disease are being studied. Certain phases of the alfalfa disease investigations are cooperative with the Department of Agronomy and joint publications are planned.

5. *Cereal Disease, Wheat Bunt and Oat Smut Nurseries.*—These nurseries were grown as in past years and serve to show the reactions of varieties of cereals, selections and promising hybrids of wheat and oats to the common diseases affecting these crops in Kansas, such as smuts, rusts, powdery mildew, black chaff disease, Septoria-spot and blotch, and any other disease that may become epiphytotic because of favorable conditions. Uniform nurseries of wheat and oats, devoted to bunt and oat smut studies, were planted in cooperation with the Division of Cereal Crops and Diseases. These tests gave the reactions of promising varieties, hybrids and selections to these diseases, and help to determine their value as satisfactory varieties or parents for breeding purposes.

(Project 76; Department of Botany. Leaders, L. E. Melchers, H. Fellows, D. B. Creager, and C. H. Ficke; state fund.)

***Fruit and Vegetable Disease Investigations.***—Work during the biennium on this project included studies on improved methods for controlling Irish potato diseases through seed treatment, investigation on sweet-potato disease control and varietal improvement, raspberry anthracnose spraying tests and a continuation of the cucumber mosaic resistance breeding investigations.

*Potato Disease Investigations.*—Mercuric chloride has in the past consistently proved the most effective fungicide for treating potatoes used for planting stock. The results during 1938 and 1939, like those prior to 1938, indicate that dip treatments in a solution of 3 parts mercuric chloride in 500 parts



water acidulated with one percent hydrochloric acid is as effective for controlling *Rhizoctonia* as is the 10-minute soak treatment in a solution of 1 part mercuric chloride in 500 parts water acidulated with one percent hydrochloric acid.

The dip application requires considerably less time than does the 10-minute soak treatment. Quantitative mercury determinations indicate that it requires slightly more mercuric chloride to dip potatoes in the more concentrated solution than to soak them for 10 minutes in the lower concentration solution.

In 1938, 1.08 percent and 1939, 1.32 percent of the experimental potato plants in commercial potato fields in the Kansas river valley were attacked by soil-borne *Rhizoctonia*. This is comparatively a low percentage of infection by the organism, and indicates that the extremely dry field soils in the summers of 1937 and 1938 were unfavorable for the persistence of *Rhizoctonia* in the soil.

It was found that *Rhizoctonia* can spread easily to distances of 6 inches and less frequently to distances of 9 inches from infected seed pieces. In 1939 the spread of *Rhizoctonia* during this period extended to 12 inches in numerous cases.

Decay of potato seed pieces in the soil was not severe either in 1938 or 1939. More decay occurred, however, among untreated pieces than among those that were treated with corrosive sublimate or with yellow oxide of mercury. Results in 1938 and 1939, like those of previous years, indicate that seed treatment with mercurial compounds is the most effective method for preventing potato seed piece decay.

*Sweet Potato Varietal Improvement.*—Stem rot resistant strains of Nancy Hall were tested further in stem rot infested soils. Comparisons of single hill selections were made from different lines in order that the best strain be isolated for propagation. Evidence was obtained that the two strains No. 6-2 and 11-2 are more resistant to stem rot than is the common Nancy Hall.

Prior to 1938 certain single hill selections of Nancy Hall from line M25 of the 1933 crop were noted to have roots with orange flesh color. Roots from several such single hills were saved for propagation. Through repeated isolation and through propagation of selected hills in hill units, certain lines were obtained that have deep orange colored flesh, and otherwise possess the characteristics of Nancy Hall. This orange-fleshed strain has been named "Nancy Gold" to distinguish it from the regular Nancy Halls.

Selections of Little Stem Jerseys that bear roots with orange color flesh are being propagated and compared and the most desirable of these are being increased. The orange flesh colored Little Stem is similar to the common Little Stem Jersey in all respects but root color and has been named "Orange Little Stem."

*Black Raspberry Anthracnose Control Investigations.*—Additional data were obtained that indicate the effectiveness of dormant applications of commercial liquid lime-sulfur for preventing anthracnose disease of black raspberry. Lime sulfur at a concentration of 1 part to 10 parts water controlled anthracnose more effectively than it did at the concentration of 1 to 20. Two dormant applications of liquid lime sulfur at the concentration of 1 to 10 produced considerably better anthracnose control than did a single application.

*Mosaic Resistant Cucumber Breeding Investigations.*—The hybrid cucumber developed from mosaic-resistant Chinese Long and from the variety Double Yield was continued. Pure lines of mosaic resistant slicer-type cucumber have been developed whose mosaic resistance and horticultural characteristics appear to be fixed. The pure lines are now being tested by growers in different localities for performance and quality.

Cross-pollinations of the mosaic resistant hybrid cucumber and Double Yield were made in an attempt to develop a mosaic resistant small pickle-type cucumber. The resultant hybrid was backcrossed to the mosaic resistant parent and self-pollinated seed of the resulting generation have been produced.

(Project 130; Department of Botany. Leader, O. H. Elmer; state fund.)

*A Study of Combined Resistance of Winter Wheat to Leaf and Stem Rust Races.*—Varieties, hybrids, and selections of domestic spring and winter wheats, as well as foreign introductions and species related to cultivated wheat were inoculated with important physiologic races of leaf and stem rust in experiments conducted in coöperation with the Bureau of Plant Industry, United States Department of Agriculture. Collections of leaf and stem rust were made in the field each spring and analyzed for their physiologic race content. From these the physiologic race flora of Kansas and adjoining states was determined. Many crosses were made in an effort to obtain selections with combined resistance to leaf and stem rust as well as other diseases and insects. A rust nursery containing approximately 3,000 rows of winter wheat and 500 rows of spring wheat, consisting mostly of hybrid material, was grown each year. The effect of leaf rust on the yield and protein content of winter wheat was studied in nursery sowings. Oversummering, overwintering, and epidemiology of both leaf and stem rust were studied in the field. Studies on the inheritance were made in the greenhouse.

Many winter and spring wheat selections from crosses in which Hope, H-44, or Marquillo were used as sources of resistance, exhibited a high degree of resistance to leaf and stem rust in both greenhouse and rust nursery tests. Spring wheat varieties, Renown, Premier, Pilot, Merit, Mercury, and Rival exhibited marked resistance to both rusts and therefore are valuable parental stock. Apex and Thatcher were resistant to stem rust but susceptible to leaf rust.

Three main groups of winter wheat hybrid selections were studied in the rust nursery. These were (a) winter wheat X Hope. (b) winter wheat X Marquillo, and (c) winter wheat crossed with promising rust-resistant spring wheats such as Thatcher, Renown, and selections of Ceres X Hope-Florence. Many selections from such crosses as Mediterranean X Hope, Hope X Kawvale, Hope X Cheyenne, Hope X Turkey, and Red Rock X Hope were highly resistant to both rusts, but were lacking in one or more other respects such as winter hardiness, yielding capacity, or grain texture. They therefore are being used as parental stocks in further crosses with winter wheat. Selections from five crosses involving Marquillo as the rust-resistant parent were grown in the rust nursery. Selections of Marquillo X Oro and Marquillo X Tenmarq were more promising than those from other crosses. Two F<sub>2</sub> selections of Marquillo X Oro have been found to have combined resistance to leaf rust, stem rust, bunt, and Hessian fly, and have been promoted to farm plots.

Crosses in which the spring wheat varieties, Apex, Renown, Thatcher, and Ceres X Hope-Florence, were used as sources of rust resistance still are in early generations and their promise is as yet unknown. However, it has been noted that much undesirable brown necrosis appears in crosses involving Renown as well as Hope and H-44.

Little or no leaf rust overwintered in Kansas in 1938, but there was some overwintering in 1939. Overwintering was abundant in Texas and Oklahoma in 1938 and infection appeared in Kansas unusually early. As a consequence, the most severe epidemic of leaf rust ever reported occurred in the hard red winter wheat belt in 1938. Despite some overwintering, leaf rust did not develop rapidly enough in 1939 to cause great damage. There was abundant evidence of the south to north movement of both leaf and stem rust in both seasons. Stem rust apparently did not overwinter in Kansas in either of the years.

Physiologic race 56 was the most abundant and widely distributed race of stem rust in the hard red winter wheat area in 1938 and 1939, although races

11, 17, and 38 were frequently found in 1939. A total of 16 physiologic races were isolated from field collections of leaf rust made in Kansas and near-by states in 1938 and 20 races were isolated from similar collections made in 1939. Physiologic race 9 was by far the most prevalent race in both years. Races 15, 19, 28, and 37 also were important ones in 1938 while races 15, 28, and 105 were fairly abundant in 1939. A composite of all of the races isolated in greenhouse studies were used as inoculum in producing artificial epidemics in the rust nursery.

The inheritance of resistance to leaf and stem rust was studied in the greenhouse. In a Mindum X Oro Cross very abnormal segregation for resistance to leaf rust was observed in  $F_2$ . This apparently was due to floret sterility in  $F_1$ , caused by incompatibility. Resistance seemingly was recessive and due to a single main factor difference. In several compound common wheat crosses seedling resistance to leaf rust was recessive while adult plant resistance was dominant, each explainable on the basis of a single main factor difference. Resistance to stem rust in the same plants was dominant and apparently due to two main factors. Resistance to both rusts was clearly independently inherited.

The effect of leaf rust on the yield and protein content of grain was studied in 15 resistant and 15 susceptible lines of Cheyenne X Kawvale and 9 resistant and 9 susceptible lines of Oro X Kawvale. In 1938 susceptible lines yielded 27.3 percent less than resistant lines, had an average kernel weight reduction of 15.78 percent, and had an average of 1.4 percent less protein in the grain. The straw of susceptible lines also was severely broken over at the uppermost nodes. While yields were not reliable in 1939 due to hail damage, the kernel weight of susceptible lines was reduced 6.83 percent, and they had 0.45 percent less protein than resistant lines.

(Project 171; Department of Botany. Leaders, C. O. Johnston and L. E. Melchers; Purnell fund.)

**Breeding for Disease Resistance in Wheat, Oats, and Sorghum.**—This project was organized in 1938 in cooperation with the Bureau of Plant Industry, United States Department of Agriculture. During the biennium an endeavor has been made to assemble strains and varieties of the various crops which are resistant to the many diseases that are hazards to their production. Numerous crosses have been made to combine resistance and good agronomic performance. A number of strains already on hand or hybrids nearly ready for advancement when the project was started have been tested in the Agronomy Nursery for agronomic characters. Disease reactions of varieties and hybrids under epidemic conditions are studied in the Botany Rust and Smut Nurseries conducted by the coöperators.

*Winter Wheat.*—Leaf rust and loose smut were of importance under natural conditions in the Agronomy Nursery in 1939. Leaf rust varied from a trace in resistant hybrids involving Marquillo, Kawvale, Hope, Mediterranean, etc., to over 70 percent for susceptible varieties such as Turkey, Oro, Kanred, Cheyenne, etc. It is evident that many strains now being tested have practical resistance to leaf rust.

Hail partially destroyed the crop in 1939, but several strains of disease-resistant, winter wheat yielded more than Turkey and Tenmarq and had a higher test weight per bushel.

A soft red winter wheat nursery was grown near Columbus Kan., where many hybrid strains involving Hope, Mediterranean, Marquillo, Kawvale, and other resistant stocks were tested for agronomic characters. Several strains with soft kernel type were advanced for tests in 1940.

Segregating populations were studied in the special rust and smut nurseries. Resistant selections having satisfactory appearance agronomically were advanced for further tests. Stocks having resistance to Hessian fly are being used also in practically all of the hybrids.

*Oats.*—Several crosses supplied by the Division of Cereal Crops and Diseases, Bureau of Plant Industry, United States Department of Agriculture, are being used to develop disease-resistant oats adapted to Kansas. These crosses are: Fulghum Sel. X (Victoria X Richland), (Fulghum X Markton) X (Victoria X Richland), and (Kanota X Markton) X (Victoria X Richland). The crosses were in the  $F_2$  and  $F_3$  generations in 1938 and strains resistant to smut and stem and crown rust with Kansas adaptation have been selected. A number of strains are being tested in small nursery plots for their agronomic characters in 1940.

*Sorghums.*—In breeding sorghums to develop a smut-resistant forage sorghum, Atlas sorgo was crossed with (Red Amber X Feterita). A number of smut-resistant lines have been obtained, most of which are not equal to Atlas in plant characters. These lines will be backcrossed to Atlas in an attempt to improve their agronomic value.

A smut-resistant grain sorghum was selected several years ago from the cross, Blackhull kafir X Spur feterita. The strain proved unsatisfactory and was therefore backcrossed to Blackhull kafir. The  $F_3$  and  $F_4$  generations were studied during the biennium and several promising smut-resistant strains have been selected. These have been again backcrossed to Blackhull kafir in order to develop a smut-resistant grain sorghum resembling Blackhull kafir.

Darso sorghum is well adapted to certain areas in south Central Kansas, but is objectional because of the bitter seed and because it is also susceptible to the milo disease. Darso was crossed with Dawn kafir and Western Blackhull kafir. Resistant strains of sorghum with white and red grain which appear promising have been selected from this cross and are now in plot tests at several locations in the state.

(Project 207; Departments of Agronomy and Botany. Leaders, L. P. Reitz, E. G. Heyne, L. E. Melchers, D. B. Creager, and C. O. Johnston; Bankhead-Jones funds.)

*Climate and Injurious Insect Investigations.*—The work during the biennium has consisted of the following: (1) Preparing and publishing the annual insect population summaries; (2) preparing a summary of grasshopper population, 1850-1940; (3) a study of high soil and air temperatures in relation to insects on alfalfa and other plants and on the ground; and (4) a study of insect population in relation to weather and behavior variations in connection with other studies.

The year, 1938, was the eighth in the drought cycle beginning in 1931. Precipitation during the year from April to August was normal or more, but drought conditions prevailed in the state during the spring, and extreme drought from September until the close of the year, particularly in central and eastern Kansas.

The following insects were in outbreak in 1938: Apple grain aphid, melon aphid, beet webworm, blister beetles, flat-headed borer, crambids, striped cucumber beetle, army worm, pale western cutworm, grasshoppers, squash bug, wheat white grub. The following forms and most of those mentioned above were more numerous than in 1937: Pea aphid, redbud aphid, locust borer, boxelder bug, mourning cloak butterfly, cankerworm, chinch bug, codling moth, army cutworm, clover cutworm, false wireworm, screwworm flies, Hessian

fly, leaf hoppers (*Empoasca* and *Erythroneura*), maple worm, mosquitoes, polistes wasp, American sawfly, rose slug, common stalk borer, silverfish, stored grain insects, strawberry insects, sheep-head maggot, wheat strawworm, and the garden webworm.

The following species were approximately as plentiful as in 1937: Ants, green bug, bagworm, black cricket, botflies, clover-leaf weevil, cotton cutworm, onion plant bug, poultry pests, sphinx moths except tomato horn worm, termites, wheat-stem maggot, white grubs, and the carrot beetle.

The following species were scarce or practically absent in 1938: Corn-leaf aphid, corn-root aphid, and the corn-root worm.

The following species, in addition to the above, were less plentiful than in 1937: Cattle grubs, corn billbug, corn-ear worm, fall army worm, biting flies, house flies, biting and sucking lice, tomato horn worm, and wireworms.

The following insects were in outbreak in 1939: Greenbug, pea aphid, elm-leaf aphid, blister beetles, cankerworms, pale western cutworm, false wireworm, wheat white grub, screwworm flies, grasshoppers (west only), brown mites, red spiders, chiggers, cedar scale, squash bug, and wheat white grub (spring).

The following forms and most of those mentioned above were more numerous in 1939 than in 1938: Corn seed beetle, ailanthus webworm, boxelder aphid, cabbage aphid, cottonwood petiole gall aphid, apple leaf skeletonizers, common stalk borer, boxelder bug, cattle grubs, codling moth, Colorado potato beetle, chinch bug (fall), wheat head army worm, fleas, green June beetle, harlequin bug, chiggers, clover mites, common pentatomids, silverfish, tarnished plant bug, tomato horn worm, wheel bug, *Triatoma*, and stored wheat pests.

The following insects were approximately as plentiful in 1939 as in 1938: Yellow ant, alfalfa caterpillar, carrot beetle, clover-leaf weevil, pale western cutworm, corn-ear worm, variegated cutworm, black cricket, false wireworm, wheat white grub, biting flies, screwworm flies, leaf hoppers on grape, woodbine, spirea, and roses, brown mites, red spiders, rose slug, cedar scale, southern corn-root worm, termites, beet and garden webworms.

The following insects were scarce or practically absent in 1939: Cutworms, especially army and common garden species, Hessian fly (in spring), rose sawfly, and the wheat-stem maggot.

The following species in addition to those above were less plentiful in 1939 than in 1938: House ants, kafir ant, melon aphid, blister beetles, flat-headed and other borers, grasshoppers, Hessian fly (in fall), horse flies, onion plant bug, peacock butterfly, rose bud worm, American saw fly, striped cucumber beetle, squash bug, walnut worm, wheat saw fly, white grubs and wireworms.

Experimental and further analytical work was done on the problem of "effect of high soil and air temperatures on certain alfalfa insects." This study was begun in an effort to determine what happens to the insects of an alfalfa field when the alfalfa is mowed. It has been found that soil surface temperatures above 120° F. are fatal in proportionately shorter time. Death results at soil temperatures of 140°, for example, to small larvae in a fraction of a minute. There is a wide variation in the degree of resistance to high, lethal temperatures by the large larvae.

It has been found that there are frequent overturns in temperature above the surface of the soil. On some days in summer the soil surface is cooler than the air 12 to 24 inches above the soil while on other days the reverse occurs. On cool days, many insects crawl to the tops of plants while on hot days they may be on or near the ground. These overturns may occur during the day.

The "Summary of Grasshopper Populations in Kansas from 1850 to 1940" has been written except for several pages of analysis.

(Project 6; Department of Entomology. Leader, Roger C. Smith; Hatch fund.)

**Hessian Fly and Other Wheat Insects.**—Insects studied during the biennium included Hessian fly, sawfly, wheat strawworm, bee fly, wireworm, and wheat white grub.

In the fall of 1938 and during 1939, due to dry weather, the Hessian fly population in the neighborhood of Manhattan continued at a low level. Isolated infestations were located in 1939 near Navarre, Junction City, Wheeler, Ramona, and at a few localities in south-eastern Kansas. Late fall infestations taking place after the fly-free date were frequent both years. At Ramona the infestation carried a considerable percentage of parasitism by three species of parasites. No summer generations were observed. In the early summer of 1939 a heavy and unusually late outbreak of green bugs in wheat was studied throughout central Kansas.

Infestations by the wheat strawworm, *Harmolita grounds*, have been secured in variety-depth-of-planting plots. Heavier infestations were secured on the more shallow planted wheat. There was further evidence of resistance in certain wheat X rye hybrids. In the latter the eggs of the first generation of wheat strawworm were laid and larvae hatched in the young tillers which were often stunted, but rarely, if ever, contained large larvae.

Collections of grasshopper eggs and parasites and predators have been secured for rearing. Especial attention has been paid to larvae of bee flies, (*Bombyliidae*). In 1938, eight specimens were reared and in 1939, 122 specimens emerged from 390 larvae received. Three species are represented.

**Subterranean Insects.**—Besides a large number of beetles collected and retained for rearing purposes, 300 beetles were dissected in 1939 and the parasitic fly larvae counted and reared to adults. As many as five fly larvae were found in one beetle. The entire contents of the abdomen were destroyed. In many females, both fly larvae and the eggs were found within the abdomen. Counts of the number of eggs in the abdomen of the unparasitized females indicated that 30 was about the number of eggs present at one time. Fewer eggs were found in the parasitized beetles. It was also found that the males were more heavily parasitized than the females. An explanation for this may lie in the fact that the flies can attack and deposit eggs on the body of the males when they have their wings expanded in flight. Flies were observed following the males in flight.

Three species of flies not previously reported attacking *P. lanceolata* Say, were reared: namely, *Sarcophaga kellyi* Ald., *S. misera* var *sarenioides*, *S. cimbicis* Tns. *Muscina stabulans* Zett. *Sarcophaga prohibita* was the only species which had been reported previously attacking wheat white grub adults.

(Project 8; Department of Entomology. Leaders, R. H. Painter and H. R. Bryson; Hatch fund.)

**Corn-ear Worm and Other Insects Injurious to Corn.**—Studies were continued during the biennium with the corn-ear worm and other insects injurious to corn, including sugar cane rootstock weevils.

Studies of the oviposition of the corn-ear worm on silks of sweet corn were made during the 1939 season. A series of 304 sweet corn ears were observed daily from the first appearance of the silk until the silk was over half dry. A surprisingly large number of eggs were deposited after the silks had started to dry. The color of the silk appeared to have no significance on oviposition.

Injury to corn seedlings by the common field cricket was observed in Neosho county in May, 1940. Nearly all plants in the field had been attacked and fully 50 percent destroyed.

Records of the mass flights of a pentatomid, *Thyanta custator*, which occurred on the night of October 14, 1938, were secured from 12 localities situated on a direct northeast to southwest line across the state. This insect has been observed feeding on corn as well as on numerous cornfield weeds. There were reports of a few large swarms in widely different regions again in 1939.

Chinch bugs were considerably below normal in abundance during the summer of 1938. Those that went into hibernation during the winter of 1938-'39 survived with only slight mortality. The first generation of bugs produced in the wheat and barley fields were not in sufficient numbers to injure the early small grains.

Environmental conditions in wheat and barley fields during the spring of 1939 were favorable to the development of the chinch bug, but the maturity of the small grain was retarded. As a result of this combination of ecological conditions, the first-generation bugs became adults before the small grains matured. Before harvest and after harvest these adults flew to the fields of young sorghums and corn where the second generation developed an enormous population. When the nymphs of this generation became adults, the latter migrated by flight to late-planted corn and sorghums where they continued to feed until the sorghums and corn were harvested. Injury to late sorghums or corn by the attacks of adult bugs migrating by flight from old plants to late plants has not been recorded before.

Adults attacking sorghum plants in the variety nursery at the Agronomy Farm were dusted with calcium cyanide without injury to plants when applied from 6 to 10 a. m. and when the wind velocity was not too high. The dust proved too expensive to use on a field scale.

One of the sugar-cane rootstock weevils, *Anacentrinus deplantus* Cdy., was found attacking a row of Shantung Kaoliang growing in the sorghum variety nursery. Pupae and adult weevils were found in the cavities within the stalks. This is the first report of these weevils attacking sorghum in Kansas. Previously the beetle had been reared from larvae found in barnyard grass *Echinochloa Crus-galli*.

The larvae hollow out cavities in the lower part of the sorghum stalk near the crown, and destroy the conducting tissue. Stalks so damaged failed to produce seed and lodged badly. Apparently, only one generation of beetles is produced. Milo, Kaoliang, African kafir, feterita, and hegaria were attacked more than other varieties. The larvae change to pupae in these cavities and emerge as beetles about August 5 to 10. No correlation has been established between the infestation occurring in the sorghum and the prevalence of barnyard grass in the vicinity of the sorghum field.

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

**Fruit and Vegetable Insect Investigations.**—Work was continued during the biennium on this project to include studies of fall and spring crankerworms, redbud aphid, redbud whitefly, leafhoppers on the redbud and juniper midge. A brief summary of the observations made are as follows:

**Cankerworms.**—These insects have caused considerable damage to unsprayed apple, elm, hackberry and honey locust trees in the eastern half of Kansas during the biennium. In Manhattan and many other cities lead arsenate sprays have controlled these insects on the shade trees. Poorly sprayed orchards had slight damage to leaves.

The first fall cankerworm female was trapped January 9, 1939, and February 15, 1940. The bulk of the emergence in 1939 came during the first week in March and that for 1940 during the last two weeks of March. In 1939, the greatest number of female moths trapped on any one tree was 76 fall and 214 spring or a total of 290 females. In 1940, the greatest number of female moths trapped on any one tree was 20 fall and 279 spring or a total of 299 females. The greatest number of females on any tree in one day was 25 spring cankerworms on March 14, 1939, and 41 spring females on March 19, 1940.

*Redbud Aphis* (*Aphis pawneeae* Hottes).—This insect was first discovered in Kansas in 1934 on a redbud plant above the soil. In 1936 it was found on the roots of a plant and attended by the ant *Crematogaster missouriensis*. This aphid was again found on a plant above the soil in the spring of 1938. In November of 1938, eggs of this insect were found on the underside of branches. This insect was not seen in 1939.

*Redbud Whitefly*.—During the late summer and fall, redbud leaves became infested with this whitefly (*Trialeurodes* n. sp.). This insect disfigures the leaves by sucking out the sap and causes a spotted brown mottling of the foliage. An identification of this insect has been made as a species of *Trialeurodes* near the species of *vaporariorum* (Westwood), which is the common whitefly. Collections were made in 1939 and further collections are to be made for additional specimens for determination.

*Leafhoppers on the Redbud*.—Collections of several species of these insects were made at intervals throughout the season of 1939 for determination. Further collections are to be made for the same purpose. The nymphs cause a silver brown discoloration of the leaves of the plant by sucking out the sap.

*Juniper Midge*.—This new minute, brownish-orange fly (*Contarinia juniperina* Felt) has been infesting junipers for several years and was recently recognized as the causative agent of the injury.

A partial study of the biology and control of this insect was made in 1939. The larvae infest the tips of the twigs and as they become mature, drop to the soil for pupation. Soil fumigation by the use of ethylene dichloride, paradichlorobenzene and dichloroethyl ether were successful in the control of the mature larvae and pupae.

(Project 13; Department of Entomology. Leader, R. L. Parker; Hatch fund.)

***Insects Attacking the Roots of Staple Crops***.—Insects studied on this project during the biennium have included *Melanotus* larvae, wireworms, white grubs and the species of *Elateridae* found in Kansas. Notes on the identification of soil insects by their burrow characteristics have been summarized and published.

*Melanotus* larvae studied do not migrate in the soil farther than necessary for food or other suitable environmental conditions. Observations in the field indicate that they do not disperse rapidly from an infested plot to an adjacent uninfested one. This habit no doubt accounts in part for the fact that spotted infestations often occur in fields after a period of two or three years.

Field observations regarding the burrowing habits of soil insects indicate the burrowing insects which construct definite burrows and bring excavated soil to the surface may be identified by these burrow characteristics which are fairly definite for the species.

Progress was made toward the completion of a phase of the project dealing with the *Elateridae* of Kansas. This phase is to be quite comprehensive and is to include illustrations and drawings of typical representatives of the species attacking the roots of staple crops in Kansas. Life history studies are to be included with the amount and nature of the damage done, the ecological conditions which tend to build up wireworm infestations and the relation of these conditions to farm practices.



Life history studies of wireworms and white grubs were continued. Three years were required to complete the life cycle. A summary of the number of eggs deposited by *Melanotus fissilis* indicates that an average of 250 eggs may be deposited over a period of two weeks. The average amount of time required for the eggs to hatch was 10 days with very little variation above or below this average.

Flies reared from Southern corn root worm beetles, *Diabrotica duodecimpunctata* were identified as *Celatoria diabrotica* Shim., *Phyllophaga submucida*, which ordinarily is found in greatest abundance on high prairie land, but it was found abundant on an area of low ground which had been wheat land but had been permitted to become weedy. The ecological studies on corn at the Agronomy Farm showed this species attacking corn on tile-drained land.

Wireworm injury to corn has diminished during the past dry years. Reports from elsewhere in the state indicate less injury to corn than in years of normal rainfall. Diggings on various areas showed no white grubs in plots which had been in sweet clover or a pure stand of alfalfa for a period of two years.

(Project 100; Department of Entomology. Leader, H. R. Bryson; Hatch fund.)

***Insects Injurious to Alfalfa, Grasses, and Allied Plants.***—

Two groups of problems were given attention in this project during the biennium: Timely and urgent problems which demanded immediate investigation as well as a continuation of general studies on control of primary and secondary pests of alfalfa and other forage crops. A partial review of the results obtained and observations made follow:

Grashoppers lived longer when confined on castor bean plants than when starved or fed on water only. The foliage was unattractive to grasshoppers and, when given a choice, they ate other kinds of crop plant foliage in preference to castor bean foliage.

During studies on the "soil webworm" (*Nomophila noctuella* D. & S.), it was observed that there were several larvae in the same habitat closely resembling it but differing in spotting and setal patterns. Rearings showed that many spotted larvae forming silken tubes in soil were sod webworms or Crambids. It was found that *Crambus vulgivagellus* Clem. was the most abundant species near Manhattan, but *C. mutabilis* Clem. and *C. hemiochrellus* Zeller were plentiful in grass land also.

Studies on the "rapid plant bug" (*Adelphocoris rapidus* Say) were completed. This bug is common in alfalfa and clover fields. The species winters here most likely in the egg stage, though adults probably survive in some states.

The study on identification of grasshopper eggs by the sculpturing on the chorion was completed and published. Slides were made of one-fourth sections of the eggs of known identity of 48 species of midwestern grasshoppers. A characteristic section of each egg was described and photographed.

Cage and field studies on the tarnished plant bug were continued both years of the biennium. The severe loss of alfalfa blossoms and buds and of shriveled, imperfect seeds caused by feeding on the seed pods, has been repeatedly demonstrated. In seven of the eleven alfalfa cages containing a varying number of bugs, no seed pods formed in the cages containing the insects. In the other four cages no more than 11 percent of the blossoms developed seed pods. The development of seed pods in the check cages varied from 30 to 100 percent of the blossoms.

In the experiments with sweet clover, the results were even more definite. No seed pods were formed in eight of the nine insect cages. Development in the other cage was only 2.5 percent. The damage under normal conditions,

is much less extensive. However, under severe infestations the seed production is undoubtedly reduced materially.

The great increase in the cactus borer (*Melitara dentata* Grote) made some studies on it advisable. The light gray to bluish caterpillars bore through the leaves and kill the cactus plants, freeing the area for pasture grasses. When mature, the larvae left the burrows and spun grayish silken cocoons on the leaves. Several unusual syrphid flies, notably *Copestylum marginatum* and *Volucella* sp. were reared from infested plants. A cerambycid borer, *Monolema annulatum* Say also destroyed many clumps in western Kansas.

(Project 115; Department of Entomology. Leader, Roger C. Smith; state fund.)

**Study of the Biology and Control of Fruit and Vegetable Insects.**—A study of the biology and control of the strawberry leafroller (*Ancylis comptana fragariae* W. & R.) has been practically the only phase of work active on this project during the biennium. Observations were continued on the life habits of the leafroller and an attempt had been made to synchronize control measures with those habits to obtain maximum effectiveness.

Straw mulch on strawberry plants tends to spread the time of pupation and adult emergence. The first generation eggs are laid on leaves nearest the ground or on leaves that are available at the time of oviposition.

Of the eight insecticide combinations used for control of the first generation, lead arsenate applied before blooming and then followed by nicotine sulfate plus summer oil emulsion combination sprays was the best control method; effectiveness varied from 92 percent to 96 percent. Nicotine sulfate plus summer oil emulsion combination gave the excellent control of 84 to 96 percent. Pyrethrum dusts containing 0.2 to 0.5 percent pyrethrins provided good control with the 20 percent Pyrocide dust (0.4 percent pyrethrins) giving 94 percent control.

Lead arsenate or cryolite, plus summer oil emulsion, produced good control in the second and third generations in all kinds of cultural treatments when applied to attack the larvae on the underside of the leaves.

Summer oil emulsion should not be used at a stronger dosage than 1 pint to 50 gallons of water or spray mixture.

The above control measures are advocated for the one-crop plan of production of strawberries.

(Project 187; Department of Entomology. Leader, R. L. Parker; Purnell fund.)

**Study of the Biology and Control of the Codling Moth.**—Studies in the biology and control of the codling moth (*Carpocapsa pomonella* L.) have been carried on in the Blair experimental orchard during the past four years. Under drought conditions the use of lead arsenate without a sticker or spreader has produced good control. Under humid conditions, the use of a sticker is recommended.

Four lead arsenate combinations and basic copper arsenate were used as sprays for control during the season of 1939. Lead arsenate summer oil emulsion and lead arsenate soybean flour combinations also produced good control. The basic copper arsenate, a new insecticide, appeared to give good first brood control but was the poorest in control at the end of the season. Soybean flour at the rate of one-fourth pound to 100 gallons of spray mixture caused no noticeable leaf injury. Calculated on a percentage basis of clean

fruit, produced at the end of the season of 1939, the ranks are given in the following table:

Percent clean apples	Insecticide treatment per 100 gallons of water
98.9	Lead arsenate 4 pounds, plus Spraysoy A ¼ pound
89.3	Lead arsenate 4 pounds, alone
89.3	Lead arsenate 4 pounds, plus zinc sulphate ¼ pound, plus Orthol K oil 1 quart
86.0	Lead arsenate 4 pounds, plus Orthol K oil 1 quart.
46.7	Flask copper arsenate 4 pounds, alone

Samples of apples from all the plots were analyzed for arsenic before washing and after commercial and laboratory washing. The commercial wash did not reduce the arsenical residue below the tolerance of 0.01 grain per pound of fruit, due to faulty maintenance of acid content, of the wash. The laboratory washing removed the arsenical residue below the tolerance.

(Northeast Kansas Experiment Fields; Department of Entomology. Leaders, R. L. Parker and P. G. Lamerson; state fund.)

**Resistance of Crop Plants to Insect Attack.**—The work of the project has been primarily concerned with the development of wheat resistant to the Hessian fly and particularly the transference of the resistance of Marquillo and other spring wheats to wheats of winter growth habit. Studies of the resistance of corn to corn-ear worm have been continued. Records have been made of differential infestation of other crop plant varieties by a number of insects as opportunities were available.

**Resistance to Hessian Fly in Wheat.**—Duplicate nurseries of more than 1,000 strains of wheat varieties and hybrids have been studied at Manhattan, Kan., and Springfield, Mo., in coöperation with the Bureau of Entomology and Plant Quarantine.

At Manhattan in June and July, 1938, records were obtained and fly-free plant selections were made from a number of varieties of spring wheat following a late fly infestation which gave practically no spring infestation on winter wheat. The hot, dry weather of the fall of 1938 and 1939 and spring of 1939 resulted in rather low and sometimes nonuniform infestations of fly at Manhattan. Selections were made in the spring of 1939 on the basis of agronomic characters and fly infestation obtained at Manhattan and Springfield. In the fall of 1939 the recently installed sprinkling system made possible a Hessian fly infestation in the nursery at Manhattan while none occurred in near-by areas in Kansas. Among the uniform checks Tenmarq had 43 percent of the plants infested, Kawvale 3 percent and Marquillo X Tenmarq 1 percent, while many hybrids involving Marquillo or other fly resistant spring wheats had no infestation.

At Springfield, the 1939 fall fly infestation was highly satisfactory for experimental study; for among 333 F<sub>1</sub> compound hybrids involving Marquillo which were previously selected for resistance, 72 percent lay within the range of the resistant parents, only 6 percent in the range of the susceptible parents and most of the remainder were still segregating. In this same nursery 53 F<sub>1</sub> Marquillo hybrids, many of which are in the rod row Agronomy Nursery, were tested in the dissection series. Of these, 47 had no infestation, four had below 15 percent of the plants infested, two were still apparently segregating for fly resistance, while 22 susceptible varieties and winter parental checks had from 75 percent to 100 percent plant infestation.

In the greenhouse and field, evidence has been found that there are at least three genetic factors or factor groups resulting in fly resistance among the common spring wheats. Certain crosses involving a spring wheat parent have, in F<sub>1</sub>, been susceptible to hard wheat belt fly and resistant to soft wheat belt

fly in two separate tests. This appears to be additional evidence of the presence of biological strains of fly.

A large group of Marquillo hybrids have been given limited advanced tests in the Agronomy yield nursery. Crosses with Oro and Tenmarq have been particularly promising while those involving Kawvale, Minturki and Kanred X Hard Federation are of lesser promise. The Marquillo X Oro strains were most numerous in advanced stages of testing because of their general agronomic promise. Crosses with Tenmarq do not carry bunt resistance but have other desirable features. Results in 1939 are somewhat unreliable, perhaps due to a severe hailstorm, but eight strains of Marquillo X Oro gave a better yield and better test weight per bushel than Tenmarq. Two Marquillo X Tenmarq strains exceeded Tenmarq in both respects and both outyielded the best Marquillo X Oro strains. Therefore, it seems likely that resistance to pests and good agronomic type are not incompatible.

A publication summarizing the eight years' study of Marquillo and Marquillo hybrids in their resistance to fly and wheat jointworm and to stem rust, leaf rust, bunt and mildew has been prepared.

*Resistance of Corn to Corn-ear Worm.*—Additional data were obtained on the resistance of various inbreds and hybrids of field corn and popcorn to corn-ear worm in 1938 and 1939. The data secured were used along with the usual information by the agronomist in making selections for planting. Use of this information which has been available for about ten years, was perhaps evident in a recent experiment in which Kansas double-cross hybrids were compared with similar out-of-state hybrids. Without exception the Kansas hybrids all showed less injury by ear worm than did any hybrid from other states.

The more important conclusions in a summary of the results of 12 years' study of differential injury to corn by corn-ear worm are as follows:

1. Consistent tendencies toward resistance or susceptibility to ear-worm damage to ears have been transmitted to certain inbred lines of corn.

2. Length of husk and date of flowering have some influence on the amount of damage to ears, particularly in heterogonous material, but many marked breaks in the correlations appear, suggesting other and more subtle causes of differences in severity of injury.

3. Under Manhattan conditions the relatively susceptible strains appear more sensitive to the influence of date of flowering and length of husk than do the relatively resistant strains. The greater influence of these factors in open-pollinated varieties may be due to the high proportion of susceptible individuals present.

4. Differences in resistance and susceptibility to injury to the developing curl or bud of young corn plants are also apparently inherited. Such differences appear to be independent of the differences in the damage to ears by the same insect.

5. There are indications that resistance to ear-worm injury may be increased by mass selection.

(Project 164; Department of Entomology and Agronomy. Leaders, R. H. Painter, L. P. Reitz, R. W. Jugenheimer, and E. G. Heyne; Purnell fund.)

*The Effect of Different Systems of Management of Grasslands and Conservation Areas Upon the Grasshopper, Cutworm and Other Insect Populations.*—This project was put into operation April 1, 1939, and is organized into two main division—eastern and western. An area for intensive observation of grasshopper biology and ecology was established in Finney county. Work with grasshoppers and other grassland insects formerly carried on in connection with Project 115-B was transferred to this project and surveys started under that project in 1933 have been continued.

Approximately 70 percent of the total grasshopper population in the Finney county area was represented by two species, the thistle hopper, *Aeoloplus turnbulli bruneri*, and the lesser migratory hopper, *Melanoplus mexicanus*.

In a study of species and plant association, it was found that *A. t. bruneri* population was highest in areas abounding with thistles. The results of the survey in Finney county indicated the significance of the thistle hopper and the Russian thistle in the present grasshopper situation.

Data were obtained on the species and grasshopper populations of terrace intervals, terraces, and roadsides under different plant associations on Soil Conservation Service areas in Seward and Greeley counties. Only the egg survey data have been summarized and in Greeley county roadside thistle areas contained 1.8 egg pods per square foot as compared with 0.43 per square foot on unterraced fields and 0.89 per square foot on terraced fields.

Numerous tests of grasshopper baits were made and poison bran mash continued to be the most effective method. Scattering of poisoned burlap bags was tried for cricket, control in alfalfa fields, but without success. Poisoned apple peelings produced good results and will be tested further.

Other insect pests studied included pea aphids on alfalfa, blister beetles attacking alfalfa, prickly pear insects and cricket injury to alfalfa seed.

In the work in Eastern Kansas, studies on insect populations of three types of grasslands have been continued. It has been noted that as the drought years progressed there was a marked decrease of the grasshopper population in native prairie pasture and a considerable increase in the weedy Kentucky bluegrass and in the orchard brome-grass pastures.

Insect surveys were begun of certain Soil Conservation Service projects in Southeast Kansas in order to determine the effect of different practices upon insect populations. Five surveys will be made each year.

(Project 211; Departments of Entomology and Agronomy. Leaders, D. A. Wilbur, Roy Fritz, and K. L. Anderson; Bankhead-Jones fund.)

**Physiology of Reproduction.**—Work was carried on in four phases during the biennium.

1. *Studies on the Adrenal Glands of Chickens in Relation to Their Gonads.*—Continued work has confirmed observations that the removal of the adrenal glands in chickens causes the gonads to decrease to only a small fraction of their original size. The combs, wattles, and plumage change to those of capons.

2. *The Effects of Adrenalectomy on the Pituitaries of Fowls.*—The pituitaries from adrenalectomized, castrate, and normal fowls were studied in detail histologically. The pituitaries from adrenalectomized birds contained many degenerate basophilic cells. The castrate birds showed many large, active basophils of the "castrate cell" types. These two groups were compared with normal tissue. The conclusion was drawn that adrenalectomy in fowls causes the basophilic cells to become inactive, thus withdrawing the stimulus for testis maintenance. Testis degeneration causes the secondary sexual characters to change.

3. *The Effect of Male Hormone on the Developing Ovaries of Young Chickens.*—Chemically pure male sex hormone was injected into young female chickens to determine the degree of pituitary depression. Different dosages of male sex hormone were administered and for different ages, but the ovaries from all were slightly smaller than the normal control birds and the follicle development, as evidenced from studies of sectioned material, was not as great in the injected birds as in the controls. Minimal dosage was given. The conclusion was drawn that injection of male sex hormone inhibits ovarian development, and it probably does this through pituitary depression.

4. *The Response of Fowl Gonads to the Gonadatropic Substances.*—The commercial preparations of Antuitrin and Antuitrin-S have been injected into

young chickens to study the response of the gonads to these gonadotropic substances and to compare these two. Antuitrin is somewhat more effective than Antuitrin-S.

(Project 191; Department of Zoölogy. Leader, E. H. Herrick; Purnell fund.)

### DISEASES OF FARM ANIMALS

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

*Miscellaneous Animal Disease Investigations.*—Phases of this project that have received special attention during the biennium have included studies of Equine Encephalomyelitis, bovine lymphogenous leukemia, equine strongylidae, and the effect of sulfanilamide and sulfapyridine on botulism in poultry and goats. The studies on equine encephalomyelitis are being carried on in coöperation with the Horse and Mule Association of America.

1. *Equine Encephalomyelitis.*—The number of cases of sleeping sickness declined markedly in 1939 and but one case was reported for the state to our knowledge during the first six months of 1940. The western strain of the disease was the only strain recovered last season in Kansas.

An immune horse sera prepared against the Rosenow streptococcus appeared to have no therapeutic value in treating field cases of the disease in the veterinary clinic. It was found that the incubating hen's egg is a suitable medium to use in determining the presence of the virus of equine encephalomyelitis in the tick's body. It was found that the virus passes the molt from the larvae to the nymph stage in *Dermacenter variabilis* and can infect guinea pigs. The same is true in the case of *Rhiphicephalus Sanguineus*.

In repeated experiments it has been found that the virus is concentrated in lethal quantities for guinea pigs in the peripheral circulation of guinea pigs and rabbits from 24 to 48 hours after inoculation either subcutaneously or intraperitoneally and that the quantity rapidly lessens after this period to disappear by the ninety-sixth hour.

2. *Studies on Bovine Lymphogenous Leukemia.*—During the past two years there has been a marked increase in the number of cattle afflicted with lymphogenous leukemia presented at the veterinary clinic. Several veterinary practitioners have reported an increase in the number of such cases in their practice, especially during the drought years.

Blood studies are being made of the typical and atypical cases presented at the veterinary clinic to determine the value of the blood picture as a differential diagnostic aid. During this biennium a positive diagnosis based on the blood count has been rendered on 61 cattle, of which 24 have been subjected to post-mortem examinations, and in all except two cases the post-mortem findings have substantiated the laboratory diagnosis. The remainder of the 61 have been marketed by the owners or are being held by them for observation.

3. *Parasitological Investigations.*—Investigations of the incidence of equine strongylidae in this area have been completed and the results of these investigations published.

Although the true cultivation of a parasitic nematode has proved to be beyond our facilities, the influence of hydrogen ion concentration and various other environmental factors on *Strongylus vulgaris* have been studied and the results of these investigations published. Report of our discovery of a measurable rigor mortis in *Strongylus vulgaris* has been published. This gives an accurate criterion of the death time of the organism. Chemotherapeutic in-

vestigations of this type are planned for the future. An attempt is being made to test anthelmintics against parasites in their normal habitat. Results obtained by these methods are very promising. In the course of these tests a new modification of the Stoll egg count has been developed.

*Effect of Sulfanilamide on Botulism in Poultry.*—The results obtained on this phase indicated that sulfanilamide was quite toxic for chickens in dosages in excess of 20 grains when repeated or not repeated and that even 5-grain doses were detrimental. In all cases except one, loss of body weight occurred and a variable susceptibility to the drug was noted.

Two groups of chickens were starved for 18 hours and then fed botulinus toxin corn of a known toxicity in a self-feeder. As the birds began to present symptoms of botulism they were treated orally and intravenously with sulfanilamide, pepsin solution, trypsin solution, methylene blue solution, and sodium bicarbonate solution. In every case the disease terminated in death. It was concluded that the above drugs, chemicals and solutions in the amounts used have no beneficial effect in the treatment of botulism in chickens.

(Project 102; Department, of Veterinary Medicine. Leaders, J. H. Whitelock, E. E. Leasure, L. M. Roderick, W. W. Thompson, and C. H. Kitselman; state fund.)

*Abortion Disease Investigations.*—The work on this project during the biennium was devoted to routine testing of owners' cattle and hog blood samples with special study being directed toward improving the rapid test antigen and a study of the effect of a living culture Bang's abortion vaccine as an immunizing agent in cattle. An experimental group of eighteen mature cows and a bull owned by the station were used to test the vaccine. These were subdivided into four subgroups. In addition five privately owned herds were added for a similar study on the vaccine under field conditions. A brief summary of the results during the biennium are:

No agglutinin response followed the injection of the vaccine.

No abortion traceable to the vaccine could be discovered and no evidence of the strain localizing in the body of the cow or offspring could be found.

A marked opsonocytaphagic response followed the injection of the vaccine in each cow.

Following the eye exposure regardless of whether the cow was vaccinated or not the blood of the cow agglutinated in dilution of 1/200 and in either case dropped to 1/50 or lower in five to seven months.

Following the exposure to the "Tripp" strain the titer rose to 1/2400 or higher and continued positive for a year or longer.

Some of the cows bought for infection contact aborted in the herd and some had living calves, although in most of the calving Bang examinations were positive culturally. There was evidence of the existence of live Bang germs at all times during this two-year period on the premises.

The fact that two of the cows in the control group had living calves and one a weak calf during the first year speaks for a low degree of virulence of the germ or a fair degree of resistance in the cows. Two had reacted in dilution of 1/25 before the experiment started. During the second year replacement cows were added as controls and of four, three had live calves and one cow aborted dead twins in 280 days. This cow and the heart blood of the calves tested 1/50 at term, but no Bang organisms were recovered.

Summary of results in private herds:

Herd I. —The vaccinated cows are due to freshen in September. None have aborted to date, although abortions have been occurring in the infected (positive reactors) and among the unvaccinated cows.

Herd II. —The vaccine when used on old blood reactors proved valueless. On four 1-50 (suspicious) blood reactors and on seven negative cows 100

percent calf crop was obtained last year. 71 percent of the unvaccinated (control) cows calved normally during the same period.

Herd III.—80 percent of the vaccinated cows calved normally, while 47 percent of the unvaccinated cows calved normally.

Herd IV.—83.5 percent of the vaccinated cows calved normally for a two-year period compared to 50 percent of the unvaccinated.

Herd V.—Quote from owner's letter, "Not interested in going ahead with the vaccination on an experimental basis, as, in my opinion, it has proven itself on a practical basis."

(Project 135; Department of Veterinary Medicine. Leader, C. H. Kitselman.)

**Anaplasmosis Investigations.**—Studies in anaplasmosis conducted in cooperation with the Bureau of Animal Industry, United States Department of Agriculture, have included field investigations of outbreaks of the disease as to type and number of cattle affected, treatment, methods of handling, etc. Routine examination has been made of cattle that have been "carriers" from two to ten years with particular attention to blood picture.

Field trips have been made to different parts of the state for the purpose of studying anaplasmosis as to history, type of infection, breed, age of cattle affected, mode of transmission, and methods of treatment employed. In one of the herds examined, the disease was spread by means of dehorning shears and in another instance was due to natural causes.

There is yet no conclusive evidence that the use of sodium cacodylate or any other medicinal treatment has been effective in curing or alleviating the course of anaplasmosis infection in cattle.

Attempts to cure this disease in cattle, produced experimentally at our laboratories, by administration of drugs, have given negative results.

A mild type of infection was produced in a 12-weeks-old calf three weeks after the latter had been inoculated with blood from a known "carrier." "Carrier" infection was demonstrated by inoculation in one cow eleven years after recovery from acute infection, and in one steer two years after recovery from a mild type of anaplasmosis infection.

Intermittent warming and chilling of a blood sample taken from an actively infected animal apparently destroyed the infective properties of the blood even though anaplasma bodies were still demonstrable in some of the intact red blood corpuscles.

Attempts to cultivate anaplasma marginale in artificial media has been unsatisfactory, largely because dehydration of culture during incubation has not been successfully eliminated.

(Project 180; Department of Veterinary Medicine. Leaders, H. Farley and L. M. Roderick; state fund.)

**Feeder Cattle Disease Investigations.**—The work on this project during the biennium has consisted of five phases of field and laboratory studies of cattle diseases.

1. *Mineral Deficiencies of Feeder Cattle.*—The livestock owners were advised to add steamed bone meal, alfalfa and grain to the rations in instances of calcium deficiency. The addition of these products was probably responsible to a large extent for checking losses in these herds.

2. *Ensilage Poisoning.*—Composite samples of ensilage obtained from silos on farms where losses occurred when fed to sheep, a goat, rabbits and guinea pigs failed to reproduce the diseased condition in these animals. Molds and fungi isolated from suspected ensilage when prepared and fed to rabbits and



guinea pigs gave negative results. *Bacillus botulinus* toxin apparently is not a contributing factor in the production of this disease, since samples of suspected ensilage when incubated under anaerobic conditions failed to reproduce the disease in small laboratory animals.

3. *Shipping Fever*.—Strict observance of sanitation was largely responsible for relieving the diseased condition in two herds in which "shipping fever" outbreaks were reported. In two instances, *Pasteurella bovisepitica*, the organism associated with shipping fever or hemorrhagic septicemia, has been isolated from cattle. In one case it was isolated from a wound or abscess in the throat region of a cow, and in the second case from a calf affected with keratitis.

4. *Keratitis or "Pink Eye"*.—Keratitis or "pink eye" was observed among cattle in 17 herds. Acute type of infection was observed among calves in a dairy herd during February, 1939.

All ages and breeds of cattle were represented in the diseased herds. Candle filtered secretion from acute and chronic cases of "pink eye" will not reproduce the disease in susceptible cattle. Nine out of fourteen cattle repeatedly exposed to infection in screened stalls, with the use of candle filtered eye secretions, were proved susceptible when exposed with virulent eye secretions.

Three attempts to transmit "pink eye" by using flies (*Musca domestica* and *Stomoxys calcitrans*) proved negative. This experiment was conducted in outdoor screened enclosures in the presence of sunlight and wind.

5. *Cornstalk Disease*.—There is no known means of saving affected cattle with this disease other than to keep them out of stalk fields where the condition has been diagnosed. The results have been entirely negative in the curing or protection of cattle from so-called cornstalk disease.

(Project, 194; Department of Veterinary Medicine. Leaders, H. Farley and L. M. Roderick; state fund.)

*Studies in Mastitis*.—Work done on this project during the biennium was a continuation of a long-term study of mastitis in dairy cattle. There is considerable evidence to indicate that the disease is due to a filter-passing virus in the cow's milk. Thus far, attempts to isolate the virus have proved unsuccessful.

Milk sediments were obtained by centrifugation of milk samples from 28 class C cows (animals with long-chained streptococci in milk). Smears were made and fixed and strained by seven different methods. It was impossible to conclude that many of the observed bodies of various shapes, sizes and staining reactions were virus bodies. In most sediments streptococci, both intracellular and extracellular in position, were found. Inoculation of the chorioallantoic membrane of the developing chick embryo with milk from diseased animals failed to demonstrate any evidence of virus in eggs. Treated milk samples injected into the lactating glands of rabbits and guinea pigs failed to develop mastitis in these animals.

In a small dairy herd one cow was discovered which was infected in one quarter with a Beta-hemolytic Lancefield C streptococcus; the other three quarters appeared to be normal. Sulfanilamide was administered by mouth in sufficient dosage to keep the blood level of the drug near 6.0 mg. percent for a 10-day period. The experiment was discontinued after failure to clear up the infection in this animal.

During the past two years 1,157 samples of milk have been examined for evidence of mastitis in producing cows. Bovine mastitis is widespread in Kansas dairy herds, the incidence being nearly 17 percent of all animals examined.

An extensive study of the Hotis test for the detection of mastitis in dairy cows was conducted. In view of the high correlation between the Hotis test and the microscopic examination of incubated samples, it may be concluded that for a simple cultural procedure that lends itself to wide use, the Hotis test has few equals.

There is no indication that vaccination of cows with lacto-vaccine is helpful in the control of mastitis infection. Control methods employed in the station herd include isolation of cows after calving until they are classified, hand milking after freshening until some congestion leaves the udder, washing udders with individual sterile cloths and chlorine solution before milking, dipping teats in chlorine solution after milking, use of separate machines and operators on clean and infected cows.

Departments of Bacteriology and Dairy Husbandry. Leaders, L. D. Bushnell, V. D. Foltz, A. O. Shaw and F. W. Atkeson; state fund.)

**Poultry Disease Investigations.**—There have been six phases of this project carried on during the biennium. A brief discussion of each phase is given below.

1. *General Observation and Studies of Poultry Diseases.*—The procedure of laboratory examinations of the various diseases among chickens and other birds has not been changed. During the biennium 3,159 birds from 1,519 outbreaks were examined. Letters received from Kansas poultry producers in regard to poultry diseases totaled 1,308 and there were approximately 100 letters received from correspondents in 31 other states. A marked increase in the number of outbreaks of fowl cholera have been observed during the biennium. No outbreak of typhoid has g encountered during the same period.

A summary of the miscellaneous activities done under this phase of the project follows:

Trichomoniasis examination.....	65
Feed samples tested for poisoning.....	15
Miscellaneous examinations.....	11
Culture of bacteria sent to other labs.....	18
Telephone calls concerning poultry diseases.....	118
Field trips.....	14
Blood samples tested.....	335
Doses of pox virus distributed.....	7,500
Doses of pullorum antigen distributed.....	8,150
Doses of autogenous bacterin supplied.....	188

2. *Studies of Protozoan Parasites of Poultry.*—The first severe outbreak of Trichomoniasis in turkeys occurred during the summer and fall of 1936. The disease has been encountered from all sections of the state where turkeys are raised, as well as surrounding states.

The majority of cases have been found in mature and adult birds. This is probably explained by the housing condition of the poults and adult birds. The poults are raised on screen wire which is used to control blackhead and which also controls this protozoan disease. The adult birds are closely housed during the winter months. Under these conditions they come in contact with wet straw used for litter, which seems to be the source of infection. Outbreaks in birds not confined were found to have access to old straw stacks, stagnant pools of water or wet soil surrounding the drinking fountain.

Mixed cultures of protozoa and bacteria have been carried in culture media for 30 days. Frequent transfers were made in order to keep the culture alive. The presence of certain bacteria in large numbers seems to have a detrimental effect. Considerable time has been spent in attempting to obtain a pure culture of the protozoa, but without success. The procedures employed consisted of the dilution method, Barber's single cell method, and the use of various chemicals and dyes, and the use of V tubes.

Pigeons have been inoculated and were found to harbor the protozoa in large numbers without apparent injury. One pigeon has been found to be a carrier for over one year.

It has been observed that inoculated turkeys may be carriers of the organism without causing any pathological changes. The incubation period has been found to vary from a few days to a month or more. What appears to be another trichomonad species, found in the posterior digestive tract, has also been encountered in the past biennium. Poults varying in age from seven

days to five weeks were the most susceptible. Outbreaks have been controlled by strict sanitation and the use of copper sulphate at the rate of 1-5,000 in the drinking water.

3. *Studies of Fowl Paralysis.*—Fowl paralysis apparently is but one of the manifestations of the so-called "leucosis" complex and is undoubtedly a tumor. It has been reported as a virus disease from other stations. Chicks ranging from seventy-two hours to four weeks of age have been inoculated and fed material obtained from typical cases of leucosis presented at this laboratory. Over one hundred chicks have been inoculated without success. Observations and reports from other stations indicate that the incubation period varies from a few days to many months, making it difficult to study experimentally.

It was impossible to isolate a single case of *Salmonella aertrycke* organism from cultures of over 1,300 birds examined. The prevailing opinion at present in this laboratory is that they are of no importance as far as fowl paralysis is concerned.

The experimental work on inoculating chicks with leucosis has not been completed, but to date the results indicate as many leucosis birds in the control group as in the injected group. Identical results were also obtained in previous experiments with leucosis.

4. *A Study of Tapeworms in Poultry.*—The species *Hymenolepis carioca* has been found to be a common and widely distributed poultry parasite over the state. This particular species has never been commonly reported before this time, probably due to its small size and the fact that it is frequently covered with mucous of the intestine. Over four hundred individuals have been counted in one bird. The fact that *H. carioca* is commonly found along with *Raillietina cesticillus* would indicate that these two species evidently have the same intermediate hosts.

5. *Study of Pullorum Disease in Regard to Vaccination with Fowl Typhoid Vaccines.*—Reports received from the field that the fine agglutination frequently observed while testing for pullorum disease would disappear following the use of fowl typhoid bacterin led to a study of this particular phase.

This experiment was carried out in connection with the Poultry Department. Three hundred and twenty-eight birds were tested and over 40.60 percent showed fine agglutination. These birds were given 5.0 c.c. each of fowl typhoid bacterin subcutaneously. Approximately seven weeks later they were retested and the titer obtained in the first test was not changed to any great extent. Instead of a decrease, an increase of 19.6 percent was found to have occurred between the first and second test. The conclusion is that the use of a fowl typhoid bacterin to eliminate the fine agglutination is of no value. These birds will be retested to determine if the increase in number of reactors was due to the typhoid bacterin or some other cause.

6. *Factors Influencing the Pullorum Agglutination Test.*—It has been suggested that the poultry mashes containing soybean meal are responsible for a fine agglutination reaction in testing for pullorum.

As an experiment, twenty birds were obtained with some reactors. These birds were tested and then placed on a commercial mash plus 20 percent soybean meal. These birds were fed on this ration for sixty days and then retested. The results indicate that soybean meal had no effect upon the agglutination reaction.

(Project 85; Department of Bacteriology. Leaders, L. D. Bushnell and M. J. Twiehaus; state fund.)

*Parasitological Investigations.*—During the past biennium, the work has consisted of studies on the principal intermediate hosts of the fowl tapeworm *Raillietina cesticillus* (Molin); the effect of the tapeworm *Raillietina cesticillus* upon growing chickens; the susceptibility of mature chickens to tapeworm infections; and of observations on human tapeworm infections.

Previous studies indicated that ground beetles might be important factors in the spread of fowl tapeworm disease. By collecting adult beetles in regions unfrequented by chickens, supplies of beetles were secured for experimental feeding of tapeworm segments containing the parasite eggs of *Raillietina cesticillus* (Molin). These eggs in the body cavities of the beetles develop into mature cysticercoids (larvae) in from 11 to 21 days. Subsequent feeding of these cysticercoids to chickens results in tapeworm infections in the chickens. Individual tests during the biennium upon 1,000 beetles have resulted in the discovery of five new genera and 30 species of beetles as intermediate hosts of fowl tapeworms.

Efforts to determine the intermediate hosts of the two largest tapeworms, *Raillietina tetragona* and *Raillietina echinobothrida* have been negative. So far, attempts to confirm the reports from Maryland that ants may serve as the intermediate hosts have been negative.

To test the effect of tapeworms upon growing chickens, day-old chicks were raised in confinement. At 3.5 months of age, 18 of these were parasitized and 7 kept as controls. After 24 days of infection, the parasitized chicks showed a blood sugar level of 168.7 mg. per 100 c.c. of blood as compared with 190 mg. from the controls. In this period, the parasitized chicks gained an average of 102 gm. and the controls 167 gm. in weight.

In a second test, 80 cysticercoids, 10 per week, were administered to each of 10 chickens while four birds were kept as controls. The chickens were four months of age. At the end of eight weeks of infection, the experiment was terminated with the following results:

The hemoglobin of the parasitized chickens was 55 percent as compared with 60 percent in the controls; the blood sugar was 141.1 mg. per 100 c.c. of blood in the parasitized birds as compared with 176.6 mg. in the controls. An average gain of 720 gm. was made by the parasitized chickens and 967 gm. by the controls. The results of the two experiments, in which the parasitized chickens had from four to 25 tapeworms, indicate that infections of *Raillietina cesticillus* of from three to eight weeks duration may reduce the growth rate of chickens and the sugar content of the blood, and in eight weeks the hemoglobin percentage also may be reduced.

As older chickens were found at this laboratory to be more resistant to the growth of tapeworms than were younger chickens, tests were made to ascertain if mature chickens may become infected with tapeworms. The results from feeding 100 tapeworm larvae (cysticercoids) to each of four chickens 223 to 225 days old resulted in all chickens becoming infected with tapeworms.

A study of four cases of human tapeworm infection showed deleterious effects of the parasites upon the hosts. The findings did not support the hypothesis that tapeworm symptoms are due to worry from knowledge of the infection.

(Project 79; Department of Zoölogy. Leader, J. E. Ackert; Adams fund.)

**Factors in the Resistance of Animals to Parasitism.**—During the biennium, work on factors in the resistance of chickens to the nematode *Ascaridia galli*, has included: determination of the food of the fowl nematode *Ascaridia galli*; a histological study of intestines (worm habitat) of young, susceptible chickens and of older resistant chickens, also of younger and older rats; culturing young *Ascaridia galli in vitro*; and the study of duodenal goblet cell mucus as a factor in age resistance to parasitism.

(a) *Determination of the food of the fowl nematode Ascaridia galli.* —Experiments begun during the previous biennium to ascertain whether the nematode *Ascaridia galli* feeds on host tissue or on the host ingesta were completed during the last two years. Chickens of the same age and breed were

parasitized with the same numbers of infective eggs of the parasite. After allowing one week for the young worms to hatch and grow some in the chickens, the parasitized birds were divided into two lots: The experimental chickens to be nourished only by water *per os* and intramuscular injections of glucose solution; the other group to receive water and the regular ration by mouth. The chickens under comparison were killed at the same time and the worms isolated, counted and measured. The results of this series of experiments which extended over a period of two years and involved 267 chickens, showed that the worms in the injected chickens failed to grow, whereas those in the regularly fed chickens made normal growth. The conclusion is drawn that the large roundworm, *A. galli*, of chickens normally feeds on the host ingesta and not on the host tissues.

The repeated demonstrations of increased resistance of chickens three to four months of age against the growth of *Ascaridia* in their intestines led to a histological study of the intestines of chickens four months of age as compared with the small intestines of five-day-old chicks. The most conspicuous difference between the intestines of the two ages was a marked increase of duodenal goblet cells in the older chickens. The gradual increase of the goblet cells in the older chickens paralleled quite closely the increase in resistance of the chickens to the growth of the *Ascaridia*.

As older rats likewise develop increased resistance to their intestinal nematodes (*Nippostrongylus* Sp.), histological studies were made of the small intestines of young and of older rats. These likewise demonstrated markedly more duodenal goblet cells in the older animals. This observation of larger numbers of duodenal goblet cells in older than in younger animals apparently had not been reported previously. The same was true of a possible relationship between the duodenal goblet cells and the resistance of the host to its intestinal nematodes.

As the parasitic mode of life of nematodes prevents direct observations on their feeding habits, efforts were begun to culture the young *Ascaridia galli* in nutrient media by removing young worms from chickens and incubating them in a nutrient solution. Using agar slants covered by a nutrient salt-dextrose solution, it was possible, not only to keep the worms alive for several days, but when incubated at temperatures approximating those of the host chickens, some of the young worms made increases of as much as 53 percent of their length, whereas the control worms in saline solution failed to live as long or to grow as much.

The technique was soon improved markedly by omission of the agar plates, upon which contaminating molds and fungi grew rapidly. By transferring, twice daily, to fresh media, chance contamination of molds and fungi was greatly reduced.

The results of these experiments in which the young *Ascaridia* lived for several days and made definite increases in length are promising for future experimentation upon such problems as factors in host resistance and the development of effective anthelmintics. The results also indicate that the *Ascaridia* are able to take dextrose from the culture medium and convert it into glycogen, since it is known that glycogen makes up one-fourth or more of the dry substance of the ascarid body.

With the successful maintenance of living *Ascaridia* in culture media and the presence of numerous duodenal goblet cells in the older and more resistant chickens, tests were made to ascertain if mucus from the goblet cells of the older chickens would affect the growth of the *Ascaridia* in culture. The tests were made by introducing autoclaved mucus from the duodenum of the chickens into the culture media containing the *Ascaridia* and comparing their growth with that of control *Ascaridia* in similar media lacking the mucus. When mucus from chickens three to four months of age was used, the growth of the worms was retarded. In some cases, in fact, no growth resulted, whereas in the controls the worms nearly always made significant increases in length.

(Project 169; Department of Zoölogy. Leader, J. E. Ackert; Purnell fund.)

### STUDIES IN HOME ECONOMICS

Several lines of investigational work that have for their purpose the development and improvement of conditions in the rural home have been conducted during the biennium. A brief statement of the work done follows.

*The Vitamin Content of Foods in Relation to Human Nutrition.*—Two phases of this project have been operative during the biennium. A determination of the vitamin H ( $B_6$ ) content of the liver of beef, calf, pork, lamb and mutton was made. A comparison was made of the thiamin (vitamin  $B_1$ ) content of a specially milled flour containing the aleurone layer and white flour milled in the ordinary manner from the same wheat.

1. *Vitamin H Content of Liver.*—Standard test rats were fed samples of the liver of the different animals after being depleted of Vitamin H, using the technique of Booher. The amount of food which each animal consumed was recorded and the rate of growth was determined by weekly weighings. The data have been completed and will be analyzed.

2. *The Vitamin  $B_1$  Content of Different Flours.*—Samples of wheat flour, ground whole wheat, and flour milled by the Morris process, all processed from the same wheat were assayed for their vitamin  $B_1$  content by the rat curative procedure of Kline, Tolle and Nelson.

A preliminary examination of the data reveals qualitatively significant amounts of vitamin  $B_1$  in all three samples. Quantitative analyses have not yet been tabulated.

(Project 158; Department of Home Economics. Leaders, Olga Saffry, Bernice Kunerth, Pauline Nutter; Purnell fund.)

*An Investigation of the Effect upon the Animal Body of Varying the Amount of Vitamin in the Diet.*—Because of failure in reproduction of Vitamin C-deficient guinea pigs, an investigation was conducted on some factors appearing to contribute to this failure. To study the effect upon the animal body of varying the amount of vitamin C in the diet with special reference to reproduction and development of the embryo, guinea pigs were fed vitamin C abundantly from three sources, crystalline Cebione, orange juice and sprouted oats.

Although the analysis is not completed, it seems that sprouted oats is a better vitamin C-supplement than either Cebione or fresh orange juice. Growth curves and general health have been used as a measurement of efficacy of vitamin C from the three sources. The growth curve for the animals which were fed sprouted oats as the source of vitamin C was more even and constant than from the growth curves for those animals which were fed orange juice or Cebione and over a long period of time it reached a higher level. There were fewer deaths among the animals fed sprouted oats than in the other groups and there were fewer cases of ailing or listless animals. There were fewer differences between the growth curves of those animals fed fresh orange juice and Cebione as a vitamin C-supplement than there were between those fed sprouted oats and either of the other two supplements.

(Project 188; Department of Home Economics. Leader, Mary T. Harman; Purnell fund.)

*The Nutritional Status of College Women.*—Five phases of this project are operative and similar projects are being carried on in a number of colleges and universities in the Midwest. Because of the nature of the project and the time required for its completion, no phase has been closed. Given below is a brief resume of the progress made in each phase.

1. *A Study of the Anthropometric Measurements of College Women.*—It is desired to determine whether growth occurs, where it occurs if found and to ascertain whether nationality or geographical location are factors affecting growth. Height, weight, chest breadth and depth, circumference of each arm and left leg, pulse, respiration, temperature and strength of right and left grips have been measured, at yearly intervals, four times on a group of 17 women, three times on 15, two times on 20, and once on a group of four.

2. *A Study of the Basal Metabolism of Women of College Age in Kansas.*—It is desired to determine whether the basal metabolic rate of college women changes during the four years spent in college. In the past biennium tests have been made yearly on approximately 90 college women, bringing the total to 339 tests made since the project was started. These data have been tabulated for statistical analysis.

3. *A Study of the Blood Picture of College Women in Kansas.*—Hemoglobin, cell volume and erythrocytes counts have been made on 150 college women of different ages during successive years in college, in order to determine what the normal blood picture may be and some of the factors affecting it.

4. *A Study of the Intake and Utilization of the Food of a Selected Group of Kansas College Women.*—Two seven-day balance studies have been conducted on six college women eating freely chosen diets. Two of these same subjects have been used for nitrogen, calcium and phosphorus balance studies on a controlled diet. The data obtained from these trials will be tabulated and analyzed.

5. *A Study of the Dietary Habits of Kansas College Women.*—This study, classified according to type of eating place, *i.e.*, sorority, residence hall, boarding house, home, and light housekeeping, has been conducted among two groups of college women. It appears that during the period studied, when no division is made of place of eating, that with the exception of greater usage of citrus fruits and tomatoes, the diets of upperclass college women are no better than those of lowerclass students. High-school diets seem to be uniformly poorer than college diets, lacking especially in citrus fruits, tomatoes and green vegetables. The data have not been tabulated according to type of eating place.

(Project 201; Department of Home Economics. Leaders, Martha S. Pittman, Dena Cederquist; Purnell fund.)

*A Study of Factors Affecting the Service Qualities of Certain Textile Fabrics.*—Two phases of this project, have been completed during the biennium.

1. *Synthetic Textile Fabrics.*—Viscose, cuprammonium and cellulose acetate rayon fabrics were subjected to light and heat under uniform conditions. Breaking strength, copper number, ash alkalinity and sodium hydroxide solubility were determined for each class.

Light decreased the breaking strength of all rayons uniformly. Heat decreased the breaking strength of the viscose and cuprammonium fabrics more than that of the cellulose acetate fabric. Light had little effect on the color of any of the samples. Heat affected the color of all fabrics considerably, but that of cellulose acetate was affected the least. The ash alkalinity of the

rayons was not affected by light or heat. The copper numbers and sodium hydroxide solubility of viscose and cuprammonium rayons was affected more by heat than was the cellulose acetate rayon. All tests indicated that the cellulose acetate rayon was superior to the viscose and cuprammonium rayons in its resistance to the effects of light and heat.

2. *Adequacy of Labeling of Certain Textile Fabrics.*—Fabrics tested were purchased in 18 stores in seven localities in the Midwest. Information was solicited from the sales clerk at the time of purchase regarding the fabric if the label did not supply such information. Of the 268 fabrics purchased, 133 contained one kind of fiber and the remainder were of mixed fiber content. In each case the information given by the label and/or the sales clerk was compared with laboratory determinations. More of the one-fiber fabrics were labeled and more of the information on the label was accurate than of the information regarding mixed fabrics. The accuracy of the information gained from both sources—sales clerks and labels—was low and the information inadequate.

(Project 161; Department of Home Economics. Leader, Hazel Fletcher; Purnell fund.)

*A Study of Factors Affecting the Expenditures for Family Living of Kansas Farm Families.*—During the past year work on this project has consisted of the gathering of supplementary information which will assist in analyzing the data now assembled by the Departments of Home Economics and Agricultural Economics.

Data on incomes and size and types of farms will be correlated with expenditures to determine the interrelationships. The income data, the data on types of farming, and data on sizes of farms are assembled and ready for analysis in connection with the studies of farm families for whom expenditures for family living are available for a number of years, as well as for those for which data are available for only one or two years.

(Project 196; Departments of Home Economics and Agricultural Economics. Leaders, Myrtle A. Gunselman and W. E. Grimes; Purnell fund.)

#### BRANCH EXPERIMENT STATIONS

The work of the central station at Manhattan is supplemented by work at four branch experiment stations all in the western part of the state, located at Hays, Garden City, Colby, and Tribune. The work at each of these stations is closely correlated with that of the central station, but planned and conducted with particular reference to local conditions. At all of these stations, with the exception of Tribune, coöperative assistance is obtained for the investigation of tillage and rotation problems from the Division of Dry-land Agriculture, Bureau of Plant Industry, United States Department of Agriculture. In addition, coöperative assistance is obtained at the Fort Hays Branch station from the following agencies of the United States Department of Agriculture: Forest Service with the production and distribution of trees; Soil Conservation Service with moisture conservation and erosion problems; Divisions of Cereal Crops and Diseases and Forage Crops and Diseases of the Bureau of Plant Industry with weed, cereal, and forage-crop problems; and Bureau of Agricultural Chemistry and Engineering with wheat-storage



problems. At the Garden City branch station coöperative assistance is obtained for the investigation of soil conservation problems, especially those relating to wind erosion and revegetation studies by the Soil Conservation Service.

The experimental and demonstrational work at these branch stations has been maintained on a high plane during the past biennium. Each station has presented the results of its work to the public through meetings, field days, demonstrations, bulletins, press reports, and other publications. A brief description of the work conducted and of the results secured is given in the following pages.

#### FORT HAYS BRANCH EXPERIMENT STATION

The Fort Hays Branch Experiment Station was established on the old Fort Hays Military Reservation by legislative enactment in 1901. At the present time, 3,440 acres comprise the station property, approximately 1,800 acres of which is under cultivation and 1,375 in native grass pasture. The balance is in building sites, feed lots, creek bed and roads. In addition about 410 acres of land infested with bindweed is leased from the Fort Hays Kansas State College for experimental studies in eradication of this serious weed pest.

The station is equipped to conduct experimental work with soils, crops, livestock, horticulture and forestry. Brief statements about the more important projects follow:

**Dry-land Agriculture.**—The tillage and crop rotation investigations begun in 1906 with additions at intervals since that time to keep abreast of changes in equipment, embrace experiments in methods of production of principal crops adapted to this area and a study of factors influencing yields.

The investigations include: the use of many different methods of seedbed preparation in continuous cropping and alternate cropping with fallow for winter wheat, barley, corn, kafir, milo, oats, and spring wheat; rotations of these crops with alfalfa and brome grass using various combinations; the use of green manure crops, commercial fertilizers, barnyard manure and the effect of burning of straw on soil condition and yield; the effect of various widths of row spacing of corn and sorgo crops on succeeding grain crops and the effect of pasturing winter wheat on fallow and manured fallow on subsequent yield; special study of various types of tillage machinery in the preparation of seedbed for crop and fallow using plow, chisel, subsoiler, lister, basin listers and basin-making equipment and the effect of these on the penetration of water in the soil and losses by evaporation.

A study of the effect of the various tillage operations upon the nitrate content of the soil and the effect of tillage methods and crop rotation on the protein content of wheat is also being made.

A study of the effect of paper mulch on the conservation of water and resulting effect on crop performance is under way with sorghums planted in 40-inch rows.

Metrological observations, including maximum and minimum temperatures, wind velocity, humidity, precipitation and the loss of water by evaporation from a free water surface have been taken since the establishment of the project in 1907.

The average precipitation for the last seven years shows an accumulated shortage of 35 inches for the period, or 5 inches per annum less than the annual average of 22 inches. This shortage has greatly affected crop production. A below-average wheat crop was produced in 1938 and much less in

1939. The sorghum crops failed to produce grain and very little forage was harvested. Row crops on summer fallow produced some forage, but there was not sufficient moisture available to produce grain. The 1940 wheat crop was sown in dry soil and there is little prospect of a crop. (A. L. Hallsted, in charge.)

**Forage Crop Investigations.**—The primary object of these investigations is to improve by selection or by breeding and selection, new strains or varieties of native grasses and develop methods of planting for use in reestablishing them on areas suited to their propagation. Previous investigation with domestic and imported grasses at this station has disclosed the superiority of native types. Over 7,000 individual buffalo grass plant selections are now being studied in the grass nursery with many of blue grama and side oat grama. Distinctly superior lawn types of buffalo grass have been isolated.

The seeding of the light fuzzy-seeded native grasses is a problem with present drilling equipment. During drought seasons much difficulty has been experienced in getting stands from the planting of recleaned seed of blue grama grass. However, when cured hay of these native grasses is scattered on summer fallowed land with a manure spreader and the hay forced into the soil with a packer, a protective mulch is left in immediate contact with the seed and germination is much more certain. The mulch reduces evaporation, aids in preventing runoff, prevents wind erosion and soil crusting and covering from torrential rains. Late April and early May spreadings have proved most satisfactory with all of the native grasses excepting western wheat, which responds better to late winter seeding. Protecting a portion of the native grass pasture during the normal-seeding period permits the production of seed which can be harvested as hay, and improves the vegetative cover of the pasture area.

Buffalo grass has been successfully established by pressing small chunks of sod into deeply cultivated ground with a weighted packer. This method becomes expensive if the sod chunks are placed at close intervals. Placed at wide intervals the nucleus of a buffalo grass pasture is secured on a practical basis. Grama grass seed can be later drilled in the area to provide the buffalo-grama grass balance which is desired in preference to pure stands of either.

The irrigation of selected types of buffalo grass for the production of large quantities of seed appears to be entirely practical. Irrigation stimulates the growth of the grass, permitting harvesting with mower equipment, thereby saving a much larger proportion of the seed.

It has been found that buffalo grass must go through an aging process before ready germination can take place. Pre-soaking the seed hastens germination, without the use of the aging process. The seed may be dried after pre-soaking and still maintain its hastened germination when planted several months later.

Other investigations include the testing and development of improved strains and methods of establishing and producing sweet clover and alfalfa. Highly wilt resistant selections of alfalfa have already been isolated and one selection is now being increased. The long series of adverse seasons experienced have made it impossible to secure stands of sweet clover by using best-known methods. (Leon E. Wenger, in charge.)

**Noxious Weed Control Investigations.**—The scope of these investigations has been broadened from that of bindweed investigational work to include experiments in the control of hoary cress, dogbane, and prickly-pear cactus. Twenty-two experiments are now under way. Nineteen of these are studies in the control of field bindweed based largely on the following four main points of attack: (1) clean cultivation, including time of beginning, frequency and depth of cultivation experiments; (2) competitive cropping in combination with clean cultivation, including experiments with fall-planted wheat and rye, summer annual crops and alfalfa and sweet clover; (3) herbicides, including experiments comparing different chemicals and different dates, rates and methods of applying sodium chlorate; and (4) fundamental studies of the trends of food reserves in the roots of bindweed and dogbane under undis-

turbed conditions and various treatments. Several other minor experiments on various phases of bindweed control were conducted.

Clean cultivation and certain combinations of competitive crops with clean cultivation periods continue to give the most consistently satisfactory eradication results. Five to six more cultivations were required to eradicate bindweed during the dry seasons of 1938 and 1939 than had been necessary for the same treatments in previous years. On the average 16 cultivations were required to eradicate bindweed when it was allowed to grow above the ground 12 days each time; 17 were required when eight days' top growth was allowed; 21 when four days of growth was permitted; and 29 were necessary when the bindweed was cultivated the first day of emergence each time. When 16 days or more of top growth was allowed between cultivations necessary, the period of eradication was lengthened. When 20 or more days of top growth was permitted, eradication was not complete after three years of treatment.

Different dates of beginning intensive fallow treatment, for bindweed control were about equally effective from the standpoint of the number of cultivations required for eradication. May 1 and in July immediately after small grain harvest proved to be the most satisfactory times for beginning fallow treatment considering all factors. Cultivating eight and twelve inches deep did not reduce the number of operations necessary to eradicate bindweed sufficiently to offset the higher costs of the deeper tillage as compared to cultivating to a depth of four inches.

Sweet sorghum and Sudan grass proved to be effective smother crops when preceded by clean cultivation periods. Results showed considerable advantage for fallowing one full year and until late June of the second year before drilling the crop. Millet was not a satisfactory smother crop. Wheat and rye were promising as competitive crops where preceded by a full year of intensive fallow. Alternate fallow and wheat and two years of fallow followed by wheat gave quicker eradication of bindweed but produced considerably less wheat.

Sodium chlorate continued to give more consistent results than other chemicals, but the results were much less satisfactory in the dry seasons of 1938 and 1939 than in previous years. The dry and spray methods of applying sodium chlorate averaged about equally effective. September and August applications gave better results than treatments made at other times during the year. The optimum rate of applying sodium chlorate during 1938 and 1939 was four to five pounds per square rod as compared to two and one-half to three pounds in earlier experiments. (F. L. Timmons, in charge.)

**Wheat and Sorghum Grain Storage Investigations.**—The study of wheat storage during the past years has been devoted chiefly to the study of the factors influencing the quality of wheat during farm storage and the development of effective grain bin ventilation systems. From 1,000 to 4,500 bushels of wheat from each year's crop since 1936 has been stored and at least a part of each crop in under observation at the present time. Seven 1,000-bushel, three 300-bushels, and fourteen bins of smaller capacity have been used for these studies in addition to two underground bins of 1,000 bushel capacity.

**Wind Ventilated Bins.**—Bins with perforated floors but without means for forcing air through the wheat were effective for equalizing moisture content between wet and dry layers of wheat, but the safe average initial moisture content was not more than one-half of 1 percent in those bins. A suction cowl on the roof of a bin of this type, with all the other openings closed, will improve the efficiency to the extent that grain with approximately one and one-half percent higher moisture content can be stored than in ordinary unventilated storage.

The results from the tests of the experimental grain bins to date indicate that the most effective and practical method of ventilating grain bins in the western half of the state is to introduce the air from a windpressure cowl directly into the center of the mass of the grain, permitting it to escape in all directions through approximately equal distances of grain. The tests have been most successful on bins having less than five feet of air travel between the air intake and exhaust surfaces.

*Underground Storage.*—The temperature of grain stored in underground bins was maintained approximately 20 degrees F. cooler than the grain in conventional aboveground storage during the summer months. The rate of deterioration was also less. However, in an unventilated type of underground bin, the grain increases slowly in moisture content. The initial temperature of the grain decreased very slowly and the grain became musty and moldy where it came into contact with the walls of the bin.

By a simple ventilating system employing a windpressure cowl and a bin wall lining of wire screening, these troubles were corrected. The grain in the bin so equipped dried from 13.7 percent to 12.7 percent in the first month. The temperature of the grain decreased from 84 degrees F. at the time the bin was filled to 74 degrees F. in the first 15 days of storage; thereafter, the temperature of the grain remained approximately half way between the ground and air temperatures.

*Grain Sorghum Storage.*—In March, 1939, 2,100 bushels of grain sorghum were placed in bins of various types and sizes. The grain sorghum that was stored in the 1,000-bushel wind-pressure ventilated bin at a moisture content of 13.5 percent dried to 9.4 percent by mid-July after four months of storage. Part of the same lot of grain was stored at the same time in a 500-bushel wind-suction ventilated bin and it required seven months to reach 9.7 percent. Similar grain, also stored at the same time, reduced only 0.2 percent in moisture content while stored in the 500-bushel tight bin for five months. The grain from all the bins showed no deterioration at the conclusion of the experiment in November, 1939. The storage season was dry and hot with low humidity.

In November, 1939, two 1,000- and two 500-bushel experimental wind-ventilated bins were filled with grain sorghum of approximately 17 percent moisture. The grain in the 1,000-bushel bin, having a small revolving wind-suction cowl drawing the air up through a perforated floor and 8 feet of grain began to heat shortly after loading and since that time the grain has been ventilated several times with a power blower, moved, and recleaned. Despite this treatment the grain has become musty and caked and is of distinctly low quality.

Wind-pressure cowls used on the remaining ventilated bins to introduce the air near the center of the mass of the grain. The air travel ranged from 4.5 feet to 7 feet in these bins. The bins with the shortest air travel increased in moisture content up to 17.6 percent moisture in January, but dried rapidly during the spring to 12.4 percent moisture on May 20. This grain contained approximately 7.7 percent of cracked grain and other foreign material and dried from 14.4 percent to 2.4 percent during May when the average temperature of the grain was approximately 61 degrees F. (W. R. Swanson, in charge.)

*Cereal Investigations.*—The object of these investigations is to test sorghum, winter wheat, winter and spring barley, oats, corn, flax, and broomcorn and to determine the best varieties for ultimate distribution to farmers. Plant breeding methods and selection are used to improve the sorghums and barley. The period from 1933 to 1940 were years of uncertain and inadequate rainfall and considerable difficulty has been experienced in carrying forward experimental work. Greater emphasis has therefore been placed on securing early maturing varieties in all crops in order to evade drought.

Improvement of spring barley is being sought by selecting pure lines from crosses between Atlas X Vaughn, Stavropol X Flynn, Flynn X Vaughn, and Flynn X Trebi. Smooth-awned, stiff-strawed selections with medium earliness, and with high grain yields are desired objectives.

Improvement of both grain and forage sorghums by hybridization is being continued. In the grain sorghums, seed with attractive yellow or white color is sought. Crosses between Club X Day and Dawn X Wheatland have given lines with attractive seed color and with plants both tall and dwarf as to height. A selection from the cross Weskan X Greeley has shown considerable earliness with attractive seed type and good yield. A selection from the cross Atlas X Early Sumac is being increased for possible distribution as a substi-

tute for Atlas in the western part of the state where earliness is essential. This selection has a sweet stalk and a white seed.

Palatability studies with sorghums as fodder feeds have been conducted for a period of five years. The cattle showed a preference for the stems over the leaves in most varieties of the forage group. In grain sorghum, the cattle also showed a preference for the stems over the leaves when the crop has failed to make grain. When grain production was high, the leaves of grain sorghums were preferred to the stems. Chemical analysis has shown that the total carbohydrate values were higher in the stems than in the leaves, as was the moisture content. Under heavy grain production there was evidence that the sugars were translocated from the stem to the head to form the grain, thus depleting the feeding value of the stems.

A minor observation was made when a sample of wheat was milled and baked from a lot of 800 bushels which had been kept in storage in a steel bin for a period of 11 years. This wheat was stored in 1927 and was removed from the bin for the market in July, 1938. The wheat milled satisfactorily considering its age. The flour gave a dough with a long mixing time and excellent mixing tolerance. Seed from this lot germinated satisfactorily in the field when sown. (A. F. Swanson, in charge.)

**Beef Cattle Feeding Investigations.**—The beef cattle feeding investigations for the biennium were largely concerned with a continuation of the study of the value of various protein supplements fed with sorghum silage to calves and yearlings in wintering rations. The 1938-'39 feeding work completed the series with yearlings in the utilization of eight protein supplements composed of alfalfa hay, cottonseed meal, linseed meal, soybean oil meal, peanut oil meal, corn gluten meal, tankage and wheat bran fed with Atlas sorgho silage. In each year the silage was made from drought stricken sorghums containing no grain.

As with the feeding results with calves reported upon in the last biennial report, the three years results with yearlings again show that bran fed at the rate of 3 pounds per head daily, despite its high price, produced cheaper gains than any of the other supplements used. This was true for each year of the experiment as well as for the average of the three years.

Two years out of three, 4 pounds of alfalfa hay ranked second among the eight protein supplements fed. The third year, 4 pounds of alfalfa hay ranked fourth.

An average, based upon the daily gains of the three experiments, shows that the supplements fed at the rate of 1 pound per head daily ranked as follows: cottonseed meal, corn gluten meal, soybean oil meal, tankage, linseed meal, and peanut oil meal, but all of them below wheat bran and alfalfa hay.

The feeding experiments with calves in the 1938-'39 season were concerned with determining how much bran and how much alfalfa hay was equal to 1 pound of cottonseed meal as a protein supplement to sorghum silage.

The gains in the lots fed wheat bran varied in direct proportion to the amount of bran fed. The lot fed 3 pounds of bran per head daily gained 1.13 pounds; those fed 2 pounds gained .91 pounds, and those fed 1 pound gained .68 pounds daily. Two pounds of wheat bran produced approximately the same gain as 1 pound of cottonseed meal.

In the 1939-'40 feeding experiments the same comparisons with bran and alfalfa hay made with calves the previous year were made again with yearlings and with calves. Results in the main are similar to those obtained in experiments the previous year. These experiments will be carried on for another year before closing the series, and making the final report on the results. (L. C. Aicher and C. W. McCampbell, in charge.)

**Pure Seed Distribution.**—The 1933 season proved satisfactory from the standpoint of the production and distribution of certified Tenmarq seed wheat, but the sorghum crops failed to produce seed excepting in a few low places and on fallow land. Only 4,380 pounds of alfalfa seed was produced. Seed sales for the 1937-'38 season embraced 727 orders, reaching 79 counties in Kansas and 17 states, and were composed of Tenmarq wheat and alfalfa produced in 1938 and sorghum seed mostly produced in 1937. Tenmarq wheats consti-

tuted 364,425 pounds of a total of 460,935 pounds of seed distributed, ten other varieties of crop seeds accounting for the additional 96,000 pounds. Sorghum seed composed 74,550 pounds of the total, which is approximately one-third of the usual sorghum seed sales.

The seed sales for the 1939 season were greatly reduced, owing to the failure of the sorghum seed crop. All seed stocks with the exception of wheat and alfalfa seed were produced in 1937 and carried over. Nearly all the wheat and the alfalfa seed sold was produced in 1938.

Seed sales for the year reached 501 orders, which were distributed in 78 counties and 15 states. Tenmarq wheat amounted to 90,069 pounds. Sorghum seed sales reached a total of 105,049 pounds. Some Flynn barley was produced in 1938 and 34,928 pounds of this seed was distributed. (L. C. Aicher, in charge.)

**State Forest Nursery.**—The 1938 season in the nursery was satisfactory from the standpoint of both sales and planting survival of new stock. Demand for trees was good and wide distribution was made over the western half of the state. A power-driven tree-planting outfit mounted on a "chisel" in the station shop proved a great time-saver in speeding up the planting of seedlings.

The cherry crop grown on terraced land on 9 to 10 percent slope was good despite late freezes. The total production of all varieties was four tons, which were sold on the trees at 5 cents a pound. Early Richmond continues to lead Montmorency in production. This variety matures earlier than Montmorency, reaching maximum production in seven years from transplanting date. Montmorency is at least three years slower in reaching maturity. The orchard remains thrifty despite the several drought years.

For the first time, it was necessary in the spring to spray American elms along the station roadway to prevent serious injury from cankerworms. Arsenate of lead with a casein spreader was found effective for this work.

An early invasion of gray blister beetles injured tomato plants in the tomato variety experiments. In an experiment to study the effect of shade and pruning on tomatoes grown under field conditions, it was found that shaded plants bore less fruit and of inferior quality than those without shade and without pruning. The fruit from pruned plants was invariably damaged by sunburn, birds, or insects. Yields of tomatoes were low owing to unfavorable late summer conditions.

Despite dry weather and unfavorable planting conditions there was a substantial increase in seedling distribution over the state in 1939. The closing out of the ornamental tree and shrub section of the nursery caused considerable decrease in the distribution of ornamental species. There will be a small surplus of some varieties of ornamental stock available for distribution in 1940. Thereafter only seedling trees distributed in cooperation with the United States Forest Service through the Clarke-McNary act and the Norris-Doxey act will be available. The seedling distribution in 1939 reached 396,360 units divided as follows: Chinese elm, 142,146; red cedar, 94,632; Austrian pine, 15,350; and Ponderosa pine, 11,870. There has been considerable interest in the planting of the strip pit areas of southeastern Kansas.

Tomato variety trials were continued in 1939, but owing to bad seasonal conditions low yields were obtained as in 1938. Insect damage continued high even to the extent of most of the blossoms being eaten off despite strenuous efforts at control.

The set of fruit in the cherry orchard was light in 1940 due to late spring frosts. Most of the crop produced came from Early Richmond trees. Demand for fruit was brisk and 2,937 pounds were sold on the trees at 5 cents a pound. For the first time since the orchard was set out nine years ago, the trees failed to make a substantial growth. This is due to the accumulated deficiency of soil moisture brought about by seven years of drought. In their present weakened condition the trees may fall prey to insects and diseases unless more moisture is available in 1940.

A comprehensive study of species of shrubs and trees which might prove of value to the Plains area was started in 1939. Arrangements have been

made with Soil Conservation Service to secure several hundred new species for testing purposes looking towards their value for erosion control. (F. P. Eshbaugh, in charge.)

**Soil Erosion and Water Conservation.**—The soil erosion and water conservation investigations were continued in 1938 on the same basis reported upon in the past biennium. The measuring of soil and water losses was continued on 70 terraced and unterraced watersheds having different degrees of slope, different types and spacings of terraces and subjected to various tillage and cropping systems.

The collecting of data on water and soil losses and moisture penetration on pastures contoured experiment areas and on the control plots has been continued.

When the soil erosion and water conservation experimental project was set up at the Hays station in 1929, plans were made at that time to carry on the work for ten years. It was contemplated that at the close of the ten-year period some of the investigations would be discontinued. Pursuant to this plan a general revision of the soil erosion and water conservation investigations was made, same to be effective July 1, 1939. Since much of the work previously carried on was discontinued, Mr. Ackerman was transferred to other work in the service. The investigations to be carried on were placed under the direction of the superintendent, who was made a coöperative agent in the Soil Conservation Service. He will be assisted by Mr. Wenger, Forage Crops specialist at this station.

The investigations now under way have the following objectives: (1) to determine the losses of soil and water from contour farmed control plots having a slope of 5 percent; (2) to determine the loss of water from contoured native grass pastures; (3) to determine the effects of contouring on the production and succession of native grasses under grazing conditions; (4) to determine methods of reëstablishing native grasses and the best adapted species on cultivated land having a slope of 4 to 10 percent and on land varying from 0 to 1 percent; (5) to determine the best grasses to use and best methods of establishing grasses on terrace outlets and floodwater courses.

All of this work has been started with the exception of grassing terrace outlets. It is anticipated these will be established shortly. (L. C. Aicher, in charge.)

#### GARDEN CITY BRANCH EXPERIMENT STATION

The Garden City Experiment Station consists of 556 acres of land located five miles northeast of Garden City. An additional area of 136 acres were acquired by purchase in the spring of 1939.

The work of the station is divided into six major divisions: dry-land agriculture investigations; plant breeding and crop adaptation studies; irrigation investigations; soil and moisture conservation studies; entomological investigations; and lamb-feeding investigations.

**Dry-Land Agriculture.**—The Division of Dry-Land Agriculture, United States Department of Agriculture, in coöperation with the station, carried on studies of various tillage practices, rotations, and seedbed preparations for the production of wheat, and sorghums. The value of cowpeas, green manures, and barnyard manure for crop production was also studied. Soil-moisture determinations were made on a few of the wheat and sorghum plots at seeding time, at different stages of growth and at harvest time.

Precipitation, both in 1938 and in 1939, was below average. The former was 15.19 inches and the latter 9.79 inches. The wheat in 1938 was nearly a failure, for only five plots were harvested and these were on fallow. The highest yield was 2 bushels per acre. Only a few milo plots and a feterita plot produced grain. Several more plots of wheat were harvested in 1939 than in 1938, but

the yields were extremely small. The only milo plots to yield grain were some of those on fallow and in wide row spacing.

One experiment was started in 1938 to demonstrate the loss of moisture from the soil by evaporation. Two one-fortieth-acre plots were laid out and both listed. The ridges on one were covered with waterproof paper and a strip approximately six inches in width was left bare. Milo was grown on the plots in 1938 and kafir in 1939. No grain yields were recorded on the plots in either year, but the stover yield in 1938 was 2.25 times greater on the covered plot than on the uncovered. In 1939 the yield of stover was 1.51 times greater on the covered than on the uncovered plot.

The basin lister project which was started in the spring of 1938 was continued, but the yields of sorghum and wheat were so small that no definite conclusion can be drawn. Soil samples for total nitrogen and organic carbon determinations were taken on the plots before the virgin sod was broken. These samples were run during January and February, 1939. Moisture equivalent determinations were also made on the plots which were sampled for moisture. (Howard J. Haas, in charge.)

**Plant Breeding and Crop Adaptation Studies.**—Plant breeding work was continued with sorghums and alfalfa. A major share of the sorghum work consisted of testing strains for resistance to *Pythium* disease. Resistant selections of the more important varieties have been obtained.

Alfalfa breeding work in cooperation with the forage office of the Bureau of Plant Industry was continued. This work consists of plant selection and seed production of several promising strains resistant to bacterial wilt. Good yields of seed were obtained in 1938, but hot winds killed the young seedlings in the summer of 1939. The 1940 seedlings are off to a good start.

Variety testing has been continued with spring small grains, sorghums, corn, winter wheat, and alfalfa. Date-of-planting tests in connection with the variety tests were carried on with wheat and sorghums. The corn varieties were under irrigation and a series of sorghum varieties under irrigation was added in 1939. All variety testing on dry land has been on summer fallowed land, and in spite of adverse weather, satisfactory yields of some varieties have been obtained.

Adaptation studies of native grasses and a study of seedbed preparation methods for returning cultivated land to grass was instituted in the spring of 1940. All grasses came up to satisfactory stands. This work is being conducted in cooperation with the nursery section of the Soil Conservation Service.

Coöperative studies on regrassing cultivated and range land are also being conducted in the Elkhart, Kan., area. The work is in cooperation with the research section of the Soil Conservation Service. (Alvin E. Lowe, in charge.)

**Irrigation Investigations.** —Data on the cost of pump irrigation were continued during the biennium, and in the spring of 1940 an experiment was started which will show the relationship of rate and time of watering alfalfa to hay and seed production. (Alvin E. Lowe and L. M. Sloan, in charge.)

**Soil and Moisture Conservation Studies.**—In the spring of 1939, two projects were undertaken in cooperation with the Division of Dry Land Agriculture and the Soil Conservation Service of the United States Department of Agriculture. Those projects are for the purpose of studying the effects of various tillage and cropping practices on soil fertility, soil aggregation, and water conserving capacities of soils, and the relationship of these practices to soil and moisture conservation. (Alvin E. Lowe and Howard J. Haas, in charge.)

**Lamb-feeding Investigations.** —Problems of range lamb feeding were continued during the biennium. Comparisons were made of ground versus chopped sorghum fodder versus sorghum heads versus threshed grain; comparisons of milo versus kafir versus sumac grain; alfalfa hay versus sorghum roughage versus wheat pasture alone versus wheat pasture plus various supplemental feeds. Results with the 500 lambs fed each year continued to demonstrate the value of sorghum forage and grain as major portions of a lamb-fattening ration.



A more complete report of these investigations is continued in Coöperative Studies in Lamb Feeding, page 74. (L. M. Sloan and R. F. Cox, in charge.)

**Entomological Investigations.**—In April, 1939, a project was established for a study of the effects of different systems of management of grasslands and conservation areas upon the grasshopper, cutworm, and other insect populations.

The work of the first season was devoted primarily to grasshopper observations in the Garden City area and in soil conservation areas of Seward, Greeley, and Thomas counties. Most of the work around Garden City was in a 40-square-mile intensive study area. Minor investigations were also carried on with a number of other insect pests that came to the attention of the assistant entomologist in charge of the field work. A more complete report of these investigations is contained in *The Effect of Different Systems of Management of Grass Land and Conservation Areas upon Grasshopper, Cutworm, and Other Insect Population*, page 118. (Roy F. Fritz and D. A. Wilbur, in charge.)

#### COLBY BRANCH EXPERIMENT STATION

The Colby Branch Experiment Station consists of 274 acres of land owned by the state and 320 acres of leased land. The work of the station is divided into four major projects: dry land agriculture investigations, general crop investigations, dairy investigations, and orchard investigations.

**Dry-Land Agriculture.**—The experiments in cultural practices and soil management studies, together with the securing of climatic data in coöperation with the Division of Dry-Land Agriculture, United States Department of Agriculture, were continued substantially as in the last biennium. The project now includes 284 tenth-acre plots for the study of crop rotations, methods of seed-bed preparation and other tillage, the effect of barnyard manure and green manure, and methods of summer fallow among other cultural practices. More recently studies of moisture conservation by the use of the basin lister and levees around some of the plots to check run-off have been undertaken.

Both 1938 and 1939 were drought years. The precipitation was slightly above normal in 1938, the first time since 1930. All crops were so poor, however, due to the character and distribution of the rainfall and other unfavorable climatic factors that it is classed among the dry years. The precipitation in 1939 was over 3.5 inches below normal and crop yields were very low. In 1938, the average yield of winter wheat on the plots was 9.2 bushels to the acre on fallow and 5.9 bushels on crop land. In 1939, the winter wheat averaged 6 bushels on fallow and 1.8 bushels on crop land. Milo averaged 13.7 bushel on fallow and 8.5 bushels on crop land in 1938. In 1939, milo averaged 12 bushels on fallow and 72 bushels on crop land. Corn averaged 3.7 bushels on fallow and 1.5 bushels on crop land in 1938. In 1939, corn averaged 3.7 bushels on fallow and .8 of a bushel on crop land.

Both years were characterized by inhibiting factors in crop production which largely overcame differences in cultural practices. The precipitation was so small, and most of it came in such light showers that not much moisture was stored by either summer fallow or the use of dams. The fall months were so dry both years that only indifferent stands of winter wheat were secured. The wheat which came up in the fall of 1938 went through the winter without the secondary root system because the soil was so dry at the crown of the plant that these roots could not develop. Infestations of pale western cutworms of varying intensity over the project in the spring of both years thinned out the stands of winter wheat on most of the plots to such an extent as to reduce the yields materially. The infestation was much more serious in 1939 than in 1938. The wheat crop of 1938 was further damaged in varying degrees by unusually severe freezes in April and May.

Soil blowing was not nearly so serious a factor during these two years as during the preceding four years. Particularly was this true during the spring months. There was much dust and some soil blowing during the summer

months, however, in both 1938 and 1939. The high winds and dust accompanied by high temperatures at critical times in June of both years reduced the yields of small grains, and similar unfavorable conditions late in the summer proved almost too severe for even the sorghum crops.

Grasshoppers and rabbits were numerous and did much more damage than usual to winter wheat, oats, barley, and corn on the project, particularly in 1939. (J. B. Kuska, in charge.)

**General Crops.**—Variety tests with winter wheat, spring wheat, oats, barley, corn, and the sorghums were conducted during the biennium. Crop conditions were only fair during both seasons and no large yields of any crop were produced.

Yields of winter wheat were fairly low in 1938 and all varieties failed in 1939. There is less than a two-bushel difference in the average yield of the four leading winter wheat varieties—Kanred, Turkey, Tenmarq, and Black-hull. Four years' results show September 20 to be the optimum time of seeding winter wheat. Results of the drill test for the eight-year period, 1930 to 1938, show little difference in yield between the 8-inch common drill and the 11-inch furrow drill, while the yield secured from the 14-inch spaced drill yielded a little more than two bushels less than the other two.

Flynn remains the highest yielding variety of barley. Its ten-year average yield is two bushels to the acre higher than its nearest competitor, Vaughn, and four bushels higher than Local 6-Row. Some promising new strains have been developed in the nursery. At the present time, a strain of Atlas X Vaughn shows considerable promise.

Reward spring wheat and Kanota oats are the highest yielding varieties of those crops.

Corn was practically a failure in both years of the biennium. A large number of hybrids were tested, but none appeared to be as drought resistant as better open-pollinated varieties.

A rather large number of the earlier maturing grain and forage sorghums are being tested. Colby milo is perhaps the best combine type of grain sorghum, Early Kalo, the best binder type of grain sorghum, and Early Sumac or Leoti Red the best forage type. In the date-of-planting test with the sorghums the first week in June appears to be the best time to plant these crops. (E. H. Coles, in charge.)

**Dairy Herd Improvement.**—The dairy herd improvement work of breeding a herd of grade cattle through continued use of purebred sires was continued. The average production of the 11 grade cows in 1938 was 8,745 pounds of milk and 360.5 pounds of butterfat; and in 1939, 12 grade cows produced on an average of 8,965 pounds of milk and 370.7 pounds of butterfat. Three cows in this project have produced more than 100,000 pounds of milk. Cow No. 29 has produced 150,155 pounds of milk containing 5,794.18 pounds of butterfat. Cow No. 30 has produced 128,243 pounds of milk and 4,960.29 pounds of butterfat. Cow No. 42, a 12-year-old has produced 100,634 pounds of milk containing 4,169.54 pounds of fat on April 1, 1940. She has been in production 9 years 1 month and 16 days. (E. H. Coles, in charge.)

**Orchard Investigations.**—While it is not believed that northwestern Kansas is adapted to commercial fruit production, an effort is being made to find fruits that are well enough adapted to furnish that type of food for the family table.

In 1938 a coöperative agreement was made with the Cheyenne Horticultural Field Station for this investigation. The old orchard site (10 acres) has been cleared and the area summer fallowed until six feet of moist soil was available at the time the young trees were planted.

The planting now consists of 26 varieties of apples, 11 pears, 10 apricots, 16 plums, and 8 cherries. Most of the trees planted have made satisfactory growth.

More space is allowed for each tree than was provided in the old orchard. Apples and pears are spaced 35 by 40 feet, apricots 30 by 40 feet, and plums and cherries 20 by 40 feet. (E. H. Coles, in charge.)

TRIBUNE BRANCH EXPERIMENT STATION

The Tribune Branch Experiment station consists of 110 acres located near Tribune, Greeley county, Kansas. The results secured apply to the high plains area extending from the Smoky Hill river to the Arkansas river. The work is planned to study variety response, seedbed preparation, and date-of-seeding of the principal adapted crops: wheat, oats, barley, corn, and sorghums. The production of legumes, grass, garden crops, flowers, and trees is also included in the work on the station. The production and distribution of three widely used crop varieties, Cassel white corn, Leoti Red sorgo, and Greeley sorghum, are largely due to the work done at this station.

The year 1938 was an excellent season for crop production and yields were above the average. During this year, the precipitation was 3.65 inches above the 26-year average of 16.0 inches. The temperatures were above average, although there were few days of extremely high temperatures. The wind movement was slightly below average and the evaporation was 8.3 inches below the 18-year average. The year 1939 was a poor crop production year. The rainfall was below normal. The temperature, wind movement, and evaporation were all above long-time averages.

Satisfactory yields on the wheat seedbed preparation project, started in 1933, were obtained for the first time in 1938. The yields secured on the second year after fallow series were as follows:

<i>Treatment</i>	<i>Yield bus. per acre</i>
Early plowed preparation.....	16.6
Early listed .....	15.6
Early one-way and second one-way if needed.....	15.4
Late one-way .....	18.1
Stubble-in .....	13.3

In 1939, the early plowed, early listed, and early one-wayed plots each produced nearly the same yield, 1.7 to 1.8 bushels per acre. The late one-wayed plot produced 1.0 bushel per acre and the yield on the stubbled-in plot was zero.

Early Blackhull was the highest yielding variety of wheat in 1939 with a yield of 11.6 bushels per acre. In 1938, Cheyenne made the highest yield in the wheat variety test, 23.2 bushels per acre; and Kanred was the second highest, 22.2 bushels. Blackhull, Turkey, and Tenmarq all made higher yields than Early Blackhull in 1938. The early maturity of Early Blackhull gives it an advantage in years of low yields. Early Blackhull is not a desirable variety because it is not winter hardy, lodges easily, and bread baked from the flour is of poor quality.

Wheat is sown on four dates: August 25, September 1, and 15, and October 1. Wheat sowed on September 15 made the highest yield in 1938, as it has for an average for nine years. Wheat sowed on October 1 made the highest yield in 1939. The use of the common drill or furrow drill does not change the most desirable date for sowing wheat. Wheat sowed with the common drill made the highest yield in 1938, 1939, and over a 14-year period, although the difference is small.

Excellent yields of grain were secured on the sorghum variety plots in 1938. The highest yielding variety was Kalo, 41.4 bushels per acre. Dwarf Yellow milo made the second highest yield, 29.7 bushels per acre, and Early Kalo ranked third among fifteen varieties with 25.1 bushels per acre. Other high yielding varieties were Greeley, Day milo, and Weskan. Greeley has made the highest average gram yield among seven varieties over an 11-year period. No sorghum grain yields were secured in 1939. Leoti Red made the highest forage yield in both years, 4.39 tons per acre of dry forage in 1938 and 1.56

tons in 1939. Sorghums planted on June 5 made higher grain and forage yields than when planted on May 20, in 1938, and in an average for an 11-year period.

One of the best methods of insuring a supply of forage feed in this area of low rainfall is to plant the feed crop on fallow. In 1939, Leoti Red sorghum produced 9,317 pounds of green weight per acre after fallow, and 3,273 pounds the second year after fallow. Over a six-year period the sorghum on fallow has produced 4,983 pounds of green weight per acre compared to 2,775 pounds after a crop. During the last three years, the basin lister has been used both in cultivating the fallow and in planting on the fallow and on crop land. The basin lister increased the green weight of forage 1,896 pounds per acre in 1937, and 829 pounds in 1939 on crop land. On fallow the basin lister increased the yield 1,047 pounds per acre in 1937 and 1,528 pounds in 1939. Comparative yields cannot be given for 1938 because of poor stand obtained on the land listed without the basin attachment.

The highest yielding variety of barley was Stavropol in 1938 and over a ten-year period. Vaughn made the highest yield in 1939. Barley makes a slightly higher yield when sowed with a furrow drill than when sowed with a common drill.

The production of a home garden and the growing of trees is given considerable attention because of the lack of both in this region. Cobbler potatoes have proved to be the highest yielding variety—producing 76.3 bushels per acre in 1938, 20.2 bushels in 1939, and an average of 56.9 bushels over a 19-year period. Yields of over fifty bushels per acre were secured eleven of the 21 years during which yields have been secured. The yield was less than 20 bushels in only four of the 21 years. Small vegetables, lettuce, radishes, and onions are grown successfully each year with windmill irrigation. Beets are usually successful. Peas and beans are difficult to grow. Tomato plants can usually be grown well by using a burlap windbreak, but the fruit frequently fails to set. The Chinese elm has proved to be the best shade tree. (T. B. Stinson, in charge.)

#### STATION PUBLICATIONS

The results of investigations by the Agricultural Experiment Station are reported in four series of publications: Biennial reports, technical bulletins, bulletins, and circulars.

**Biennial Reports.** —At the close of each biennium a report is made giving a brief survey of all the work of the station. It consists primarily of progress reports on the various projects actively pursued 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. Four such bulletins were issued during the biennium.

**General Bulletins.** —The reports of specific investigations for popular distribution are published as bulletins. The material is presented in such a manner as to be readily understood by the average reader. Thirteen bulletins were printed during the biennium.

**Circulars.** —Brief popular reports of experimental results and popular discussions on various agricultural problems are published as circulars. Eight circulars were published during the biennium.

The following are the regular station publications issued during the biennium, listed by series and showing the title, size of edition, and the number of pages:

BIENNIAL REPORT				
No.	Title	Edition	Pages	Total pages
	Ninth Biennial Report of the Director.....	2,000	145	290,000
TECHNICAL BULLETINS				
45	Nitrogen and Organic Carbon of Soils as Influenced by Cropping Systems and Soil Treatments.....	2,000	36	72,000
46	The Carotenoid Pigments.....	2,000	74	148,000
17	A Physiological Study of the Winter Wheat Plant at Different Stages of Its Development.....	4,000	167	668,000
48	Identification of the Eggs of Midwestern Grasshoppers .....	2,000	39	78,000
GENERAL BULLETINS				
278	Sweetpotatoes in Kansas.....	7,500	52	390,000
279	Smuts of Cereal and Forage Crops in Kansas and Their Control .....	10,000	37	370,000
280	Barley Production in Kansas.....	7,500	27	202,500
281	Blankets, Sheets, and Towels for the Home.....	7,500	31	232,500
282	Soybean Production in Kansas.....	8,000	28	224,000
283	Assessment and Collection of Farm Real Estate Taxes in Kansas .....	5,000	93	485,000
284	Poultry Diseases, Their Prevention and Control.....	20,000	125	2,500,000
285	Woodlands in Kansas.....	7,000	42	294,000
286	Equipment for Swine Production.....	15,000	45	675,000
287	Feeding Range Lambs in Kansas.....	25,000	80	2,000,000
288	Kansas Corn Tests for 1939.....	5,000	29	145,000
289	Comparison of the Quality of Hard Red Winter and Hard Red Spring Wheats.....	10,000	57	570,000
290	Growing an Orchard in Kansas.....	7,500	47	352,500
CIRCULARS				
192	The Trend of Real Estate Taxation in Kansas, 1910 to 1935 .....	4,000	22	88,000
193	Strawberry Growing in Kansas.....	5,000	19	95,000
194	Roadside Marketing of Horticultural Products in Kansas .....	3,000	27	81,000
195	Kansas Oil Property Taxation in Relation to Farm Taxes .....	3,000	27	81,000
196	Hybrid Corn in Kansas.....	18,000	20	360,000
197	Pruning Fruit Plants.....	7,500	27	202,500
198	Control of Mammals Injurious to Agriculture in Kansas .....	10,000	10	100,000
199	Combating Fruit Pests in Kansas.....	10,000	45	450,000
ABSTRACTS				
1	Abstracts of New Publications.....	9,500	2	19,000
MISCELLANEOUS				
---	Flora of Kansas.....	3,000	266	798,000

SOME INFORMATION REGARDING EACH PUBLICATION ISSUED  
BIENNIAL REPORT

**NINTH BIENNIAL REPORT OF THE DIRECTOR: For the Biennium July 1, 1938, to June 30, 1940.**—This biennial report outlines the scope of the work of the Agricultural Experiment Station for the period. Abstracts of reports of progress or abstracts of the results are given for the projects conducted during the biennium. The annual financial statements and a list of the publications of the station and of contributions by staff members to various scientific publications are included in the report.

A section of the report, "Fifty Years of Service to Kansas Agriculture," was reprinted as a separate. The section, containing 16 pages, sets forth the history of the establishment and development of the Agricultural Experiment Station and also discusses the station's relation to other governmental agencies. Pictures of all former Directors are included in the separate. (By L. E. Call, Director, Agricultural Experiment Station; 148 pages; 3 figures; 20 tables.)

TECHNICAL BULLETINS

**TECHNICAL BULLETIN 45: *Nitrogen and Organic Carbon of Soils as Influenced by Cropping Systems and Soil Treatments.*** —Nitrogen and organic carbon were determined from samples taken from the soil fertility plats at the Kansas Agricultural Experiment Station, established in 1910. Rates of loss or gain since 1915 were obtained. A 16-year rotation, a three-year rotation, and continuous wheat, produced fairly similar losses of nitrogen and carbon. The 16-year rotation lost nitrogen more rapidly than the other two cropping systems. In general, manure and green manure treatments maintained higher soil nitrogen and carbon levels than were maintained on control plats. (By W. H. Metzger; Department of Agronomy; 36 pages; 1 figure.)

**TECHNICAL BULLETIN 46: *The Carotenoid Pigments. Occurrence, Properties, Methods of Determination, and Metabolism by the Hen.*** —A comprehensive review of the literature on carotenoid pigments. Carotenes and xanthophylls are discussed with respect to their occurrence, properties, and methods of determination. Recent developments in technics for the separation of carotenoids by means of absorption columns and the application of spectrophotometric methods in the characterization of the pigments are also presented in considerable detail. The provitamin A (carotene content of a number of pasture plants and a variety of farm feeds are also given, with data on the effects of heat, sunlight and conditions of storage on the carotene concentration. In this connection interesting findings on the effect of gene dosage on the distribution and concentrations of carotenoid pigments in maize are also presented. A large part of the experimental portion of this bulletin is concerned with the metabolism by the hen of the carotenoid pigments, both in the chemically pure form and as naturally found in feeds. These were quantitative balance studies which demonstrated the capacity of the fowl to selectively utilize the xanthophylls, or hydroxy derivatives of the carotenes, in preference to the pure hydrocarbons. Carotenoid studies on normal and olive-colored egg yolks are also reported. (By W. J. Peterson, J. S. Hughes, Department of Chemistry; and L. F. Payne, Department of Poultry Husbandry; 74 pages; 6 figures; 27 tables.)

**TECHNICAL BULLETIN 47: *A Physiological Study of the Winter Wheat Plant at Different Stages of Its Development.*** —Wheat plants grown in the same soil varied markedly in their production of dry matter during different years. Heads of wheat at maturity composed from 25 percent to 40 percent of the total dry weight of the plants, dependent on the kind of season and type of plant. After blooming, dry matter decreased in the stems and leaves and increased in the heads. Increase of dry matter in heads was greater than decrease in stems and leaves. Nitrogen began to increase in the heads at about the same time it began to decrease in the stems and leaves. Total phosphorus in stems and leaves and other aerial parts never reached one percent on a dry basis and reached a maximum at harvest. Greatest gains in the amount of carbohydrates in the stems and leaves occurred during the earlier stages of the formation of the heads. (By Edwin C. Miller, Department of Botany; 167 pages; 28 figures; 28 tables.)

**TECHNICAL BULLETIN 48: *Identification of the Eggs of Mid-western Grasshoppers.*** —Brief diagnostic descriptions of the external features, especially chorionic sculpturing, of 48 species of grasshoppers from Kansas and the Great Plains, microphotographs of the cap end of the eggs of 40 species and detail drawings of types of sculpturing characteristics of many grasshopper eggs are contained in this publication. A key for their identification also is included. (By J. B. Tuck and Roger C. Smith, Department of Entomology; 40 pages; 11 plates; 2 figures.)

BULLETINS

**BULLETIN 278: *Sweet Potatoes in Kansas.***—The first part of this bulletin discusses methods for producing and storing sweet potatoes. The second part describes sweet-potato diseases and other pests and gives control methods. The discussion presents good practices for producing and storing the sweet-potato crop. It emphasizes improvement of planting stock through selection and through elimination of diseases. Specific information is given concerning hill selection, seed treatment, the hotbed, and sterilization of storage houses. (By O. H. Elmer, Department of Botany; 52 pages; 11 figures.)

**BULLETIN 279: *Smuts of Cereal and Forage Crops in Kansas and Their Control.***—This publication describes the smut diseases attacking the important cereal and forage crops which are grown in Kansas and gives the more common methods for their control. The economic losses and the cost of smut diseases are discussed and the most common symptoms by which these diseases may be recognized in the field are described. A section of the bulletin deals with the subject of whether the smut fungi are poisonous to livestock. Recent developments in fungicidal dust treatments for the control of smuts are described. The most common types of seed-treating equipment used for liquid and dust treatments are discussed. (By L. E. Melchers, Department of Botany; 37 pages; 17 figures.)

**BULLETIN 280: *Barley Production in Kansas.***—The publication discusses the importance and adaptation of spring barley in Kansas. It includes a description of varieties and their comparative yields. Methods of growing the crop are considered, including preparation of the land, seeding, harvesting and threshing. Sections are devoted to diseases of barley and their control, insect enemies, utilization of barley and the production of winter barley. (By A. F. Swanson, Fort Hays Branch Station; and H. H. Laude, Department of Agronomy; 27 pages; 8 figures; 5 tables.)

**BULLETIN 281: *Blankets, Sheets, and Towels for the Home.***—A publication for homemakers as well as teachers and extension workers. Includes a discussion of qualities desirable in fabrics for home use and factors affecting these qualities with helpful aids for their selection. Rules for care of blankets, including methods of cleaning and satisfactory storage. (By Katharine Hess, Department of Home Economics; 31 pages; 13 figures.)

**BULLETIN 282: *Soybean Production in Kansas.***—The soybean is adapted to the eastern three or four tiers of counties in Kansas. Grows under about the same general conditions as corn. No other grain crop in Kansas will produce so much protein per acre as the soybean. The bulletin discusses seedbed preparation, inoculation, varieties, cultivation, harvesting, and threshing. It also presents information on soybean hay production. Of interest primarily to those living in the eastern one-fifth of Kansas. (By J. W. Zahnley, Department of Agronomy; 25 pages; 7 figures; 6 tables.)

**BULLETIN 283: *Assessment and Collection of Farm Real Estate Taxes in Kansas.***—In this study two methods of measuring adequacy in the administration of the general property tax are applied. One is a test of the equality in assessment among different farming areas, among individual properties, and among low- and high-value properties. The other method is an analysis of the amount and character of tax delinquency. Suggestions are made for correcting certain administrative weaknesses. Wide variations in the ratios of assessed to sale values are discovered. There are wide discrepancies in practices among the different counties. These and other things result in inequalities affecting property owners. Of value to any who are willing to make a close and constructive study of the tax situation in Kansas. (By Harold Howe and L. F. Miller, Department of Agricultural Economics; 93 pages; 6 figures; 26 tables.)

**BULLETIN 284: *Poultry Diseases, Their Prevention and Control.***—This publication is exactly what its title implies. Disease is one of the important reasons for failure in the poultry industry. Practically all of the diseases of economic importance affecting poultry are discussed under the outline, general description, symptoms, and control. Occasionally there is a paragraph on post-mortem findings. It is a revision of Bulletin 247. Those having Bulletin 247 on hand will in most cases find it equal in value to Bulletin 284. (By L. D. Bushnell and M. J. Twiehaus, Department of Bacteriology; 125 pages; 38 figures; 2 tables.)

**BULLETIN 285: *Woodlands of Kansas.***—This bulletin tabulates the results of a forest survey of Kansas, made in cooperation with the U. S. Forest Service, United States Department of Agriculture. The growth, utilization and depletion of natural and planted forests are discussed. Several suggestions for a long-term forestry program for Kansas are contained in the bulletin. (By E. R. Ware, Forest Service, U. S. Department, of Agriculture, and Lloyd F. Smith, Department of Horticulture; 42 pages; 4 plates; 4 figures; 21 tables.)

**BULLETIN 286: *Equipment for Swine Production.***—This publication is a reprint of Bulletin No. 243 and contains several sets of plans and the accompanying bills of material for hog houses, feeding platforms, loading chutes, watering and feeding troughs, etc. In addition to discussing the desirable features of buildings, the authors discuss the importance of hog-house location, merits of individual and community houses, etc. The bulletin was written in cooperation with the Engineering Experiment Station. By B. M. Anderson, Department of Animal Husbandry; and V. R. Hillman, Department of Agricultural Engineering; 45 pages; 32 figures.)

**BULLETIN 287: *Feeding Range Lambs in Kansas.***—The range-lamb feeding industry has grown considerably in Kansas, especially in the western part of the state where there is an abundance of wheat pasture. Size, quality, and type of feeder lambs are discussed, as well as methods of obtaining lambs and types of contracts between producer and feeder. The bulletin is well illustrated with photographs of lamb feeding equipment, feed lots. Feeds and methods used in fattening lambs are discussed. The experienced lamb feeder will find many valuable suggestions in the publication, and those contemplating fattening range lambs will find the bulletin a source of much information. Every phase of the lamb feeding industry is discussed. (By Rufus F. Cox, Department of Animal Husbandry; 80 pages; 45 figures; 6 tables.)

**BULLETIN 288: *Kansas Corn Tests, 1939.***—The results of the 1939 Kansas Corn Performance Tests and the Kansas Coöperative Corn Strip Tests are contained in this bulletin. The Corn Performance Tests were conducted in five districts in the eastern section of Kansas. From 60 to 70 hybrids and open-pollinated varieties were tested in each district, in each of two-fields. The corn tested was entered by commercial seed companies, and by federal and state agencies. Corn variety and hybrid strip tests were conducted on farms to obtain information over a wide range of conditions. (By A. L. Clapp, H. D. Hollebeak, Department of Agronomy; and R. W. Jugenheimer, L. W. Skold, Division of Cereal Crops and Diseases, Bureau of Plant Industry, U. S. Department of Agriculture; 32 pages; 1 figure; 10 tables.)

**BULLETIN 289: *A Comparison of the Quality of Hard Red Winter and Hard Red Spring Wheats.***—A critical examination and presentation of the conclusions of published knowledge dealing with the respective qualities of hard red winter and hard red spring wheats is contained in this publication. Seventy-one literature citations are included. The question of relative qualities of hard winter and hard spring flours is of more than academic interest, since it springs out of commercial trends and practices and therefore is of importance from the strictly practical point of view.



Results of various tests by many workers in the field are included in the tabular material. When the two classes of wheat are compared on the same protein basis, the hard red winter wheats are found to be quite equal to the hard red spring wheats in intrinsic baking quality. (By R. K. Larmour, Department of Milling Industry; 57 pages; 4 figures; 32 tables.)

**BULLET 290: *Growing an Orchard in Kansas.*** —This bulletin is a revision of Bulletin 254 and contains formation useful to the orchardist concerning adapted varieties of the different fruits and recommended cultural practices. The apple and the sour cherry have been found to be the most profitable tree fruits for Kansas. Orchard soil management is the most important and the most complicated problem of Kansas orchardists, and the bulletin contains much useful information on that topic. The application of nitrates, phosphates or potash to young apple trees at the station orchard at Manhattan failed to show profitable results. A cover-crop system of soil management is recommended over intercropping in young orchards in Kansas, even where corn or other cultivated crops are grown as the intercrop. (By R. J. Barnett, Department of Horticulture; 48 pages; 17 figures; 3 tables.)

#### CIRCULARS

**CIRCULAR 192: *The Trend of Real Estate Taxation in Kansas, 1910 to 1935.*** —Trend of farm real estate taxes for the state government and each political subdivision. Information given for state as a whole and for the principal agricultural sections of the state. Taxes per acre. Trend of taxes on city real estate. Factors responsible for tax trends. Farm and city real estate taxes compared. Of value to anyone interested in property taxes in Kansas. (By Harold Howe, Department of Agricultural Economics; 22 pages; 9 figures; 14 tables.)

**CIRCULAR 193: *Strawberry Growing in Kansas.*** —When preparing this circular, the author had in mind both the commercial and the home-patch grower of strawberries. Varieties for Kansas, selection of site, obtaining plants, cultural operations, pests and harvesting the fruit are considered. Some precautions for new growers of this garden crop are included. (By R. J. Barnett, Department of Horticulture; 19 pages; 9 figures.)

**CIRCULAR 194: *Roadside Marketing of Horticultural Products in Kansas.*** —Gives the extent and areas of roadside marketing in Kansas. Desirable locations for different types markets. Products handled, costs involved, prices charged, and market patronage. Best time of the day and days of the week for sales. Factors to be considered in effective advertising. A brief discussion of fruit and vegetable wholesale and retail markets in a few Kansas cities. (By Franklin L. Parsons, Department of Agricultural Economics; 27 pages; 19 figures; 3 tables.)

**CIRCULAR 195: *Kansas Oil Property Taxation in Relation to Farm Taxes.*** —The oil industry in Kansas. Production by years, general location, and value compared with agricultural commodities. Present method of assessing oil-producing property in Kansas. Tax rates on Kansas oil-producing property compared with rates in other states. Tax burden on Kansas oil-producing property compared with that on Kansas agricultural property. Severance tax and taxation of oil-producing property in Kansas. Of value to persons interested in the tax situation in Kansas. (By L. F. Miller, Department of Agricultural Economics; 27 pages; 6 figures; 6 tables.)

**CIRCULAR 196: *Hybrid Corn in Kansas.*** —What is hybrid corn? The circular gives the answer. There is a discussion of inbreeding and its technic. Several kinds of hybrids are possible. These are described. Importance of testing new hybrids is emphasized. Of value to corn growers in the eastern half of Kansas. This circular is a semitechnical publication. (R. W. Jugenheimer, Division of Cereal Crops and Diseases, U. S. Department of Agriculture; 20 pages; 12 figures; 2 tables.)

**CIRCULAR 197: *Pruning Fruit Plants.*** —A revision of Circular 153 under the same title. New material is hardly sufficient to warrant those having the former circular in hand requesting this revised circular. The publication treats of bearing habits of fruit trees, pruning for tree building and pruning for fruit production. Paragraphs discuss the pruning of each important fruit tree, vine and bush. (R. J. Barnett and G. A. Filinger, Department of Horticulture; 27 pages; 13 figures.)

**CIRCULAR 198: *Control of Mammals Injurious to Agriculture in Kansas.*** —Detailed instructions for the control of the pocket gopher, prairie dog, ground squirrel, woodchuck, meadow mouse, house mouse, rat, rabbit and mole are contained in this circular. Baiting of runways and burrows with poisoned grain is the most economical method of control for field rodents. Directions are included for the proper mixing, handling, and storing of poison grain and other poison mixtures. (By George E. Johnson, revision by E. H. Herrick, Department of Zoölogy; 10 pages; 1 figure.)

**CIRCULAR 199: *Combating Fruit Pests in Kansas.*** —Control of pests is equally as important as proper soil management and cultural practices in the proper maintenance of an orchard. Detailed instructions about spraying, mixtures of spray materials and spraying schedules for fruit-tree diseases and orchard insects are included in this circular. The circular is illustrated with pictures of diseased stems and leaves, proper spraying technics. The publication is a revision of Circular 169 by W. F. Pickett and G. A. Filinger. (By G. A. Filinger, Department of Horticulture; 48 pages; 20 figures; 3 tables.)

MISCELLANEOUS

**MISCELLANEOUS PUBLICATION: *Flora of Kansas.*** —This publication is a botanical catalogue of the plants of Kansas, including the ferns and flowering plants. Maps showing the distribution of the various species are included in the catalogue. The work is prefaced by a brief note upon the topography, geology and climate of the state. In the annotated listing are 683 genera, including 2,063 species. The listings give the botanical name, the common name, type of soil and general location of the plants. (By F. C. Gates, Department of Botany; 266 pages; 80 plates, 2 figures.)

PUBLICATIONS BY DEPARTMENTS

The following table contains a list, classified by departments, of the regular publications of the Agricultural Experiment Station, and also the technical articles contributed to scientific journals by members of the station staff:

LIST OF PUBLICATIONS BY DEPARTMENTS

Department of Agricultural Economics		
Serial No.	Year of issue	Title, author, and publication
97	1938	Goals in Conservation Policy. W. E. Grimes. Jour. Farm Econ. 20:247-254.
98	1938	The Trend of Real Estate Taxation in Kansas, 1910 to 1935. Harold Howe. Kan. Agr. Expt. Sta. Circ. 192:1-22.
99	1938	Some Factors Related to Tax Delinquency of Farm Real Estate in Kansas. L. F. Miller. Jour. Farm Econ. 20:705-709.
100	1938	Roadside Marketing of Horticultural Products in Kansas. F. L. Parsons. Kan. Agr. Expt. Sta. Circ. 194:1-27.
102	1938	Debt-carrying Capacity of Farm Property in Relation to Cash Income. W. H. Pine. Jour. Amer. Soc. Farm Managers and Rural Appraisers, 2:59-63.
104	1938	Kansas Oil Property Taxation in Relation to Farm Taxes. L. F. Miller. Kan. Agr. Expt. Sta. Circ. 195:1-27.
105	1939	Assessment and Collection of Farm Real Estate Taxes in Kansas. Harold Howe and L. F. Miller. Kan. Agr. Expt. Sta. Bul. 283:1-93.
106	1939	The Storage of Butter. F. L. Parsons, W. H. Martin, D. L. Murray. National Butter and Cheese Jour. 30:(5)16-18; (6)50-52.
107	1940	Potato Marketing Investigations. F. L. Parsons. Kan. State Hort. Soc. Bien. Rpt. 45:155-157.

**Department of Agronomy**

<i>Serial No.</i>	<i>Year of issue</i>	<i>Title, author, and publication</i>
274	1938	Rejuvenation of Nursery Soils. R. I. Throckmorton. Kan. State Hort. Soc. Bien. Rpt. 44:97-103.
276	1939	Nitrogen and Organic Carbon of Soils as Influenced by Cropping Systems and Soil Treatments. W. H. Metzger. Kan. Agr. Expt. Sta. Tech. Bul. 45:1-36.
277	1938	Relation of Some Plant Characters to Yield in Winter Wheat. H. H. Laude. Jour. Amer. Soc. Agron. 30 :610-615
279	1938	Barley Production in Kansas. A. F. Swanson and H. H. Laude. Kan Agr. Expt. Sta. Bul. 280:1-27.
281	1939	The Nature, Extent, and Distribution of Fertilizer Residues in the Soil of Some Old Fertility Plots. W. H. Metzger. Soil Sci. 47:15-26.
282	1938	Effect of Certain Crops and Soil Treatments on Soil Aggregation and the Distribution of Organic Carbon in Relation to Aggregate Size. W. H. Metzger and J. C. Hide. Jour. Amer. Soc. Agron. 30:833-848.
283	1938	Improvement of <i>Andropogon scoparius</i> Michx. by Breeding and Selection. K. L. Anderson and A. E. Aldous. Jour. Amer. Soc. Agron. 30:862-869.
284	1939	Phosphorus Fixation by Horizons of Various Soil Types in Relation to Dilute and Extractable Iron and Aluminum. Dale S. Romine and W. H. Metzger. Jour. Amer. Soc. Agron. 31 : 99 - 108 .
285	1938	More Alfalfa for Kansas. C. O. Grandfield. Kan. State Bd. 31st Bien. Rpt. 36:132-139.
286	1938	A Soil Conservation Program for Kansas. R. I. Throckmorton. Kan. State Bd. 31st Bien. Rpt. 36:39-53.
287	1939	Soybean Production in Kansas. J. W. Zahnley. Kan. Agr. Expt. Sta. Bul. 282 : 1-28 (Revision of Bul. 249.)
288	1939	Laboratory Teaching in Beginning Courses in Crops and Soils. R. I. Throckmorton. Jour. Amer. Soc. Agron. 31:232-238.
289	1940	Soil Reaction and Plant Growth. R. I. Throckmorton. Kan. State Hort. Soc. Bien. Rpt. 45:77-80.
290	1939	Diurnal Cycle of Heat Resistance in Plants. H. H. Laude. Sci. 89 : 556-557.
291	1939	Hybrid Corn in Kansas. R. W. Jugenheimer. Kan. Agr. Expt. Sta. Circ. 196:1-19.
292	1939	Phosphorus Absorption by Wheat as Influenced by Application of Lime and Phosphorus. A. T. Perkins, W. H. Metzger, and H. H. King. Trans. Kan. Acad. Sci. 42:229-232.
293	1939	The Effect of Cultivation and Erosion on the Nitrogen and Carbon of Some Kansas Soils. J. C. Hide and W. H. Metzger. Jour. Amer. Soc. Agron. 31 : 625 - 632 .
295	1940	Resistance of Corn Seedlings to High Temperature in Laboratory Tests. E. G. Heyne and H. H. Laude. Jour. Amer. Soc. Agron. 32:116-126.
298	1940	Kansas Corn Tests for 1939. A. L. Clapp, R. W. Jugenheimer, H. D. Hollembeak, and L. N. Skold. Kan. Agr. Expt. Sta. Bul. 288:1-29.
300	1940	Inbreeding in Little Bluestem. K. L. Anderson. Jour. Amer. Soc. Agron. 32:159-160.
301	1940	The Kansas Hybrid Corn Program. R. W. Jugenheimer. Kan. State Bd. Agr. Quart. Rpt. 59:36-47.
...	1940	Soil and Water Conservation and Land Utilization. R. I. Throckmorton. Pamphlet for Agr. Com. of Kansas Bankers Assn.

**Department of Animal Husbandry**

<i>Serial No.</i>	<i>Year of issue</i>	<i>Title, author, and publication</i>
121*	1936	Elimination of Fat for Potash Clearing. Ralph Bogart and Sam Long. Trans. Kan. Acad. Sci. 39:257-261.
125*	1936	Barley as a Feed for Beef Cattle. A. D. Weber. Amer. Soc. Anim. Prod. Proc., 1936, p. 63.
134	1938	Freezer Lockers in Kansas. D. L. Mackintosh. Amer. Soc. Anim. Prod. Proc., 1938, p. 204.
136	1939	Feeding Range Lambs in Kansas. R. F. Cox. Kan. Agr. Expt. Sta. Bul. 287:1-80.

\* Omitted from Ninth Biennial Report, 1936-'38, by error.

<i>Serial No.</i>	<i>Year of issue</i>	<i>Title, author, and publication</i>
	1938	The Purpose of a Regional Sheep and Wool Investigational Program Within a State. C. W. McCampbell. Amer. Soc. Anim. Prod. Proc., 1938, p. 152.
...	1939	Beef Cattle Investigations. 1938-39. Fort Hays Branch Experiment Station. C. W. McCampbell and L. C. Aicher. 26th Ann. Rpt. Beef Cattle Investigations, 1938-'39. Fort Hays Branch Expt. Sta. pp. 1-8.
...	1940	Beef Cattle Investigations. 1939-'40, Fort Hays Branch Experiment Station C. W. McCampbell and L. C. Aicher. 27th Ann. Rpt. Beef Cattle Investigations, 1939-'40, Fort Hays Branch Expt. Sta. pp. 1-7.

**Department of Bacteriology**

<i>Serial No.</i>	<i>Year of issue</i>	<i>Title, author, and publication</i>
169	1939	Poultry Diseases, Their Prevention and Control. L. D. Bushnell. Kan. Agr. Expt. Sta. Bul. 284 : 1-125. (Revision of Bul. 247.)
171-A	1938	An Apparent Induced Loss of Nitrogen-Fixing Ability in Azotobacter. Charles R. Stumbo and P. L. Gainex. Jour. Agr. Research, 57:217-227.
174	1939	A Note on the Suitability of Various Lots of Dye for Use in the Resazurin Reduction Test. F. E. Nelson. Jour. Dairy Sci. 22:335-336
175	1939	Protection of Ice Cream Against Contamination After Pasteurization. F. E. Nelson. Ice Cream Rev., February, 1939, pp. 46-67.
176	1939	Comparisons of the Inactivation of Phosphatase Enzyme and the Killing of Escherichia-Aerobacter Organisms as Criteria of Satisfactory Pasteurization of Ice Cream Mix. F. E. Nelson, W. J. Caulfield, and W. H. Martin. Jour. Dairy Sci. 22:535-541
177	1939	Nonmotile Variants of Bacillus, Alvei. F. E. Nelson. Jour. Bact. 38:491-497.
178	1939	Effects of Soil Amendments upon Bacterial Populations Associated with Roots of Wheat. F. E. Nelson. Trans. Kan. Acad. Sci. 42:91-96.
179	1939	The Adsorbed Ions of Colloidal Clay as a Factor in Nitrogen Fixation by Azotobacter. T. M. McCalla. Soil Sci. 48:281-286.
180	1939	Effects of Organic Amendments upon the Microflora of the Rhizosphere of Cotton and Wheat. F. E. Clark and Charles Thom. Trans. Third Commission Internat. Soc. Soil Sci. A : 94-100.
181	1940	The Effect of the New Standard Milk Agar on the Plate Count of Dairy Products. F. E. Nelson. Jour. Bact. 39 :263-272.
182	1940	Measuring the Quality of Ice Cream. W. H. Martin, F. E. Nelson, and W. J. Caulfield. Jour. Dairy Sci. 23:135-147.
183	1940	Experiments of Absorption in the Crop of the Chicken. E. E. Leasure and V. D. Foltz. Jour. Amer. Vet. Med. Assn. 96 : 236 - 238.
187	1940	Fowl Cholera. L. D. Bushnell. Jour. Vet. Med. 35 : 252-255.
188	1940	Fowl Typhoid. L. D. Bushnell. Jour. Vet. Med. 35 : 313-315.
189	1939	Diagnosis of Poultry Diseases. M. J. Twiehaus. Jour. Vet. Med. 34 : 698-710.
190	1940	Trichomoniasis in Turkeys. L. D. Bushnell and M. J. Twiehaus. Jour. Vet. Med. 35 : 103-105.
191	1939	The Sanitary Quality of Ice Cream. F. E. Nelson, W. J. Caulfield, and W. H. Martin. Ice Cream Rev., January, 1940, pp. 44-54. Ice Cream Field, 34:14-28.

**Department of Botany**

<i>Serial No.</i>	<i>Year of issue</i>	<i>Title, author, and publication</i>
357	1939	Soil Infestation by Ophiobolus graminis and Its Spread. Hurley Fellows and C. H. Ficke. Jour. Agr. Research, 58:505-519.
362	1938	Smuts of Cereal and Forage Crops in Kansas and Their Control. L. E. Melchers. Kan. Agr. Expt. Sta. Bul. 279 : 1-37. (Revision of Bul. 210.)
367	1938	Sweet Potatoes in Kansas. O. H. Elmer. Kan. Agr. Expt. Sta. Bul. 278 : 1-52.

<i>Serial No.</i>	<i>Year of issue</i>	<i>Title, author, and publication</i>
371*	1937	Virus Diseases of Plants. L. E. Melchers. Proc. 13th Ann. Mtg. Cent. Plt. Bd., K. C., Mo., pp. 28-30 (Abstract).
378	1938	The Wheat Stem Rust Epidemic of 1937 in Kansas. C. O. Johnston, L. E. Melchers, and J. O. Miller. Plant Dis. Reporter Sup. 107:83-94.
379	1938	Kansas Mycological Notes, 1937. C. O. Johnston and Travis E. Brooks. Trans. Kan. Acad. Sci. 41:121-123.
380	1938	Kansas Botanical Notes, 1937. Frank C. Gates. Trans. Kan. Acad. Sci. 41:97-98.
381	1938	Wood Plants, Native and Naturalized in Kansas. Frank C. Gates. Trans. Kan. Acad. Sci. 41:99-118.
383	1938	<i>Taraxacum lacvigatum</i> f. <i>scapifolium</i> , A New Form of Dandelion. Frank C. Gates and S. Fred Prince. Trans. Kan. Acad. Sci. 41:119-120.
384	1939	A Chlorotic Mottling of Wheat Leaves Caused by Infections of Bunt <i>Tilletia Laevis</i> . C. O. Johnston and C. L. Lefebvre. Phytopath. 29:456-458.
386	1939	Seed Germination and Development of the Seedling in <i>Commelina Virginica</i> . James C. Bates. Trans. Kan. Acad. Sci. 42:109-112.
387	1939	Trends of Tree Migration in Kansas. Frank C. Gates. Trans. Kan. Acad. Sci. 42:127-132.
388	1939	Kansas Botanical Notes, 1938. Frank C. Gates. Trans. Kan. Acad. Sci. 42:133-134
389	1939	New Forms and Nomenclatorial Combinations in the Kansas Flora. Frank C. Gates. Trans. Kan. Acad. Sci. 42:135-138.
390	1939	The Bearing of Zalenski's Law on Conifer Leaves. Lucile B. Burt. Trans. Kan. Acad. Sci. 42:113-121.
391	1940	Flora of Kansas. Frank C. Gates. Kan. Agr. Expt. Sta. Miscel. Pub., pp. 1-266.
392	1939	A Physiological Study of the Winter Wheat Plant at Different Stages of Its Development. E. C. Miller. Kan. Agr. Expt. Sta. Tech. Bul. 47 : 1-167.
394	1939	The Wheat Stem and Leaf Rust Epidemics of 1938 in Kansas. L. E. Melchers and C. O. Johnston. Plant Dis. Reporter Sup. 116:51-68.
397	1939	Conditions for the Flowering of <i>Utricularia resupinata</i> . Frank C. Gates. Liloa, 5:159-162.
402	1940	Bog Levels. Frank C. Gates. Sci. 91:449-450.

**Department of Chemistry**

<i>Serial No.</i>	<i>Year of issue</i>	<i>Title, author, and publication</i>
218	1938	Selenium and Tenmarq Wheat. A. T. Perkins and H. H. King. Jour. Amer. Soc. Agron 30 : 664-667.
227 (1)	1938	Riboflavin Content of Milk Collected in Different Months and Correlated with Other Constituent of the Milk. C. H. Whitnah, Bernice L. Kunerth, and Martha M. Kramer. Jour. Dairy Sci. 21:593-600.
228	1938	The Composition of the Uterine Secretion of the Domestic Fowl B. W. Beadle, R. M. Conrad, and H. M. Scott. Poultry Sci. 17:498-504
229 (2)	1939	Fluctuations of Phosphatase and Inorganic Phosphorus in the Blood of the Laying Hen During the Cycle of One Egg. W. J. Peterson and D. B. Parrish. Poultry Sci. 15:54-58.
230	1939	Phosphatase and Inorganic Phosphorus in the Plasma and Whole Blood of the Fowl. W. J. Peterson and D. B. Parrish. Poultry Sci. 18:59-62.
231	1938	The Formation of the Egg of the Domestic Fowl. R. M. Conrad and H. M. Scott. Physiol Rev. 18:481-494.
235	1939	Relation of Vitamin C, Lecithin, and Carotene Content of Milk to the Development of Oxidized Flavor. G. H. Beck, C. H. Whitnah, and W. H. Martin. Dairy Sci. 22 :17-29.
236	1939	Carotene Balance and Blood-Carotene Levels in Heifers and Lactating Dairy Cows and Their Relation to the Production of Off-Flavor Milk. C. H. Whitnah, W. J. Peterson, F. W. Atkeson, and H. W. Cave. Jour. Agr. Research, 58:343-355.

\* Omitted from Ninth Biennial Report, 1936-'38, by error.

1. Cont. No. 227 in Ninth Bien. Rpt. was in error. It should have carried No. 217.
2. Cont. No. 229 in Ninth Bien. Rpt. was in error. It should have carried No. 219.

<i>Serial No.</i>	<i>Year of issue</i>	<i>Title, author, and publication</i>
236-A	1939	Growth of the Hen's Ovum. D. C. Warren and R. M. Conrad. Jour. Agr. Research, 58 : 875 - 894.
237	1939	The Alternate White and Yellow Layers of Yolk in Hen's Ova R. M. Conrad and D. C. Warren. Poultry Sci. 18:220-224
	1938	Variations in the Fat and Solids-Not-Fat Content of Milk. C. H. Whitnah, and F. W. Atkeson. Internat. Assn. Milk Dealers, Oct., 1938.
n 240	1939	The effect of High Temperature on the Blood Calcium of the Laying Hen. e R. M. Conrad. Poultry Sci. 18:327
241	1940	The Production of Double Yolked Eggs in the Fowl. R. M. Conrad and D. C. Warren. Poultry Sci. 19:9-17
243	1939	The Carotenoid Pigment W. J. Peterson, J. S. Huglies, and L. F. Payne. Kan. Agr. Expt. Sta. Tech. Bul. 46 : 1-74.
244	1939	Changes in Ovomucin During Egg Storage. R. M. Conrad and H. M. Scott. 7th World's Poultry Cong. Proc. pp 528-530
245	1940	The Effect of Grass Silage on Egg Yolk Color. L. F. Payne, C. L. Gish, and W. J. Peterson. Poultry Sci. 19:154-156.
246	1939	Report on Mineral Mixed Feeds. A. T. Perkins and B. W. Beadle. Jour. Assn. Official Agr. Chemists, 22:647-650.
251	1939	Blood Calcium Levels of the Fowl Following Injections of Theelin. T. B. Avery, H. M. Scott, and R. M. Conrad. Endocrinology, 27:83-86.
	1938	Report on Mineral Mixed Feeds. A. T. Perkins and J. F. Merrill. Jour. Assn. Official Agr. Chemists, 21:4.
	1939	Nutritional Diseases of Poultry. W. J. Peterson and J. S. Hughes. Jour. Vet. Med. 34:731-733.
	1940	Vitamin Considerations in Wheat Products. W. J. Peterson and J. S. Hughes. Southwestern Miller, 19:19-20

**Department of Dairy Husbandry**

<i>Serial No.</i>	<i>Year of issue</i>	<i>Title, author, and publication</i>
118	1939	The Riboflavin Value of Milk. Martha M. Kramer, Sister Regina Marie Dickman, M. D. Hildreth, Bernice L. Kunerth, and W. H. Riddell. Jour. Dairy Sci. 22:753-759.
122	1938	Milk as a Source of Riboflavin (Vitamin G). Bernice L. Kunerth and W. H. Riddell. Trans. Kan. Acad. Sci. 41:231-232.
	1939	Carotene Balance and Blood-Carotene Levels in Heifers and Lactating Dairy Cows and Their Relation to the Production of Off-Flavor Milk. C. H. Whitnah, W. J. Peterson, F. W. Atkeson, and H. W. Cave. Jour. Agr. Research, 58 : 343-355.
124	1939	Relation of Vitamin C, Lecithin, and Carotene Content of Milk to the Development of Oxidized Flavor. G. H. Beck, C. H. Whitnah, and W. H. Martin. Jour. Dairy Sci. 22:17-29.
125	1938	Variations in the Fat and Solids-Not-Fat Content of Milk. W. J. Caulfield, C. H. Whitnah, and F. W. Atkeson. Internat. Assn. Milk Dealers, Oct., 1938.
126	1939	Certain Factors Affecting the Phosphatase Test When Applied to Ice Cream. W. J. Caulfield and W. H. Martin. Jour. Dairy Sci. 22:261-270.
127	1939	The Influence of Three Methods of Cleaning the Cream Separator and Cream Storage Temperature on the Keeping Quality of Cream. W. J. Caulfield and W. H. Martin. Jour. Dairy Sci. 22 :683-589
128	1939	Comparisons of the Inactivation of Phosphatase Enzyme and the Killing of <i>Escherichia-Aerobactor</i> Organisms as Criteria of Satisfactory Pasteurization of Ice Cream Mix. F. E. Nelson, W. J. Caulfield, and W. H. Martin. Jour. Dairy Sci. 22:535-541.
129	1939	The Storage of Butter. F. L. Parsons, W. H. Martin, and D. L. Murray. National Butter and Cheese Jour. 30:(5)16-18; (6)50-52.
130	1939	Measuring the Quality of Ice Cream. W. H. Martin, F. E. Nelson, and W. J. Caulfield. Jour. Dairy Sci. 23 :135-147.
131	1940	The Sanitary Quality of Ice Cream. F. E. Nelson, W. J. Caulfield, and W. H. Martin. Ice Cream Rev., January, 1940, pp. 44-54. Ice Cream Field, 34 :14-28.

Department of Entomology

Serial No.	Year of Issue	Title, author, and publication
386	1940	Pollen Needs for Brood Bearing. R. L. Parker. Iowa State Apiarist Rpt. for 1939, pp. 87-89.
387	1940	Overcoat Winter Protection Cases. R. L. Parker. Iowa State Apiarist Rpt. for 1939, pp. 90-93.
388	1940	Honey Production Under Drought Conditions. R. L. Parker. Iowa State Apiarist Rpt. for 1939, pp. 93-94.
449-A	1938	Substitutes for Lead Arsenate Used as Sprays for Codling-moth Control During the Season of 1936. R. L. Parker and P. G. Lamerson. Kan. State Hort. Soc. Bien. Rpt. 44:115-121.
452	1938	Small-Fruit Insects. R. L. Parker and P. G. Lamerson. Kan. State Hort. Soc. Bien. Rpt. 44:107-115.
453	1938	Substitutes for Lead Arsenate Used as Sprays for Codling-moth Control During the Season of 1937. R. L. Parker and P. G. Lamerson. Kan. State Hort. Soc. Bien. Rpt. 44:121-130.
454	1938	A Five-Year Summary of Codling Moth Control in Kansas. R. L. Parker and P. G. Lamerson. Kan. State Hort. Soc. Bien. Rpt. 44: 130-133.
455	1938	Annual Insect Population Records, with Special References to the Kansas Summary. R. C. Smith. Jour. Econ. Ent. 31:618-622.
458	1938	Some Phases of Entomological Writing from the Viewpoint of the Reader. R. C. Smith. Jour. Econ Ent. 31:563-565.
459	1938	Columbine Culture in Kansas. H. R. Bryson. Kan. State Hort. Soc. Bien. Rpt. 44:169-181.
460	1938	The Contribution of Kansas to the Science of Entomology. G. A. Dean. Trans. Kan. Acad. Sci. 41:61-73.
461	1938	A Preliminary Report of the Insects Attacking Bindweed with Special Reference to Kansas. R. C. Smith. Trans. Kan. Acad. Sci. 41:183-191.
462	1939	The Biology and Control of the Strawberry Leafroller. R. L. Parker and P. G. Lamerson. Proc. 7th Internatl. Kongress fur Ent. 7:2376-2387.
463	1939	Two New Species of South American Bombyliidae. R. H. Painter. Arb. Morph. Taxon. Ent. Berlin-Dahlem, 6:42-44.
464	1939	Mass Flights of the Pentatomid, <i>Thyanta custator</i> (Fabr.) in Kansas. D. A. Wilbur. Jour. Kan. Ent. Soc. 12 :77-80.
465	1940	Lead Arsenate Combinations and Nicotine Combinations as Control Measures for the Codling Moth, 1938. P. G. Lamerson and R. L. Parker. Jour. Econ. Ent. 32:828-832. Kan. State Hort. Soc. Bien. Rpt. 45:29-37.
466	1939	Collecting Insects Inhabiting Grasses by the Use of Shoebox Emergence Cages. D. A. Wilbur and Roy Fritz. Jour. Econ. Ent. 32:571-573.
467	1940	Insect Collection and Rearings on Castor Bean Plants. R. C. Smith. Jour. Econ. Ent. 32:749-758.
468	1940	Control of the American Strawberry Leafroller <i>Ancylis fragariae</i> , in the Lower Missouri River Vally. P. G. Lamerson and R. L. Parker. Jour. Econ. Ent. 32:824-828. Kan. State Hort. Soc. Bien. Rpt. 45:39-46.
469	1939	Insects Which Attack the Redbud. R. L. Parker. Garden Gleanings, 1:(1)6: (2)3. Kan. State Hort. Soc. Bien. Rpt. 45 :239-242.
470	1940	Notes on Type Specimens and Descriptions of New North American <i>Bombyliidae</i> . R. H. Painter. Trans. Kan. Acad. Sci. 42:267-301.
471	1939	The Eight Annual Insect Population Summary of Kansas Covering the Year 1938. R. C. Smith and E. G. Kelly. Trans. Kan. Acad. Sci. 42:303-323.
472	1939	Some Recent Observations on the Activities of <i>Phyllophaga lanceolata</i> say ( <i>Scarabaeidae</i> ). H. R. Bryson. Jour. Kan. Ent. Soc. 12:94-96.
473	1939	Biological and Taxonomic Observations on the Mosquitoes in Kansas. Mrs. Nobless DeMoss Hill. Trans. Kan. Acad. Sci. 42 :255-265.
475	1939	The Identification of Soil Burrowing Insects by Their Burrow Characteristics. H. R. Bryson. Trans. Kan. Acad. Sci. 42:245-253.
476	1940	Rate of Reproduction of the Pea Aphid on Different Alfalfa Plants. R. G. Dahms and R. H. Painter. Jour. Econ. Ent. 33:482-485.
477	1939	Identification of the Eggs of Mid-western Grasshoppers R. C. Smith and J. B. Tuck. Kan. Agr. Expt. Sta. Tech. Bul. 48:1-39.

Serial No.	Year of issue	Title, author, and publication
478	1940	Control of the Strawberry Leafroller <i>Ancylis comptana fragariae</i> W. & R., During the Season of 1939. R. L. Parker and P. G. Lamerson. Kan. State Hort. Soc. Bien. Rpt. 45:173-179.
479	1940	Observations on <i>Stenomoma mistrella</i> Busck ( <i>Stenomidae</i> , <i>Lepidoptera</i> ). H. D. Oliver Miller. Jour. Kan. Ent. Soc. 13:1-3.
484	1940	New and Effective Control for the American Strawberry Leafroller. R. L. Parker. Trans. Iowa State Hort. Soc. 74 : 37-39.
485	1940	Effective Codling Moth Control. R. L. Parker. Trans. Iowa State Hort. Soc. 74:39-41.
486	1940	An Effective Control for the Larger Apple Curculio. R. L. Parker. Trans. Iowa State Hort. Soc. 74:45-47.
487	1940	Pollen Needs for Broodrearing. R. L. Parker. Trans. Iowa State Hort. Soc. 74:305-307.
488	1940	Overcoat Winter Protection Cases. R. L. Parker. Trans. Iowa State Hort. Soc. 74 :307-310.
489	1940	Honey Production Under Drought Conditions. R. L. Parker. Trans. Iowa State Hort. Soc. 74:311-312.
491	1940	The Juniper Midge, <i>Contarinia juniperina</i> Felt, A Pest of Red Cedars. R. L. Parker and Otto E. Wenger. Jour. Kan. Ent. Soc. 13 :46-50.
493	1940	The Ninth Annual Insect Population Summary of Kansas, 1939. R. C. Smith and E. G. Kelly. Jour. Kan. Ent. Soc. 13:65-85.
494	1940	Grasshopper Populations of Typical Pastures in the Bluestem Region of Kansas ( <i>Orthoptera</i> , <i>Acrididae</i> ). D. A. Wilbur and Roy Fritz. Jour. Kan. Ent. Soc. 13 :86-100.

**Department of Home Economics**

Serial No.	Year of issue	Title, author, and publication
73	1939	Riboflavin Value of Milk. Martha M. Kramer, Sister Regina Marie Dickman, M. D. Hildreth, and W. H. Riddell. Jour. Dairy Sci. 22:753-759.
79	1938	Milk as a Source of Riboflavin (Vitamin G). Bernice L. Kunerth and W. H. Riddell. Trans. Ken. Acad. Sci. 41:231-232.
80	1939	Adequacy of Labeling of Textile Fabrics with Regard to Fiber Content. Hazel M. Fletcher and Lois Denhardt. Jour. Agr. Research. 58:895-903.
81	1939	A Long-Time Study of Nitrogen, Calcium, and Phosphorus Metabolism on a Low-Protein Diet. Bernice L. Kunerth and Martha S. Pittman. Jour. Nutr. 17:161-173.
82	1939	A Long-Time Study of Nitrogen, Calcium, and Phosphorus Metabolism on a Medium-Protein Diet. Bernice L. Kunerth and Martha S. Pittman. Jour. Nutr. 17:175-185.
84	1940	The Adequacy of Labeling of Certain Textile Fabrics with Regard to Fiber Content. Hazel M. Fletcher and Lois Denhardt. Jour. Home Econ. 32:37-40.
85	1939	Quantitative Microscopical Analysis of Mixed Fabrics. Hazel M. Fletcher. Amer. Dyestuff Reporter, 23:624-626.
86	1939	Injection of Corpora Lutea Extract in Pregnant Guinea Pigs on a Vitamin C-limited Diet. Olga B. Saffry and John C. Finerty. Trans. Kan. Acad. Sci. 42:483-485.
87	1939	Some Effects on Guinea Pigs of Feeding Vitamin C Intermittently. Mary T. Harman and Abbie Miller. Trans. Kan. Acad. Sci. 42:445-449.
837	1938	Blankets, Sheets and Towels. Kathrine Hess. Kan. Agr. Expt. Sta. Bul. 281 :1-31.

**Department of Horticulture**

Serial No.	Year of issue	Title, author, and publication
151	1938	Strawberry Growing in Kansas. R. J. Barnett. Ken. Agr. Expt. Sta. Circ. 193:1-19.
152	1939	Woodlands of Kansas. E. R. Ware and L. F. Smith. Kan. Agr. Expt. Sta. Bul. 285 :1-42.
153	1940	Factors Controlling the Early Development and Survival of Eastern White Pine ( <i>Pinus strobus</i> L.) in Central New England. L. F. Smith. Ecological Monographs, 10:373-420.
154	1939	Pruning Fruit Plants. R. J. Barnett and G. A. Filing. Kan. Agr. Expt. Sta. Circ. 197:1-27 (Revision of Circ. 153.)



<i>Serial No.</i>	<i>Year of issue</i>	<i>Title, author, and publication</i>
155	1939	Greenhouse Soils. S. W. Decker. Southern Florist, 47:3
156	1940	Problems in Marketing Kaw Valley Potatoes. S. W. Decker. Kan. State Hort. Soc. Bien. Rpt. 45:55-65.
160	1940	Kansas Orchardists must Save Their Rainfall. R. J. Barnett. Kan. State Hort. Soc. Bien. Rpt. 45 :97-100.
161	1940	The Relationship Between Leaf Structure, Chlorophyll Content and Photosynthesis in Apple Leaves. W. F. Pickett and A. L. Kenworthy. Amer. Soc. Hort. Sci. Proc., 1939, 37:371-373.
162	1940	What the Droughts of the '30's Did to Apple Orchards in the Arkansas River Valley in Kansas. R. J. Barnett and W. G. Amstein. Amer. Soc. Hort. Sci. Proc. 37:116-118.
163	1940	Marketing Kaw Valley Potatoes. S. W. Decker. Kan. State Hort. Soc. Bien. Rpt. 45:145-153.
166	1940	Combating Fruit Pests in Kansas. G. A. Filing. Kan. Agr. Expt. Sta. Circ. 199:1-45. (Revision of Circ. 189.)

**Department of Milling Industry**

<i>Serial No.</i>	<i>Year of issue</i>	<i>Title, author, and publication</i>
54	1938	Direct Current for the Tag-Heppenstall Moisture Meter. E. B. Working. Cereal Chem. 15 :500-508.
55	1938	A Balanced Circuit for Electrometric Titration. E. B. Working. Indus. and Engin. Chem. (Analytical Edition) 10:397-398.
56	1938	An Electronic Voltage Regulator with Supplementary Circuit to Supply Low Voltages. E. B. Working. Indus. and Engin. Chem. 10:434-435.
57	1939	The Wheat-Meal-Time-Fermentation Test II. Effect of Proteases, Protease Activators and Protease Inhibitors. C. O. Swanson and F. T. Dines. Cereal Chem. 16:168-177.
58	1939	The Wheat-Meal-Time-Fermentation Test III Effect of Bran, Protease and Activators on the "Time" of Flour. C. O. Swanson. Cereal Chem. 16 :365-376.
59	1939	Variations in Dough Development Curves. C. O. Swanson. Cereal Chem. 16:625-643.
60	1939	<b>Comparison of the Allis-Chalmers and the Buhler Automatic Experimental Mills.</b> Max E. McCluggage, J. E. Anderson, and R. K. Larmour. Cereal Chem. 16 :610-619.
61	1939	<b>Determining the Moisture Requirements for Tempering Wheat for Experimental Milling.</b> Max E. McCluggage. Assn. Operative Millers Bul., June, pp. 962-963.
62	1939	Quality Tests on Hard Red Winter Wheats. R. K. Larmour, E. B. Working, and C. W. Ofelt. Cereal Chem. 16:733-752.
63	1940	Quality Tests on Soft Red Winter Wheats in Kansas. R. K. Lamour, E. B. Working, and C. W. Ofelt. Cereal Chem. 17:18-29.
64	1940	The Effect of Milk on the Bromate Requirements of Flours. C. W. Ofelt and R. K. Larmour. Cereal Chem. 17:1-18.
65	1940	The Wheat -Meal-Time-Fermentation Test IV. Inhibitory and Accelerating Factors. C. O. Swanson. Cereal Chem. 17:355-372.
66	1940 A	Comparison of the Quality of Hard Red Winter and Hard Red Spring Wheats. R. K. Larmour. Kan Agr. Expt. Sta. Bul. 289 : 1 -57.
67	1940	A Review of the Literature on Wheat Conditioning. Max E. McCluggage. Assn. Operative Millers Bul., May, pp. 1026-1030.
...	1939	The Effect of Environment on Wheat Quality A resume R. K. Larmour. Trans. Kan. Acad. Sci. 42 :81-89.

<i>Serial</i>		<b>Department of Poultry Husbandry</b>	
<i>No.</i>	<i>Year of issue</i>	<i>Title, author, and publication</i>	
110	1938	The Composition of the Uterine Secretion of the Domestic Fowl. B. W. Bendle, R. M. Conrad, and H. M. Scott. Poultry Sci. 17:498-504.	
111	1938	The Formation of the Egg of the Domestic Fowl. R. M. Conrad and H. M. Scott. Physiol. Rev. 18:481-494.	
112	1939	Growth of the Hen's Ovum. D. C. Warren and R. M. Conrad. Jour. Agr. Research, 58:875-894.	
113	1939	The Alternate White and Yellow Layers of Yolk in Hen's Ova. R. M. Conrad and D. C. Warren. Poultry Sci. 18:220-224.	
114	1940	Brachydactyly in the Fowl. D. C. Warren. Jour. Heredity, 31:141-144.	
115	1939	Spike-blade—A Heritable Single Comb Variation in the Fowl. D. C. Warren. Jour. Heredity, 30:257-260.	
116	1939	Density of Suspension and Morphology of Sperm in Relation to Fertility in the Fowl. F. R. Sampson and D. C. Warren. Poultry Sci. 18:301-307.	
117	1940	Crossing Over and Sex in the Fowl. D. C. Warren. Amer. Nat. 74:93-95.	
118	1939	The Effect of Temperature on Size of Eggs from Pullets in Different Latitudes. D. C. Warren. Jour. Agr. Research, 59:441-452.	
119	1940	The Production of Double Yolked Eggs in the Fowl. R. M. Conrad and D. C. Warren. Poultry Sci. 19:9-17.	
120	1939	The Carotenoid Pigments. W. J. Peterson, J. S. Hughes, and L. F. Payne. Kan. Agr. Expt. Sta. Tech. Bul. 46:1-74.	
121	1939	Changes in Ovomucin During Egg Storage. R. M. Conrad and H. M. Scott. 7th World's Poultry Cong. Proc., pp. 528-530.	
122	1940	The Importance of Herbage in Poultry Management. C. L. Gish and L. F. Payne. Poultry Sci. 19:35-40.	
123	1940	The Porosity of the Egg-Shell in Relation to Hatchability. Clyde D. Mueller and H. M. Scott. Poultry Sci. 19:163-166.	
124	1940	The Effect of Air Temperatures on Egg Shell Thickness in the Fowl. D. C. Warren and R. L. Schnepel. Poultry Sci. 19:67-72.	
125	1940	The Effect of Grass Silage on Egg Yolk Color. C. L. Gish, L. F. Payne, and W. J. Peterson. Poultry Sci. 19:164-156.	
126	1940	A Note on Abnormal Shape of Egg. H. M. Scott. Amer. Nat. 74:185-188.	
127	1940	Inheritance of Pinkeye in the Fowl. D. C. Warren. Jour. Heredity, 31:291-292.	
131	1940	Blood Calcium Levels; of the Fowl Following Injections of Theelin. T. B. Avery, H. M. Scott, and R. M. Conrad. Endocrinology, 27:83-86.	
<i>Serial</i>		<b>Department of Veterinary Medicine</b>	
<i>No.</i>	<i>Year of issue</i>	<i>Title, author, and publication</i>	
72	1938	A Preliminary Report on the Influence of Hydrogen-Ion Concentration Upon the Longevity of Strongylus Vulgaris (Looss, 1900) in Vitro. J. H. Whitlock and E. E. Leasure. Jour. Parasitology (Research Notes) 24:469.	
73	1938	The Resistance of Cows to Bang's Disease After Being Infected at Birth and Raised to Maturity in an Environment Free of Infection. C. H. Kitzelman, Lederle Vet. Bul. 7:105-108.	
74	1939	Studies Upon Strongylus Vulgaris. I. The Incidence of Strongylus Vulgaris in Mid-Continental North America and the Reaction of the Infested Ceca. J. H. Whitlock and E. E. Leasure. Amer. Jour. Hygiene, 29:Sec. D: 83-87.	
75	1939	Studies Upon Strongylus Vulgaris. II. Initial Development of Apparatus Adapted for the Study of Strongylus Vulgaris in Vitro. J. H. Whitlock. Amer. Jour. Hygiene, 30:Sec. D: 1-3.	
76	1939	Studies Upon Strongylus Vulgaris. III. The Influence of Hydrogen-Ion Concentration Upon the Longevity of Strongylus vulgaris in Vitro. J. H. Whitlock, R. P. Link, and E. E. Leasure. Amer. Jour. Hygiene, 30:Sec. D: 5-14.	
77	1939	The pH (Hydrogen-Ion Concentration) of the Contents of the Digestive Canal of the Equine. E. E. Leasure, R. P. Link, and J. H. Whitlock. Cornell Veterinarian, 29:362-366.	

<i>Serial No.</i>	<i>Year of issue</i>	<i>Title, author, and publication</i>
78	1940	Experiments on Absorption in the Crop of the Chicken. E. E. Leasure and V. D. Foltz. Jour. Amer. Vet. Med. Assn. 96:236-238.
80	1940	Studies Upon Strongylus Vulgaris V. Comparative Toxicity of the Cupric Halides and Copper Sulphate for Strongylus vulgaris in Vitro. J. H. Whitlock. Amer. Jour. Hygiene, 26 :49-57.
81	1940	Studies Upon Strongylus Vulgaris IV. A Method of Determining the Endpoint of the Reaction of a Lethal Agent Against Adults in Vitro. J. H. Whitlock. Amer. Jour. Hygiene, 26:45-47.
<b>Department of Zoölogy</b>		
<i>Serial No.</i>	<i>Year of issue</i>	<i>Title, author, and publication</i>
191	1938	Concerning the Postnatal Obliteration of the Umbilical Vein and Arteries, the Vitelline Vein and Artery, and the Ducturs Arteriosus in the Guinea Pig. Mary T. Harman. Trans. Kan. Acad. Sci. 41: 369-377.
192	1938	The Development and Atrasia of the Graafian Follicle and the Division of the Intra-Ovarian Ova in the Guinea Pig. Mary T. Harman and H. D. Kirgis. Amer. Jour. Anat. 63:79-99
196	1938	Susceptibility of Mature Chickens to Tapeworm Infections. J. E. Ackert and Arthur A. Case. Trans. Kan. Acad. Sci. 41:299-302.
198	1939	Notes on Four Kansas Cases of Human Tapeworm Infestation. J. E. Ackert. Volume honoring Professor Doctor Sadao Hoshida, Eminent Parasitologist of Japan, II:221-224.
199	1938	Growing Larval <i>Ascaridia lineata</i> (Nematoda) in Vitro. J. E. Ackert, A. C. Todd, and Wm. A. Tanner. Trans. Amer. Micro. Soc. 57 :292-296.
200	1939	The Origin and Fate of the Entoderm Elements in the Embryogeny of <i>Porcellio Laevis</i> Lat. and <i>Amardillidium Nasatum</i> B. L. Isopoda. A. L. Goodrich, Jr., Jour. of Morphology, 64 :401-409.
201	1938	Newer Knowledge of Poultry Parasites. J. E. Ackert. Proc. 24th Ann. Mtg. U. S. Livestock San. Assn., Dec. 1938. pp. 197-208.
202	1939	Goblet Cells and Age Resistance of Animals to Parasitism. J. E., Ackert, S. Allen Edgar, and L. P. Frick. Trans. Amer. Micro. Soc. 58:81-89.
203	1939	An Unusual Anomaly of a Post Caval Tributary in the Thoracic Region of the Domestic Cat. D. J. Ameel. Trans. Kan. Acad. Sci. 42:421-422.
204	1939	Some Effects on Guinea Pigs of Feeding Vitamin C Intermittently. Mary T. Harman and Abbie Miller. Trans. Kan. Acad. Sci. 42:445-449.
205	1939	Intermediate Hosts of Chicken Tapeworms Found in Kansas. Arthur A. Case and J. E. Ackert. Trans Kan Acad. Sci. 42:437-442.
206	1940	The Food of the Fowl Nematode <i>Ascaridia lineata</i> (Schneider). J. E. Ackert, J. H. Whitlock, and A. E. Freeman, Jr. Jour. Parasit. 26:17-32.
207	1939	Factors in the Resistance of Chickens to Parasitic Worms. J. E. Ackert. 7th World's Poultry Cong. Proc., pp. 265-267.
208	1939	Injection of Corpora Lutea Extract in Pregnant Guinea Pigs on a Vitamin-C Limited Diet. Olga B. Saffry and John C. Finerty. Trans. Kan. Acad. Sci. 42:483-485.
209	1940	The Effect of Male Sex Hormone on the Developing Ovaries of Young Fowls E. H. Herrick and Chas. H. Lockhart. Endocrinology 26:508-510.
210	1940	On the Resistance of Chickens to the Intestinal Nematode <i>Ascaridia lineata</i> (Schneider) Following Immunization. L. L. Eisenbrandt and J. E. Ackert. Amer. Jour. Hygiene, 32:1-11.
211	1940	Control of Mammals Injurious to Agriculture in Kansas. E. H. Herrick. Kan. Agr. Expt. Sta. Circ. 198:1-10. (Revision of circ. 120.)
214	1940	Starling Attacks Upon Warble Infested Cattle in the Great Plains Area. A. L. Goodrich, Jr., Jour. Kan. Ent. Soc. 13 :33-40.

			<b>Director's Office</b>
<i>Serial</i>	<i>Year of issue</i>	<i>Title, author, and publication</i>	
No. 64	1938	Ninth Biennial Report of the Director of the Kansas Agricultural Experiment Station. L. E. Call. Kan. Agr. Expt. Sta. 9th Bien. Rpt., 1936-'38, pp. 1-145.	
65	1938	Should a Larger Portion of the Work of the Agricultural Experiment Stations Go Into Research on the Processing of Agricultural Crops and Products? L. E. Call. Proc. Assn. Land-Grant Colleges and Univs., pp. 184-185. (Abstract.)	
66	1940	Sorghum Versus Corn for Kansas. L. E. Call. Kan. State Bd. Agr. Quart. Rpt. 59 :27-35.	
67	1940	Abstracts of New Publications. Kan. Agr. Expt. Sta. Abstract No. 1:1-2.	
			<b>Fort Hays Branch Experiment Station</b>
<i>Serial</i>	<i>Year of issue</i>	<i>Title, author, and Publication</i>	
No. 25	1938	Barley Production in Kansas A. F. Swanson and H. H. Laude. Kan. Agr. Expt. Sta. Bul. 280:1-27.	
26	1938	"Weak Neck" in Sorghum. A. F. Swanson. Jour. Amer. Soc. Agron. 30:720-724.	
29	1940	Inflorescence Variations in Buffalo Grass ( <i>Buchloe Dactyloides</i> ). Leon E. Wenger. Jour. Amer. Soc. Agron. 32:274-277.	
	1939	Beef Cattle Investigations, 1938-'39, Fort Hays Branch Experiment Station. C. W. McCampbell and L. C. Aicher. 26th Ann. Rpt. Beef Cattle Investigations, 1938-'39, Fort Hays Branch Expt. Sta. pp. 1-8.	
	1940	Beef Cattle Investigations, 1939-'40, Fort Hays Branch Experiment Station. C. W. McCampbell and L. C. Aicher. 27th Ann. Rpt. Beef Cattle Investigations, 1939-'40, Fort Hays Branch Expt. Sta. pp. 1-7.	

**BIENNIAL REPORT OF DIRECTOR**

**FINANCIAL STATEMENT, 1939-'40**

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

	<i>Federal appropriations</i>	<i>State appropriations and receipts</i>	<i>Totals</i>
Main station .....	\$140,050.96	(a) \$61,719.41	\$201,770.37
Branch stations, appropriations.....		(b) 74,748.45	74,748.45
Branch stations, sales.....		70,734.82	70,734.82
<b>Totals .....</b>	<b>\$140,050.96</b>	<b>\$207,202.68</b>	<b>\$347,253.64</b>
Personal services .....	\$122,951.35	\$100,160.61	\$233,111.96
Supplies and materials.....	7,405.16	24,538.62	31,943.77
Communication service .....	25.04	2,384.26	2,409.30
Travel expenses .....	2,149.05	4,331.68	6,480.73
Transportation of things.....	53.16	1,867.02	1,920.18
Publications .....	84.13	1,315.62	1,399.75
Heat, light, water, power.....	17.71	6,594.03	6,611.76
Contingent expenses .....		809.38	809.38
Equipment .....	6,747.45	22,214.60	28,962.05
Buildings and land.....	617.92	7,264.53	7,882.47
Balance .....		35,722.29	35,722.29
<b>Totals .....</b>	<b>\$140,050.96</b>	<b>\$207,202.68</b>	<b>\$347,253.64</b>

(a) Includes a balance on hand June 30, 1939, of \$10,959.41.

(b) Includes a balance on hand June 30, 1939, of \$2,498.45.

**FINANCIAL STATEMENT, 1938-'39**

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

	<i>Federal appropriations</i>	<i>State appropriations and receipts</i>	<i>Totals</i>
Main station .....	\$133,794.59	(a) \$62,459.39	\$196,253.98
Branch stations, appropriations.....		(b) 88,587.42	88,587.42
Branch stations, sales.....		64,902.00	64,902.00
<b>Totals .....</b>	<b>\$133,794.59</b>	<b>\$215,948.81</b>	<b>\$349,743.40</b>
Personal services .....	\$114,631.55	\$104,814.93	\$219,446.48
Supplies and materials.....	5,658.26	22,413.68	28,071.94
Communication service .....	19.89	2,158.54	2,178.43
Travel expenses .....	1,142.41	4,631.09	5,773.50
Transportation of things.....	11.87	1,558.55	1,570.42
Publications .....	52.90	2,442.34	2,495.24
Heat, light, water, power.....	24.38	7,232.77	7,257.35
Contingent expenses .....	4.85	562.38	567.23
Equipment .....	6,281.76	18,444.49	24,726.25
Buildings and land.....	5,966.52	29,777.19	35,743.71
Balance .....		21,912.85	21,912.85
<b>TOTALS .....</b>	<b>\$133,794.59</b>	<b>\$215,948.81</b>	<b>\$349,743.40</b>

(a) Includes a balance on hand June 30, 1938, of \$13,149.35.

(b) Includes a balance on hand June 30, 1938, of \$12,387.42.

