

AGRICULTURAL EXPERIMENT STATION

KANSAS STATE COLLEGE OF AGRICULTURE
AND APPLIED SCIENCE

MANHATTAN, KANSAS

EIGHTH BIENNIAL REPORT OF THE DIRECTOR

1934-1936



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KANSAS AGRICULTURAL EXPERIMENT STATION

Manhattan, Kansas

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LETTER OF TRANSMITTAL

OFFICE OF DIRECTOR,
June 30, 1936.

To His Excellency, Alfred M. Landon, Governor of Kansas:

I have the honor to submit herewith the report of the Agricultural Experiment Station of the Kansas State College of Agriculture and Applied Science for the biennium ending June 30, 1936. The report includes brief descriptions of the work in progress during the biennium, summaries of some of the more significant results, changes in the personnel of the station staff, a list of the publications of the station and of the published scientific contributions of the station staff. and a statement of receipts and expenditures during the biennium.

L. E. CALL, *Director.*

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DIRECTOR'S REPORT¹

INTRODUCTION

This report contains a brief statement of the work of the Kansas Agricultural Experiment Station for the biennium ending June 30, 1936. The work is conducted at the central station at Manhattan, at the four branch stations in western Kansas, and on numerous outlying farms and experimental fields. As in the past, the work has been conducted upon the project basis and is set forth in this report under five distinct fields of activity as follows: Agricultural economics, soil conservation, the plant industries, the animal industries, and home economics. This report makes brief mention of each of the more important projects and summarizes the more important results secured during the biennium.

COOPERATION WITH OTHER AGENCIES

The station has had helpful cooperation during the past biennium with a number of related agencies working in the same or closely allied fields. Agencies with whom cooperative relations have been maintained include other state agricultural experiment stations, the United States Department of Agriculture, other departments of the state of Kansas, other research agencies, and farmers. These relationships have been pleasant, satisfactory, and helpful, and have resulted in an increase in the efficiency of the work conducted.

The cooperative work with the United States Department of Agriculture during the past biennium has included studies with the following bureaus and divisions:

1. The Bureau of Plant Industry relating to (a) production and breeding of small grains and corn and the control of cereal diseases in cooperation with the Division of Cereal Crops and Diseases; (b) alfalfa improvement, the control of alfalfa diseases, and forage crop production in cooperation 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 cooperation with the Division of Dry-land Agriculture.

2. The Bureau of Chemistry and Soils in the preparation for publication of the results of soil survey and in an advisory capacity in connection with the Regional Soybean Research Laboratory at Urbana, Ill.

3. The Bureau of Animal Industry in a study of anaplasmosis.

4. The Bureau of Entomology in a study of insects attacking staple crop plants.

1. Contribution No. 58 from the director's office.

5. The Bureau of Agricultural Economics in studies of farm organization, cost of producing farm products, land utilization, and the marketing of farm products.

6. The Bureau of Agricultural Engineering in the study of storage of wheat.

7. The Soil Conservation Service in studies of soil erosion and water conservation.

8. The Forest Service in the propagation and distribution of forest trees and in a survey of the forest resources of Kansas.

The station has participated in a cooperative project with the Resettlement Administration in a study of land utilization in the state and members of the station staff have given assistance and advice in connection with many other emergency problems pertaining to rural resettlement, wind erosion control, shelterbelt planting, agricultural adjustment, and rural credit.

As outlined in previous reports, the station has continued to cooperate with the Kansas State Board of Agriculture by providing personnel and facilities for analytical determinations of feeding-stuffs, livestock remedies, fertilizers, and dairy products and has maintained in cooperation with the board a state seed-testing laboratory. Cooperation has been continued, also, with the State Livestock Sanitary Commissioner in a study of livestock diseases. Cooperative research on industrial projects has been undertaken with a few commercial agencies. Farmers from all parts of the state have cooperated in studies of problems in which there was mutual interest.

THE BANKHEAD-JONES ACT

The event of outstanding significance to the Agricultural Experiment Station during the biennium was the passage by the Seventy-fourth Congress of the Bankhead-Jones Act. This act, approved by President. Roosevelt on June 29, 1935, authorized increased federal appropriations for three purposes: (1) Resident teaching, (2) extension, and (3) agricultural research. The amount to be made available to each state for agricultural research is based on the rural population of the state in relation to the rural population of the United States. The amount of the appropriation authorized by the act begins at a certain figure as determined by rural population, which for the fiscal year 1935-'36 for the state of Kansas was \$12,512.62. This amount is to be increased annually by approximately equal amounts each year for five years, after which it continues at the maximum amount subject to appropriations by Congress. The wording of the Bankhead-Jones act as it applies to agricultural research is as follows:

PUBLIC- No. 182—74TH CONGRESS
(H. R. 7160)

AN ACT to provide for research into basic laws and principles relating to agriculture, and to provide for the further development of cooperative agricultural extension work, and the more complete endowment and support of land-grant colleges.

BIENNIAL REPORT OF DIRECTOR

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Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled:

TITLE I

SECTION 1. The Secretary of Agriculture is authorized and directed to conduct research into laws and principles underlying basic problems of agriculture in its broadest aspects; research relating to the improvement of the quality of and the development of new and improved methods of production of, distribution of, and new and extended uses and markets for, agricultural commodities and by-products and manufactures thereof; and research relating to the conservation, development, and use of land and water resources for agricultural purposes. Research authorized under this section shall be in addition to research provided for under existing law (but both activities shall be coordinated so far as practicable) and shall be conducted by such agencies of the Department of Agriculture as the secretary may designate or establish.

SEC. 2. The secretary is also authorized and directed to encourage research similar to that authorized under section 1 to be conducted by agricultural experiment stations established or which may hereafter be established in pursuance of the act of March 2, 1887, providing for experiment stations, as amended and supplemented, by the allotment and payment as provided in section 5 to Puerto Rico and the states and territories for the use of such experiment stations of sums appropriated therefor pursuant to this title.

SEC. 3. For the purposes of this title there is authorized to be appropriated, out of any money in the treasury not otherwise appropriated, the sum of \$1,000,000 for the fiscal year beginning after the date of the enactment of this title, and for each of the four fiscal years thereafter \$1,000,000 more than the amount authorized for the preceding fiscal year, and \$5,000,000 for each fiscal year thereafter. Moneys appropriated in pursuance of this title shall also be available for the purchase and rental of land and the construction of buildings necessary for conducting research provided for in this title, for the equipment and maintenance of such buildings, and for printing and disseminating the results of research, Sums appropriated in pursuance of this title shall be in addition to, and not in substitution for, appropriations for research or other activities of the Department of Agriculture and sums appropriated or otherwise made available for agricultural experiment stations.

SEC. 4. Forty percentum of the sums appropriated for any fiscal year under section 3 shall be available for the purposes of section 1: *Provided*, That not to exceed 2 percentum of the sums appropriated may be used for the administration of section 5 of this title. The sums available for the purposes of section 1 shall be designated as the "Special research fund, Department of Agriculture." and no part of such special fund shall be used for the prosecution of research heretofore instituted or for the prosecution of any new research project except upon approval in writing by the secretary One half of such special research fund shall be used by the secretary for the establishment and maintenance of research laboratories and facilities in the major agricultural regions at places selected by him and for the prosecution, in accordance with section 1, of research at such laboratories.

SEC. 5. (a) Sixty percentum of the sums appropriated for any fiscal year under section 3 shall be available for the purposes of section 2. The secretary shall allot, for each fiscal year for which an appropriation is made, to Puerto Rico and each state and territory an amount which bears the same ratio to the total amount to be allotted as the rural population of Puerto Rico or the state or territory bears to the rural population of Puerto Rico and all the states and territories as determined by the last preceding decennial census. No allotment and no payment under any allotment shall be made for any fiscal year in excess of the amount which Puerto Rico or the state or territory makes available for such fiscal year out of its own funds for research and for the establishment and maintenance of necessary facilities for the

prosecution of such research. If Puerto Rico or any state or territory fails to make available for such purposes for any fiscal year a sum equal to the total amount to which it may be entitled for such year, the remainder of such amount shall be withheld by the secretary. The total amount so withheld may be allotted by the Secretary of Agriculture to Puerto Rico and the states and territories which make available for such year an amount equal to that part of the total amount withheld which may be allotted to them by the Secretary of Agriculture, but no such additional allotment to Puerto Rico or any state or territory shall exceed the original allotment to Puerto Rico or such state or territory for that year by more than 20 percentum thereof.

(b) The sums authorized to be allotted to Puerto Rico and the states and territories shall be paid annually in quarterly payments on July 1, October 1, January 1, and April 1. Such sums shall be paid by the Secretary of the Treasury upon warrant of the Secretary of Agriculture in the same manner and subject to the same administrative procedure set forth in the act of March 2, 1887, as amended June 7, 1888.

SEC. 6. As used in this title the term "territory" means Alaska and Hawaii

SEC. 7. The Secretary of Agriculture is authorized and directed to prescribe such rules and regulations as may be necessary to carry out this act.

SEC. 8. The right to alter, amend, or repeal this act is hereby expressly reserved.

Following the passage of this act, Secretary Wallace set out the rules and regulations for the administration of the act in a letter to the directors of the agricultural experiment stations. This letter, among other things, emphasized the following points: (1) That the act places responsibility for administration of all research features upon the secretary and that the Office of Experiment Stations would act for the secretary in the administration of the act; (2) that every effort would be made to formulate and develop a strong coordinated program of research basic to the major problems of agriculture; (3) that the act makes available a "Special research fund for the Department of Agriculture" and authorizes and directs the secretary to encourage research by the state stations similar to that authorized for the Department of Agriculture; (4) the desirability of selecting subjects for study on a regional basis with similar research of the United States Department of Agriculture; (5) that the research to be conducted might well be directed to a study of those basic laws and principles which must be better understood before they will be a permanent solution of practical problems now under study; (6) that the funds for research made available under this act cannot be used to replace other federal funds or state funds; (7) that it will be necessary for each state station to submit evidence satisfactory to the secretary as to the amount of offset funds which will be made available for research from other than federal sources for each fiscal year.

The Kansas Agricultural Experiment Station has already started a number of projects of the character authorized by this act and supported from Bankhead-Jones funds.

THE DROUGHT OF 1934

The season of 1934 was one of the most disastrous from the standpoint of drought of any year in the 77 years that weather records have been taken at Manhattan. In only two other seasons, 1860 and 1875, was the total precipitation less than 19.38 inches, the amount received during 1934. Furthermore, the drought of 1934 was accentuated by deficiency in precipitation for the two preceding years, 1932 and 1933. The total deficiency for the three years, 1932 to 1934, inclusive, amounted at Manhattan to 28.46 inches, or nearly as much as an entire season's normal precipitation of 31.27 inches. Deficiencies in precipitation similar to the deficiency at Manhattan occurred throughout the state. For example, at Dodge City where the normal precipitation for a period of 50 years has been 20.5 inches, there was a total precipitation of only 11.5 inches in 1934. Furthermore, with a normal precipitation of 11.5 inches from July 1 to March 1, the precipitation from July 1, 1934, to March 1, 1935, was but 6.5 inches.

The lack of rain during the fall of 1934 made it impossible to secure stands of wheat in western Kansas. Where there was sufficient moisture to start the crop a lack of precipitation during the winter months resulted in insufficient moisture to maintain it. Thus in western Kansas practically all fields that had been prepared for wheat were without a protective cover of vegetation when the strong winds started to blow in 1935. Furthermore, due to the drought of 1934, there was a shortage of feed for livestock. Wheat stubble, corn and sorghum stalks, and weeds were harvested for feed or grazed off so closely that little or no crop cover was left on the fields. Even buffalo grass pastures had been so heavily overgrazed that the soil on these fields was not adequately protected.

These conditions led to the most destructive soil blowing that has occurred in the history of the state. A careful survey of the situation made through the Extension Service showed that serious blowing occurred in the spring of 1935 in 47 of the 105 counties of Kansas. These 47 counties are all located in the western and central parts of the state. The cultivated area in these counties exceeded 12,000,000 acres of which over 8,000,000 were in conditions to be eroded by wind. The exact area from which wind erosion occurred was not determined, but a report made to the Extension Service by the county agents of western Kansas showed that 3,360,245 acres of land had been cultivated by farmers during the spring and summer of 1935 from funds granted from the Kansas Emergency Relief Committee for the control of soil blowing.

Native grass, trees, and shrubs suffered severely from the drought. As has been stated buffalo and grama grass pastures in western Kansas were severely damaged by drought, overgrazing, and the drifting of the soil. In central Kansas bluestem pastures were se-



FIG. 1.— Scotch and Jack pine grove on Horticultural Farm planted in 1898. (A) Photograph taken on July 6, 1936. (B) Photograph taken in December, 1929. The Jack pines died during the drouth of 1934. Many of the Scotch pines died during 1934 and 1935.

verely damaged by drought and overgrazing and in eastern Kansas, particularly in the northeastern portion of the state, many Kentucky bluegrass pastures were completely destroyed.

Records were taken on the drought injury to ornamental trees on the campus for the years 1934 and 1935. The records were taken in the fall of each year before the leaves fell. The amount of injury was determined by estimating the amount of damage to foliage. Out of 3,713 trees on the campus in 1934, which includes 100 species, 308 died from the effects of the drought, during the biennium. In 1934, 1,505 trees showed slight injury as compared with 905 trees showing approximately the same injury in 1935. Severe injury was recorded on 232 trees in 1934 and 116 in 1935. (Fig 1.)

BUILDINGS AND EQUIPMENT

On the evening of August 3, 1934, Denison Hall, which housed the main research laboratories of the Department of Chemistry was destroyed by fire of undetermined origin. Within this building were 16 rooms used exclusively for the work of the Agricultural Experiment Station. In addition to these rooms, three hallways had been equipped as grinding and still rooms. Several thousand square feet of attic space were used for drying samples and for storage of samples and apparatus. All of the equipment and supplies with the exception of the contents of the fireproof vault and one or two articles removed during the fire were destroyed. It is estimated that the loss of equipment amounted to \$85,000. This includes a loss of expensive apparatus such as X-ray, spectrophotometric, thermostatic machines, vacuum outfits, etc., which are indispensable to fundamental agricultural research work.

Arrangements were promptly made to provide rooms to continue certain lines of research in laboratories in other buildings. At the close of the biennium some \$12,000 worth of apparatus and supplies had been purchased to replace equipment lost in the fire and to continue the most important lines of research. Due to the loss of important types of apparatus and to the lack of suitable space, several lines of research have been temporarily stopped. At this time the research facilities of the Department of Chemistry are woefully inadequate and will continue to be inadequate until a new chemical laboratory building is provided.

The only building to be erected during the biennium was a 20-by-100-foot brooder house completed early in February, 1936, on the college poultry farm. It was constructed with funds made available by the Bankhead-Jones act at a cost of a little more than \$2,000. The house is divided into 20 pens, each about 8 by 10 feet in size, giving a total capacity for 3,000 chicks up to eight weeks of age. Each pen is equipped with electric lights and running water. Electric hovers are used to supply heat. These are supplemented with three gas heaters to provide additional heat in cold weather. The walls and ceilings are insulated and ventilation is provided in such a way as to avoid drafts, even though wire partitions only

are used from roosts to ceilings to separate the pens. The building will be used primarily for fundamental research work in poultry genetics.

During the biennium a start was made toward remodeling the buildings formerly used for the manufacture of anti-hog-cholera serum into laboratories for veterinary research. During the past biennium a master fence was built around the lot containing the buildings so as to positively control the admission of both human beings and animals to the veterinary research laboratory group. A gas main was extended to the buildings for heating purposes. An old heating unit was remodeled, a high-pressure steam boiler installed, and running hot water facilities have been provided for the laboratories. An electrical transmission line, with a proper distribution system at the buildings, has been extended from the college power plant so as to provide current for light, power, and refrigeration. The entire water-distributing system has been remodeled and improved. Cattle stalls and stanchions have been built and all of the facilities provided for research now underway in a study of the anaplasmosis of cattle. A total of approximately \$5,000 was used during the biennium for these improvements.

At the Fort Hays Branch Experiment Station there was erected during the biennium, through a cooperative arrangement with the Works Progress Administration, a battery of reinforced concrete pit silos. (Fig. 2.) These silos are 35 feet deep and 18 feet in diameter and are estimated to hold 200 tons of silage each or a total of 1,200 tons of silage. Heavy angle-iron framework, resting on concrete pillars, supports carrier trackage whereon large metal buckets holding approximately 1 cubic yard of silage are hoisted from each silo for the purpose of loading the silage into the silage wagons. These silos have been constructed primarily for the purpose of providing a reserve supply of feed to overcome the hazard of scarce feed supplies during drought periods.

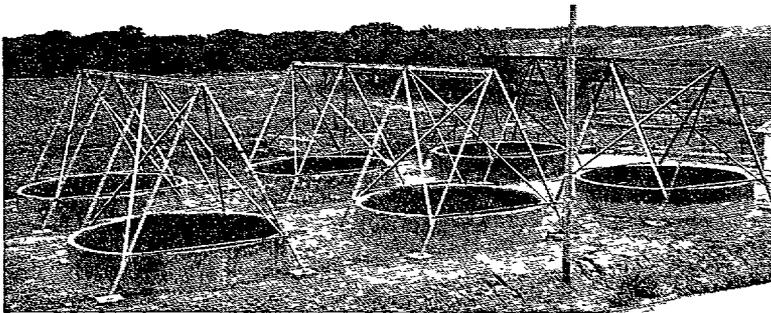


FIG. 2.—Battery of six pit silos; capacity, 1,200 tons.

There was developed and built at the Fort Hays Branch Experiment Station during the biennium an attachment for the lister known as the basin lister attachment. Through this attachment small dams of earth are made in the lister furrow at intervals of approximately 10 feet. These dams serve to prevent the loss of water from the lister furrow and to retain the water in the furrow until it penetrates the soil. This new equipment is proving popular with farmers who have had an opportunity to try it. It is expected that the equipment will prove exceedingly valuable in preventing soil erosion and the loss of water from cultivated fields.

PERSONNEL

Director L. E. Call, who was on leave of absence serving as president of the Federal Land Bank of Wichita, resumed his duties as director of the station February 1, 1935. Dr. W. E. Grimes, who had served as acting director during the absence of Director Call, resumed his duties as head of the Department of Agricultural Economics upon the return of Director Call.

Dr. G. E. Johnson, Professor of Zoology, and in charge of injurious-mammal investigations, died on March 18, 1935. Through his death the station lost one of its most meticulous research workers.

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

- W. H. Pine, assistant in agricultural economics
- C. D. McNeal, assistant in agricultural economics.
- F. L. Parsons, fruit and vegetable marketing.
- Glenn S. Fox, assistant in, agricultural economics.
- R. J. Doll, assistant in agricultural economics.
- J. C. Hide, soil investigations.
- Frank G. Parsons, assistant in cooperative experiments.
- F. E. Davidson, assistant in charge of Southeastern Kansas Experiment

- A. B. Erhart, assistant in charge of Southwestern Kansas Experiment Fields.
- Bruce R. Taylor, livestock investigations.
- F. W. Atkeson, head, Department of Dairy Husbandry.
- C. D. Arndt, inspector state institutional dairy herds.
- Lloyd F. Smith, forestry investigations.
- Erwin Abmeyer, assistant in charge of Northeastern Kansas Experiment

- Rowland J. Clark, wheat and flour investigations.
- Clarence L. Gish, foreman poultry farm.
- Fred P. Eshbaugh, forest nurseryman, Fort Hays station.
- Charles K. Otis, farm machinery.
- J. F. Knappenberger, poultry diseases.
- B. W. Beadle, assistant chemist.
- P. G. Lamerson, assistant in entomology.
- Myrtle Gunselman, household economics.
- Alice D. Kimball, technician, anaplasmosis.
- G. E. Cauthen, assistant in zoology.
- E. H. Herrick, injurious mammals.

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

- R. M. Green, grain marketing.
- Morris Evans, farm organization.
- J. B. Roberts, assistant in agricultural economics.
- C. D. McNeal, assistant in agricultural economics.
- F. L. Duley, soils.
- I. K. Landon, assistant in charge of Southeastern Kansas Experiment Fields.
- F. L. Timmons, assistant in cooperative experiments.
- W. E. Connell, livestock investigations.
- J. B. Fitch, head, Department of Dairy Husbandry.
- F. B. Wolberg, inspector state institutional dairy herds.
- T. R. Reitz, assistant in charge of Northeastern Kansas Experiment Fields.
- F. J. Feight, foreman poultry farm.
- F. J. Zink, farm machinery.
- C. A. Logan, farm machinery.
- C. A. Brandy, poultry diseases.
- H. W. Loy, assistant chemist.
- Mary F. Taylor, household economics.
- Charles A. Pyle, anaplasmosis investigations.
- C. G. Dobrovlny, assistant in zoölogy.

SCOPE OF THE STATION WORK, JULY 1, 1934, TO JUNE 30, 1936

A list of the principal active projects carried during the biennium ending June 30, 1936, is given below, together with statements of the sources of financial support and references to the discussions included in this report:

NAME.	Project No.	Department	Leader	Funds	Discussed on page—
Studies of Factors Affecting the Organization and Operation of Kansas Farms	95	Agricultural Econ . .	W. E. Grimes J. A. Hodges Morris Evans	Purnell and State .	22
Investigations in Land Tenure and Other Related Problems	132	Agricultural Econ .	Harold Howe W. H. Pine.	Purnell . .	22
The Marketing of Kansas Wheat	143	Agricultural Econ . . .	George Montgomery	Purnell .	23
The Marketing of Kansas Livestock and Livestock Products.	149	Agricultural Econ . .	Homer J. Henney	Purnell	25
The Marketing of Kansas Fruits and Vegetables . .	177	Agricultural Econ . . .	George Montgomery . . Franklin L. Parsons	Purnell	25
A Study of Factors Governing the Marketing of Dairy Products in Kansas	185	Agricultural Econ	George Montgomery Franklin L. Parsons	Purnell . .	26
The Economics of the Poultry Industry in Kansas . .	144	Agricultural Econ .	J. A. Hodges . .	Purnell . . .	27
A Study of Factors Affecting the Social Well-being of Rural People in Kansas	195	Agricultural Econ . . .	Randall C. Hill	State	27
Soil Fertility Investigations	17	Agronomy	W. H. Metzger	Hatch and State . . .	28
Plant Nutrition Investigations	152	Chemistry	A. T. Perkins	State	29
Influence of the Absolute Reaction of the Soil Solution Upon the Growth and Activity of Azotobacter	128	Bacteriology	P. L. Gainey . . .	Adams	29
Influence of Legumes and Free-living Nitrogen Fixing Organisms on the Growth of Plants and on the Nitrogen Balance	172	Agronomy	H. E. Myers	Purnell	30
A Study of the Soil Solution as Governed by H-Ion Concentration and Other Factors	155	Chemistry	A. T. Perkins	Purnell	30

SCOPE OF THE STATION WORK—CONTINUED

NAME.	Project No.	Department	Leader.	Funds.	Discussed on page—
A Study of Some Replacable Cations and Anions in Some Kansas Soils	179	Chemistry.	H. H. King A. T. Perkins.	Purnell	31
Soil and Crop Experiment Fields . . . . .	.....	Agronomy Horticulture Botany Entomology	R. I. Throckmorton R. J. Barnett. L. E. Melchers. G. A. Dean.	State	31
Temperature Relations of Crop Plants	157	Agronomy	H. H. Laude	Purnell	35
Small Grain and Sorghum Improvement	67	Agronomy	J. H. Parker	Hatch	37
Inheritance of Factors Affecting Quality in Wheat	178	Agronomy Milling Industry	J. H. Parker C. O. Swanson.	Purnell	33
Varietal Tests of Small Grains and Sorghum	129-1 and 2.	Agronomy	H. H. Laude	Hatch	39
Variety and Cultural Tests of Soybeans	129-3	Agronomy	J. W. Zahnley	Hatch	40
Miscellaneous Legumes for Forage	129-4	Agronomy	J. W. Zahnley	Hatch	40
Corn Production and Improvement	156	Agronomy	A. M. Brunson.	Purnell	41
Alfalfa Investigations in Relation to Winter Hardiness and Bacterial Wilt	183	Agronomy	C. O. Grandfield	Purnell	42
Pasture Improvement Investigations	96	Agronomy	A. E. Aldous	Purnell	44
Weed Eradication	166	Agronomy	J. W. Zahnley	State	45
Coöperative Experiments with Farmers . . . . .	. . . .	Agronomy	A. L. Clapp	State	46
The Influence of the Method of Harvesting and Baling Alfalfa Hay Upon Quality	182	Agricultural Engin.	F. J. Zink C. K. Otis.	Purnell	48
A Study of the Efficiency of the Combined Harvester-Thresher for Harvesting Grain Sorghum	181	Agricultural Engin.	F. J. Zink	Purnell	48

SCOPE OF THE STATION WORK—CONTINUED

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NAME	Project No	Department.	Leader.	Funds	Discussed on page—
Factors Influencing the Quality of Wheat During Farm Storage	143	Milling Industry	C. O. Swanson.	Purnell	49
Chemical Factors Influencing the Quality of Wheat and Flour.	60-A	Milling Industry	E. B. Working C. O. Swanson.	State	50
Varietal Factors Influencing the Milling and Baking Qualities of Wheat	60-B	Milling Industry	R. J. Clark	State	51
Factors Which Influence the Protein Content of Wheat	60-C	Milling Industry	C. O. Swanson .	State	52
Tempering Factors Affecting the Quantity and Quality of Wheat Flour	170	Milling Industry	R. O. Pence J. E. Anderson. C. O. Swanson.	Purnell and State.	52
Factors Which Influence the Colloidal Properties of Dough.	200	Milling Industry	R. J. Clark	Bankhead-Jones .	53
A Physiological Study of the Hard Winter Wheat Plant.	189	Botany. .	E. C. Miller .	Purnell .	53
Orchard Investigations.	25	Horticulture	R. J. Barnett . W. F. Pickett G. A. Filinger	State	54
Small Fruit Investigations	26	Horticulture	W. F. Pickett. G. A. Filinger	State	56
Flower and Vegetable Investigations	27	Horticulture	W. B. Balch	State	57
Relation of Leaf Structure to the Rate of Photosynthesis in Fruit Plants	199	Horticulture	W. F. Pickett	Bankhead	58
Nutritive Requirements of Swine	38	Animal Husbandry Chemistry .	C. E. Aubel J. S. Hughes	Adams and State..	60
Swine Feeding Investigations	110	Animal Husbandry	C. E. Aubel	State	60
Investigations in the Use of Silage for Fattening Beef Cattle	78	Animal Husbandry	A. D. Weber..	State	62

SCOPE OF THE STATION WORK—CONTINUED

NAME.	Project No.	Department.	Leader.	Funds.	Discussed on page—
Methods of Utilizing Native Pasture in Beef Cattle Feeding	151	Animal Husbandry . .	C. W. McCampbell. . .	State . . .	63
Lamb Feeding Investigations	111	Animal Husbandry	Rufus P. Cox . .	State	63
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STUDIES IN THE ECONOMICS OF AGRICULTURE

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

Studies of Factors Affecting the Organization and Operation of Kansas Farm.— Two phases of work have been pursued during the past biennium as follows:

1. *Regional Adjustments in Agriculture.*— The object of this study was to determine the necessary adjustments in crop and livestock enterprises to maintain fertility, control erosion, and to promote an efficient and sound farm-management program. The study was undertaken in cooperation with the Production Planning Section of the Agricultural Adjustment Administration, United States Department of Agriculture, and the Kansas Planning Board in a regional planning project. The method adopted in making the study was a comparison of typical or representative farms, based on the 1931 assessor's rolls, with suggested farm organizations by the budget method. Changes by counties, types-of-farming areas, and the state were based upon these comparisons. Typical farms had been set up for 31 counties at the beginning of 1936. Typical and suggested organizations had been set up at the close of the biennium for 98 of the 105 counties in the state. A budget analysis has been practically completed for 80 of these, and others are in progress.

2. *Factors Affecting Farm Income as Determined by a Study of Records from the Farm Bureau-Farm Management Associations of Kansas.*— This study consisted of an analysis of the records from 208 farms in 1934 and 215 farms in 1935. During the biennium there was prepared a number of mimeographed reports from the 1933 and 1934 records, including comparisons in many cases with 1932 and 1931. These reports covered a summary of receipts and expenses by income records, by size of farms, and by tenure. A percentage distribution of these items was made and the number of factors affecting income, such as fixed charges, crop yields, and time of marketing livestock were determined.

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

Investigations in Land Tenure and Other Related Problems.— The work on this project during the past two years has consisted of (1) a study of the assessment and collection of farm real estate taxes; (2) a study of the elementary schools in Kansas as related to taxation; and (3) a revision of Bulletin 235 and Circular 159 of this station on "The Trend of Real Estate Taxation in Kansas."

The study of the phase of this problem having to do with the relation of assessed to sale value of farm real estate which covers a period from 1923 to 1933 has been concluded. Some conclusions from the study are:

a. Assessed value more nearly approaches sales value during a period of economic depression. From 1923 to 1930, inclusive, assessed value remained at approximately 69 percent of sales value. In 1931 it increased to 87.8 percent; in 1932, to 92.2 percent; and in 1933, to 94 percent.

b. The average percentage of assessed to sales value for the period 1923 to 1933, inclusive, varied widely within the state, being 81.1 percent in type-of-farming Area 1 which is in southeastern Kansas, and 50.3 percent in Area 11, which is in northwestern Kansas.

c. There is a definite tendency to over assess properties of low sales value. This tendency is clearly illustrated in Table I.

TABLE I.—THE ASSESSED VALUATION OF FARM REAL ESTATE IN PERCENT OF SALE PRICE BY SIZE GROUPS, FOR 2,935 PROPERTIES, FOR THE THREE-YEAR PERIOD, 1931-1933.

SIZE GROUPS BASED ON SALE PRICE.	Number of properties.	Sale price.	Assessed value.	Ratio of assessed to sale value, percent.
0— \$1,499.99	516	\$425,998	\$707,857	166.2
1,500— 2,999.99	629	1,333,486	1,590,051	119.2
3,000— 4,999.99	747	2,822,866	2,836,205	100.5
5,000— 9,999.99	749	4,969,508	4,364,131	87.8
10,000— 14,999.99	205	2,391,062	1,825,463	76.3
More than 15,000.00	89	1,801,702	1,187,538	65.9

Data were obtained in CWA Project F-6, and were from 46 Kansas counties.

A study of short- and long-time delinquencies was made to determine the character of tax delinquency in a 31-Kansas-county sample for the period 1928 to 1932, inclusive. This study shows that:

- a. Of the properties that became delinquent during the period studied, 57.9 percent were delinquent for more than one year.
- b. Of the total land in farms, 42.9 percent was delinquent at some time during the five years.
- c. The average period of delinquency was 2.1 years.
- d. Of the properties delinquent in 1932, 66 percent were delinquent in some previous year. The properties were studied also to determine if there was any tangible evidence to show that faulty assessment contributed to delinquency. This study has not been finished but there appears to be some positive correlation between the properties that tend to be over-assessed; namely, the small properties, and those properties that are long-time delinquencies. The delinquent properties must be studied in greater detail, however, before any positive statement can be made.

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

The Marketing of Kansas Wheat. —The research on this project during the last biennium has dealt with the following phases:

1. *Economic Analyses of the Business Policies and Practices of Coöperative Elevator Associations.* —In 1934 the financial records of 121 cooperative elevator associations were analyzed and in 1935, 150 cooperative associations were surveyed and analyzed. The current analyses complete the five-year records for more than 100 of the associations, and, for approximately 25 of the associations, records for a ten-year period are available.

An analyses of these records warrant the following conclusions concerning the financial condition and the operating practices of Kansas cooperative elevator associations.

- a. The recent years of short crops have emphasized more than ever the importance of an adequate volume of business over which to distribute the fixed expenses. An adequate volume of business is associated with a membership of 150 or more, 100,000 bushels of grain handled, a capacity turnover of 10 for the average elevator and at least 85 percent of the members patronizing the organization.
- b. The recent years of limited income from handling grain and greater dependence upon income from sidelines have demonstrated the necessity of

a rigorous credit policy for coöperative elevators which handle sidelines. Those organizations which have shifted to a cash basis or which have adhered to a carefully planned credit policy have shown substantially larger profits. For a typical group of approximately 75 elevators in eastern and northwestern Kansas the average accounts receivable per organization were reduced \$1,400 in the four-year period 1932 to 1935. The average reduction in receivables for southwestern Kansas elevators was \$4,000.

c. In general, the elevators analyzed have maintained margins of four cents on the grain handled. Reductions in income have been offset by reductions in operating expenses. For a group of elevators in southwestern Kansas, which have been analyzed since 1931, the operating expenses were reduced from \$14,240 per elevator in 1930-'31 to \$8,049 in 1934-'35. About 50 percent of this reduction has been in salaries and wages.

d. Southwestern Kansas elevators have maintained a much better position than eastern Kansas elevators in regard to surplus and reserves. Elevators in the southwest on the average have maintained consistently a surplus equal to the value of capital stock, while in eastern Kansas the par value of the capital stock has been impaired.

e. Sideline sales are an important source of profits for coöperative elevators, especially in years of short grain crops. Those elevators which realize sufficient gross profits on sidelines to cover 40 percent of the total expense, show larger and more consistent profit than those with smaller income from profits. Net profits tend to increase with increase in amount of sideline business until sideline sales exceed 20 percent of the total business.

2. *The Effect of Weather Upon Wheat Yields in Kansas.*— Data on seeded acreage, abandonment, yield and production of wheat since 1910 in 55 western Kansas counties are being studied by type-of-farming area. In connection with this study the weekly crop reports of the Kansas State Board of Agriculture have been summarized to obtain information concerning the development and condition of the Kansas wheat crop under various climatic influences. This study is being made to supply information basic to forecasting production and prices of hard winter wheat at Kansas City.

The study indicates that there is a definite and consistent relation between fall precipitation and wheat yields in the western two thirds of Kansas. The effect of spring rainfall in western Kansas, and the influence of total precipitation in eastern Kansas has not been established.

3. *Protein Content and Premiums for High-Protein Wheat.*— There is evidence that the amount of premium and the seasonal variation in the premium paid for high-protein wheat is influenced not only by the current production, but during the latter part of the season it is affected by the anticipated new crop production in the hard winter states.

4. *Cash-future, Interoption, and Intermarket Price Spreads.*— The study of the cash-future spreads and interoption spreads of wheat prices at Kansas City has been continued. Cash-future spreads by ten-day periods at Kansas City since 1910 have been calculated and shown graphically. A number of intermarket spreads for wheat, namely, Kansas City-Chicago, Kansas City-Winnipeg, and Kansas City-Buenos Aires have also been determined. The season of 1935 is the fourth since 1910 in which price relationships similar to those of this year have occurred. In all of these years the decline in price of cash wheat has been similar in amount, and also in regard to time and character of decline. The year of 1935 has been one in which information on price spreads has been especially helpful in judging the market.

5. *Time of Peak Prices.*— The time of monthly peak prices of wheat, and also corn, at Kansas City since 1910 has been computed and shown graphically. The peaks were shown by two-, three-, four-, six- and twelve-month periods. These data have aided in establishing more definitely the seasonal variations in wheat prices.

[Project, 143; Department of Agricultural Economics. Leader, George Montgomery; Purnell fund.]

The Marketing of Kansas Livestock and Livestock Products.— There have been four active phases of this project as follows:

1. *Organizations Engaged in Marketing Kansas Livestock and Livestock Products.*— Study was concentrated during the biennium particularly on the auction sale and the interior packer. Community auction sales are by far the most important interior organizations in Kansas dealing with the marketing of livestock. Interior packers are of the next importance. The cooperative livestock shipping associations are becoming less important. There is every indication that both the community auction sale and the interior packing system of buying livestock are on the increase, and that these interior method of marketing livestock are increasing at the expense of the larger terminal markets.

2. *When and Where Livestock Products Move to Market.*— As in the past data have been collected relative to most of the grades and classes of livestock shipped into and out of Kansas. The nature of the work is routine and is available in supplying basic information for marketing studies. For some years, data on the movement of horses and mules have been collected as a part of the livestock record. This will be discontinued, as well as the compilation of data on the movement of steers into and out of the bluestem area of Kansas. There is need for reformation upon the movement of livestock by trucks at the ports of entry for the state of Kansas. As soon as funds are available this record will be compiled and kept available for research purposes.

3. *Economic Factors Influencing the Time and Place of Marketing Livestock and Livestock Products.*— Studies as to the factors affecting the time of marketing livestock have been confined principally to those dealing with weather as a factor in affecting the supply of feed and grass within the state. Some studies on weather cycles of an analagous type have been completed. These studies show that in so-called dry grazing seasons, cattle do not get fat and for the most part are not shipped early in dry years as is the general opinion. Apparently the factor of finish, where finances permit, is a bigger factor in determining the time of marketing than is the amount of grass left in the pastures for grazing purposes. This is contrary to most opinions that in dry years the cattle are shoved onto the market earlier and in a greater proportion over a short period of time. Even in the 1934 drought period many cattle were not sent into market channels, but moved back to Texas and other sections of the country and came to market during the following year.

4. *Price Trend and Price-Making Factors in the Livestock Industry.*— Studies during the biennium have dealt with three possible price-making factors as follows: (a) The advancing and declining price cycles for the different grades and classes of livestock; (b) the effect of a price change for a short period upon a subsequent change; and (c) the use of seasonal changes in prices for determining the primary trend of a particular commodity.

To date the results are valuable in that it appears that a change in price over a two- to four-month period will often bring out a factor which indicates the general trend of that particular commodity for the next six to eight months.

It is contemplated that the three above-mentioned type-of-price studies will be continued during the next biennium, with special emphasis on "c," which has to deal with the two- to four-month seasonal changes as an indication of the cyclical changes in prices.

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

The Marketing of Kansas Fruits and Vegetables.— Three phases of work have been active during the biennium, namely: (1) A study of price-making factors for apples and peaches at the

Kansas City and Omaha markets; (2) a study of the marketing of Kaw Valley potatoes; and (3) a start on a survey of roadside fruit and vegetable markets. The following are some pertinent observations from these studies:

a. The production of apples in states surrounding the Kansas City and Omaha markets had little effect on the prices in those markets. On the other hand, production in the northwestern states apparently had considerable effect on apple prices in Kansas City and Omaha.

b. Peach prices at Kansas City vary depending upon the source of supply. In years when large supplies come from Arkansas, Georgia and Illinois, the market tends to break sharply in July and rally again later in the season. In years when California, Utah and Colorado supply a large part of the total, prices early in the season remain on a comparatively high level but break rather sharply late in the season.

c. Since 1932 a much higher percentage of the Kansas potato crop has been shipped to points east of the Mississippi river. A larger percentage of the crop has been shipped to Chicago than formerly.

d. Twenty-four roadside markets were visited in northeastern Kansas and observations and notes taken on approximately fifty more. Data pertaining to location, physical facilities, source of products sold, distribution of business, costs, personnel, advertising, prices, and profits were gathered and partially analyzed. In several cases studies were made to determine the best time of day, day of the week, and side of the road for sales. Preliminary observations indicate that from 3 to 6 o'clock in the afternoon is the best time of day, and Sunday is the best day of the week for sales. More sales are made to motorists returning towards town. The best side of the road usually is the right side as people head toward town. Results of this survey should show the trend, possibilities, and practicability of marketing Kansas fruits and vegetables through roadside markets.

[Project 177; Department of Agricultural Economics. Leaders, George Montgomery and Franklin L. Parsons; Purnell fund.]

A Study of Factors Governing the Marketing of Dairy Products in Kansas.— The work for the biennium has consisted mainly of a revision in the manuscript of "Factors Affecting the Butterfat Prices in Kansas"; a study of some factors affecting the consumption of butter; a study of the comparative magnitude of variation in average monthly prices of milk and dairy products and in prices of dairy feeds for certain periods of time; and work on butter storage problems and storage possibilities for the larger Kansas creameries.

A study of the factors affecting the consumption of butter indicated that the quantity of butter consumed varied directly with payrolls when butter prices were high, but when butter prices were extremely low per capita consumption of butter increased in spite of low pay rolls. Consumer income, as well as butter price, affects the use of butter substitutes. When butter prices become high, the low and middle-income groups of people tend to use margarine or other butter substitutes. An increase in per capita consumption of butter can be brought about by a low price of butter and by augmented incomes to low and middle-income groups of people.

[Project 185; Department of Agricultural Economics. Leaders, George Montgomery and Franklin L. Parsons; Purnell fund.]

The Economics of the Poultry Industry in Kansas.— The work for the biennium has consisted chiefly of two phases.

1. *Analysis of Material from Two Farm Bureau-Farm Management Associations.*— This phase includes a study of such factors as monthly and total receipts, home-use products, production and receipts per hen, comparison of results by breed and size of flock, some of the more important methods and cost factors, and the relationship of the poultry enterprise to the organization and income from the farm business. Data are available from 239 records for 1931, 207 for 1932, 209 for 1933, 218 for 1934, and 192 for 1935.

Since the analysis of these data is not complete, only tentative results can be stated as follows:

a. Efficiency of the poultry enterprise is more closely related to net farm income in years of relatively low farm income. Therefore, a good poultry enterprise helps to stabilize net farm income from year to year.

b. Distribution of monthly poultry-and-egg receipts from these records confirm the idea that the poultry enterprise tends to distribute the farm income more evenly throughout the year than most other farm enterprises.

c. Poultry receipts per hen have tended to increase from 1932 to 1935.

d. Differences in results secured from flocks of medium breeds and flocks of light breeds appear to be partly due to the relative price of poultry and eggs. In 1933 there was little difference between the types of breeds, but in 1934 and 1935 the medium-weight breeds showed considerably higher receipts per hen.

2. *Price Studies.*— This study has consisted of (a) bringing up to date the series of prices at Kansas City previously tabulated from 1908 to 1933 for first eggs, heavy hens, light hens, broilers, springs, and roosters; (b) bringing up to date the series on farm price of eggs of Kansas, the series previously having been tabulated by counties and crop-reporting districts from 1925 to 1933, inclusive; and (c) analysis of price data in preparation of a manuscript on "Kansas Poultry and Egg Prices." This analysis includes factors affecting prices, trend of prices, seasonal tendencies, egg-feed ratios and their effect, and other appropriate relationships.

[Project 144; Department of Agricultural Economics. Leader, J. A. Hodges; Purnell fund.]

A Study of Factors Affecting the Social Well-Being of Rural People in Kansas.— In July, 1935, in cooperation with the Division of Social Research, Works Progress Administration, a study was undertaken of some factors affecting the social well-being of rural people in Kansas. The work has consisted of a study of relief and nonrelief households, the extent, character, and course of current changes in the rural relief population, and of the public and private agencies which have provided assistance in 13 counties in Kansas.

Tabulations concerning such items as composition of household, residence, tenure status, employment history, indebtedness, size of farm, and forms of assistance, have been made for 1,040 rural households, representing four counties in Kansas. These data are now being put in table form for interpretation.

In the study of the extent, character, and causes of the current changes in the rural relief population, tabulations have been made concerning such items as composition of household, age, sex, residence, extent of relief received over a period of years, current employment status, working or seeking work, usual occupation, training, tenure, farm or nonfarm family, for 1,627 families, representing 13 counties. This material is being assembled in table form for inter-

pretation. Tabulations and tables are being made to show the trend in number of opened, reopened, and closed relief cases and the reasons for the changes.

[Project 195; Department of Agricultural Economics. Leader, Randall C. Hill; state and social research WPA funds.]

SOIL CONSERVATION

The conservation of the soil is recognized today as a major obligation of the nation. The problem is receiving increased attention as the basic consideration of the agricultural adjustment program of the federal government. The problem is one that has received the careful attention of this station for many years. It has received the usual consideration during the past biennium. Brief descriptions of the studies relative to this problem are given on the following pages.

Soil Fertility Investigations.— The field experiments that constitute this project have been under way for 25 years. The relative yields of crops, therefore, in the various cropping systems and with the various fertilizer treatments have become fairly well stabilized. The usual yield determinations have been continued during the biennium, and various types of data accumulated during the 25 years have been analyzed to disclose the tendencies which have developed. Studies of the soils of these experimental plots have also been inaugurated in order to determine the changes which have been brought about by a quarter century of cropping and treatments.

A rotation which includes four years of alfalfa in each 16 years of cropping has continued to produce higher yields of both corn and wheat than either a three-year rotation including soybeans; (two years), wheat rotation or continuous cropping. The rotation including soybeans has produced higher yields of wheat and corn than either of the last two cropping systems mentioned. Superphosphate and a complete fertilizer have increased alfalfa and wheat yields significantly, but neither has produced profitable increases of corn. Manure has been somewhat effective on corn but has produced more profitable increases on alfalfa and wheat.

Studies of nitrogen and organic carbon in the soils of the field experiments have shown that corn production is two to three times as destructive of these constituents wheat cropping. Alfalfa in continuous culture for varying periods of time up to 25 years, with the top growth regularly removed as hay, has increased nitrogen on all land on which the original nitrogen content was medium to low. On soil in which the organic carbon content originally was low, this constituent was also increased by alfalfa cropping. Carbon-nitrogen ratios were narrowed over the 25-year period by cropping with alfalfa, but other crops used in the various cropping systems did not greatly change these ratios.

Data have been summarized from an experiment in which the residual effects of alfalfa cropping periods of varying lengths have been studied. Wheat grown continually after breaking the alfalfa sod in each case was used as the test crop. Foot rot became established in the wheat plots and in several years seriously affected yields. In years when the disease was not prevalent yields of wheat were increased by all previous alfalfa cropping periods, which varied from one to nine years. Protein content of the wheat was increased very significantly in all years by previous alfalfa cropping. The quantity of nitrate nitrogen in the soil at wheat-seeding time was increased by the alfalfa cropping periods, the longer periods showing the more pronounced and more

extended residual effects. After five to seven years of wheat cropping following alfalfa. however, the effects of even the longest periods of alfalfa cropping had declined rather markedly.

The data from a uniform cropping trial covering a period of nine years on a group of 36 plots have been analyzed. The crops grown were as follows: corn, oats, wheat (two years), alfalfa (three years), and Atlas sorgo (two years). No plot consistently showed better yields than other plots, though two were fairly consistently high yielding. Likewise, only two fairly consistently ranked lower in yield than others. The great majority of the plots were quite erratic in their yield performance. A heavy yield one year was in many cases followed by a light yield the following year. The variability among the plots was highest in years of low rainfall. Hence it appears that under the conditions represented by these tests a uniform cropping trial is of decidedly limited value as a means of indicating relatively permanent differences in the productivity of a group of experimental plots.

Summarization of data regarding the relation of the nitrate nitrogen content of wheat land on the fertility project at seeding time and the yield and protein content of the succeeding wheat crops has warranted the following conclusions: (a) Nitrates and protein are very closely and positively correlated; (b) nitrates and yields are likewise correlated, though the correlation is more variable; and (c) soil samples taken to a depth of 1 foot reveal these relationships as adequately as samples taken to a depth of 3 feet.

[Project 17; Department of Agronomy. Leader, W. H. Metzger: Hatch fund.]

Plant Nutrition Investigations.— The nature of the work of this project has of necessity been somewhat changed due to the loss of soils and equipment in the fire that destroyed the chemistry building. The new work has been along the lines of the effect of minor elements on wheat. During the past year the major interest has been devoted to selenium. Increasing applications of sodium selenate were added to Derby soil in 2-quart glazed pots. Tenmarq wheat was grown. The applications were on the basis of p. p. m. of selenium to the soil. The data show that applications of 5 p. p. m. or more will kill the wheat plants. During the fall, growth of the wheat was retarded in proportion to the amount of selenium applied.

[Project 152; Department of Chemistry. Leader, A. T. Perkins; state fund.]

Influence of the Absolute Reaction of the Soil Solution Upon the Growth and Activity of Azotobacter.— The work during the past biennium has consisted of two phases: (1) A continuation of the cylinder experiments previously reported, and (2) a continuation of the field studies relative to "spotted" wheat fields.

The cylinders were sampled for soil analysis during 1933 and the soils were analyzed for total nitrogen during the past biennium. No significant differences were noted in the nitrogen content of the variously treated soils.

The field studies relative to "spotted" wheat fields, their cause, artificial production, and effect upon composition and yield of gain have been completed and the results incorporated in a technical bulletin entitled "Nitrogen-The Major Cause in the Production of Spotted Wheat Fields." This bulletin is now in press.

Certain facts relative to the presence of Azotobacter in the soil collected from spots and immediately adjacent were recorded; the most striking one being a marked reduction in the Azotobacter content of soil from the spots. Efforts have been made to correlate the observed reduction in the density of the Azotobacter population in the soil from spots with a change in reaction, but so far this has been impossible. The next apparently most logical factor

responsible for the observed difference was the difference in the soluble nitrogen, particularly nitrate nitrogen.

Accordingly, studies were undertaken and have been vigorously pursued during the past biennium to determine both in soil and in pure culture the influence of nitrate nitrogen upon *Azotobacter*. The results thus far obtained justify the statement that in some soils a moderate concentration of nitrate nitrogen will not only cause a decrease in the density of the *Azotobacter* population but may even cause their complete elimination in a comparatively short period of time.

More than a hundred strains of *Azotobacter* have been isolated and studied as to their tolerance of nitrate nitrogen. Very marked differences in tolerance have been observed. By gradually increasing the concentration of nitrate nitrogen the tolerance of most cultures can be markedly increased.

It seemed desirable to ascertain the cause of the injurious effect of the NO_3 radical upon *Azotobacter*. Thus far studies have been directed toward ascertaining the effect of nitrates upon the nitrogen-fixing ability of the organisms. The effect seems to vary with different strains, but a few strains have been studied in which the organisms have apparently been caused to lose their nitrogen-fixing ability by growing them in relatively high concentrations of nitrates. This, if proved to be true, is a highly significant point both from a theoretical and practical point of view.

[Project 128; Department of Bacteriology. Leader, P. L. Gainey; Adams fund.]

Influence of Legumes and Free-Living Nitrogen Fixing Organisms on the Growth of Plants and on the Nitrogen Balance.—The work on the project during the biennium consisted of a continuation of the field work, plus laboratory and greenhouse studies of various phases of the general problem.

Crop yields during the biennium were in general very unsatisfactory due to the extreme droughts of both seasons. That was especially true of corn and kafir, both of which failed to produce grain in 1934. In 1935 a small amount of each of these grains was produced. Row crops following alfalfa and one year of sweet clover made much less growth than following either a non-legume or two years sweet clover or soybeans. Moisture studies during both seasons indicated that the primary cause of this difference was the differential influence of the various crops on the supply of moisture available to the row crop.

Deep-soil moisture samples from several plots demonstrated that sweet clover growing for two years during seasons of deficient rainfall may reduce the moisture to the wilting point to a depth of 14 feet. One-year-old sweet clover was shown to reduce the moisture to a maximum depth of 9 feet during a season of low rainfall. The study dealing with the effect of various legumes on deep subsoil moisture has been completed and the results published.

Preliminary greenhouse investigations into the cause of crop burning following legumes and fertilizers indicated that corn grown on soils fertilized with ammonium sulfate was not more susceptible to injury when exposed to high temperatures than corn growing on unfertilized soil. The work thus far does not permit of definite conclusions.

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

A Study of the Soil Solution as Governed by H-Ion Concentration and Other Factors.—The work of the biennium has consisted primarily of a study of soil separates and fractions which govern the soil solution. Four soils differing in geologic origin and fertility have been studied. The results show that the finer the par-

ticles, the greater is the base exchange capacity per unit weight, but the less it is per unit surface area. In these studies there is no outstanding difference between fertile and nonfertile soils. The soil separates have been broken up into fractions according to specific gravity.

The results show for the lighter soil fractions that the base exchange capacity per unit weight remains constant regardless of size; but that for the heavier separates, the base exchange capacity increases per unit weight as the size of the particles decreases. In considering surface area alone the base exchange capacity decreases for all fractions as the size of the particle decreases, but the decrease is much greater for the light particles than it is for the heavier particles. Comparison of the fertile and nonfertile soil indicates that the fertile soils contain a much larger percent of the light minerals than the nonfertile soils but these data are of a preliminary nature and are not conclusive.

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

A Study of Replaceable Cations and Anions in Some Kansas Soils.— Work was continued during the biennium upon the determination of the solubility of calcium phosphate under conditions of varying pH values both in contact with soils and in mixtures of known content. Much of this work was devoted to the determination of sharper definition of curves already drawn from data previously taken; that is, smaller increments of reagents were used between critical points already established in order to ascertain with greater exactness the pH values at which the volubility of phosphorus in contact with calcium abruptly decreased and finally reached a minimum.

Because of the destruction by fire of all materials formerly used in this work, a very considerable amount of preparatory work, such as collection and construction of apparatus, preparation and standardization of solutions, aid in designing and placing of laboratory tables and shelves, etc., was necessitated. After this was accomplished some experiments concerning the effect of aeration upon $\text{CaCO}_3\text{-H}_3\text{PO}_4$ systems were conducted.

The object of this work was to determine the variation in the reaction between systems containing CaCO_3 and dilute H_3PO_4 from which none of the CO_2 liberated was removed and similar systems which were subjected to varying periods of aeration.

Although only a limited amount of work has been done on this phase of the subject, the data collected appear to show: (a) That the retention of CO_2 in these systems tends to lower the pH values of the filtrates; (b) that aeration is an effective means of removing CO_2 ; and (c) that pH values of the filtrates rose with the time of aeration up to about 2 hours and from there on remained constant, indicating that further aeration was ineffective.

Work planned for next year is to study more carefully the effect of Fe, Al, and CO_2 on phosphorus volubility both in soils and salt solutions. A paper entitled "The Effect of Calcium Ions and Reaction upon the Solubility of Phosphorus" has been prepared for publication.

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

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

Southeastern Kansas Experiment Fields.— Two fields one in Cherokee county (Columbus) and the other in Allen county (Moran) have been operated during the past biennium. The work has consisted of fertility studies and variety tests with the more important crop plants. In spite of the fact that the weather conditions have been very unfavorable for crop production the data secured tend to substantiate those previously reported.

In the wheat-variety test, Kawvale, a relatively new variety and one which is especially well adapted to southeastern Kansas, made the highest yield. The average yields for the biennium for the different varieties of wheat were as follows:

<i>Variety</i>	<i>Yield, bushels per acre</i>
Kawvale	39.31
Tenmarq	38.25
Michigan Wonder	36.94
Blackhull	35.88
Fulcaster	35.79
Clarkan	35.56
Kanred	32.05
Harvest Queen	31.53
Currell	30.26

The adverse weather conditions during the biennium caused a complete failure of corn at Columbus both years. At Moran the yields were so low in 1934 that no appreciable difference could be established for any given soil treatment, but in 1935 the yields and increases were both about normal. Hays Golden, due to its earliness, tended to escape the drought in 1934 and made the highest average yield of any corn variety that year. For the biennium the best showing was made by some Pride of Saline hybrids.

The flax seedbed and preceding crop test at Columbus has continued to give wide differences in flaxseed yields, although all yields have been low. Disked or plowed soybean stubble or summer-plowed oats stubble continued to be the best method of flax seedbed preparation. The yields of flax seed from the different treatments have been as follows:

<i>Treatment and preceding crop</i>	<i>Av. yield, bushels per acre</i>	
	<i>1934-'35</i>	<i>1931-'35</i>
Spring-disked soybean stubble	7.2	11.2
Spring-disked kafir stubble	4.0	5.6
Spring-disked corn stubble	4.9	6.7
Fall-plowed corn stubble	4.7	7.9
Fall-plowed kafir stubble	4.0	7.3
Fall-plowed soybean stubble	7.2	11.1
Fall-plowed oat stubble	2.9	3.5
Oats-soybean green manure plowed under in fall	7.3	12.2
Summer-plowed oat stubble	5.9	9.6

Other flax experimental work consisted of fertility, variety and rate- and date-of-seeding tests.

Alfalfa yields at both fields have been nearly normal in spite of the adverse weather conditions. All fertility tests tended to substantiate the data previously reported. The average yield of the different alfalfa varieties at each field for the biennium was as follows:

<i>Variety</i>	<i>Yield, tons per acre</i>	
	<i>Moran</i>	<i>Columbus</i>
Kansas Common	3.23	1.97
Grimm	3.32	2.08
Utah Common	2.80	1.79
Arizona Common	2.60	...
Ladak	3.52	2.26
Kansas 308	3.59	...
Turkestan 86696 .....	...	2.02
Hairy Peruvian	1.48	...

The Kansas Common variety has been at a slight disadvantage during this biennium because an abnormally large part of the crop has been obtained from the first cutting. Kansas Common usually does not yield as high the first

cutting, but higher the second and third cutting, than Grimm, Ladak, and Turkestan. Kansas 308 has made good yields and appears to be a good variety. The Ladak was resistant to the pea aphid invasion in 1934.

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

Southcentral Kansas Experiment Fields.— The Wichita and Kingman Experiment Fields were operated under this project during the past biennium. The work consisted of soil fertility, soil management, crop variety, as well as date, rate, and method of planting studies. The fertility work consists of studies on fertilizer treatments, crop sequences, and straw burning. Special attention was given to pasture grasses and legumes that may be adapted to this region.

Superphosphate and nitrogen applied to wheat on these fields has not increased the yields sufficiently to pay for the fertilizer except in the more favorable years. There was a good increase in the yield of wheat in 1934 from the use of superphosphate. Manure delayed maturity about three days in 1934 and this resulted in a decrease in yield of 1 bushel per acre. There was an increase in the yield in 1935 of 4 bushels per acre from the use of manure on continuous wheat.

The yield of potatoes was increased from 6,700 to 8,300 pounds per acre by the use of superphosphate and nitrogen in 1935. The percentage of potatoes grading U.S. No. 1 was increased from 43 to 60 by the use of fertilizers. Mulched potatoes were a complete failure, due to the water-logged condition of the soil during the months of May and June.

The application of lime at the rate of 300 pounds per acre in the row-with sweet clover seed produced as much top growth as that applied at the rate of 2 tons per acre broadcast. Successful stands of sweet clover were obtained in 1934, 1935, and 1936 when seeded with oats as a nurse crop. Fall seeding of sweet clover has been successful after oats or wheat three of the last four years; conditions were not favorable in 1935 for fall seeding. Yellow-blossom varieties of sweet clover withstood the drought better than did the white-blossom varieties.

Early maturing wheat varieties produced the highest yields in 1934 while the late-maturing varieties produced the highest yields in 1935. Wheat planted September 25 at Kingman has produced an average of 3.4 bushels more per acre than that planted September 11, and 2.8 bushels per acre more than that planted October 9.

Brunker was the highest yielding variety of oats for the last two years. This variety produced an average yield of 47.1 bushels per acre on the two fields as compared to 44.1 for Kanota. Oats planted about March 1 has given the best yields.

Flax yields were high in 1935 and fair in 1934. Early planting has given the best results and the 40-pound rate has been superior to either the 30- or 60-pound rates of seeding. Winona has produced an average yield of 12.5 bushels per acre for the two fields for the best rate- and date-of-seeding compared to 11.5 for Southwestern and Bison.

Corn yields have been poor. There was a complete failure at Kingman in 1934 and very low yields at Wichita. Hays Golden has been the outstanding variety. The April 18 date of planting produced the highest yields and June 11 the lowest.

Early maturing grain sorghums in general produced the best grain yields in 1935; there was very little grain produced in 1934. Darso was the leading variety for the two years and it was closely followed by juicy Fink Kafir. Kansas Orange was outstanding in the production of forage, with Atlas second.

Ladak was the outstanding alfalfa variety, with an average yield of 3,760 pounds per acre compared to 3,600 for Kansas Common. Ladak was noticeably resistant to the severe infestation of pea aphids in 1934. Yields of alfalfa have been very low, due to the severe weather conditions.

The work will continue for the next biennium along the same lines as in the past with the addition of work with native grass varieties. Plantings have

been made of big bluestem, little bluestem, blue grama, side-oat grama, and western wheat grass. Ground is being fallowed for other plantings at each field this fall.

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

Southwestern Kansas Experiment Fields.— The Kansas legislature of 1935 appropriated funds for the establishment of experiment fields in southwestern Kansas. A field consisting of Richfield silt loam and suitable for the work was located on the farm of John Hiatt in Meade county during the latter part of 1935. Plans for the experiments were completed during the winter of 1935-'36, and field work was started in the spring of 1936. The entire project will be in operation by 1937.

The experiments outlined for the field include intensive studies of the effect of different methods of soil management on moisture conservation and crop yields of all farm crops adapted to this section of the state. Time and method of seeding studies will be conducted with the more important farm crops.

Trials will be conducted with native varieties and introduced species and varieties of grasses to obtain grasses that are adapted for seeding in southwestern Kansas.

Plans are being made for the location of an additional field on the Richfield sandy loam, which extends over a large area of southwestern Kansas.

Experimental work on the very sandy soil types will be conducted in several places in cooperation with farmers.

[Department of Agronomy. Leader, R. I. Throckmorton and A. B. Erhart; state fund.]

Northeastern Kansas Experiment Fields.— Five experiment fields have been operated in northeastern Kansas during the past biennium as follows: The potato field at Newman, the crop field at McLouth, the young orchard planting at Atchison, the mature apple orchard at Blair, and the small-fruit field at Wathena.

Results with potatoes at the Newman field during the biennium were contradictory. Potatoes yielded best following potatoes in 1934, and following alfalfa in 1935. Green-manure crops decreased the yield in 1934, and increased the yield in 1935. The yield of potatoes was highest following sweet clover, being twice that of the check. In the depth-of-planting test, the 6- and 2-inch depths-of-planting yielded less than the 4-inch depth. The 6-inch depth-of-planting made the potatoes more difficult to dig and was discontinued. The average percentage grading U.S. No. 1 was 84.1 for the 4-inch depth-of-planting as compared to 75.4 for the 2-inch depth-of-planting. The rate-of-planting tests gave no definite results in 1934, but in 1935 the yields were directly in proportion to the rate of planting.

A complete commercial fertilizer gave an average increase of 46.8 bushels per acre over the unfertilized check plots in 1935, as compared to an average increase of 16.8 bushels for a combination of a complete fertilizer plus a green manure crop.

Crops on the McLouth field were almost a total failure during both years of the biennium. Yields of wheat and corn for silage following various forage crops were contradictory. In a two-year rotation of corn and oats, phosphorus increased the yield of oats 17.2 bushels. Kanred, Blackhull, Tenmarq, and Kawvale were the leading wheat varieties, Kanota oats yielded highest in the early plantings, while Fulghum × Marton gave the best yields in late plantings. Kansas Common, Kansas 308, Ladak, and Grimm were the outstanding alfalfa varieties. Phosphorus applied to bluegrass resulted in a yield of 1.467 pounds per acre; the application of nitrogen and phosphorus increased the yield to 2,641 pounds as compared to a yield of 968 pounds for the unfertilized plot.

Trees mulched with straw in the young apple orchard at Atchison made the most growth, but trees intercropped with corn have the most desirable shape, due to the windbreak effect of the corn.

At Blair mature apple trees growing under a straw mulch and those given clean cultivation plus a cover crop of vetch yielded the highest, but the percentage of apples under 50 percent color was greatly increased by these methods of soil management as compared to the sod culture method. Application of ammonium sulfate to trees growing in sod increased the yield but also increased the percentage of apples under color. The average percentage of apples under color for the various methods of soil management in 1935 were as follows:

<i>Method</i>	<i>Percent</i>
Clean cultivation and fertilizer	31.5
Straw mulch	37.6
Clean cultivation and vetch	39.5
Bluegrass sod	14.5
Bluegrass sod and fertilizer	17.7

Lightly pruned trees yielded higher than trees pruned moderately or heavily, and the fruit colored nearly as well. Many of the fruit spurs on trees heavily pruned changed to twig growth, temporarily throwing them out of fruit production.

Strawberries were dirty and unsalable when not mulched at the Wathena field. The strawberry variety Ettersburg winterkilled badly and in addition was very susceptible to strawberry leaf spot.

The potato disease investigations at the Newman field are reported under Project 130 (Department of Botany). The apple and strawberry insect investigations at the Blair and Wathena fields are reported under Project 13 (Department of Entomology).

[Departments of Agronomy, Horticulture, Botany, and Entomology. Leaders, R. I. Throckmorton, R. J. Barnett, L. E. Melchers, G. A. Dean and Erwin Abmeyer; state fund.]

INVESTIGATIONS IN THE PLANT INDUSTRIES

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

Temperature Relations of Crop Plants.— Investigation of the comparative cold resistance of the winter cereals, wheat, rye, barley, and oats during transition from the dormant winter condition to the active growing spring stage were continued from the preceding biennium. Also investigations of the changes within the cells during the transition were continued. Some preliminary studies of the resistance of crops to high temperature were made and equipment, was devised and installed which provides a room 6 by 6 by 9 feet in which temperature and relative humidity are automatically and independently controlled. Temperature may be controlled to as high as 150 degrees F. and relative humidity from about 10 to 90 percent.

In the low-temperature studies changes in the relative cold resistance of several varieties of winter wheat were found in the transition from the dormant to the active stage of growth. Certain varieties possessing a marked degree of resistance when hardened were not superior and in some cases were inferior in this respect several days after spring growth was artificially induced by the transfer of hardened plants to the greenhouse. In general the hardiest varieties lost resistance to cold most rapidly in the favorable growth environment of the greenhouse. Minturki, which was most hardy among the six varieties studied, changed so rapidly that it became least resistant to cold

after six days. The slower change in Kanred resulted in showing that variety superior to Minturki within a week. Quivira and Tenmarq were about equal in cold resistance at all stages of hardening. Blackhull lost resistance at about the same rate as the latter varieties and therefore maintained its relatively low position. Harvest Queen was intermediate in cold resistance between Tenmarq and Blackhull when hardened, but it changed more slowly in the greenhouse and within a week was markedly superior to those varieties.

It is apparent therefore that the rate at which cold resistance is lost in varieties of winter wheat in transition is not necessarily associated with the degree of cold resistance in the hardened condition. No physiological reason is known that would prevent the possibility of finding or developing through hybridization a hardy variety of winter wheat that will retain a relatively high degree of resistance into the spring growth period.

No evidence was found to indicate a relation between time of maturity and rate of change in cold resistance in the winter-spring transition. The short time for spring growth in early maturing varieties apparently is not antagonistic to the maintenance of cold resistance. Quivira ripens two or three days earlier than Tenmarq but lost its cold resistance at about the same rate. Kanred is about two days earlier than Minturki but changed more slowly in cold resistance.

Plants of the four winter cereals grown outdoors were transferred to the greenhouse during the winter when they were hardened to cold. The loss in cold resistance under the influence of the greenhouse environment was found to proceed at a decreasing rate, being rapid during the first part of the transition period and gradually becoming slower until after two weeks little change was taking place. The results indicate that the rate at which a crop loses resistance to cold is roughly proportional to the degree of hardening.

A marked increase in water content was found during the first day after hardened plants were transferred to the greenhouse, a similar increase the second day, somewhat less the third, and gradually less on successive days until the ninth when a maximum percentage of moisture was attained and after which there was no material change. The amount of juice extracted from plants increased appreciably during the first day the plants were in the greenhouse and continued to increase at the same rate throughout the transition period.

In the high-temperature investigations it was found that testing 14-day-old corn seedlings for six and one half hours in a room with temperature controlled at 140 degrees F. and relative humidity at about 30 percent it was possible to distinguish among inbred lines with respect to drought resistance. Essentially the same order of relative resistance among the strains were obtained with the seedlings as was noted for the full-grown plants in the field.

The study of relative cold resistance of different cereals during winter-spring transition and associated changes will not be continued further. It is planned, however, to continue the study of relationships among varieties of winter wheat during the winter-spring transition in the attempt to find varieties that are both winter-hardy and spring-hardy and to determine whether the slow transition change in Harvest Queen is characteristic of soft wheats as a class. It is also contemplated to stress the work in high-temperature studies, particularly to learn the relative resistance of cereals and the comparative resistance at different stages in the development of a crop.

Two manuscripts representing work of this project have been submitted for publication this year. They are "Cold Resistance of Winter Wheat, Rye, Barley and Oats in Transition from the Dormant to the Active Stage of Growth" and "A Method for Studying Resistance to Drought Injury in Inbred Lines of Maize."

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

Small Grain and Sorghum Improvement.— This project is in cooperation with the Bureau of Plant Industry, United States Department of Agriculture, and includes plant-breeding work on winter wheat, spring oats and barley, and grain and forage sorghums.

Winter Wheat Breeding.— The following average yields of a few important varieties grown in the plant breeding nursery for nine years, 1927 to 1935, give some idea of the progress made in wheat improvement.

Variety	Yield	
	Bushels per acre	
	HARD RED WINTER	
Turkey		32.0
Kanred		33.7
Tenmarq		41.6
	SOFT RED WINTER	
Harvest Queen		32.9
Fulcaster		36.3
Kawvale*		43.0

*Semihard.

Tenmarq was planted on about 250,000 acres in the fall of 1935 for harvest in 1936. Kawvale was grown on about 40,000 acres in 1934, and there was a large increase in the acreage planted to Kawale in the fall of 1935.

Among the new hybrid wheats, selections of Oro × Tenmarq for bunt resistance, winter-hardiness and high quality, and of Kawvale × Tenmarq, for resistance to Hessian fly and leaf rust, appear promising. Several selections of each of these crosses were promoted from the nursery to single one-fortieth-acre plots in the fall of 1935.

Quivira is an early, high-yielding variety of hard red winter wheat developed from the cross, Prelude × Kanred. It is probably more winter-hardy than any other variety of equal earliness, but is much less cold resistant than Turkey, Kharkov, and Kanred. Flour of Quivira has higher carotene content than flour of Tenmarq. Quality factors and agronomic characters of Quivira require further study. Two early maturing selections of Kanred × Hard Federation appear promising as "combine" types, because of their short, stiff straw.

Oats Breeding.— For 15 years, Kanota has been the dominant variety of oats in Kansas. A good deal of emphasis is placed on the production, by hybridization, of new varieties of oats having the earliness, high yield, high test weight, and Kansas adaptation of Kanota, combined with resistance to Smut, crown rust, and stem rust. Distinct progress is being made in all three respects. A new variety of oats resistant to smut and superior to Kanota in yield, seems almost at hand, as shown in the following table:

Variety	5-yr. av., 1931-'35	Percent smut
	Bus. per acre	1935
Kanota	49.9	8.4
Fulghum × Markton	68.8	0.0

Crosses of Kanota (Fulghum) × Richland for stem rust resistance and of Kanota (Fulghum) × Bond and Victoria for resistance to crown rust and smut have produced rust-resistant types, but only a few of these have the desirable agronomic characters of Kanota.

Barley Breeding.— Due to severe drought, no barley nursery was grown at the Colby branch station in 1935, and no significant results were obtained at Hays. About 600 bushels of Flynn, an early maturing variety with smooth awns, was grown under irrigation by a member of the Kansas Crop Improvement Association at Fowler, Kansas, in 1935. All of this certified seed has been sold to other farmers in western Kansas for planting in 1936.

Sorghum Breeding.— Atlas sorgo is very popular and widely grown in eastern Kansas. It is a little too heavy and late to be well adapted, as a grain and forage crop, in western and northern Kansas. A selection from the cross,

Atlas × Sunrise (early) appears promising. Several early, white seeded selections of crosses between Atlas and Early Sumac are now being tested at Hays and appear promising. Experiments at Manhattan and at Lawton, Okla., have shown that Atlas is resistant to chinch bugs. A selection of Kansas Orange × Dwarf Yellow Milo, is also highly resistant to chinch bugs.

The sorghum nursery grown at the Agronomy Farm in 1935 included 418 rows. The cross, Spur feterita × Blackhull kafir, has given rise to a few promising selections in which the feterita resistance to kernel smut is combined with the juicy stalks and other desirable characters of Blackhull kafir. From the crosses of Darso on Dawn, Western Blackhull and Club kafirs, selections have been made in which the partial resistance to kernel smut, high yield and apparent drought resistance of Darso, are combined with the white kernel color of the kafir parent.

Several selections of Dwarf Yellow milo × Early White milo appear promising for northwestern Kansas, because of their earliness. A selection of Kafir × milo, No. 27317, appears superior to Wheatland. Studies of heterosis in sorghum crosses are being continued. The inheritance of resistance to milo disease is being studied in the greenhouse at Manhattan in cooperation with the Department of Botany and in the milo disease nursery at the Garden City branch station.

A sorghum-breeding nursery has been established at Kingman for special plant-breeding studies with combine types of grain sorghums.

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

Inheritance of Factors Affecting Quality in Wheat.— Chief emphasis during the years 1934 to 1936 was given to quality studies of 1935 crop samples, using (1) the dough ball or wheat-meal-time fermentation test, and (2) curves from the K. S. C. recording dough mixer.

Protein determinations were made on 376 samples of varieties, selections and crosses grown in the wheat-breeding nursery. Milling and baking tests were made on about 20 samples of wheats grown in the nursery. ball "time" and protein determinations were made on 107 strains of wheat grown in the nursery in 1935. The correlation coefficient for these two determinations of quality or "strength" in wheat is negative and not significant, $r = -.199 \pm .066$. Similar results were obtained in 1934, using 139 strains, $r = -.222 \pm .057$.

This indicates that protein content is not the chief factor determining dough-ball "time." Gluten quality is probably of greater importance than quantity of protein as a factor related to baking "quality" or "strength" of wheat varieties.

The dough-ball "time" determinations of a few strains of winter wheat grown in the nursery in 1936 are as follows:

Variety	Minutes
Oro	200
Tenmarq	188
Cheyenne	118
Kanred	93
Turkey	79
Kawalo	74
Harvest Queen	46
Michigan Wonder	34
Gladden	29

Some F3 lines of the cross Tenmarq × Early Blackhull gave clear evidence of segregation of the genetic factors governing "time" of dough balls. The average "time" of five Tenmarq parental checks is 127 minutes, of five Early Blackhull checks, 51 minutes. The "time" of 23 hybrid selections ranges from 51 minutes for a segregate evidently resembling Early Blackhull in "time"

factors, to 195 minutes for a segregate having somewhat longer "time" than Tenmarq. The dough-ball test should prove useful in evaluating the quality characteristics of hybrid selections in a cross such as this one, where the parental varieties are clearly separated, and where it is desired to discard the segregates resembling one parent and keep those resembling the other.

Curves from the K. S. C. recording dough mixer seem to give a clear picture of some of the inherent quality characteristics of wheat varieties. Thus Blackhull, Turkey, Tenmarq, Harvest Queen, and other varieties tend to produce a curve of characteristic type, even when grown in different seasons, or under a rather wide range of soil and climatic conditions in the same season.

Some preliminary studies of the relation between "time" of dough balls to break and type of dough development curves, as made on the K. S. C. recording dough mixer, show that, in general, those wheats with short "time" produce curves characteristic of "weak" or soft wheats, while most of those with long "time" produce curves resembling the hard or "strong" wheats.

Much more work needs to be done to relate the curve types and dough-ball "time" to the baking test. If the results of these three tests of quality in wheat are not always closely correlated, it is not necessary to place all the criticism on these newer tests. The baking test itself is subject to variation and is not a perfect or infallible measure of quality. It is planned to continue the work of this project along about the same lines during the next biennium.

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

Varietal Tests of Small Grains and Sorghum.— The work of this project was principally a continuation of investigations started previous to the present biennium, and included variety tests of wheat, oats, and flax; adaptation tests of barley and spring wheat; a study of the interrelation of wheat varieties and time of planting; and a study of changes in the ratios of strains of wheat differing in adaptation when grown in competition in a mixed population. A quantitative study of the component parts of the plant of different varieties of sorghum was started in 1935.

Among the varieties of sorghum tested Darso manifested superiority in its ability to head during dry warm weather in both years of the biennium. This characteristic was reflected in the yield of grain in 1935 when one strain of Darso (Oklahoma) averaged 33.4 bushels per acre and another strain (Kansas) 28.1 bushels, whereas Standard Blackhull kafir averaged 13.2. Western Blackhull kafir 11.2, Red kafir 16.0, and Pink kafir 8.4 bushels per acre. Ajax and Kalo did well under the adverse conditions, averaging 20.6 and 19.2 bushels, respectively.

A quantitative study of the component parts of the plant in several varieties of sorghum representing widely different types of growth indicated that the plant weight was closely associated with the weight of internode. The principal quantitative difference between plants of dwarf or small types such as Ajax, Feterita \times Smith HC312, and Club, and large forage types such as Kansas Orange and Atlas was in weight of stalk excluding leaf, leaf sheath, and head.

In a study of the significance of adaptation, mixed populations of easily distinguishable varieties of wheat have been used. In four years the varietal ratios have changed markedly toward the better adapted strain in each case. At the beginning of the experiment two varieties were mixed in the ratio of equal numbers of kernels. Since then seed of the composite group each year has been used for planting the next crop. The cumulative change in the variety mixture of Kanred and Harvest Queen has been from the ratio of 50-50 to 70 percent Kanred and 30 percent Harvest Queen in four years. A similar mixture of Kanred and Currell has reached the ratio of 82 percent Kanred and 18 percent Currell.

A study of the relative yields of varieties of wheat during the last 25 years shows that when compared with standard varieties, new varieties made relatively higher yields during their early history than at later times. This suggests the possibility that a variety may not be stable and that, like individuals and species, it may have a life cycle.

[Project 129-1,2; 5 Department of Agronomy. Leader, H. H. Laude; Hatch fund.]

Variety and Cultural Tests of Soybeans.— The work of this project has included tests of 15 varieties, 62 selections, and 145 recently imported varieties of soybeans. Ten varieties of cowpeas were included with the soybean variety test. Tests of different methods and rates of planting were conducted also.

The yields of seed and of hay in 1934 were the lowest recorded for the varieties now being grown at this station. Only five varieties produced over five bushels of seed per acre. The highest three of these were selections made at this station from the A. K. variety. Selection No. 25 ranked first with 6.62 bushels. Only three varieties produced as much as 900 pounds of hay per acre, the Laredo ranking first with 909 pounds. In 1935 the yields were relatively high, despite the drought and high temperatures. The highest eight varieties in yield of seed were selections from A. K. Yields of these ranged from 26 to 28, compared with 25.8 bushels for the parent variety. Chiquita ranked first in yield of hay with 6,191 pounds, and Laredo second with 5,735 pounds. No other variety approached these yields of hay, the nearest being more than 1,100 pounds less. The performance of many of the varieties in these two abnormal seasons was not consistent with that of previous years.

Tests of methods of planting indicate that in dry seasons higher yields of both hay and seed can be obtained by planting in cultivated rows. Plantings in close rows with a grain drill resulted in failure of the crop in 1934 while in 1935 yields by that method were higher than those from cultivated rows. Growing in cultivated rows has been more satisfactory on land that is infested with weeds.

Six rates of planting with the grain drill have been made each year. There is no consistent difference in yield of seed from rates ranging from 70 to 116 pounds per acre.

Cowpeas produced no seed in 1934 and the hay crop was too short to harvest successfully. In 1935 the highest yield of hay, 2,354 pounds per acre, was produced by the Progressive White variety. This was only slightly higher than the yield of New Era, Victor, and Whippoorwill. Tepary beans produced more than twice as much hay per acre as the cowpeas but the yield of seed was lower than that of any of the latter except Whippoorwill and Progressive White conclusions cannot be drawn from results obtained during the last two abnormal seasons.

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

Miscellaneous Legumes for Forage.— During the last biennium this project has included four phases of work as follows: (1) Plot tests of 28 varieties and strains of sweet clover for determination of yields of forage and seed; (2) seeding sweet clover in the fall for seed production; (3) the completion of tests of 11 varieties for palatability and endurance when used for pasture; and (4) nursery plots of 20 species and varieties of miscellaneous legumes grown to determine their adaptability and possible value.

At least four new varieties of sweet clover appear to be superior to the common white blossom variety in quality of forage, rate of growth in the first season, resistance to frost in the fall, and uniformity of ripening seed.

Fall planting for seed production has been found to be desirable as it eliminates the trouble with weeds common to spring planting, and permits the growth of a small grain during the season that the sweet clover is planted. High yields of seed were obtained in 1935 from fall planting, four varieties producing from 672 to 1,058 pounds of unhulled seed per acre. The yields of forage from fall planting have been approximately the same as those from spring plantings, ranging from 19 to 2.9 tons of air-dry material per acre. A study of the amount of winterkilling in fall-sown sweet clover has shown that the loss from this cause is very little when seeding is done around September 1.

In the pasture tests, dairy cows showed a preference for the early and medium yellow varieties in the early part of the season. The late white blossom varieties seemed least palatable. An area of one and five sixths acres furnished the equivalent of 266 days of pasture for one cow, despite severe drought during May and June which greatly reduced the carrying capacity of all varieties.

Among the miscellaneous legumes the *Crotalaria* and *Sesbania* appear to be of some value as annual crops for green manure. Unsatisfactory seed production is the chief disadvantage of these species in this state. Austrian winter pea is unable to withstand the winters here. Spring vetch succumbs to the first period of hot weather and must be regarded as worthless as a crop for this locality. Winter vetches, hairy, woolypod, and smooth, have formed a good soil cover over winter and produced good vegetative growth from March to the middle of June. Woolypod has produced low yields of seed.

Pasture tests of sweet clover varieties and work with certain miscellaneous legumes have been completed. Continuation of sweet clover variety tests for at least one more year is contemplated. Selection of individual plants having desirable characters should be begun.

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

Corn Production and Improvement.— This project is conducted in cooperation with the Bureau of Plant Industry, United States Department of Agriculture.

The main emphasis during the past biennium has continued to be placed on the production of superior hybrids from selfed lines, both in dent corn and in popcorn. Other phases also have been given attention, including cultural experiments and variety tests, production of an open-pollinated yellow variety similar to *Pride of Saline*, improvement of popcorn by mass selection, studies of insect resistance in corn, physiological studies with corn, studies of the methods of determining moisture in popcorn, and the relation between temperature and relative humidity of the air and the moisture content of stored popcorn.

The project has been greatly handicapped during this biennium by two of the most disastrous droughts on record. At Manhattan corn was a total failure in 1934 and nearly so in 1935. Not only were the comparative tests ruined for both years, but even more serious was the impossibility of propagating inbred lines and growing hybrid seed. Considerable time and money were spent in the spring of 1936 in test borings and drillings to locate water for irrigation on the Agronomy Farm, but without finding an adequate supply.

Although all plots of varieties and hybrids were almost complete failures from the standpoint of grain production in both 1934 and 1935, pronounced differences in drought injury were evident, and valuable information concerning relative drought-tolerance of inbred lines and hybrids was obtained.

Statewide cooperative yield tests are being depended on to determine whether *Yellow Selection No. 1*, a new yellow corn from *Pride of Saline*,

should be named and distributed. In 1934 only one cooperative test was harvested and in 1935, out of 68 tests planted only 20 were harvested, and comparable yields for Yellow Selection No. 1 were obtained from only 10. In northeastern Kansas it tied with Pride of Saline as the highest yielding variety. In southeastern Kansas it fell below Pride of Saline in yield but was practically the same as Midland, the best yellow variety for that section. In south central Kansas, Yellow Selection No. 1 yielded less than Pride of Saline but more than any other yellow variety. It will have to be tested further before deciding whether or not it should be distributed. Cooperative biological assays with rats conducted by the Department of Home Economics indicate that this new synthetic yellow variety has at least the vitamin A potency of Reid Yellow Dent, the standard yellow corn of the corn belt.

Trials in cooperation with the Department of Entomology indicate that, while there are noticeable and consistent differences in degree of injury suffered by various hybrids and inbreds from chinch bugs and from corn ear worms, there probably is no hope for complete immunity from either insect. Hybrid vigor and rapidity of growth are associated with tolerance of chinch-bug attacks. In addition varieties whose history includes a considerable period of natural selection in chinch-bug infested territory seem to have developed a certain amount of resistance to chinch-bug injury lacking in northern varieties.

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

Alfalfa Investigations in Relation to Winter Hardiness and Bacterial Wilt.— This project, conducted in cooperation with the Bureau of Plant Industry, United States Department of Agriculture, has consisted of four phases as follows:

1. *Crop Sequence in Relation to Bacterial Wilt.*— Presumably because of the dry weather of the past few years no information has been obtained on the relation of previous cropping to bacterial wilt. As a part of this study, subsoil moisture samples were taken to a depth of 25 feet. From these data it was found that previous alfalfa cropping had depleted the soil of available moisture to a depth of at least 25 feet. Clean fallow restored the available subsoil moisture to a depth of 25 feet in approximately two years, and a subsequent seeding of alfalfa again depleted this moisture in about the same length of time. The conclusion was drawn that two years after seeding alfalfa the subsoil was depleted of moisture to a point near the wilting coefficient, making it necessary for the crop to depend on current rainfall. Also that two years of fallow were necessary to restore subsoil moisture on old alfalfa ground to a point where the roots of a newly seeded crop could penetrate through moist soil to a depth of 25 feet or more.

2. *Variety Tests of Alfalfa.*— During the course of this experiment which was started in 1927, 160 different strains and varieties of alfalfa have been grown in a total of 431 plots. This experiment has served the purpose of getting information on a large number of strains and has made it possible to eliminate all the strains except those that show wilt resistance, such as the Turkestans grown, Ladak, Kansas 308, Cossack 2671, Hardistan, and Kaw. These plots are being discontinued this year and square-rod plots will not be used in the future. As new strains are developed or imported, they will be tested in close-spaced replicate rod rows instead of in the square-rod plots.

The drought of the past two years has affected the results from the series of larger variety plots seeded in 1930. The varieties were seeded in duplicate on both bottom land and upland. Because of the dry weather the upland plots were not affected by the wilt, and consequently held their stands until the winter of 1935-36. Only the wilt-resistant strains survived the winter. On the bottom land series wilt developed sufficiently to destroy the most susceptible varieties the second year. After the fifth year all varieties except the most resistant were practically eliminated.

A new block of variety test plots was seeded in 1935 with alfalfa of the Turkestan type together with Ladak, Kansas 308, and Cossack, all of which have some wilt resistance, with Kansas Common as a check. The varieties are replicated four times, two series of which will be cut when the Turkestans are ready and the others when Kansas Common is ready. This test is intended to give information on the effect of the leaf diseases on the yield of the Turkestan alfalfas.

3. *Selection and Breeding of Alfalfa.*— From the results obtained in the variety tests and the rod row nurseries, it is evident there are alfalfas that have sufficient wilt resistance for this region and could be recommended for use except that they are susceptible to the leaf and stem diseases. From a number of selfed lines and selections of Kansas Common and Kaw, seed increase blocks have been planted on the Garden City branch station to increase the seed supply in order that further tests may be made.

More information is needed in regard to environmental effect on seed setting. This need has led to the development of a humidity and temperature control chamber in which growing plants can be placed. A feature used in this cabinet which has not been used before with growing plants is that of controlling the relative humidity by using aqueous solutions of sulfuric acid. By using a glass construction, natural sunlight is utilized which, of course, places the plants under a more nearly normal condition than could be obtained by artificial light.

4. *Root Reserves in Alfalfa in Relation to the Time of Fall Cutting.*— Twenty years of experimental studies relating to the time and frequency of cutting alfalfa at this station have gradually indicated that the fall of the year is the critical period insofar as cutting practices are related to organic root reserves and permanence of stand. Experiments were conducted from 1929 to 1932 in a study of the trend of nitrogen and carbohydrate reserves as affected by various cutting practices during the year, especially in the late fall, and the effect of these reserves on plant survival.

It was found that when growth starts in the spring, and after each cutting, there is a rapid decline of total carbohydrates and of nitrogen until a minimum is reached, after which there is a rapid increase. During the seasons studied, the minimum carbohydrate and nitrogen content was reached about 20 days after each cutting. The maximum accumulation apparently occurred when the plants were in about full bloom.

Early and frequent cutting, as in the bud stage, appeared to result in a lower carbohydrate and nitrogen content of the roots when winter arrived, and conversely, infrequent cutting resulted in a higher content of these reserves. Clipping every 10 days after the last cutting greatly reduced the nitrogen and carbohydrate reserves and also the stand.

Data were secured which seem to afford rather conclusive evidence that the amount of growth which takes place after the last regular cutting has a material bearing on the organic reserves stored in the roots before winter. If this amount is small the reserves are depleted and there is no opportunity to restore them. It appears that there must be at least 8 to 10 inches of growth to permit maximum storage.

Recent work reported from Denmark and Sweden which was apparently contradictory in some respects to the work mentioned above prompted the initiation of a new time of cutting experiment in which the development of new crown bud growth is being studied by both quantitative and qualitative methods. The Scandinavians found that, if the late fall growth was allowed to remain, new crown bud development would be retarded and lower yields obtained the following spring. From the preliminary work done it would appear that the earlier results of the work of this station will be substantiated.

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

Pasture Improvement Investigations.— During the past biennial investigations were conducted on eight phases of this project.

1. *Management of Livestock on Native Bluestem Pastures.*— The drought of 1934, which extended until May, 1935, greatly reduced the vegetation in the experimental pastures, making it necessary to reduce the number of animals grazing them by about 40 percent. The desirable grasses in all the pastures were reduced two thirds, while the weeds and undesirable plants were increased one third. Kentucky bluegrass, which was very common in three of the experimental pastures, was almost eradicated by the drought. The damage from the drought was very much less on ungrazed areas, the grasses having been reduced about 20 percent, with a correspondingly smaller increase in the weeds. The annual weedy grasses were not present in any of the ungrazed areas, although they were common on adjacent grazed land.

2. *Effect of Burning on Bluestem Pastures.*— Owing to the extreme drought none of the experimental plots was burned in the fall of 1934 or in the spring of 1935. Counts of vegetation on all quadrats were made in June, which showed the drought had been most severe on the plots burned in the fall, both with respect to reduction in stand and yield of vegetation. The density of the grass was reduced the following percentages on the experimental plots from June, 1933: Fall burned, 75; unburned, 16; early spring burned, 65; medium spring burned, 51; and late spring burned, 34. The reduction in yield of vegetation was approximately the same as the decrease in density of vegetation.

Investigations were started in June, 1935, to obtain information on the effect of burning grass land on runoff and erosion. Two plots were established on a 7 percent slope. Both will receive the same treatment, being unburned for the first two years, when one will be burned annually.

3. *Eradication of Undesirable Plants from Pastures.*— The results obtained last season substantiated previous results in weed eradication, namely, that the effectiveness is directly correlated with the quantity of food reserves when the plants are cut. Investigations were started in the spring of 1935 to determine methods of eradicating the annual grasses which have invaded all pastures, largely as a result of the drought. Two experimental areas were established in southeastern Kansas for this purpose, one at Moran and one at Columbus, each having a dense stand of the annual grasses mainly little barley (*Hordeum pusillum*). The land was thoroughly disked and all the common tame grasses were seeded singly and in mixtures during April, 1935. All the seedings at Moran were very successful, with the exception of brome grass. Very good stands of orchard grass, meadow fescue, red top, and Korean lespedeza were obtained. A mixture of orchard, meadow fescue, and Korean lespedeza produced an excellent stand. The annual grasses were eliminated in all plots where more than a half stand of tame forage plants was obtained.

4. *Effect of the Frequency, Height, and Time of Harvesting on the Yield and Succession of Pasture Vegetation.*— Owing to the injury to the vegetation during the summer of 1934, none of the experimental clipping plots was clipped during the growing season of 1935. The quadrats on each of the clipping plots were charted in June, 1935. These data show that the drought was most severe on the plots clipped most frequently. The bluestem grasses on the plots clipped more than once each month are being replaced by blue and hairy grama (*Bouteloua gracilis* and *B. hirsuta*) and buffalo grass (*Bachloe dactyloides*.)

5. *Effect of Fertilizers on the Yield, Quantity, and Succession of Pasture Vegetation.*— Nine fertilizer treatments were applied to native grass in duplicate under protection and grazing. The plots on which nitrogen was applied at the rate of 200 pounds of (NH₄)₂SO₄ and manure were injured very little by the drought. The yield of vegetation on these plots was 30 percent greater than the plots receiving no treatment.

6. *Grass and Forage Crop Nursery.*— The grass and forage crop nursery contain plots of all the common tame and native grasses. Plots of the best

mixtures of tame grasses and legumes have also been established. A mixture of 12 pounds of brome grass and 4 pounds of alfalfa has the most favorable possibilities. The alfalfa will supply nitrogen to provide a high yield of brome grass and will not be abundant enough to produce a serious hazard from bloat. The nursery also includes approximately 15 grasses introduced from foreign countries, eight of which are very promising. It is planned to increase the seed supply of these grasses as rapidly as possible in order to plant them in plots large enough to permit grazing to obtain information on their palatability, yield, and resistance to grazing as well as their adaptability to different parts of the state.

7. *Grass Breeding Nursery.*— A grass breeding nursery was established in the spring of 1935. It contained 1,080 parent plants, representing eight native and six tame grass species. All the parent plants were selected for yield and quality of foliage, drought resistance, and seed production, the latter being a very important factor for the native grasses. The greatest emphasis is being placed on the breeding and selection of big bluestem (*Andropogon furcatus*), little bluestem (*Andropogon scoparius*), and blue grama (*Bouteloua gracilis*) of the native grasses and brome grass (*Bromus inermis*) of the tame grasses. The big and little bluestem selections exhibited a wide variation in yield of seed, ranging from approximately 10 pounds to 550 pounds per acre. The big bluestem varied in height from two feet to seven and one half feet. Twenty-eight selections were made from brome grass. It is planned to propagate second generation plants from all the original parent plants next year. To do this will require increasing the nursery to about 13,000 plants. Studies will be made in the inherited characters in the second generation plants. Work will also be started on the cytology of a few of the species.

8. *Coöperative Pasture Experiments.*— Coöperative pasture experiments were conducted in four places in eastern Kansas to obtain information on the best method for artificially reseeding farm pastures that have been depleted by drought and by overgrazing or a combination of these factors.

Kansas Station Bulletin 272. The Management of Kansas Permanent Pastures, based upon the results of the work of this project, has been published.

[Project 96; Department of Agronomy. Leader, A. E. Aldous; Purnell and state funds.]

Weed Eradication.— The work on this project for the past two years has consisted mainly of attempts to determine methods by which sodium chlorate may be used most effectively in killing field bindweed. The following phases of the problem have been studied: (1) The comparative effect of one, two, and three applications of sodium chlorate in solution as a spray; (2) tests to determine the relation of growth conditions to the effectiveness of sodium chlorate; (3) a comparison of applications of dry sodium chlorate with the spray method; (4) tests to determine the most effective method of treating return growth the second season; and (5) studies of the trend of root reserves throughout the season and its relation to condition of the top growth of the weed.

Limited attention has been given to growth habits and methods of reproduction and distribution of Russian Knapweed. Hoary Cress, Johnson grass, and Austrian Field Cress.

Single spray treatments have, in all cases, given less satisfactory results than when the same quantity of chlorate was used in two or three applications. The effectiveness of sodium chlorate spray treatments depends to a large extent upon the condition of the bindweed growth. A vigorous top growth following the normal period for seed production has been favorable for effective treatment.

Dry applications of sodium chlorate were approximately as effective as spray treatments in the fall of 1935. The very heavy rainfall, aggregating more than 19 inches for the four-month period, August to November, was apparently favorable for the dry treatments. In seasons of light precipitation in the fall months the spray method has given better results than dry applications in nearly all tests at Manhattan.

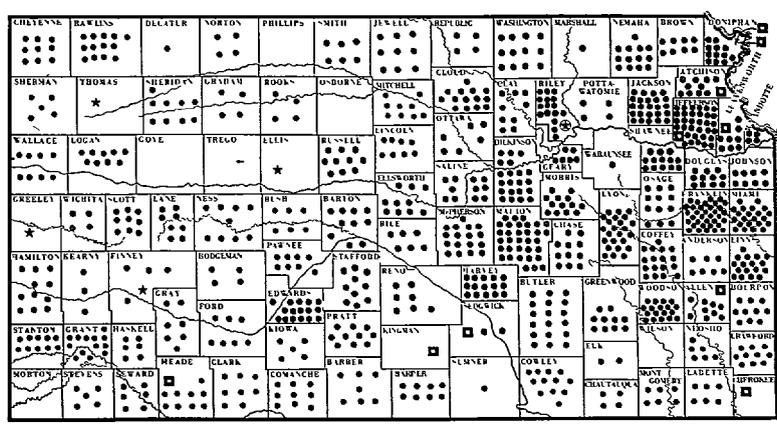
Further evidence has been obtained to indicate that second-year treatments should be made in early summer before the plants have recovered from their weakened condition. The latter half of May appears to be the most desirable time for such treatments.

Root Studies have consisted of taking root samples to a depth of 1 foot at intervals of two weeks throughout the growing season and analyzing these for total starches, dextrins, and sugars. These studies were made to determine, if possible, the period at which the plant would be most readily damaged by treatment. Seasonal conditions seem to cause some variation in the time when reserves are lowest but this period appears usually to fall between July 15 and October 1.

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

Cooperative Experiments with Farmers.— The work in cooperative experiments during the biennium included 940 tests with the principal crops of the state. These tests were conducted in cooperation with farmers in 94 counties. (Fig. 3.)

The wheat variety tests are mostly located in central and western Kansas. However, in 1935 the number of tests was slightly increased in eastern Kansas because of the need of additional information on new varieties adapted to that section, principally Clarkan, Kawvale, and Tenmarq. The fertility tests are located in the central and eastern sections with the exception of a limited number of alfalfa, potato, and sugar beet fertility tests which are located on irrigated land in the western part of the state. Corn and sorghum tests are



○ COOPERATIVE EXPERIMENTS (940), 1934 AND 1935
 ⊕ AGRICULTURAL EXPERIMENT STATION (CENTRAL STATION)
 * BRANCH AGRICULTURAL EXPERIMENT STATION □ EXPERIMENT FIELD

FIG. 3. Location of experimental work conducted during the biennium.

distributed over the entire state. However, sorghums are stressed in western Kansas and corn in eastern Kansas.

The potato fertility work conducted in cooperation with the American Cyanamid Company was completed in 1934 and the results published in 1935. The study of the use of 300 pounds of lime per acre drilled with sweet clover seed has been continued and the use of light applications of lime with alfalfa started. The testing of sweet clover varieties was started on an extensive scale during this biennium. Several grass variety tests were located in 1934. Due to drought, no results were secured from these tests and other tests were not located in 1935. This work will be increased as soon as weather permits. A study of the effect of bindweed on the yield of wheat and oats was made during the biennium.

Wheat Varieties.— The standard wheat varieties, Kanred, Turkey, Blackhull Harvest Queen and Fulcaster, have been continued in the tests. Tenmarq has continued to make the high yield in south central Kansas and Kawvale in the eastern section. The acreage planted to these two new varieties has been greatly expanded during the last two years. In an effort to find a satisfactory early-maturing wheat variety, two new Kanred × Hard Federation hybrids were included in the tests in 1935. Results secured so far have not been sufficient to warrant making a decision as to their value. Clarkan, a new soft wheat variety similar in plant characteristics to Harvest Queen, has made higher yields than Harvest Queen and has been approved for distribution in eastern Kansas.

Fertility Tests with Wheat.— Wheat fertility tests which included phosphate and a combination of phosphorus and nitrogen drilled with wheat seeded in the fall, and nitrogen applied as a top dressing in the spring, showed that (a) phosphate will increase the yields of wheat a sufficient amount to be profitable on some soil types in central Kansas but not on others; and (b) top dressing with sodium nitrate in the spring was profitable in only one of eight tests in 1934 and one of nine tests in 1935. Sodium nitrate delayed the date of ripening sufficiently to cause increased damage from drought under growing conditions occurring in 1934.

Fertility Tests with Potatoes.— The use of commercial fertilizers in the production of potatoes in the Kansas river valley has been studied for four years. It was found that a combination of nitrogen and phosphorus applied in the form of 11-48-0 fertilizer, at the rate of 200 pounds per acre, returned the highest profit in years of high yields. Phosphorus or nitrogen alone gave very little increase in yield. The addition of potash to phosphoric acid and nitrogen did not increase the yield enough to pay the additional cost of potash in the fertilizer.

Sweet Clover Varieties.— Information from a limited number of tests indicates that certain new sweet clover varieties are superior to the common white and yellow varieties now being grown in Kansas in length of pasturing season, leafiness, and resistance to frost. These new varieties have shown that they will at least equal the common varieties in yield and may be superior. More information will be secured from tests planted in the spring of 1935 and 1936.

Alfalfa Varieties.— Results secured so far indicate that Ladak alfalfa may have superior yielding ability in certain sections of the state. This variety also has other desirable characteristics such as resistance to wilt and aphid damage. Kansas 308 appears superior to Kansas Common in eastern Kansas.

Effect of Bindweed on Wheat and Oat Yields.— Yield samples taken from wheat and oat fields on farms located in Marion, Clay, and Dickinson counties showed that bindweed reduced the yield of wheat 4.4 bushels per acre and oats 16.6 bushels per acre.

Corn and Sorghum Varieties.— Because of adverse weather conditions, little definite information was secured from the corn and sorghum variety tests. Yellow Selection No. 1, a new variety of yellow corn, appears promising but needs further testing. Hegari did not compare favorably with adapted varieties of sorghum in 1935. Hegari in seven tests averaged 3.8 bushels of grain

per acre, Atlas 16.7 bushels and Western Blackhull kafir 26.7 bushels. In 14 tests. Hegari made a yield of 8.3 tons of silage per acre compared to 11.3 tons for Atlas.

Barley Varieties.— Yield data have been secured from only a limited number of barley variety tests during the biennium. However, Flynn continued to make a high yield compared with other varieties. Flynn has been tested in 79 cooperative tests located on farms in western Kansas since 1927. This variety has outyielded Stavropol, the commonly grown "feed" barley western Kansas, 2.4 bushels per acre in the southwestern section and 1.7 bushels in the northwestern section. Flynn was distributed to the farmers of the state for planting in the spring of 1936.

The only phase of the work which will be discontinued is the potato fertility work in the Kansas river valley. This work was completed and the results published February, 1935, in Kansas Station Circular 174, Commercial Fertilizers for Potatoes in the Kansas River Valley.

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

The Influence of the Method of Harvesting and Baling Alfalfa Hay Upon Quality.— Due to unfavorable climatic conditions during the 1934 haying season the work done on this project during that season was confined largely to laboratory studies on effects of temperature and relative humidity on the rate of drying hay.

During the baying season of 1935 field studies were resumed. The effect of moisture content at time of storage and the effect of methods of storage on the heating in storage, color loss, and leafiness were observed. Hay was baled with a windrow pickup baler at three different moisture contents (33 percent, 32 percent, and 21 percent) and stored in a hay shed. Records were kept on the moisture loss in storage and the effect of the storage on quality. Another quantity of hay was chopped at 33, 23.21, and 20 percent moisture content and stored in a partitioned metal grain bin. Resistance thermometers were inserted in each portion and records of temperature obtained. The hay was sampled for quality at time of storage and observations made of color, moisture content, and leafiness at time the bin was emptied.

The highest temperature recorded in the chopped hay was 141 degrees F., which was near the top of the hay containing 33 percent moisture when chopped. The condition of this heated hay when removed from the bin was good, although it was brown in color. This hay also showed much less shattering of leaves than the other hay put up at lower moisture contents. The green color was maintained in the hay chopped at the lowest (20 percent) moisture content and practically no mold was detected even at the edges of the bin.

It is planned to reorganize the project into an expanded study of the effect of method of storage and the moisture content at time of storage upon the quality of alfalfa hay in cooperation with the Departments of Agronomy, Dairy Husbandry, and Chemistry.

[Project 182; Department of Agricultural Engineering. Leaders, F. J. Zink and C. K. Otis; Purnell fund.]

A Study of the Efficiency of the Combined Harvester-Thresher for Harvesting Grain Sorghums.— During the last two years because failures occurred in the sorghum crop in western Kansas, no field work has been done. During the fiscal year 1934-'35 funds for the support of this project were withdrawn. During the year 1935-'36 only a small portion of the funds available were used. The work carried on has been in the nature of laboratory

investigations. Points investigated in the laboratory have included the following: (1) Determination of the moisture equilibrium in grain sorghums at a different range of temperatures from near freezing to 100 degrees F.; (2) determination of the rate of drying of grain sorghums when exposed to air of different humidities; and (3) an investigation of humidities which prevail in the western Kansas sorghum-raising section during the time when grain sorghums are likely to be stored.

The moisture equilibrium studies are essentially completed and show that grain sorghum is somewhat higher in moisture equilibrium than wheat and other grains. They also show that at the humidities prevailing in an area in western Kansas during the fall and winter months, grain sorghums are likely to contain larger amounts of moisture than will permit their safekeeping under present storage methods. Grain sorghums gain or lose moisture rapidly when exposed to varying humidities.

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

Factors Influencing the Quality of Wheat During Farm Storage.— Since no active storage experimental work has been possible at the Fort Hays branch station, due to failures of the wheat crops during the past two years in that territory, the work conducted on this project has been of a laboratory nature, conducted by the Department of Milling Industry at Manhattan. The work has centered on four groups of factors which affect diastatic activity in wheat or flour: (1) The effect of cutting at various moisture contents; (2) the effect of drying damp wheat under various conditions; (3) the effect of artificially wetting dry wheat in the straw; and (4) the effect of moisture, temperature, granulation, and other conditions.

Wheat was cut at various moisture contents ranging from 46 to 13 percent. Bundles were dried in the sun without cover, in the sun but covered with paper, in a cool basement room, in a storage room at 55 degrees F., and in another at 30 degrees F. Bundles were also wet by soaking head ends in water for 10- and 30-minute periods, one, two, three, and four times, respectively. After soaking, duplicate bundles were dried in the sun and in the shade. Studies were also made of the effect of the temperature of grinding and method of grinding as they affected the granulation or fineness of particle, and segregation of meal from various portions of the kernel.

Diastatic activity is very little influenced by the amount of moisture present in the wheat at the time of cutting provided the kernels are biologically mature. Neither is the diastatic activity influenced by the conditions of drying after cutting except as these conditions influence the rate of drying. Diastatic activity is also not influenced by wetting after cutting unless the amount of wetting and the duration of the wet condition is sufficient to start the process of germination. The increase in diastatic activity is then apparently due to two factors: (1) Production of more diastatic enzymes of secretion by the epithelial layer of cells between the germ and the endosperm; and (2) activating the enzymes of storage in the endosperm. Wheat kernels artificially germinated and then divided into germ ends and brush ends showed the following: Conditions of germination for 72 hours increased the sugar content in the whole wheat from 65 to 140 and the diastatic activity from 245 to 980, both measured as milligrams of maltose. The germ ends, after being in the germinator, had 205 milligrams sugar and the diastatic activity was

1,280; the brush ends had 50 milligrams sugar and the diastatic activity was 550 after being in the germinator.

Diastatic activity varies greatly in the different parts of the wheat kernel, being greater in the germ and in portions near the germ. Flour ground on warm rolls has a higher diastatic activity than flour ground on cool rolls. This explains why flour milled in a commercial mill in continuous operation has a higher diastatic activity than flour ground on a small experimental mill.

[Project 143; Department of Milling Industry. Leader, C. O. Swanson; Purnell fund.]

Chemical Factors Which Influence the Quality of Wheat and Flour.— Study was continued of the centrifugal method of determining flour absorption. This method measures the water-holding capacity of flour under fixed conditions by soaking the flour in a large quantity of water and then removing the excess water by a constant centrifugal force.

The amount of water held by the flour under these conditions has been found in the past to correlate very closely with that necessary for baking. There were occasional exceptions, and it was noted that flours for which the determination apparently indicated too high an absorption for baking were almost always flours which develop very slowly in mixing. Such flours when mixed with the amount of water indicated by the centrifuge and for the short time previously considered standard for all baking tests, gave doughs which were too slack, but when mixing was continued for the time found necessary for proper development, the dough was found to have stiffened to correct consistency.

Occasional failures of the absorption values obtained for flours by means of the supercentrifuge to correspond accurately with the water needed for baking were found to be mostly, if not altogether, due to failure to mix the dough to optimum development in the baking test and not to error in the centrifugal method of determining absorption. The attempt was made to mix each of the flour samples of the 1935 crop for the optimum time for that sample, and in no case was any discrepancy found between the absorption indicated by the centrifuge and that required for baking.

Apparatus was constructed for the measurement of respiration in flour, and determinations were made over a period of several months. Samples included freshly milled flours, flours placed in storage at about minus 16 degrees C. immediately after milling and held several weeks, and flour that had been stored in the mill about eighteen months.

A very low rate of respiration was found in newly milled flour which increased very greatly after a few weeks. The rate then fell off gradually to about its original value. Flour which had been kept in very cold storage immediately after milling was much slower in starting the rapid respiration when removed from cold storage, but after this rapid respiration started, its course was almost identical with that of the normal flour. The respiration rate in flour from eighteen months to two years in age was about the same as that of newly milled flour. Respiration appears to be related to the condition known as sweating of flour, a problem of serious economic importance.

Investigation of the phosphatides and other fatty constituents of flour has been resumed. Flour has been extracted with various solvents, and the extract separated into several fractions according to solubility. The extracted flour was tested by the various physical means available, and the various fractions of the extract were tested by adding them to extracted flour and to normal flour.

The extraction of fatty substances and of phosphatides from flour causes marked changes in various physical properties of the flour. Likewise, the addition of these substances, and also of similar fatty substances to either

normal flours or extracted flours also causes marked changes. Many of the results are yet difficult to explain, and some appear even conflicting so that much more work will be required before the problem is solved.

A photoelectric calorimeter for the determination of gasoline color value of flour and a photoelectric reflection meter for the study of color and texture characteristics of bread and of flour were designed and constructed. The reflection meter was found to be very sensitive to minute variations in the preparation of the surface of the sample, and numerous methods were tried for putting the flour and bread into such conditions that the surface would be uniform, representative, and reproducible.

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

Varietal Factors Influencing the Milling and Baking Qualities of Wheat.— The sources of the varieties tested during the biennium were as follows: Agronomy Farm, Mahattan; branch experiment stations; and cooperating farmers in Kansas. The characteristics found in any variety in comparison with those found in Turkey wheat furnish the basis for either dropping a variety from further testing because of some pronounced objectionable characteristic or for the testing of the variety more comprehensively because of the presence of a preponderance of favorable characteristics.

The final testing of varieties includes comprehensive baking tests in which 12 loaves are baked for each variable introduced. It has also included the milling of 10-bushel lots of wheat and the testing of the flour by a number of laboratories in various sections of the United States, Canada, and Europe. In this comprehensive testing the following varieties were included during the biennium: Tenmarq, Kanred, Turkey, Quivira, and Early Blackhull. The main purpose of this testing was to evaluate Quivira in comparison with Early Blackhull. The other wheats were included for comparison. The facts found in regard to Quivira and Early Blackhull may be stated as follows:

a. Quivira is preferred for use in commercial bakeries. It has a good mixing tolerance which is desired for use in high-powered mixers. It has a high water absorption which is favorable to a good bread yield. It has high gassing power, which means good loaf volume. It shows good response to oxidizing agents, permitting the use of flour improvers where such are desired. It has a fairly wide range in tolerance for bread-baking procedure; that is, several variations in methods will produce excellent bread. However, with methods unsuited to this type of flour there is a tendency to holes and openness of crumb texture.

b. Early Blackhull is preferred for making flour for the family trade. The lower water absorption is of little consequence in this type of baking. Its comparatively rapid water absorption and less mixing requirements are advantages where mixing is done by hand or in machines where there is little danger of overmixing. The lesser gassing power is easily remedied by the use of more sugar or diastatic malt.

c. Quivira is similar to Turkey in its milling characteristics when the latter is hard and flinty, and Quivira has a varietal tendency to produce hard and flinty grain. Quivira has a tendency to produce a higher ash flour, the average for a series of years being five points, higher in Quivira than in Turkey and Kanred. Whether this is due to a higher ash content of the endosperm in Quivira or to the presence of more bran particles in the flour has not been determined.

d. The main objection to Quivira is the dark color of the flour. With the right baking method this objectionable color does not appear in the bread.

Two strains of Kanred × Hard Federation, Kansas 2672 and Kansas 2673, have been subjected to the comprehensive baking tests. Both wheats were

shown to have strong gluters but the adaptability or range of conditions over which good bread can be made is greater in 2673 than in 2672.

[Project 60-B; Department of Milling Industry. Leaders, C. O. Swanson and R. J. Clark; state fund.]

Factors Which Influence the Protein Content of Wheat.—

The purpose of the work on this project for the past two years has been mainly to determine the protein content of wheat furnished from various experiments conducted by the Department of Agronomy. The following samples have been tested during the biennium:

<i>Sources of samples</i>	<i>Number of determinations</i>	
	<i>1934</i>	<i>1935</i>
Wheat varieties used in milling and other tests	151	100
Wheat variety tests, state	133	133
Fertilizer and rotation plots	41	31
Wheat fertilizer tests	48	18
State fertility tests	68	44
Nitrogen fixation tests	9	9
Wheat seedbed preparation	5	5
Plant breeding nursery	201	442
Wheat-meal-time tests	127	310
	529	1,092

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

Tempering Factors Affecting the Quantity and Quality of Wheat Flour.—

Investigation of the rate of absorption of water vapor into wheat conducted during the past biennium shows that most wheats will absorb moisture up to the amounts required for tempering in one half to two hours when treated under humidities of 94 to 97 percent.

Electrical conductivity measurements on the rate of absorption showed that the water is rapidly absorbed into the bran and that the changes in conductivity were greatest or most rapid during the first four hours after wetting the grain. The rate of change in conductivity continues up to 18 to 24 hours after tempering and continues at a slow and somewhat definite rate after this time. When 3.5 to 4.0 percent of water is added to wheat at one time, free water may remain on the outside of the bran for as long as 30 minutes after wetting as indicated by the conductivity values which remained constant for this period of time. With an excess of water in the bran coat conduction of electric current takes place around the outside of the kernels rather than through the kernels. In spring wheat water is much more rapidly absorbed during the time immediately after wetting or tempering than in the other classes. All wheats of equal moisture contents approach similar conductivities after the water has reached an equilibrium condition of distribution inside the kernels.

Measurements of temperature and relative humidity in the spouts and machines of the break system of the long process mill reveal that the stocks encounter cycles of humidities and temperatures. The highest humidities are found in the roll stands above the rolls and the lowest humidities in the elevator heads and spouts leading back to the rolls. The highest temperatures are found at and below the rolls and the lowest in the elevator heads and spouts leading from them. This indicates that both loss and gain of moisture occur in the stocks, evaporation near the rolls and in the spouts leading from them and a reabsorption of moisture as the stocks cool.

A study of the effects of moisture content of middlings on the amount and

ash content of flour produced indicates that as the moisture content of midlings decreases the ash content of the flour increases.

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

Factors Which Influence the Colloidal Properties of Dough.—The object of this project, which was started in 1935, is to study the colloidal properties of dough produced: (1) By substances which constitute the protein structure or inherent composition; and (2) by substances which constitute the protein environment. The work of this year included a study of the colloidal dough properties produced by substances constituting the protein structure.

The recording dough mixer was selected as a means of revealing these inherent protein qualities. The interpretation of the mixer curves into terms of baking characteristics presented a problem. The work, therefore, was confined to observing colloidal properties of dough as revealed by the mixer and attempting to interpret them into baking characteristics. This consideration divided the research into two procedures: (1) The mixing of flours in the recording dough mixer to obtain their consistency curves; and (2) the baking of these flours to determine their best baking abilities.

Considerable time was spent at first in making adjustments on the mixing machine which would render it more sensitive to slight variations in the flour. It was thought advisable to so adjust the mixer that small irregularities in flour quality would be greatly magnified and brought to light.

After making the adjustments on the recording dough mixer the sensitivity was increased to a point where the machine would detect a difference of ½ percent in absorption against a previous variation of 1 percent. The curve was enlarged horizontally so that instead of 10 minutes being required to disintegrate a dough, 30 minutes was necessary. By increasing the amount of flour used and opening the shock absorber on the machine any small variety characteristic of the flour was greatly magnified.

The curves made on the recording dough mixer show that each variety has definite colloidal characteristics which are peculiar to that specific variety; and, although these qualities may be modified by soil and climatic conditions, in general, each variety produces its own type curve. The "checker board" baking on the six varieties thus tested indicated that it might be possible to assign baking characteristics to a curve of a certain shape. In this way if the same shaped curve were again encountered the same baking characteristics would be expected. It was definitely proved by the laboratory and commercial bakings that the recording dough mixer accurately forecasts the mixing time or mechanical treatment required by a flour. The mixer can also be made to indicate the required fermentation period.

[Project 200; Department of Milling Industry. Leader, R. J. Clark; Bankhead-Jones fund.]

A Physiological Study of the Hard Winter Wheat Plant.—As previously reported, the purpose of this project is to determine the behavior of the wheat plant during its growth towards the nutrients of the soil and the disposition that it makes of these nutrients after their absorption. A further purpose is to determine the disposition that the plant makes of the foods which it manufactures. Samples of the wheat plant have been obtained during four growing seasons.

All the samples for the four years have been analyzed for total nitrogen, protein nitrogen, starch, hemicellulose, total sugars, nonreducing sugars, and reducing sugars. The samples for the first three years have been analyzed for total phosphorus, water soluble phosphorus, and total potassium. The dry weight of 100 plants has been determined at each stage so not only the percentage of the various constituents but also the absolute amount present in a given number of plants is known. This portion of the general project is now completed. Sufficient material, however, for all stages during the four years is held in reserve for any further chemical investigations that at a future time it might be deemed desirable to make. The data have been assembled in tables, the literature reviewed, and the general soil and climatic conditions tabulated. It is proposed to submit these data for publication as a technical bulletin at an early date. Two general observations are worthy of mention.

a. The results show very strikingly how the plants of a given crop growing on the same soil may vary in size, weight, and the actual amount of various constituents during different years. These differences are due primarily to the effects of variations of temperature, rainfall, relative humidity, and, other general weather factors during the growing season. The total dry weight of 100 Kanred wheat plants at or about maturity will suffice to illustrate this point.

<i>Year</i>	<i>Time harvested</i>	<i>Dry weight 100 plants, Grams</i>
1931-'32	June 22	3,408
1932-'33	June 21	1,138
1933-'34	June 20	2,190
1934-'35	June 20	2,395

b. A second observation was the striking similarity of the chemical analyses of Kanred and Harvest Queen wheats when grown side by side under identical climatic conditions. These two plants are very different in their vegetative characteristics and one would expect distinctive differences in the amount and proportion of their chemical constituents. This, however, is not the case. These conspicuous differences in vegetative characteristics are thus apparently not associated with any of the constituents determined in these analyses.

During the past year work has been started to determine the effect of the awns upon the transpiration rate of heads of wheat. The wheat used in these experiments was Pusa 52 x Federation, since experience had shown that this type of wheat would furnish, under greenhouse conditions, an abundance of vigorous plants in a relatively short time. The data obtained thus far show that the clipping of the awns lowers by 20 to 60 percent the amount of waters transpired from the head.

The effect of the clipping of the awns on the yield of grain is now being studied in the field upon seven different varieties of bearded wheat. This study will receive major attention the next two years.

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

Orchard Investigations.— The work of this project is conducted under four phases as follow:

1. *Spraying.*—*Apples*, cherries, peaches, and grapes were sprayed experimentally during the biennium. Due to the drought both seasons there were practically no diseases in the orchard, so no data concerning the efficiency of various fungicides were collected. The codling moth has become abundant. Considerable work was done in an effort to control it. The recommended spray schedule, consisting of seven applications of lead arsenate, gave commercial control. The arsenical residue in these plots was considerably over the federal tolerance.

Among the substitutes for lead arsenate tried were calcium arsenate, barium fluoride (Dutox), sodium aluminum fluoride (Kalo), nicotine and oils. Calcium

arsenate was the only substitute used through the season. The others were started after July 1 each year. The results were as follows:

Treatment	Percent worm-free apples		Arsenical residue
	Drops	Picked fruit	
1. Lead arsenate, 3 pounds through season	23	75	.025
2. Calcium arsenate, 2 pounds through season	23	65	.0011
3. Lead arsenate early, lead arsenate and oil later	26	79	.026
4. Lead arsenate early, calcium arsenate later	43	76	.0065
5. Lead arsenate early, Kalo later	37	77	.0025
6. Lead arsenate early, Dutox later	17	72	.0085
7. Lead arsenate early, oil emulsion later	24	77	.015
8. Lead arsenate early, nicotine later	25	58	.006
9. Check, unsprayed	6	50	Trace

Chemically-treated bands were used as a supplementary control measure for codling moth. About 3,000 feet were applied during the biennium. There was a high percent of emergence from bands by midsummer each year, especially from some types of bands. A careful study of the chemical content of the bands through the summer of 1935 and records of emergence for both seasons indicate:

- a. Chemically-treated bands are less effective during hot, dry seasons than during normal seasons.
- b. Bands carrying a heavy load of beta naphthol are more effective than those with a light load. The heavily loaded bands retain a higher percent of the beta naphthol through the season.
- c. Four-inch bands, unless carefully dipped are less effective than two-inch bands.
- d. Bands in which the chemicals remain in a gummy, sticky consistency are more effective than those in which the chemicals are dry and crystalline.
- e. Smooth-barked trees can be protected against injury by beta naphthol with a coat of linseed oil, water glass, or asphalt-water-emulsion.

No data were collected from cherries, peaches, and grapes, as the dry seasons prevented the development of pests on these fruits.

2. *Methods of Pruning Fruit Trees.*— No new work was started under this phase during the biennium. The three methods of pruning sour cherry trees, planted in 1930, were continued. The group of trees pruned to the openhead are weak in the crotch. The trees with laterals pruned lightly have made fair growth, considering the seasons, but the leaders in many of the trees have been "snuffed" out by the more vigorously growing laterals. The trees with severely pruned laterals are somewhat smaller, but appear stronger, and a higher percent have retained their leaders. The angles at which scaffold branches leave the leaders and in case of openhead trees, between scaffold branches, were measured.

It was noted that there was not much difference in angles due to different types of pruning. However, there was considerable difference between the two varieties studied. The angles are much wider in the Early Richmond than in the Montmorency trees. This may account for the spreading habit and lack of leaders which characterize the Early Richmond.

Many of the old apple trees which have been observed for several years to determine the effects of different types of pruning died during the biennium, due to drought.

3. *Orchard Soil Management Experiments.*— All experimental work in this subproject relative to the growing of cover crops and the use of chemical fertilizers in the apple orchard has been severely handicapped during the past biennium because of extremely adverse seasons. Several plantings of cover crops of rye or winter vetch were failures.

During the seasons of 1934 and 1935 the trees of bearing age of the Winesap, Stayman, Delicious, Grimes, King David, Arkansas, Rome, and York varieties set heavy crops of fruit either one or both years. The vegetative vigor of the bearing trees was greatly reduced in 1934 by a deficiency of soil moisture and the high evaporating power of the air. The same conditions prevailed in 1935. Injury of this kind is cumulative and the result was the death of 76 trees

during 1934 and 480 trees in 1935, out of an original planting of 1,300 trees. The mortality by variety was as follows:

<i>Variety</i>	<i>Trees, total number</i>	<i>Trees killed, number</i>	<i>Trees killed, percent</i>
Arkansas	25	10	40
Delicious	152	78	51
Gano	44	6	13
Grimes	91	25	27
Jonathan	236	52	22
King David	36	21	58
Livland	21	9	43
Ralls	29	5	17
Rome	62	14	22
Stayman	54	54	100
Wealthy	43	5	11
Winesap	301	244	81
York	42	6	14

In general, these trees bearing a heavy crop in 1935 were injured more than those with light crops. This may account for the difference in the mortality of Jonathan and Winesap trees. The Jonathan tress set a light crop in 1935 and the Winesaps set an unusually heavy one.

4. *Testing New and Promising Varieties of Tree Fruits.*— All varieties of tree fruits under test made but weak growth, 12 trees died outright, many of the young apple trees suffered severe injury from the flatheaded borer, and none produced mature fruit. No winter injury of note occurred during either the mild winter of 1934-'35 or the severe winter of 1935-'36. Fruit-tree diseases were of minor importance, but ravages of insects, especially the leaf-eating species and the borers, were severe.

Of the 28 varieties of hybrid plums planted in 1929, all bloom early, none has matured any fruit and 10 have died from winter injury. The remainder are not considered of sufficient promise to warrant further observation.

New varieties planted included the two bud sports of Jonathan, Blackjon and Jonared; cions of three varieties of apple from the Mountain Grove, Mo., Station, Wright, Fyan, and Grove; and two trees of a new peach variety, the Hardee, St. Medard cherry has also been reestablished by top-working on Mahaleb trees and by budding on Mahaleb seedlings. Six varieties of hardy, hybrid plums were also added to the test planting.

Own-rooted trees of the Gano, Grimes, Jonathan, Wealth, and Winesap varieties were planted in the orchard and new shoots with roots taken from layered trees.

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

Small Fruit Investigations.— The seasons of 1934 and 1935, which were characterized by high mean summer temperatures and Exceptionally low rainfall records, caused irreparable loss to the grape plants in the vineyard. No data pertaining to fruit production could be secured during either season, due to crop failures induced by adverse weather. The experiments designated to compare the ultimate effects on the plants of leaving 30, 40 or 60 nodes on fruiting canes at pruning time have been in progress since 1930. During the five-year period ending at that time, good crops of fruit were borne, but since 1930 two good crops have not been produced in succession.

In general, the experiments relative to the methods of training the fruiting canes could not be executed properly at pruning in the spring of 1935 and also in 1936 because of the extremely poor vegetative growth made by the vines during 1934 and 1935.

The use of Gloire and Clinton as vigorous root stocks for Campbell, Moore, and Concord has not increased the production of fruit over the own-rooted plants. However, the records of fruit production have been extremely meager.

During the peak of the drought and heat in 1934, an experiment designated to test the value of partial shade or irrigation to grape plants indicated that partial shade was of as much value as partial shade and irrigation or irrigation without the partial shade. The leaves on the shaded plants not irrigated maintained turgidity as well as the shaded and watered vines. This led to the conclusion that the wilting of all leaves and the death of many were caused by the high evaporating power of the air and the intense insolation of the unshaded leaves, rather than merely by a deficiency of soil moisture. Evidently the water-conducting tissues could not supply water to the sun leaves in sufficient quantity. The fruit on the shaded vines did not mature properly and the fruit on the unshaded vines was sunburned to the extent that it was worthless.

The following kinds and varieties of small fruits are being tested in the plantation established in the spring of 1935:

Strawberries	Aroma, Blakemore, Dorsett, Fairfax, Premier, Progressive, and Wayzata
Red Raspberries	Chief and Latham
Black Raspberries	Black Pearl and Cumberland
Purple Raspberries	Columbian
Blackberries	Eldorado and Youngberry
Currants	Clerry, Fay, Perfection, and Wilder
Gooseberries	Glendale, Houghton, and Poorman

Portions of two rows of gooseberries were protected during the summer of 1935 from the hot, dry winds by placing slatted "snow fence" or "cribbing" along the south side of the rows. Three of the twelve unprotected plants died and the rest all showed signs of injury, whereas the twenty protected plants all survived and appear healthy this spring.

Some preliminary work was done on winter hardiness of Latham red raspberries during the winter of 1935-'36. The raspberry plot was divided into three parts on December 16, 1935. One part, 13 hills, was covered with about 24 inches of straw, after the plants were pinned down with long wire staples. The second part, 12 plants was covered with about 5 inches of soil. The third part was left unprotected. The straw and soil were removed on March 20, 1936, and on April 13 measurements were made of the living and of the dead portions of canes. The results were as follows:

<i>Treatment</i>	<i>Alive, inches</i>	<i>Dead, inches</i>	<i>Alive, percent</i>	<i>Dead, percent</i>
Soil covered	1,674	7	99.58	0.42
Straw covered	1,321	158	89.3	10.7
Unprotected	155	1,610	8.78	91.22

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

Flower and Vegetable Investigations.— Studies of enzymatic activities and the chemical changes in asparagus roots treated to break the rest period made no progress during the past two years due to the extremely dry summers which left the roots of the plants so weakened that they would not force in the greenhouse during the winter.

The electric- and wood-heated hotbed trials in cooperation with the Department of Agricultural Engineering were continued. Results of four years' trials indicate that electrically heated hotbeds are practical if careful attention is paid to economies such as well, tightly constructed beds, if glass is covered at night during freezing temperatures, and a rate of 3 cents per kilowatt for electric energy is obtainable.

The wood-burning stove and hot-air flue are the cheapest source of heat for hotbeds if wood can be obtained for 10 cents a hundred pounds or less, if diligence is taken in practicing heat economies, and if the extra labor is not charged at over 20 cents an hour. A station circular based on the findings of this work is ready for publication.

The attempt to develop an earlier maturing, wilt-resistant, prolific tomato which also is satisfactory for home garden, market garden, and trucking conditions is progressing satisfactorily. All the desirable factors except extreme earliness have been secured and three generations a year are being grown with continual selection for earliness being made.

In the past three years three new varieties of tomatoes have been found more satisfactory than the commonly grown varieties. These are Michigan State Forcing, Rutgers, and Gulf State Market. The last is pink, the other two deep red. All are good in size, shape, and productivity, resistant to the Fusarium wilt and satisfactory either in the garden or for forcing.

The potato trials are being continued as before except that the size of piece tests have been altered. In each of the three years of the trials the three-ounce seed piece resulted in a great expense for seed with a reduction in yield as compared to the one- or two-ounce seed piece. The three-ounce piece has been eliminated and in its stead a one-and-one-half-ounce piece has been substituted.

A glassless greenhouse study has been started. In an insulated room, divided into four sections, an attempt was made to grow plants without sunlight; all the energy being obtained from electric lights. The room was divided into four sections, each planted and treated the same except the kind or intensity of light. The plants in section one were lighted with a mercury vapor lamp, in section two with a sodium vapor lamp, and in sections three and four with Mazda lamps of different intensities. The plants in sections one and two died before the end of the test. When Mazda lights furnished the energy for photosynthesis the vegetative development was normal for plants growing under limited light conditions, and the flowers were normal for the species, though small and few in number.

The preliminary tests thus concluded indicate that Mazda lamps can be used satisfactorily for plant growth if sufficient intensity is furnished but that the cost of furnishing the light is, under present costs and efficiencies of lamps, prohibitive.

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

Relation of Leaf Structure to Rate of Photosynthesis in Fruit Plants.— The object of this project, which was started in 1935, is to determine if leaf structure, as measured by the extent of the intercellular space in the mesophyll, partially governs the rate of photosynthesis by influencing the diffusive and absorptive capacity of the foliage leaves.

Leaves for the anatomical studies were selected from the middle portions of new shoots on the south side of the outer periphery of the trees. Pieces about one centimeter square were cut from near the midsection of the leaf blades. Permanent heavily stained cross sections of these were prepared on microscopic slides. To permit a study of the looseness or compactness of the mesophyll, the slides were mounted on a microscope so arranged that it served as a microprojector. At least 50 tracings of representative samples of each variety were made at a magnification of 900 diameters. The cross-sectional areas of the intercellular space were computed with a planimeter and the total linear perimeter measurement of each tracing was made with a chartometer.

It was found that the environmental conditions present during the period when the apple leaves are in an active growing state have much influence on the character of the mesophyll. Leaves produced on potted trees in the

greenhouse have less palisade development, a smaller amount of intercellular space, and a lighter weight per unit of area than orchard grown leaves.

Small leaves, those appearing as a bud in beginning its vegetative growth, were found to possess no appreciable intercellular space in the mesophyll. When the leaves had grown to a width of one centimeter, the intercellular space was present, having been formed by the mesophyll cells pulling apart by splitting the middle lamella. As the leaves become older the pectic substances gradually disappear.

Three methods of measuring the rate of apparent photosynthesis have been used: (1) Dry weight increment, (2) the quantitative determination of the carbon dioxide absorbed, and (3) comparisons of the total acid hydrolyzable carbohydrates present in the leaves at different periods of the day. No two of these methods give the same results because no two methods measure the same plant activities. In general, the dry weight increment method gives the highest values for the rate of apparent photosynthesis with the CO₂ absorption method ranking second and the analytical or determination of total acid hydrolyzable carbohydrates giving the lowest values.

In practically all determinations, York, a variety with a small amount of intercellular space, gave lower photosynthetic values than did Livland, a variety with a comparatively great intercellular space.

On several occasions potted greenhouse-grown trees were taken to the orchard so that comparison of the apparent photosynthetic activity of orchard grown and greenhouse grown leaves could be made under the same environmental conditions. In each instance the orchard-grown leaves showed a greater activity than the greenhouse-grown leaves of the same variety. Of equal interest is the fact that the orchard-grown leaves of the variety possessing the most extensive intercellular space was more active photosynthetically than a variety having less extensive intercellular space.

Comparisons, in the orchard, were made of the photosynthetic activity of leaves on branches bearing fruits with that of leaves on branches bearing no fruit. It was found that leaves on branches bearing fruit gave higher photosynthetic readings than leaves on branches not bearing fruit. Apparently, a portion of the carbohydrates are translocated to the fruits so that an accumulation of carbohydrates cannot build up which might partially inhibit photosynthesis.

No extensive changes in the management of this project are contemplated during the coming year. An additional method of estimating photosynthetic activity will be employed, however. This will consist of comparing the weights of year-old trees in the spring with their weights in the autumn. Leaf area records for each tree will be kept.

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

PART II

INVESTIGATIONS IN THE ANIMAL INDUSTRIES

The following pages contain a brief report of the work that the Agricultural Experiment Station has done during the past biennium on problems relating to the livestock industry.

Nutrition Requirements of Swine.—There was completed during the first year of the biennium three years of study in determining the phosphorus requirements of pigs when fed an adequate diet. The results of this study showed the minimum requirements to be between 0.27 percent and 0.3 percent when the level of calcium was about 0.8 percent. This phase of the work has been completed and a technical bulletin covering the work published.

Work during the second year of the biennium had to do with a study of the phosphorus requirements of growing pigs in the absence of vitamin D. Three groups of four young pigs weighing 49 pounds each were fed individually the same basal ration, but each group received a different level of phosphorus, without being exposed to sunlight or receiving codliver oil.

	<i>Percent phosphorus</i>
Lot 1	0.25
Lot 2	0.50
Lot 3	0.80

The results show that pigs on the low level of phosphorus, 0.25 percent, without sunlight or codliver oil, developed weak bones and had a low blood phosphorus. There was, however, no effect on the appetite, thirst, or body development and rate of gain in the pigs on the different levels. This would indicate that the level of 0.25 percent is too low to develop blood and bone normally, although the other body activities are apparently unimpaired. Next year the work will be repeated at higher levels of phosphorus.

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

Swine Feeding Investigations.— The work conducted under this project included in 1934-'35 a study of: (1) The value of adding a protein supplement to a corn and alfalfa pasture ration for fattening swine; (2) the comparative value of tankage, 60 percent protein, and meat scraps, 50 percent protein, as a protein supplement for fattening spring pigs on pasture; (3) the value of alfalfa pasture versus feeding in the drylot for fattening spring pigs; (4) the value of adding freshly cut green alfalfa twice a week to a corn and tankage ration in the drylot; and (5) the relative value of meat scraps and tankage as protein supplements for swine in the drylot.

In 1935-'36 the work included a study of: (1) The comparative value of tankage versus meat scraps as a protein supplement for fattening spring pigs on alfalfa pasture; (2) the comparative value of soaked shelled corn and tankage free choice on alfalfa pasture versus soaked shelled corn in semi-

solid buttermilk on alfalfa pasture; (3) the value of soaking corn for fattening pigs on alfalfa pasture; (4) alfalfa pasture versus drylot feeding for fattening spring pigs; (5) the comparative value of alfalfa hay and freshly cut green alfalfa in swine-fattening rations in the drylot; and (6) the value of peanut meal compared with tankage as a protein supplement for pigs in the drylot.

The results secured during the past biennium may be summarized as follows:

a. Meat scraps compared very favorably with tankage as a protein supplement for fattening hogs on pasture and it would be preferable to feed whichever could be purchased the more cheaply.

b. Pigs receiving corn and tankage on alfalfa pasture compared with those self-fed corn and tankage and alfalfa hay in the drylot, produced greater daily gains, consumed less feed per 100 pounds gain, and make more economical gains. The drylot-fed pigs consumed 5 pounds of tankage more per 100 pounds gain than did the pasture-fed pigs. The feeding value of the alfalfa pasture as shown in this experiment indicates that it should be more generally used in the production of pork.

c. Pigs self-fed alfalfa hay in the drylot compared with those fed freshly cut green alfalfa twice per week in the drylot, produced greater daily gains on practically the same amount of feed per 100 pounds gain. The freshly cut green-alfalfa-fed pigs consumed 2 pounds more tankage per 100 pounds gain than the alfalfa-hay-fed pigs.

d. Pigs self-fed tankage on pasture compared with those fed meat scraps made slightly larger daily gains and consumed the same amount of corn per 100 pounds gain. The meat-scrap-fed pigs consumed practically the same amount of supplement per 100 pounds gain as those fed tankage. This would indicate that meat scraps compare very favorably with tankage as a protein supplement for fattening hogs on pasture, and that it would pay to feed whichever of the two supplements that could be purchased more cheaply.

e. Pigs self-fed tankage and soaked corn, compared with those fed semisolid buttermilk on pasture, made 0.38 pound more gain per day and consumed less feed per 100 pounds gain. The pigs receiving the buttermilk as a protein supplement consumed 38.8 pounds per 100 pounds gain. The pigs receiving tankage consumed 17.1 pounds per 100 pounds gain. This is a difference of 21.7 pounds. The amount of corn consumed per 100 pounds gain by the pigs receiving the semisolid buttermilk was 369.9 pounds, whereas the pigs receiving tankage for their protein supplement consumed only 344.7 pounds. This is a difference of 35.2 pounds.

f. Pigs receiving soaked shelled corn self-fed, compared with pigs receiving dry shelled corn self-fed, made 0.12 pounds more gain per day and consumed 49 pounds more corn per 100 pounds gain. Both lots consumed practically the same amount of tankage per 100 pounds gain. This would indicate that soaking corn for pigs on pasture stimulated their appetite but did not increase the efficiency in producing gains for the more expensive pork was produced by the pigs fed soaked corn.

g. Pigs self-fed corn and tankage on alfalfa pasture compared with those self-fed corn and tankage and alfalfa hay in the drylot, produced greater daily gains, consumed less feed per 100 pounds gain, and made more economical gains. The pigs fed in the drylot consumed 18 pounds of tankage more per 100 pounds gain than did the pigs fed on pasture. The feeding value of alfalfa pasture as shown in this experiment indicates that it should be more generally used in the production of pork.

h. Pigs self-fed alfalfa hay in the drylot compared with pigs fed freshly cut green alfalfa three times per week in the drylot, produced slightly greater daily gains on practically the same amount of feed per 100 pounds gain. The freshly cut green-alfalfa-fed pigs consumed 2 pounds more tankage per 100 pounds gain than the alfalfa-hay-fed pigs.

i. Peanut meal was found to be less efficient as a protein supplement, for feeding pigs than tankage. It required more peanut meal to produce 100 pounds of gain than tankage, and the daily gains were not so great. The con-

sumption of corn per 100 pounds gain was greater also than with the pigs fed tankage.

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

Investigations in the Use of Silage for Fattening Beef Cattle.— During the first year of the biennium, 1934-'35, the work included studies of some feeding problems resulting from the prolonged drought of 1934 as follows:

1. *A Study of the Palatability of Tankage When Used as a Protein Supplement in a Wintering Ration.*— Yearling steers consumed 2.84 pounds of tankage per head daily over a period of 77 days. In order to induce the steers to eat tankage it was mixed with cottonseed meal the first 11 days of the test. After this preliminary period, cottonseed meal was not fed and the tankage was not ruined with other feed. That the steers relished tankage was shown by the fact that during the last 37 days they ate 4 pounds of tankage per head daily. In addition to tankage the average daily ration per steer consisted of 11.31 pounds of wheat strew and 3 pounds of molasses. The steers were normal throughout the entire test and gained 1.08 pounds per head daily. One steer was slaughtered at the conclusion of the test. A careful examination revealed no undigested tankage in the alimentary canal, the vital organs were normal, and there was no indication that tankage had produced a deleterious effect on the carcass.

2. *Immature Corn Silage Versus Cottonseed Hulls as the Basis of Wintering Rations for Two-year-old Heifers.*— Three lots of eight heifers each were fed 56 days. Immature corn silage and cottonseed hulls were full-fed to lots 1 and 2, respectively. The heifers in lot 3 received one half the amount of cottonseed hulls fed to lot 2, plus all the immature corn silage they would clean up. In addition to roughage, each lot was fed cottonseed meal at the rate of 2 pounds per head daily, and Bomin, a mixture of bone meal and ground limestone, at the rate of one tenth of a pound per head daily. The results indicate that (a) it is not necessary to full-feed immature corn silage to obtain satisfactory results in wintering breeding heifers during a period of feed shortage, and (b) from the standpoint of thrift and general appearance of breeding heifers, cottonseed hulls are entirely satisfactory as an emergency roughage for a short feeding period.

3. *The Value of Molasses as an Appetizer When Fed with Cottonseed Hulls.*— The results of this test indicate that sprinkling molasses diluted with water on cottonseed hulls, with which a small amount of cottonseed meal has been mixed, does not make the cottonseed hulls more palatable.

4. *The Value of Molasses as an Appetizer When Fed with Wheat Straw.*— Wheat straw of the 1934 crop, bright in color, fine stemmed, and somewhat chaffy, was used in this study. Cottonseed meal was fed at the rate of 1 pound per head daily in all periods of the test. When molasses was used it was fed at the rate of 3 pounds per steer daily. The results indicate that sprinkling molasses diluted with water over good quality wheat straw does not cause an increase in the amount of wheat straw consumed by yearling steers. It is common knowledge, however, that sprinkling molasses over carbonaceous roughages that are spoiled, coarse, or unpalatable because of other characteristics, will usually make such roughages more palatable to beef cattle.

During the second year of the biennium, 1935-'36, No. 2 ground barley and No. 2 ground shelled corn were compared when fed with and without silage. Two series of three lots each were used. Each lot consisted of 10 Hereford steer calves grading good and averaging 530 pounds when started on feed.

Each lot in Series A received a full-feed of silage, 2 pounds of cottonseed meal per steer daily, and one tenth of a pound of finely ground limestone per steer daily. In addition to these feeds, ground shelled corn was self-fed in lot

1, ground barley in lot 2, and a mixture of equal parts by weight of ground shelled corn and ground barley in lot 3.

Alfalfa hay was full-fed in Series B and cottonseed meal was fed to all lots at the rate of 1 pound per steer daily. The grain comparisons made in Series A were duplicated in Series B, lot 4 receiving ground shelled corn, lot 5 ground barley, and lot 6 a mixture of equal parts by weight of these grains.

The results were as follows:

a. The average daily gain per steer was: lot 1, 2.10 pounds; lot 2, 2.14 pounds; lot 3, 2.19 pounds; lot 4, 2.11 pounds; lot 5, 1.96 pounds; and lot 6, 2.12 pounds.

b. Ground barley was just as palatable as ground shelled corn and the mixture of these grains was slightly more palatable than either grain fed separately. The steers did not tire of barley during the latter part of the feeding period.

c. Lots 1 and 4, fed ground shelled corn, and lots 3 and 6, fed the mixture, were fatter and were appraised at a higher price at the conclusion of the experiment, than lots 2 and 5, fed ground barley. There was no significant difference in the finish or appraised price of the lots fed ground shelled corn and those fed the mixture.

d. On the basis of returns per steer over steer cost and feed cost, ground barley fed as the only grain in Series A was worth 85 percent as much per bushel as ground shelled corn and when mixed with ground shelled corn 84 percent as much. In Series B, ground barley was worth 76 percent as much per bushel as ground shelled corn irrespective of whether it was fed alone or mixed with corn.

e. The average results in Series A fed silage, and Series B, fed alfalfa, show the possibility of using silage alone as the roughage portion of cattle fattening rations.

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

Methods of Utilizing Native Grass in Beef Cattle Feeding.

— One phase of this long-time program has been studied during the present biennium: Should the winter allowance of grain be discontinued abruptly, gradually, or not at all when calves that go to grass have been wintered well, grazed to August 1, and then full-fed for the fall market? The results to date have shown that:

Calves wintered well, grazed without grain from May 1 to August 1, made a greater profit than calves handled similarly except that the winter allowance of grain was decreased gradually after May 1, or calves handled similarly except that the winter allowance of grain was continued through the grazing phase. The profits in the first instance were \$9.87 per head; in the second, \$5.17 per head; and in the third, \$3.06 per head.

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

Lamb Feeding Investigations.— Two separate experiments, embodying two types of investigation, have been conducted during the past biennium.

The 1934-'35 experiment consisted of a test of emergency rations for wintering yearlingewes as follows: Three lots of ewes were used, all lots receiving cottonseed meal in the amount of one third of a pound per head daily. For roughage, lot 1 received immature corn silage, lot 2 cottonseed hulls, and lot 3 both silage and hulls. Lots 1 and 2 received all of the respective roughages they would eat while lot 3 received one half as much hulls as was consumed by the ewes in lot 2, and all the silage they would eat in ad-

dition. A mineral mixture consisting of equal parts of Swift's Bomin and salt was kept in all the lots at all times. The feeding of these rations was continued over a period of 60 days.

The results of this test indicate that either immature corn silage or a mixture of cottonseed hulls and immature corn silage is a satisfactory roughage for wintering yearling ewes, if properly supplemented by protein and mineral feeds.

The 1935-'36 experiment consisted of a comparison of various protein concentrates as supplements in lamb fattening rations. Five lots of 12 lambs each were sorted evenly and fed a basal ration of corn, alfalfa, and Atlas silage. In addition, the lambs in the various lots received protein supplements as follows: Lot 1, cottonseed meal; lot 2, linseed meal; lot 3, peanut meal; lot 4, steam rendered tankage; and lot 5, dry rendered tankage. The grain and the protein supplements were held at the same level in the different lots. The roughages were fed in all lots according to the appetites of the lambs. The feeding period extended from November 26, 1935, to February 13, 1936, a duration of 80 days. The results were as follows:

- a. The various protein supplements ranked in the following order in producing gains on lambs: Steam rendered tankage, dry rendered tankage, peanut meal, cottonseed meal, and linseed meal.
- b. The spread between the gains made by the highest and lowest gaining lots was only 1.63 pounds total gain per lamb for the 80 days or only 0.02 pound daily gain per lamb.
- c. In economy of gains produced the supplements ranked as follows: Peanut meal, steam rendered tankage, cottonseed meal, linseed meal, and dry rendered tankage.

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

A Study of the Factors Which Influence the Quality and Palatability of Meat.— During the year, 1934-'35, the cattle used in this project were selected from two lots of yearling steers. Lot 1 was wintered well, grazed on bluestem grass pasture without grain May 1 to July 30 (90 days), and then full-fed 100 days in the drylot. Lot 2 was wintered well (same as lot 1), grazed on bluestem pasture 90 days with winter allowance of corn (4.82 pounds daily), then full-fed in the drylot 100 days.

No material difference was noted in the color of the beef from these two lots of cattle. The cattle from lot 2, which consumed 7.5 bushels per head more corn than those in lot 1, proved to be the fatter cattle. While some variation in color existed between individuals, the average for the two lots was practically identical. The fat was described as "creamy white" which is not objectionable in commercial channels. Although the pastures were not normal (very dry) during the summer of 1934, it is felt that 100 days in the drylot following 100 days on grass will produce a fat that is not objectionable in color. No cattle were slaughtered during the summer and fall of 1935. During the past year an endeavor has been made to summarize and analyze some of the data accumulated over a 10-year period on the study of grass-fattened beef. Some tentative conclusions based on the 10-year summary are as follows:

- a. External covering and marbling are closely related, a higher degree of outside covering being associated with a higher degree of marbling.
- b. Marbling appears to have a definite influence upon the tenderness of the meat, increased marbling being associated with increased tenderness.
- c. Marbling also appears to be associated with juiciness and flavor of the meat.
- d. Grass or pasture is not the factor which produces black cutters.

e. Mature cattle cut darker than yearling cattle, indicating that age is more of a factor in producing dark beef than is the pasture.

f. Mature cattle have a higher muscle hemoglobin content than that of younger cattle.

g. Finish is related to brilliance and chroma of the muscle but does not prevent dark cutters.

h. The hemoglobin content of the blood has no relation to the color of the muscle.

i. The amount of muscle hemoglobin present appears to have an influence upon the color of the meat but is not the controlling factor.

j. It is suggested that black cutters are the result of some condition of the hemoglobin in the tissue rather than the amount of hemoglobin present.

Earlier work at this Station seemed to indicate a possible relation between the mineral content of the tissue and the color and keeping quality of the meat. Eight steers are now being fed the same ration but on different levels of calcium and phosphorus with the hope of securing some definite information on this point.

[Project 165; Departments of Animal Husbandry, Chemistry, and Home Economics. Leaders, D. L. Mackintosh, J. Lowe Hall, Martha S. Pittman, and Gladys Vail; Purnell and state funds.]

Factors Influencing the Mineral Metabolism of Dairy Animals.— Four phases of this project have been active during the biennium. Each of these is discussed briefly below.

1. *Milk as a Sole Diet for Calves.* Three Holstein bulls were fed an exclusive milk diet from birth until 12 months of age. Until they were about six weeks of age, whole milk alone was fed. After that time the ration consisted of approximately one third whole milk and two thirds skim milk. The factors studied included growth, development, and general condition. At regular intervals blood samples were secured for hemoglobin, calcium, phosphorus, and magnesium determinations. No mineral supplements were given but the animals were unmuzzled and ran in a drylot where they had access to barnyard soil.

At 12 months of age the animals exceeded normal body weight by from 13 to 28 percent. The height of withers also was far above normal. There was considerable variation in the hemoglobin content of the blood but at no time was it low enough to render the animals seriously anemic.

Spasms often observed in calves on an exclusive milk diet were completely lacking. This condition has recently been attributed to a low magnesium content of the blood. Magnesium determinations on the blood of these animals showed a content in many cases less than one half the normal but no spasms occurred even under these circumstances.

Two of the experimental animals were slaughtered at 12 months of age and were given a careful post mortem examination. The only markedly abnormal symptom shown was a decided lack of development and tone of the digestive organs. Considerable dirt and bits of straw were present in the paunch of the animals. The problem has not been fully solved but certain portions of the study have been completed and are being prepared for publication. Further attempts will be made to determine the causes of spasms previously observed.

2. *Influence of the Ration on the Vitamin C Content of Cow's Milk.*— The vitamin C content of milk produced by cows on several controlled rations was determined. At the beginning of the experiment 10 cows were on the regular winter ration (alfalfa hay, silage, grain mixture). Later, six of these were turned out to young rye pasture. Ten other cows were maintained on the winter ration without silage. The total number of samples tested and the average values of vitamin C in milligrams per liter of milk are given in Table II.

TABLE II.—INFLUENCE OF THE RATION ON THE VITAMIN C CONTENT OF MILK

TYPE OF RATION.	Dry pasture plus silage.	Pasture.	Dry ration, no silage.
Number of samples tested	74	57	66
Vitamin C mg per liter	25.8	26.5	26.8
Standard deviation..	4.0	3.2	3.9

It will be seen that the average values for the three different types of milk are very similar, with the values for the pasture milk falling between the other two. The highest individual value observed was 37 mg. and the lowest 17 mg. The highest average for all results on one cow was 29.9 mg. per liter and the lowest similar average was 21.6. The results of these experiments indicate that the rations studied have no significant influence on the vitamin C content of milk. No further work is planned on this phase of the project.

3. *A Study of the Deficiencies of Prairie Hay in the Dairy Ration.*—A yearly average of 673,267 tons of prairie hay has been grown in Kansas for the five-year period, 1930 to 1934. Practically no experimental work has been done concerning the influence of prairie hay as the major roughage on growth, production, and reproduction, though many tons are fed each year. Therefore, this experiment has been designed to answer some of the following questions: (1) Is calcium a necessary supplement with prairie hay? (2) Will a good grain mixture properly supplement the low protein content of prairie hay as to quantity and quality? (3) Will the rations fed take care of the vitamin requirements for growth, production, and reproduction?

This investigation was started in May, 1934, when 18 heifers were placed on experiment, divided equally as follows: Lot 1, prairie hay plus grain mixture (equal parts white corn, bran, and cottonseed meal); lot 2, prairie hay plus same grain mixture plus ground limestone; and lot 3, prairie hay plus same grain mixture plus silage.

The heifers have been fed for growth and production according to the requirements of the Morrison standard. Monthly weight and height determinations have been made since the start of the experiment. Blood analyses (calcium and phosphorus) were made at monthly intervals until October, 1935, then at three-month intervals thereafter. Hemoglobin determinations have been made at six-month intervals. A complete record is available of the milk and butterfat production of the experimental animals. Tests of the nutritive value of the milk produced by the heifers in this investigation have been made in feeding tests with rats. Further tests of the nutritive value of the milk have been made with calves dropped in this experiment.

Eleven mineral balance trials determining the calcium and phosphorus utilization of these heifers have already been run. Nine of these were run with heifers prior to freshening with their first calves. Two trials since have been made with heifers approximately two months in their first lactation. Some of the observations have been as follows:

a. The average skeletal growth of the heifers in each lot has been normal to 24 months of age. The average weight, on the other hand, is below normal for the three groups. At 24 months of age the figures are 90.9 percent, 93.3 percent, and 96.3 percent of normal for lots 1, 2, and 3, respectively. Normal is represented by the average growth data collected on Holstein females in the Kansas State College dairy herd for the past 14 years. The heifers, while thrifty and vigorous, do not have quite the scale of Holstein heifers the same age in the College herd.

b. Little difference has been observed in the average number of services to conception between the three groups of heifers, 2.6 services for lots 1 and 2, and 2.8 per lot 3. These figures are somewhat higher than would be expected under normal conditions in the average herd.

c. In calving behavior the results are distinctly abnormal, particularly with regard to the number of retained placentas. In lot 1, three out of four heifers calved had retained placentas, while in the other lots the ratio is one out of three. Whether this can be laid to some deficiency, vitamin or other, in the rations fed cannot be answered at this time.

d. Calcium, phosphorus, and hemoglobin determinations made on the blood of the experimental heifers to date show no significant variation from normal values.

4. *Factors Influencing Vitamin C Content of Milk.*— In the fall of 1935 a series of monthly vitamin C tests was started on cows in the station dairy herd. These tests were for the purpose of studying the influence of the following factors on the vitamin C content of milk: Individual and breed differences, stage of lactation, and variations from day to day and between milkings. The tests included 40 cows in October and November and all cows in milk (55-73) thereafter.

In the spring of 1936 a study was made of the vitamin C metabolism of the dairy cow. The vitamin C intake, with green rye as the ration, and the outgo (feces, urine, and milk) were measured over a sufficient period. Vitamin C determinations were made also on the blood of these cows. The purpose was to determine what becomes of the vitamin C supplied in the green feed and the influence of a high vitamin intake (green feed) on the normal reserve of the animal.

The average vitamin C content for all breeds and for all months studied was 25.5 mg. per liter. The only consistent difference found between breeds was that Jerseys were high and this could be attributed largely to genetically related cows. Differences between individual within a breed were greater than any difference between breeds. No consistent relation was found between vitamin C concentration and yield of milk. An average increase of 10 percent in vitamin C concentration was found from the first to second month of lactation. Later changes in stages of lactation were only of minor importance. Milk produced during the severe weather of January and February with the cows in the barn contained less vitamin C than either earlier or later months.

No significant change was observed in the vitamin C of milk of three cows when the regular herd ration was replaced by freshly cut green rye. By the end of one week they were each consuming approximately 65 kg. per day of rye that average 0.86 mg. of vitamin C per gram. The vitamin C content of the blood of one cow doubled within two hours and remained high between 12 and 24 hours. Continued feeding did not maintain this high blood level nor cause a similar change in the other two cows. Within 48 hours after grass was fed the average excretion of vitamin C in urine had increased about five-fold, without affecting the concentration in the milk. The increased output of vitamin C in the urine is good evidence that the body reserves of the cows were normal. In another cow, on which a rumen fistula had been performed, it was found that at least 90 percent of the ingested vitamin C had disappeared before the food had left the rumen.

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

Dairy Cattle Feeding Investigations.— The investigations conducted under this project during the past biennium have consisted of a number of phases as follows:

1. *Silage Weight Determinations.*— The weight per cubic foot of silage as it was removed from the silo has been determined for a number of years. Due to the fact that most of the material placed in the silo the past two years has been from immature crops it seems desirable to secure data on silage of this character. Weights were taken on the silage from one silo filled with imma-

ture Atlas sorgo. The air dry weight of each cubic foot removed was determined, since moisture has some influence on weight. It will be necessary to secure more data before conclusions can be drawn but there seems to be a definite tendency for the silage lacking grain to run lighter in weight than normal silage.

2. *The Value of Tankage as a Protein Supplement for Dairy Cows.*— Preliminary work was started by feeding tankage to four cows to determine if it was readily eaten and to note the effect on the flavor of the milk produced. Increasing amounts of tankage were added to the ration until each animal was receiving 14 pounds of tankage daily. At the beginning there was some hesitancy on the part of one cow in cleaning up her ration containing tankage but soon all were eating it readily. Samples of milk to be judged for flavor were taken prior to the start of the tankage feeding and for several days after the cows received tankage. No abnormal flavor or odor that could be attributed to tankage was detected.

For the milk production test eight cows were placed on a 90-day reversal trial. During the first and third periods a tankage ration was fed, and during the second period a cottonseed-meal ration was used. In the production of milk and fat, the cottonseed-meal ration excelled the tankage ration. When the amounts of milk produced on the two rations were calculated to a 4 per cent fat basis, the results indicated that the tankage ration used was 92.6 per cent as efficient as the cottonseed-meal ration. From these results, it appears that tankage may be substituted for cottonseed meal in the dairy cow's ration with fairly satisfactory results, but that this would prove economical only where tankage was selling at a price per ton no higher than that of cottonseed meal. Due to the relatively small number of animals used, this experiment should be considered of a preliminary nature.

3. *Prairie Hay Versus Alfalfa Hay for Dairy Cows.*— During the biennium a repetition was made of a previous feeding trial in which prairie hay was compared with alfalfa hay where the protein and mineral deficiencies of the prairie hay were made up in the ration. The trial this biennium included a total of 10 cows fed by the double reversal method through three 30-day periods. All cows received a ration of sorgo silage and in addition either prairie hay or alfalfa hay. The grain ration fed with the prairie hay consisted of 2 parts corn chop, 2 parts wheat bran, and 3 parts cottonseed meal. That fed with the alfalfa hay consisted of 4 parts corn chop, 2 parts wheat bran, and 1 part cottonseed meal. Both grain mixtures contained 1 percent each of steamed bone meal, ground limestone, and salt. The results are summarized in Table III.

TABLE III.—PRAIRIE HAY VERSUS ALFALFA HAY FOR DAIRY COWS

	Average per cow per period.						
	Gain or loss in weight.	Feed consumption.			Production.		
		Grain.	Hay.	Silage.	Milk.	Fat.	F.C.M. 4 percent.
	<i>Lbs.</i>	<i>Lbs.</i>	<i>Lbs.</i>	<i>Lbs.</i>	<i>Lbs.</i>	<i>Lbs.</i>	<i>Lbs.</i>
Alfalfa	11	187.0	227 9	700 7	638.1	24.95	629.4
Prairie hay	8	189.8	222 3	698 8	630.9	25.52	635.1
Increase	19	2.8	... ..	... ..	... ..	.57	5.7
Percent increase	1.7	1.5	... ..	... ..	... ..	2 3	.9
Decrease . . . . .	... ..	... ..	5 6	1.9	7 2	... ..	... ..
Percent decrease . . . . .	... ..	... ..	2 5	.3	1.1	... ..	... ..

These results are not considered particularly significant when viewed in the light of a similar trial conducted previously with 10 cows in which the animals while on prairie hay produced 1.2 percent less 4 percent fat corrected milk than while receiving alfalfa hay.

4. *The Digestibility and Feeding Value of Russian Thistle Hay.*— In order to determine the digestibility of Russian thistle hay a digestion trial was conducted by feeding an exclusive diet of the thistle hay to three cows through a 15-day preliminary and a 10-day collection period. After determining the digestibility of the hay a feeding trial was conducted. Two lots of five cows each were fed by the double reversal method through three 30-day periods. The sole roughage of the groups consisted of either Russian thistle or alfalfa hay. The grain mixture fed with the thistle hay was made up of 2 parts ground corn, 1 part wheat bran, and 1 part choice cottonseed meal. That fed with the alfalfa consisted of 4 parts corn and 1 part wheat bran. One percent each of steamed bone meal and salt were added to each grain mixture. A small amount of black strap molasses was added to the Russian thistle ration. The Russian thistle hay used was found to contain 47.25 percent of digestible dry matter and 5.85 percent of digestible, protein. Each 100 pounds of hay contained 40.1 pounds of digestible nutrients. In the production of milk and butterfat the Russian thistle hay ration was consistently inferior to the alfalfa hay ration. Total production of 4 percent fat correct milk was 5.9 percent less on the thistle ration than on the alfalfa ration.

5. *Sudan Grass Pasture for Dairy Cows.*— The objects of this study were (1) to determine the carrying capacity of Sudan grass pasture, and (2) to study the variation in hay consumption as pasture declines in quality. Fifteen cows were pastured for several weeks on two pasture plots of 5.4 and 5.2 acres, respectively, sowed to Sudan grass. To avoid tramping the grass the cows were on the pasture in the morning and evening only until they appeared to be satisfied and stopped grazing. They were then placed in a drylot and fed alfalfa hay *ad libitum* from a rack. A grain mixture was fed at milking time at the rate of 0.4 pound for each pound of milk produced above 20 pounds by Holsteins and Ayrshires and 0.5 pound for each pound of milk above 12 pounds produced by Jerseys and Guernseys. A record was kept of body weight, hay and grain consumption, and milk and fat production. On this small amount of pasture and during a very dry and hot season production was maintained for approximately eight weeks in a very satisfactory manner. As the pastures declined in quality there was a marked increase in the amount of hay consumed by the cows.

6. *Summer Feeding and Management of Dairy Cows.*— The object of this study was to determine: (1) The effect of quality of pasture on feeding habits of cows, and (2) to compare grain with alfalfa hay as a supplement to pasture.

Two equally balanced groups of cows are being grazed continuously on alternate good and poor pastures. Changes of pasture are made at two-week intervals. The pastures used are rye, oats, and Sudan grass. One group of cows is fed alfalfa hay *ad libitum* at milking time. The other group receives a grain mixture fed at the rate of 0.3 pound for each pound of milk produced above a given base. This base amount is: Jerseys, 10 pounds; Guernseys, 12 pounds; Ayrshires 14 pounds; and Holsteins, 16 pounds.

Data on body weight, feed consumption, and the production of milk and butterfat will be secured. In addition an attendant will follow the cows constantly except during the night rest period to secure data as follows: Time of visibility for grazing morning and night, time spent in grazing, time spent in lying down, time of drinking and approximate water consumed, time spent in eating hay, distance traveled by typical cow, time spent in ruminating. The results are incomplete but it has been noted that cows on poor pasture show an increase in hay consumption and in distance traveled while grazing.

7. *Preparation and Palatability of Molasses-Corn Fodder Mixtures.*— This experiment, conducted in cooperation with the Department of Agricultural Engineering, was outlined to determine the effect of adding various per-

centages of molasses to coarse, medium, and finely ground corn fodder on (1) amount of dust, (2) molasses—holding quality, and (3) palatability to dairy cows, and also to determine keeping quality of 25 percent molasses-fodder mixtures containing various percentages of moisture. The percentages of molasses used were 10, 20, 30, 40, 50, 60, and 70 percent of the ration. In those tests where the moisture content of the fodder was varied, the percentages of moisture used were 15, 20, 25, 30, 35, and 40 percent. In testing the palatability of the various mixtures, they were offered to groups of six cows each after these cows had cleaned up their feed of silage and grain but before they had received their hay. None of the cows involved was accustomed to corn fodder or molasses. Some of the observation were as follows:

- a. Ten percent of molasses practically eliminated all dust, while 30 percent molasses eliminated fine particles and would probably keep the feed from blowing while being fed.
- b. Finely ground material held 70 percent molasses while the chopped material held 60 percent molasses.
- c. All mixtures above 30 percent molasses were quite sticky, stickiness increasing as the percentage of molasses increased.
- d. The maximum fodder moisture content for safe storage of fodder mixed with 20 percent molasses lies between 25 and 30 percent.
- e. The maximum moisture content for safe storage of fodder lies below 25 percent.
- f. Preparation of uniform mixtures by hand was difficult. Increasing the molasses increased the ease of mixing.
- g. A 30 percent molasses mixture appeared to be relished best by dairy cows but the 20 and 40 percent mixtures seemed quite palatable.
- h. The 10 percent molasses mixture seemed unpalatable because it was dry and had little sweet taste.

[Project 34; Department of Dairy Husbandry. Leaders, F. W. Atkeson, H. W. Cave, and W. H. Ridden; state fund.]

Normal Growth of Dairy Cattle.— Since 1922 weight and height determinations have been taken on all male and female calves in the College dairy herd at monthly intervals until 24 months of age, after which measurements are made twice a year. Data collected over a 14-year period are now available. It is planned to conclude the monthly weight and height measurements in the near future. Enough data are now available to give a reliable picture of the growth of females of the four major dairy breeds up to 24 months of age as maintained under College herd conditions. They will be summarized for a station publication.

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

Calf Feeding Investigations.— During the past biennium a new phase of this project was started to study the development of calves from birth to six months of age fed milk from cows that received prairie hay as roughage.

Two lots of four calves each were selected from the heifers being fed on prairie-hay rations reported in Project 147. The calves for lot 1 were selected from mothers receiving prairie hay and grain, while the calves for lot 2 came chiefly from mothers receiving prairie hay, grain, and silage. The ration for the calves in lot 1 consists of milk from cows fed prairie hay and grain, while that for lot 2 consists of milk from cows fed prairie hay, grain, and silage. Whole milk is fed for approximately two weeks after which time skim milk from the same source is substituted. In addition to milk the calves have

free access to prairie hay and a grain mixture consisting of equal parts of white corn and wheat bran. Milk consumption is limited to 12 pounds and grain consumption to 3 pounds daily. Weights and measurements are secured monthly and blood samples are secured at regular intervals for calcium, phosphorus, and hemoglobin determinations. There has not been time to secure definite results, but all calves appear to be making normal gains in weight; in general they are thrifty and no deficiency symptoms are apparent.

[Project 154; Department of Dairy Husbandry. Leader, H. W. Cave; state fund.]

Ice Cream Investigations.— Several phases of this project were active during the past, biennium, each of which is reported briefly as follows:

1. *A Comparison of Various Babcock Fat Modifications for Testing Ice Cream.*— The Minnesota and Crowe tests were selected from a group of several modified Babcock tests as the most desirable ones to use for testing ice cream. A standardized method of procedure which has been developed for the Minnesota test makes it possible to get results which agree closely with those obtained by the Mojonnier method. The Crowe test also gives satisfactory results. Each of these tests has been tentatively recommended by the American Dairy Science Subcommittee on Testing Ice Cream as a satisfactory method to use. This study has been completed, and no further work is contemplated.

2. *Relative Merits of Milk Proteins in Ice Cream.*— The relative merits of several milk proteins for use in ice cream have been determined. The products used were: (1) Kraftogen B. D., a soluble calcium caseinate powder manufactured by the Kraft-Phenix Cheese Corporation; (2) Springfield powder, a partially delactosed caseinate manufactured by the Producers Creamery, Springfield, Mo.; (3) Pro-Lac Powder, which was secured from the DeRaef Corporation, Kansas City, Mo.; and (4) sodium caseinate sol which was prepared in our own laboratory from fresh pasteurized skim milk. These products were used in ice cream mixes in varying amounts and their effects on overrun, body and texture, flavor, and other properties of the mix were observed.

The results of these studies are summarized as follows:

a. Sodium caseinate sol was the only product which consistently improved the whipping properties of the mix. Pro-Lax and Springfield powders had little effect on the whipping property. Kraftogen B. D. increased the whipping time somewhat. When used in amounts not to exceed 2 percent the effect was not pronounced.

b. The use of any of the milk protein powders to increase the serum solids of the mix beyond 12 percent greatly prolonged the time required to freeze and whip the mixes and in some cases made it impossible to secure 100 percent overrun.

c. Kraftogen B. D. was the only milk protein which consistently improved the quality of the ice cream over that of the check samples. In no case was any off flavor traced to this product.

d. Sodium caseinate sol if properly prepared produced ice cream which was generally equal or superior to the check samples in quality.

e. The flavor of the samples prepared with Pro-Lac and Springfield powder was characterized by certain off flavors such as old ingredients, powder, cooked, and stale. The most pronounced flavor defects were observed in the samples containing Springfield powder.

f. Kraftogen B. D. was the only product studied which could satisfactorily replace a part of the stabilizer in the mix.

g. Pro-Lac and Springfield powders and the sodium caseinate sol reduced the viscosity of the mixes, whereas Kraftogen B. D. caused an increase in the viscosity of the mix.

h. The acidity of the mix was lowered by Pro-Lac powder, but was not materially affected by either of the other two powders.

3. *A Study of the Keeping Quality of Sodium Caseinate Sol.*— In the course of another investigation dealing with the use of milk protein in ice cream, it was observed that one of the products (sodium caseinate sol) had very limited keeping qualities when stored at 40 degrees F. The present investigation was undertaken to study ways of improving the keeping quality of this product. Three methods were studied; namely, (1) The use of an additional heat treatment, (2) the addition of sugar to the product, and (3) freezing. A portion of the samples thus treated were used in commercial ice cream. The remainder of the samples were held for a period of approximately three months to observe the effectiveness of the treatment on keeping quality. The results briefly summarized were as follows:

a. Heating samples of sodium caseinate sol to 145 degrees F. for 30 minutes, or to 180 degrees F. for 10 minutes did not prevent proteolytic decomposition when the samples were subsequently stored at 40 degrees F.

b. The addition of 45 percent cane sugar by weight to sodium caseinate sol and storing the sweetened samples at 40 degrees F. and at -10 degrees F., respectively, prevented proteolytic decomposition of the product over a period of three months. Mold growth, however, was usually in evidence on the samples stored at 40 degrees F. at the end of approximately one month. Similar samples stored at -10 degrees F. showed no mold growth or other deterioration over the same period of time.

c. None of the treatments given the samples adversely affected their usefulness in commercial ice cream.

4. *Gelatine Versus Darylloid as a Stabilizer for Ice Cream.*— This project to compare gelatine with sodium alginate as a stabilizer for ice cream was undertaken at the request of the Gelatine Manufacturer's Research Society of America. The two stabilizers were used in ice cream mixes, which contained 11 and 14 percent butterfat. An analysis was made of each mix for butterfat, total solids, titratable acidity, pH, and viscosity. The mixes were frozen and the time required to secure 100 percent overrun and the final drawing temperature of the ice cream were determined. The ice cream mixes were scored, melting tests made, and their ability to withstand heat shocking observed. Other points considered were: Ease of adding the stabilizer to the mix, appearance of the mix, volubility of stabilizer, and the consumer's preference for the ice cream. The results of this work may be summarized as follows:

a. *Acidity.* Sodium alginate reduces the acidity of the mix slightly.

b. *Viscosity.* The basic viscosity of the aged sodium alginate mixes was about double that of the gelatine mixes. In no case was this viscosity excessive.

c. *Whipping Time.* Whether or not there is a difference in whipping time depends largely on the amounts of stabilizer used. Excessive amounts of either stabilizer will slow up overrun incorporation. When used in the proper amounts the time required to get 100 percent swell was approximately the same for the two stabilizers.

d. *Flavor.* No off flavors were noted in any of the samples.

e. *Body and Texture.* From the standpoint of smoothness of texture and firmness of body, the two stabilizers were about the same. Gelatine produced ice cream which was more resistant to melting and which stood up slightly better in storage.

f. *Ease of Incorporation into Mtx.* Gelatine was more convenient to use. Somewhat higher pasteurization temperatures than those normally used and more vigorous agitation were necessary in order to get sodium alginate incorporated into the mix.

g. *Consumer's Preference.* The majority of 36 consumers who examined the samples thought that the sodium alginate samples gave a colder sensation when eaten and melted more readily in the mouth. The majority also thought the gelatine samples were the smoother.

This study has been completed. A manuscript entitled "Relative Merits of Gelatine and Sodium Alginate as a Stabilizer for Ice Cream" has been prepared and is now ready for publication. At a meeting of the Gelatine Manufacturers' Research Society held in Chicago, November 6, 1935, the results of the work conducted at the three institutions were presented.

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

Bacteriological Study of Ice Cream.— During the past two years the studies in connection with this project have followed five main lines of investigation each of which is described briefly below.

1. *Factors Affecting Thermal Resistance of Microorganisms.*— Previous work has shown that certain sugars may increase the thermal resistance of cells. The direct bearing of this fact on the pasteurization of ice cream and the sterilization of other foods containing high percentages of sugar is obvious. Although high osmotic pressures and the resultant dehydration probably play a role in the protective action, the results clearly indicate the intervention of other unknown factors.

In order to gain some insight into the mechanism of protective action, cells have been heated in various concentrations of highly soluble salts. Where solubilities were not too low the various combinations of the following cations and anions were employed: Al, NH₄, Ba, Ca, Fe⁺⁺, Pb, Li, Mg, Mn, Ni, K, and Na; acetate, citrate, chloride, nitrate, oxalate, phosphate, and sulphate.

If the mechanism of the protective action is the result of prohibiting coagulation or even inducing peptization of a colloidal complex, it should be possible to duplicate the physical process with non-living proteins such as egg albumin and enzymes. Since rennet lends itself to this type of investigation mixtures of this enzyme with the various combinations of salts were heated. By suitable experimental procedure it was possible to determine which salts tended to retard the destructive action of heat on rennet.

The results show that the following salts afford bacteria and rennet definite protective action against heat: Sodium citrate, chloride, and sulfate; potassium acetate, chloride, and citrate; magnesium acetate and chloride; ammonium sulfate; and lithium sulfate. In addition to the above salts, the following were found to protect bacteria but not rennet: Sodium acetate and nitrate; potassium nitrate and oxalate; calcium acetate and chloride; lithium chloride; and ferrous chloride. No salt was found which would protect rennet and not protect bacteria.

Another phase of this study involved bacteriological analyses of approximately 200 samples of ice cream collected from nearly all of the ice cream manufacturers of the state. Advantage was taken of the opportunity to make parallel analyses using plain and dextrose agar. In 22 percent of the parallel determinations the analyses would have been entirely unsatisfactory with plain agar, and were entirely satisfactory when dextrose agar was used. In 32 percent of the determinations the use of dextrose agar was distinctly advantageous although not essential to an acceptable analysis. In 30 percent of the determinations the use of dextrose agar was of no advantage, and in 16 percent dextrose agar proved only slightly less satisfactory than plain agar.

2. *A Study of Escherichia-aerobacter Groups of Bacteria in Ice Cream.*— During the summer of 1934 the state dairy commissioner of Kansas conducted a survey of the sanitary quality and chemical composition of the ice cream sold in Kansas. One hundred and seventy samples were collected and brought to the station laboratories for analysis. Advantage was taken of the opportunity afforded by this collection of samples to make parallel determinations using various methods of analysis. Total bacteria counts and colon counts were made on all samples. On a basis of this data, it may be concluded that:

a. The colon count gives in a general way the same information conveyed by the plate count.

b. The colon count alone fails to detect some of the samples with high plate counts.

c. The colon count proved advantageous as an aid to the plate count in the analysis of only two out of 170 samples.

d. The colon count affords insufficient advantage over the plate count to justify using it as part of the regular routine, although it might be advantageous in special cases.

3. *Microscopic Enumeration of Microorganisms in Butter.*— The following method has been developed for microscopic examination of butter: On a standard 1 x 3-inch chemically clean glass slide place 0.1 c. c. of the melted butter to be examined. 1 drop of xylol, and 1 drop of Mayers egg-glycerine mixture (equal parts egg albumin and glycerine. The mixture is thoroughly beaten and filtered through cotton. One percent sodium salicylate may be added as a preservative.) With an "L"-shaped platinum needle stir these together until the mixture is opalescent and homogenous. then spread the mixture evenly over the entire area of the slide. Proper mixing requires from 2 to 3 minutes and it is important that the mixing of the ingredients be properly done before spreading the smear over the area of the slide. Allow the preparation to dry, and at the same time coagulate the albumin by placing the slide on a flat bottle of hot water at approximately 30 degrees C. for 10 to 15 minutes. Fix the smear in 70 percent alcohol for 10 to 20 seconds. Allow to dry. Immerse in xylol 2 minutes. Allow to dry. Stain in methylene blue for 1 minute, then wash by dipping the slide once in each of two vessels of water. Allow to dry in the air. Examine under an oil immersion lens, the field of which has been standardized to a diameter of 0.157 mm. The average number of microorganisms per field multiplied by 1,000,000 gives the number per cubic centimeter of melted butter.

4. *Simplified Methods of Testing Chlorine Disinfectants.*— Three simplified methods of testing chlorine disinfectants have been developed; namely. (1) amplitied orthotolidine test, (2) simplified Potassium iodide method, and (3) the simplified titration method. These methods will be found useful for testing starch solution in commercial dairy plant work.

5. *Mastitis Studies.*— Another phase of work conducted partly in this laboratory during the past year has been in connection with a study of practical methods of controlling mastitis. The work has consisted primarily of frequent periodic examination of the milk from each quarter of each cow in the College herd. On the basis of the information obtained from these tests, each animal in the herd has been classified in one or the other of the following groups:

Group A.— Those cows showing no physical abnormality of the milk by the strip cup test, no high leucocyte counts (above 500,000 per c. c.) and no evidence of long-chained streptococci or other possible etiological factors of mastitis upon microscopic examination of the incubated sample.

Group B.— Those cows that show a high leucocyte count (above 500,000 per c. c.) but have not shown the presence of long-chained streptococci or other probable etiological factors of mastitis in the incubated samples.

Group C.— Those come which are believed to have matitis. The milk from one or more quarters shows not only high leucocyte counts, but the presence of long-chained streptococci in the incubated specimen.

In addition to the three principal groups, a fourth group known as the Q group, or quarantine or perhaps questionable group, has been established. This includes new cows brought into the herd, first-calf heifers, and also all old cows which have just freshened. Any cow on which insufficient data are available to classify her intelligently into one of the three principal groups is classed as a Q-cow until such data can be accumulated.

The primary purpose of all of the work of classifying the animals into A, B, and C groups is to determine the extent to which mastitis can be controlled by herd management practices.

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

The Effect of Lactic Cultures on the Keeping Quality of Cream.— This study was undertaken to determine the practicality of adding lactic acid starters to cream on the farm as a cream improvement measure.

After testing the cream for butterfat and acid, it was placed in clean sterilized containers. All lots of cream other than the controls were inoculated with desired amounts of lactic culture and set at the desired temperature for further observation. The temperature was recorded and regulated twice daily. Each morning for the next seven days, the surface of the cream was examined for mold growth. The cream was then stirred and the flavors and odors noted. After an acid test was made, a fresh lot of cream was added to each container and stirred. After the seventh day no additional cream was added but observations were made for three more days. The cream was then graded, neutralized, pasteurized, ripened, and churned. The butter samples were placed in paraffined cartons for scoring. One set of samples was held at 45 degrees F. and scored after 24 hours and at two-week intervals for twelve weeks. Another set of samples was held at 0 degrees F. and was scored after being in storage four months. The following results were obtained:

- a. The rate of development of acid during the first 24 hours was greater in the cream to which culture had been added than in the noninoculated cream. The final acidity was about the same in cultured and noncultured cream.
- b. Putrid and metallic flavors and stale odors occurred in as many samples of cultured cream as in noncultured cream.
- c. Bitter flavors occurred more often in cultured samples.
- d. Yeasty and cheese-like flavors occurred more often in the noninoculated cream than in the inoculated cream.
- e. The rate of mold growth was not materially affected by the inoculation of the cream with lactic acid producing cultures of bacteria.
- f. Mold growth did not appear on any cream having a titratable acidity of less than 0.46 percent.
- g. Mold growth is apparently more dependent on the acid content of the cream than on bacterial association.
- h. There is evidence to indicate that the inoculation of cream with lactic acid producing organisms tends to curtail the development of yeast.
- i. There was no marked difference in the score and keeping quality of the butter made from inoculated and noninoculated cream.

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

An Evaluation of the Evaporation and Spray Systems of Cooling Cream.— In an effort to reduce the losses which result from the spoilage of cream during warm weather, creameries have been using the "wet-sack" or evaporation and the "spray" systems of cooling cream. These methods have been in use for some time but very little definite information was available regarding their actual value and reliability. During the past year the Departments of Bacteriology and Dairy Husbandry have made a study of a number of the factors which affect the rate of cooling and the final temperatures attainable by these systems of cooling. The factors studied were: (1) Type of wicking material; (2) manner of applying water; (3) air circulation; (4) atmospheric temperature; (5) relative humidity; (6) acidity of the cream; (7) agitation of the cream; (8) volume of water sprayed, and (9) temperature of water used for spraying.

It has been found that the type of wicking material used in the evaporation system and the manner of applying water to the wicking material had very little influence on the effectiveness of cooling, although frequent washing of the wicking material helps to maintain its efficiency.

The evaporation method of cooling proved to be better than no cooling device even under adverse conditions and was most effective for cooling cream when the atmospheric temperature was below 85 degrees F. Failure to circulate the air about the cream cans and a high relative humidity greatly impair the efficiency of the evaporation method.

The spray system of cooling was more effective than the evaporation method when atmospheric temperatures were high.

Neither system of cooling can be relied upon to cool sour cream efficiently and uniformly unless the cream is agitated at frequent intervals during the cooling process. The temperature of the spray water and, to a lesser degree, the volume of water determines the rate of cooling and final attainable temperature. A manuscript has been prepared giving the results of this study and will be published as a station circular.

[Departments of Dairy Husbandry and Bacteriology. Leaders, W. H. Martin, W. J. Caulfield, and A. C. Fay; state fund.]

A Study of the Formation, Isolation, and Properties of Milk Sugars.— The work for the biennium has consisted of two phases.

1. *A Study of Methods of Isolating Sugars in Whey by Partial Freezing or by Complete Freezing and Equilibrium Thawing.*— Samples of whey were concentrated and attempts were made to isolate and characterize rare sugars from the residue. While pure specimens were not isolated, an impure osazone of some sugar other than lactose or its constituents was obtained. Previously reported properties characteristic of d-ribose acquire new interest in view of recent findings in Europe that this sugar is a constituent of lacto-flavin.

2. *Tests of the Need of Milk Sugar for Cerebroside Formation.*— The study of the relation of learning ability of rats to lipids in the brain and to lactose in the ration has been continued in cooperation with Dr. O. W. Alm of the Department of Psychology. Rats grown on experimental rations and then trained on a regular stock ration have shown differences in learning ability. It has not been possible, however, to measure differences both in learning ability and in brain lipids in the same rat.

Differences in hemoglobin formation between rats fed lactose and others fed sucrose were found. Young rats fed the lactose ration were found to reach normal hemoglobin values sooner than stock fed rats, while rats fed the sucrose ration did not reach normal values until later than stock rats. The times required were about two, four, and five weeks, respectively. The sucrose and lactose rations were also found to differ in their ability to support reproduction. It was found that female rats fed the sucrose ration showed precocious sexual maturity, experienced only two or three oestrus cycles, and were sterile for most if not all of the normally fertile age. Ovarian cysts and persistent corpora lutea characteristic of pituitary disturbances were found in all sucrose animals. Animals fed the same ration, except that the sucrose was replaced with lactose, were normal.

Since the correlations between learning ability and brain lipids were low, the relation of learning ability to other brain constituents is being studied. A technique has been developed for measuring phosphorus, calcium, magnesium, potassium, and sodium in rat brains. Preliminary results indicate a quite definite inverse relation between the potassium content of brains, and learning ability. A direct relation between total phosphorus and learning ability confirms the similar relation of unsaturated phospholipids to learning ability.

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

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

1. *Inheritance of Crookedness of the Keel Bone.*— The work on conditions responsible for crooked keels in chickens has included both genetic and environmental factors. The major environmental factor was the roosting conditions. The results of the second filial generation as well as backcrosses to the parent stock have comprised the more recent genetic studies. It has been shown that this problem involves a very interesting case of a complicated interaction of environmental and inherent factors.

The conclusions from these studies are as follows: Crooked keels usually develop between six and twelve weeks of age. By selection, it was possible to establish strains differing markedly in incidence of crooked keels. The mean percentage of crooked keels in the straight keeled strain was less than 10 while in the crooked keeled strain it was approximately 70, when the birds of the two groups were subjected to identical roosting conditions. Males showed a slightly greater tendency to develop crooked keels than females.

2. *Factors Influencing the Feathering of Rhode Island Red Broilers.*— By selection it has been possible to establish strains of Rhode Island Reds differing in the degree of feathering at the seven weeks age. The two strains differing in the degree of feathering were each homozygous for the sex-linked factor for late feathering which is characteristic of most heavy breeds. The degree of feathering was determined by grading the feather development in each of seven tracts on the body. Studies are being made of the time of development of feathers in the various tracts in the well- and poorly-feathered strain.

It was found that feathers appeared slightly earlier on all tracts in females than in males. In the investigation of the influence of environmental factors on the development of feathers, it was found that temperature variations during growth seemed to have no bearing. The amount of vitamin A in the ration seemed not to influence feather development and the proportion of various grains in the ration seemed not to be a factor of importance. Injections of thyroxin markedly stimulated the feather development in females. Studies of chick embryos during the period of appearance of the feather follicles showed that there was a slight retardation in the appearance of the feather follicles in males when compared with females. At about eight days of incubation, the degree of development of feather follicles could be used as a basis of sex identification.

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

Physiology of Reproduction in Poultry.— Two phases of this project were studied as follows:

1. *Factors Influencing Rate of Egg Formation.*— Two major factors influence rate of laying. One is the length of the period between clutches of successive eggs and the other is the interval between the eggs of a clutch. It has been shown that the length of interval determines the size of the clutch and thus is an important factor in rate of laying. The length of interval varies from 23 to 32 hours and a study was made of how these variations in time between layings were brought about.

The data were secured through bi-hourly palpation of the oviduct and thus tracing the progress of formation of 161 eggs. It was shown that much of the difference in the absolute length of interval between eggs, which is the major factor in controlling rate of laying, is due to variations in time that the egg remains in the uterus. The time spent in the magnum (albumen-secreting section) plus the time between the previous laying and ovulation were only slightly variable and could account for only a small part of the absolute variation found in interval length. In low-intensity birds, there was also a length-

ening of the delay in ovulation which occurs in the case of the first egg of a clutch. Thus, low intensity of production is due to both a longer period for passage of the egg through the oviduct and to a longer pause between clutches.

2. *Studies of Fertility in the Fowl.*— During the 1936 breeding season, examination was made of the semen of all males kept at the College Poultry Plant both for sperm concentration and morphological abnormalities. Particular attention was given to those males which gave poor or no fertility when used in breeding pens. In such males, the microscopical examinations of the semen were supplemented by tests made by artificial insemination of virgin females with semen of the males giving poor fertility. These studies were made possible by a recently developed technique of securing semen and artificial insemination.

Most cases of poor fertility in males appeared to be due to immaturity and lack of sexual activity on the part of the males. Their spermatozoa were normal in appearance and concentration and gave good fertility by artificial insemination. One male, giving no fertility when used in a breeding pen was tested by artificial insemination and also failed to give fertile by this method. Microscopic examination of this male's semen revealed the fact that most of his spermatozoa showed definite morphological abnormalities. Twenty females were found in the breeding pens which gave no fertile eggs. These females had been with males which were giving good fertility with other females, indicating that the infertility was probably chargeable to the female. Such females were artificially inseminated by males of proved fertility and in some cases by the same males with which they previously had been mated. In all cases, excepting one, they gave good fertility when artificially inseminated, indicating that the poor fertility was a result of failure to successfully mate rather than to any inherent abnormalities of the spermatozoa or the egg. The one exceptional female is being studied further.

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

Turkey Production.— There are presented below several phases of work of this project that were studied during the biennium as follows:

1. *The Response of Breeding Turkeys to Artificial Illumination.*— On December 1, 1934, four lots of Narragansett turkeys, each consisting of 11 females and one male were placed in open-front poultry houses and subjected to different artificial lighting conditions. Lot 1 received light through a blue filter; lot 2, white light unfiltered; lot 3, light through a red filter; and lot 4, no artificial light. Solar light was common to all groups through the open-front houses. The supplementary light was administered daily from 7:30 to 11:30 a. m. The experiment was repeated in 1935-'36, using the same equipment. Two modifications were made in technique: (1) Starting December 1, 1935, the lights were turned on daily from 4:30 a. m. to daylight, and (2) the various lots did not have access to feed or water until daylight. In the 1934-'35 experiment, the females in all lots reached sexual maturity, as determined by egg production, between the dates of March 9 and 12. These results suggest that additions of light made during the daylight hours will not stimulate sexual maturity in turkeys.

The lengthening of the day by unfiltered white light and red light, as outlined for the 1935-'36 experiment, hastened the onset of sexual maturity, the first eggs being produced approximate 50 days in advance of the normal laying period. January 21, January 24, March 6, and March 10 marked the date of first egg for the white, red, blue, and no-light pens, respectively. The data suggest that the turkey exhibits wave length specificity in sexual response to light and that the red portion of the spectrum is at least indirectly responsible for the activation of the genital glands. The results also demonstrate that sexual activity is not conditioned by the length of time over which the birds can feed.

2. *Fertility Studies.*— Late in the breeding season of 1935, 34 females and three males were used in an experiment to study the decline in fertility following the removal of the males. All eggs laid between the dates of May 23 and June 28 were incubated and examined for embryonic development. The males were removed May 25. For the three days preceding the removal of the males, fertility ranged from 90 to 100 percent and no decline in fertility was observed for the first 13 days after the removal of the males. From the fourteenth to the twentieth day, the range in fertility was from 71 to 83 percent and no fertile eggs were laid on the thirtieth day, although 40 percent of the eggs laid on the thirty-fourth day after the removal of the male were fertile.

The data obtained show that previous matings will not fertilize all the eggs laid during the breeding season but that the decline in fertility of turkey eggs is not so rapid following the removal of the male as is the fertility of the chicken egg after the removal of the male chicken.

3. *The Effect of Egg Size on the Relative Loss in Weight of Incubating Turkey Eggs, on Hatchability, and on Rate of Growth.*— A total of 1,130 fertile eggs laid during the breeding season of 1935 were used in this study. The eggs were weighed on the day laid and again the evening of the twenty-fourth day of incubation. The poults were identified with the eggs from which they hatched and weighed at hatching time, two weeks, four weeks, and twenty-four weeks. It was found that the smaller eggs (mean size 77.20 grams) on a relative basis lost more weight during incubation than did the larger eggs in the three other weight classes. The difference was highly significant in each case. No significant difference could be demonstrated between the three larger weight classes although the mean difference in weight between two of the classes was 9.3 grams. It was observed that eggs of medium size hatched better than did the larger or smaller eggs.

A high positive correlation was found to exist between egg weight and day-old weight for both male and female turkeys. The weight of the males at two weeks of age was significantly correlated with egg weight while for the females there was no significant difference. Although positive, the correlations for egg weight and all weights beyond two-week weight were insignificant. Apparently any advantage in weight that a turkey may have had at time of hatching by virtue of having hatched from a large egg was lost between the second and fourth week of postembryonic life.

4. *The Fiber Requirement of Growing Turkeys.*— Four lots of 25 Narragansett day-old turkeys were placed on the experiment June 22, 1934. The basal control ration contained approximately 4.6 percent fiber. To this ration enough meat scrap and bonemeal were added to give it the same protein and ash level as ration 345 where 10 pounds of alfalfa stem meal had been added to 90 parts of the basal. Enough wood pulp containing but little ash and no vitamins was added to ration 346 to give the ration the same fiber content as ration 345. To lot 347, 3 percent magnesium carbonate was added. Additions of bone meal and meat scrap were made to rations 344, 346, and 347, to give them the same protein content as 345 and to give rations 344 and 345 the same ash content. Starch was used to bring all totals to 100 pounds. There is listed below the additions made to the various rations.

Ingredients	Lot 344	Lot 345	Lot 346	Lot 347
Basal	90.0 lbs.	90.0 lbs.	90.0 lbs.	90.0 lbs.
Alfalfa stem meal.....	.....	10.0 lbs.	.....	.....
Meat scrap	864.0 gms.	.....	868.0 gms.	864.0 gms.
Bone meal	65.2 gms.	.....	29.4 gms.	65.2 gms.
Starch	3,610.8 gms.	.....	817.4 gms.	2,248.7 gms.
Wood pulp .....	.....	.....	2,825.2 gms.	.....
Mg CO ₃ .....	.....	.....	.....	1,362.0 gms.
Total	100.0 lbs.	100.0 lbs.	100.0 lbs.	100.0 lbs.

At eight weeks the average weight of the poults was 528, 617, 649, and 549 grams, respectively, for rations 344, 345, 346, and 347. This would indicate that the two sources of fiber, alfalfa stem meal and wood pulp, markedly improved growth. It would appear that neither the increase in ash nor any of

the accessory nutrients such as vitamins that were added with the alfalfa stem meal influenced the results since the wood pulp ration gave satisfactory growth. Little if any difference could be detected in the feather quality of the birds on rations 344, 345, and 346. Ration 347, containing Mg CO₃ gave the poorest feather quality as measured by the degree of white color in the large wing feathers.

[Project 77-15 and 17; Departments of Poultry Husbandry and Chemistry. Leaders, H. M. Scott and J. S. Hughes; state fund.]

Guinea Production.—Work with guineas was continued for the purpose of studying the effect of artificial lights on egg production. Electric lights were provided for a flock of about 20 females from 4:30 a. m. to daylight, January 1 to April 1, 1936.

The results confirmed those obtained two years earlier when no benefits were secured by the use of lights. That is, lights do not stimulate egg production earlier than normal as they do with turkeys. The first guinea egg was produced April 14, 1934, when the female was 288 days old, in the lot without lights, and May 11, or at the age of 315 days in the lot that received lights. A fairly satisfactory method was developed for sexing guineas when 12 to 15 weeks of age by the wattle test. It was observed that the edges of the males' wattles in the college flock were thicker than the same structures in the females. By using this test it was possible to select the sex with an accuracy of about 85 percent.

[Project 77-21; Department of Poultry Husbandry. Leader, L. F. Payne; state fund.]

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

1. *Relation of Hatching Date to Income from Eggs.*— Several hundred Leghorn pullets were hatched at four-week intervals beginning February 13 and ending May 8, 1934. The chicks were reared under uniform conditions and 100 pullets from each hatch were placed in each of four lots in the laying house when 20 weeks of age, where they were kept for 52 weeks. All eggs produced were graded weekly and the local packing-house paying price for each grade was used to arrive at the market value of eggs from the different lots. Records were kept of feed consumed, eggs laid, market price by grades, and mortality. The birds consumed 69.3, 71.4, 68.5, and 62.2 pounds of feed each and produced an average of 173, 148, 160, and 156 eggs for lots 1, 2, 3, and 4, respectively. The average price received for eggs during the year was 23.0, 20.4, 18.4, 16.9, and 15.4 cents per dozen for the five grades. The greatest return above feed cost was \$1.24 per bird in lot 3, followed closely by lot 4. This is in agreement with recommendations of long standing, namely, that April hatched Leghorns are usually most profitable.

2. *Effect of Storage on Deterioration of Eggs.*— Studies were undertaken to compare the deterioration in market value of eggs stored one week in a cellar and the same length of time in a room above ground. The eggs were carefully graded by a commercial candler before and after the storing period and the difference in market value indicated the extent of deterioration. Continuous temperature records were made and humidity readings were taken twice daily during the tests. It was found that the eggs held in the ordinary room deteriorated in value 78 cents more per case than the eggs held in the humid cellar with a temperature below 70 degrees.

3. *Acid Treated Silage for Poultry.*— The purpose of this work was to determine the practicability of storing and feeding green-oat silage when treated by the A. I. V. process. The Department of Chemistry made the hydrogen-ion tests and furnished the acid, while the Department of Agricultural Engineering

assisted in making the ensilage. Two lots of 20 Leghorn hens and one cockerel each were used to test the value of A. I. V. silage on hatchability. The birds in lot 1 received the regular college ration, while those in lot 2 received the same ration and in addition all of the A. I. V. silage they would eat daily. This was fed from November 30, 1935, to March 31, 1936. Hatchability, egg production, and feed records were kept for the two groups of hens during the period. While the silage appeared to be spoiled in the first year's work, the xanthophyll content was apparently well preserved, as the egg yolks took on a rich golden yolk color similar to eggs obtained from hens supplied fresh green feed. It was also observed that 5 percent of the hens produced from one to five eggs with olive-colored yolks. This condition continued for only a short time, after which normal eggs were again produced. No significant difference was found in egg production or in hatchability of the eggs from the two rations. Whether or not this product is a better source of pro-vitamin A than dehydrated alfalfa and yellow corn remains to be proved.

[Project 77-20, 22, and 23; Department of Poultry Husbandry. Leader, L. F. Payne; state fund.]

Factors Influencing the Color of Yolks of Eggs.— An attempt was made in 1935 to identify the pigment which gives an olive color to the egg yolk, but with the limited equipment available at that time, little progress was made. With the installation of a new spectrophotometer in the Department of Chemistry, attention was again given to the phase of work studies in 1934, which dealt with the amount of carotinoid pigments recovered in egg yolks from hens which received varying amounts of yellow corn. During the past spring 32 White Leghorn pullets were grouped into four lots of eight each and placed in individual hen batteries where they received a basal ration with three variations as follows:

	Lot 1	Lot 2 <i>Basal, plus green buttermilk</i>	Lot 3 <i>Basal, plus alfalfa meal</i>	Lot 4 <i>Basal, with yellow corn for white</i>
	Basal lbs.	lbs.	lbs.	lbs.
White corn, ground	41.5	41.5	41.5	00
Yellow corn, ground	00	00	00	41.5
Wheat, ground	25.5	25.5	25.5	25.5
Oats, ground	10	10	10	10
Meat and bone scrap	10	10	10	10
Dried buttermilk	5	5	5	5
Alfalfa meal	0	0	3	0
Corn starch	3	3	0	3
Oyster shell	2	2	2	2
Bone meal, steamed	1	1	1	1
Codliver oil	1	1	1	1
Salt	1	1	1	1
Green buttermilk	0	*	0	0
Totals	100	100	100	100

The carotinoid pigments in the basal ration and in the green buttermilk, alfalfa meal, and yellow corn were determined before the experiment was begun. An amount of each of the above pigment-bearing feeds was added to the basal rations for lots 2, 3, and 4, to give approximately the same xanthophyll content to all. Each lot of eight hens was fed the experimental ration for three weeks before any eggs were examined. All eggs produced by each hen the fourth week were properly marked and turned over to the Department of Chemistry for analysis. Eggs were saved from each bird the fifth week and used for a study of intensity of yolk color. A chemical analysis of the rations fed showed the following results:

* 7 grams per hen daily.

<i>Rations</i>	(Mg. per 100 gms.) <i>Xanthophyll</i>	<i>Carotene</i>
Basal ration, lot 1	0.18	0.08
Basal plus green buttermilk, lot 2 .....	.922	.38
Basal plus dehydrated alfalfa meal, lot 3 .....	.924	.49
Basal plus yellow corn, lot 4.....	.940	.29†

The above amount was based on a daily feed intake of 100 grams per bird. The actual average daily feed intake, gain in weight, and total number of eggs produced by the eight birds in each lot for the four weeks were as follows:

<i>Lots</i>	1	2	3	4
Daily feed intake, grams	109	113‡	101	112
Percentage gain in weight	12	9	7	4
Number of eggs produced in four weeks	67	124	114	110
Percentage egg production	30	55	51	49

The results obtained are in accord with those reported in the biennial report for 1934 so far as yellow corn is concerned. Yellow corn was the only pigmented feed used in the previous test. The pigments from barely and dehydrated alfalfa were deposited in the egg in practically the same amount. An average of 15.87 percent of the xanthophyll fed was recovered in the egg yolk; in the case of dehydrated alfalfa, the average for the eight hens was 15.75 percent. The percentage of carotene deposited was 2.6 for barley and 2.5 for alfalfa. These results are in accord with the well-known fact that most of the color in egg yolks is due to xanthophyll.

Much more of the pigments was deposited in the case of corn. This is no doubt due to the fact that corn contains cryptoxanthine with only a small amount of carotene.

[Project 193; Departments of Poultry Husbandry and Chemistry. Leaders, L. F. Payne and J. S. Hughes; Adams fund.]

The Physiology of Egg Formation.— Two phases of this study were undertaken as follows:

1. *Deposition of Nitrogen in the Egg.*— The absolute amount of nitrogen was determined for immature eggs (isthmian eggs) and laid eggs from the same individual. In each case the laid egg was first in clutch position whereas the intercepted egg was the second egg of the same clutch. The white of consecutively laid eggs from eight females were also analyzed for total nitrogen. It was found that the intercepted egg contained 96 percent of the nitrogen of the laid egg and that the former had acquired by weight 51 percent of the white of the laid egg. It was also found that laid eggs, second in clutch position, contained only 90 percent of the nitrogen of the first egg of the clutch. This difference is due to the greater size of the first egg and a greater concentration of nitrogen in its white. These data are interpreted to indicate that protein is not added to the white in any region of the oviducal tube other than the magnum.

2. *Deposition of Ovoglobulin in the Egg.*— It has been stated that laid eggs contain more ovoglobulin than oviducal eggs removed from the uterus and that this protein fraction is added to the egg through the shell membranes while the egg is in the uterus. To study this increase in the amount of ovoglobulin, the amount of each of three protein fractions, ovomucin, ovoglobulin, and ovoalbumen were determined in the three layers of egg white for both oviducal and laid eggs. These layers are the outer thin, thick, and inner thin. The results show that the increase in ovoglobulin was greatest in the inner thin fraction which would not be true if ovoglobulin were being added to the egg through the shell membrane. These results would further indicate that nitrogen is not added to egg white in the uterine region. The data do indicate that the increase in ovoglobulin results from a change

† Kryptoxanthine.
‡ This does not include 7 grams of green buttermilk fed each bird daily.

in the solubility of the egg white proteins. This accompanies the process which converts a part of the thick white into thin white.

[Project 193; Departments of Poultry Husbandry and Chemistry. Leaders, D. C. Warren, H. M. Scott, and J. S. Hughes; Adams fund.]

The Mechanism of Egg Formation.— Three phases of this project have been studied as follows:

1. *Physiological Basis for Egg Size*— It is well known that egg size is inherited, but little is known concerning the physiological basis for differences that exist in egg size. As an approach to the problem, the eggs from a number of breeds of chickens and from turkeys and guineas were separated into their component parts and weighed. The ratio of yolk weight to the weight of the white varied with respect to breed. The mean yolk-white ratio for the Minorcas was 2.42 and for the Wyandottes 1.89. The mean ratio for the turkeys was 2.05 and for the guineas 1.65. The ratio of yolk to white was found to be significantly correlated with the length of the magnum and with the length of the entire oviduct being $+ .5019 \pm .08$ for the former and $+ .4530 \pm .07$ for the entire oviduct. Data making possible these correlations were available on 41 and 65 Leghorns, respectively. These data are interpreted to indicate that the Minorca will lay a larger egg than the Wyandotte, although the weight of the yolks may be identical in the two breeds for the reason that the oviduct is longer in the former breed. The longer oviducts, having a greater secretory surface, are capable of depositing more white about a yolk of constant weight than are the shorter oviducts. A number of other factors have been correlated with the yolk-white ratio and the values are given in the following table:

<i>Factor</i>	<i>Simple correlation coefficient</i>
Weight of first egg of clutch	$+ .0769 \pm .018$
Weight of later eggs of clutch	$- .0363 \pm .045$
Width-length ratio of egg	$- .1401 \pm .031$
Length of interval	$- .0102 \pm .045$
Period of production	$- .4847 \pm .034$
Percentage hatchability	$- .0140 \pm .051$

A significant negative correlation ($- .4847 \pm .034$) was found between period of production and the ratio of yolk to white. None of the other factors was found to be correlated with the yolk-white ratio.

2. *The Mechanics of Egg Formation*— Successive eggs laid by a group of 35 hens over a 28-day period were traced through the greater part of their formation period by manually exploring the abdominal cavity. It was found that both the first and second egg of the clutch require slightly more than 23 hours to complete their formation from the time they can first be detected in the oviducal tube. When a break occurs in the clutch, the first egg of the succeeding clutch cannot be detected in the oviduct until 20.4 hours from the time of the previous oviposition. This represents a delay in ovulation of approximately 15.5 hours. From this it is concluded that the "held" egg does not normally exist and that the day of nonlaying is the result of a delay in ovulation. Additional evidence that the first egg of the clutch requires no longer time for formation than succeeding eggs was obtained by incubating 120 pairs of eggs for 38 hours, removing the embryos, and counting the somites. The mean somite count for the first egg of the clutch was 8.64 and for the second egg 8.79. The development of the 38-hour embryo was shown to vary in the same direction as length of interval.

3. *Influence of Light on Rate of Egg Formation.*— Although somewhat over 24 hours are usually required for the egg to pass through the hen's oviduct, most eggs are laid during the day. The few eggs produced during the night usually have defective shells, indicating that they have been prematurely ex-

pelled. An attempt was made to determine the mechanism responsible for the timing of the process of egg formation so that eggs are laid only during the daylight period. This study demonstrated that the restriction of egg laying in the fowl to the daylight period is a result of the bird's reaction to normal alternation of daylight and darkness. Continuous artificial light caused the fowl to distribute its laying uniformly over the 24-hour period. A reversal of the periods of light and darkness resulted in laying being restricted to the lighted night period. Since the intervals between layings are usually more than 24 hours, successive eggs of a clutch are laid somewhat later each day. When this results in a bird being due to lay after the middle of the afternoon, the oviposition usually does not occur and a day's rest results. A new series is started with morning laying. The interruption in laying has been found to result from a delay in ovulation, rather than a retardation or interruption of the progress of the egg through the oviduct. Changes in the lighting conditions were not reflected immediately in the fowl's laying, but were expressed after about 60 hours. Thus, the regulating effect of light on laying probably has its influence on the later stages of the maturation of the ovum. Further studies are to be made in an attempt to determine the manner in which the alternating light and darkness control the maturation of the ovum

[Project 198; Department of Poultry Husbandry. Leaders, D. C. Warren and H. M. Scott; Bankhead-Jones fund.]

The Chemistry of Egg Formation.— Two studies have been in progress during the biennium.

1. *Studies in Enzymes of Egg White* —Balls and Swenson have shown that the antienzyme responsible for the resistance of egg white to proteolytic hydrolysis is located in the thin fraction of the egg white. These investigators did not separate the thin white into the outer and inner fraction in their work. Using the same method employed by Balls and Swenson for determining the proteolytic activity of egg white, it was found that the antienzyme is confined almost entirely to the inner thin fraction. Work is now in progress to determine where this inhibitor is located when this portion of the white is deposited around the yolk or is formed during the process which changes this fraction of the white from viscous to watery consistency. This work will be continued by studying the relation of enzymes to the formation of inner thin white and

TABLE IV—THE PERCENTAGE COMPOSITIOS OF THE UTERINE FLUID OF THE HEN

	High	Low	Mean	Average deviation from mean
Total solids	1 92	1 06	1 37	±0 14
Organic matter	0 77	0 36	0 58	±0 09
Protein nitrogen	0 09	0 03	0 06	±0 01
Ash	0 81	0 63	0 74	±0 04
Chlorides (as NaCl)	0 50	0 38	0 42	±0 03
Calcium	0 03	0 01	0 02	±0 003
Phosphorus		Slight trace	.	.
Sugar		Slight trace	.	.
Carbon dioxide (volume percent)	130 0	120 0	126 0	±4 0
pH	7 90	7 74	7 84	±0 04

chalaza. A paper embodying the results so far obtained has been prepared and submitted for publication.

2. *Chemical Studies of Uterine Secretion of the Hen.*—A method has been developed for securing samples of uterine secretion. About 40 samples of this secretion have been secured for chemical analysis. Table IV gives the results of the chemical analysis of these samples.

Information secured from complete analysis of this secretion will be of material help in explaining the chemistry of egg formation.

[Project 198; Department of Chemistry. Leader, J. S. Hughes; Bankhead-Jones fund.]

Influence of Hybridization Upon Vigor in Poultry.—The work for the biennium has consisted of a comparison of vigor of hybrids from crossing of various breeds. The studies are a continuation of those carried for some period of years in which the more common breeds and varieties of poultry are being compared with hybrids resulting from crossings among them. Whenever possible, vigor is measured by hatchability of eggs, rate of growth and mortality of the chicks, and egg production of the adult females. One phase of the work was in the nature of a three-way cross. The chick growth and mortality data have been given in previous reports.

The egg production of hybrid females resulting from a cross of Barred Plymouth Rock-Rhode Island Red hybrid males to White Leghorn females was compared with that of pure White Leghorn females. The average production of 78 White Leghorns was 206.8 eggs and for the 49 three-way hybrid females was 223.6 eggs. Even though the White Leghorn egg production was rather exceptional, the hybrids excelled. Heavy mortality in the laying house tended to vitiate these results. During the past year, comparisons were made of vigor of White Leghorns and five different crosses. The crosses studied were the White Leghorn male by Black Minorca female, Black Minorca male by White Leghorn female, Barred Plymouth Rock male by Rhode Island Red female, Australorp male by Barred Plymouth Rock female, and Black Minorca male by Rhode Island Red female. The results on growth at eight weeks and chick mortality to three weeks are as follows:

Cross	Number chicks	Mean weight at eight weeks		Mortality percent
		Females gms.	Males gms.	
Pure White Leghorn	286	363	365	2.5
White Leghorn ♂ × Black Minorca ♀	70	363	390	1.0
Black Minorca ♂ × White Leghorn ♀	318	404	475	2.5
Barred Rock ♂ × Rock Island Red ♀	159	373	389	7.5
Rhode Island Red ♂ × Barred Rock ♀	143	419	450	5.9
Australorp ♂ × Barred Rock ♀	93	431	433	11.8
Black Minorca ♂ × Rhode Island Red ♀	131	425	447	16.0

♂ Male; ♀ Female.

These results show considerable variability in the hybrids, indicating that the quality of the breeding stock used in the production of hybrids materially influences their vigor. Females from the crosses mentioned will be tested for egg production and additional types of hybrids will be studied.

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

Chromosome Mapping of the Genes of the Fowl.— Attention has been given to some of the autosomal factors in the fowl in an attempt to determine the linkage groups to which they belong. It is believed that a linkage group includes those genes carried by one pair of chromosomes.

The crest-dominant white-frizzling linkage group has been given considerable study. Frizzling-crest segregates totaling 246 indicate that these two genes are about 30 units apart on the same chromosome. The map distance between frizzling and dominant white as indicated by 438 segregates was 19 units. With these facts in mind, the theoretical expectation regarding the map distance on the chromosome between crest and dominant white, provided the gene for dominant white lies between frizzling and crest, would be 11 units of map distance. A calculation of the map distance between crest and dominant white based upon 1,026 segregates was found to be 11. This would demonstrate that the order of these three genes is crest dominant white, frizzling. No significant sexual dimorphism was found with respect to the percentage of crossing over in the two sexes. Some evidence was also found for the possibility of the new factor fray to be on the same linkage group as crest dominant white, and frizzling.

Considerable data were secured on the flightless silky linkage group. A repulsion phase revolving 779 individuals gave a crossing-over value of 10.8 and a coupling phase having a total of 156 individuals gave a crossing-over percentage of 17.1 for silky and flightless. The difference here is probably due to the smallness of the number in the coupling phase. Slight evidence was also found for the possibility of loose linkage between naked neck and the members of the flightless-silky linkage group. Additional data confirm the earlier evidence secured indicating that the factor fray is independent of the factors naked, pea comb, rose comb, polydactyly, white skin, feathered leg, and blue plumage. Emphasis is to be placed upon matings which will determine definitely whether the indications of linkage of fray with the crest-dominant white-frizzling group and naked with the flightless-silky group are correct. In the case of the two linkage groups mentioned, additional data are being accumulated to compare the percentage of crossing over in the two sexes.

[Project 197; Department of Poultry Husbandry. Leader, D. C. Warren; Bankhead-Jones fund.]

Studies in Inheritance and Physiology of Reproduction in Mammals.— A brief description of the two phases of this project that have been actively pursued during this biennium are given below.

1. *Inheritance and Physiology of Reproduction in Guinea-pigs.*— Progress has been made with linkage studies. At present data are being collected on the linkage relations of salmon eye (sm) with five other genes. In the meantime preparations are being made to make similar tests for eight more genes. Great difficulty is being experienced in this connection in producing long-haired (1) animals that are homozygous for the two modifiers, po and in. The only satisfactory explanation is that Po and in (and therefore also po and In) are linked with only a very small percent of crossing over taking place—the first case of linkage reported in guinea-pigs.

It has been reported previously that the pink eye gene (*p*) reveals the presence of certain modifiers. The inheritance of some of these is now known. For example, the gene causing uniform pigmentation in pink-eyed chocolates is recessive to its allelomorph which causes the chocolate to have spots of different intensities. The gene which causes pink-eyed yellows to be practically white at the base of each hair is recessive to its allelomorph which causes each hair to be yellow throughout.

Work has been started on the inheritance of conformation in guinea-pigs. Two groups of animals are being used. Both are made up of albinos. One is inbred and is distinctly nonshow type. Those making up this group remain thin throughout life, are narrow across the head and body, and are nervous. The other fattens readily, is wide across the head and body, and is sluggish. At present, photographs, measurements, and weights are being taken of the individuals in each group from birth to senility. Fat determinations are being made from a few selected animals. In the near future the two strains will be crossed. The inheritance will be studied by means of the F₂ generation and by back crosses.

For a number of years selection experiments have been in progress for the purpose of producing strains of guinea-pigs having an excess of one sex or the other in the offspring. Females appear sporadically that have a great preponderance of one sex in their progeny, as for example, twenty-one females and only three males, but up to present this tendency has not been fixed in a particular strain. There is evidence, however, that the tendency is inherited.

2. *Inheritance in Cattle.*—In crosses between polled and horned breeds of cattle the offspring are not by any means all polled, even though it is true that the latter condition is due to a dominant gene, and in spite of the fact that the polled parent is homozygous. Some scurred and horned animals usually appear. This can be explained by postulating a gene for scurs (*Sc*) which is epistatic to polled (*P*) in either heterozygous (*Scsc*) or homozygous (*Sc Sc*) males, but which is epistatic only in females which are homozygous (*Sc Sc*). A similar epistatic relation apparently holds for a special horn gene (*Ha*), distinct from the gene (*H*) carried by all horned breeds, and found principally in certain horned breeds of Africa.

A microscopic and chemical study has been made of cattle hairs for the purpose of determining the effects produced within the hair by the different color genes. Only two pigments have been found, (1) black, in the form of opaque clumps and granules, and (2) red, nongranular, transparent, and diffused throughout the hair. Various combinations of these two pigments are responsible for all the colored hairs; and the complete absence of the red, together with the almost complete absence of the black, causes the hairs to be white.

Black pigment bleaches more readily with hydrogen peroxide than red. Weak acids have no effect on the pigments, but weak alkalies do have. Eighteen different fat solvents, used singly and in combination, at both low and room temperatures, were found to have no effect on either pigment.

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

Studies in the Inheritance of the Grouse Locust.—During the biennium five of the eight or ten new elementary color patterns secured on the 1933 expedition to Mexico (supported by a grant-in-aid from the National Research Council) have been saved and bred. Their genetic positions have been reasonably well determined, and at the same time their relations to the 11 patterns previously studied have been ascertained. They all appear to be on the same, the first pair, of chromosomes. These new ones, as well as those previously employed, have come to be used largely as "markers" for the lethal

and the various combinations of the X-ray induced translocations. The more than 5,000 specimens collected on the 1933 expedition to Mexico have been further studied in the cooperative work on the "Evolution of Dominance" which is underway with Dr. R. A. Fisher, of England.

The lethal in Apotettia eurycephalus Hancock is being further studied by subjecting eggs to anemometric analyses to ascertain the differences in metabolism among those zygotes, homozygous and heterozygous for the lethal and the sibs homozygous for the normal allele.

The three or four recessive color patterns in *Paratettix texanus* Hancock are being studied further. Some of these, including a "suppressor" for a color pattern are quite subtle and difficult to follow, as they show plainly, slightly, or not at all, depending upon the genetic composition of the parents.

Work is still in progress to ascertain the inheritance behavior of long and short wings and pronota in *Tettigidea lateralis* Morse. The results so far indicate that these characteristics form a pair of Mendelian characteristics. This is different from the situation in *P. taxanus* and *A. euiycephalus* wherein these characteristics appear to be conditioned by the growing season. Short wings and pronota prevail in the late summer, fall and early winter when growth is slow, but long predominates in the early spring and summer when growth is rapid.

Our principal effort during the biennium has been devoted to the preparation of an extensive monograph as a continuation and amplification of Technical Bulletin 17 (1925). The data accumulated from 1925 to 1935 are used and a most careful analyses of the results are to be included.

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

Effects of Climate on Inheritance in the Grouse Locusts.—

The event of the biennium has been the translocation by X-raying of a section of chromosome carrying the gene W, for a stripe along the femora of the posterior legs, and attaching it to the sex, or X-chromosome. We thus now have a sex-linked character, the first to have been reported in any of the orthoptera. The deficient, or donor, chromosome was lost in the matings which followed, but the accreted, or receptor, chromosome was retained and has been carried through eight or ten generations, and in rather large numbers. This translocation marks a very profound change in the inheritance of these grouse locusts. The characteristic (stripes along the legs) is still carried in its original position and inherited in the regular way of autosomal characteristics. At the same time the identical characteristic is, even in the same individual, inherited in an entirely different (sex-linked) way. This one is different from most sex-linked characters preciously reported in other animals in that it is a dominant and the females show a single dose as well as the males.

Another peculiarity about this now sex-linked characteristic is that females carrying it double, or on both sex chromosomes, apparently do not hatch, or at least do not grow up to be recorded. We assume that the translocation consisted in an addition of chromatin to the sex-chromosomes above the normal, and that there is too much of it, or whatever it bears, when both X-chromosomes have it.

The X-ray translocation previously reported in which the portion of the first chromosome carrying the linked characteristic OTG was attached to the

fourth chromosome has been further studied. A considerable amount of data on the viability of the individuals carrying various amounts of chromatin has been accumulated. One factor of interest which has come out of this study shows that the deficient donor chromosome of this translocation and the accreted, receptor X-chromosome of the last translocation, complement each other to the extent that individuals carrying both often grow up. Some of them have been bred further. It may be recalled that individuals which carry the deficient chromosome, with no other accreted one, do not survive to be recorded.

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

Bee Investigations. — Four phases of the project have been studied during the biennium. Each phase is discussed briefly below.

1. *Nectar Secretion and Honey Production.* —The growing season of 1934 was an exceptional one in its severity. Extremely high daily temperatures and dry weather conditions prevailed. These conditions began early and continued until into September. There were 61 days which registered 100 degrees F, or more during the summer. Such conditions are decidedly inhibitory to plant growth and thus influence markedly nectar secretion.

In 1935, conditions were better during May and June and nectar was secreted by major honey-secreting flora. Due to the weather and soil conditions of 1934, colonies on scales made only slight gains during the season. These gains were not sufficient to offset the losses in weight due to colony food consumption. Colonies in the apiary had to be fed to maintain them through the winter and spring of 1934-'35. To maintain the college apiary at normal strength and feed the colonies would cost more than to buy package bees and queens in the spring. Under these conditions the number of colonies in the apiary was reduced to thirteen. The season of 1935 was not so severe as that of 1934 since the months May and June were not hot and dry. This enabled plants to make a vigorous growth and secrete nectar. The weather during July and August was hot and dry which inhibited nectar secretion. During the latter part of August and first part of September there was also a fall honey flow. Colonies on scales made a total gain of 102 to 166 pounds of honey for the season.

2. *Comparison of Races of Bees.* —Carniolan, Caucasian, and Italian races of honeybees have been maintained in the apiary for comparison in beekeeping qualities and for experiments in the artificial insemination of queen bees. The Carniolan race does not appear to build as strong colonies as the Caucasian or Italian. The Caucasian is superior to the other races in many respects. These bees winter well, do not begin brood rearing too early, build up rapidly after brood rearing begins, conserve honey store by not rearing brood heavily after the honey flow is over, and on the average gather larger crops of honey than colonies of other races. The Italian race equals the Caucasian in honey production. The Caucasian race of honeybees propolize at the entrance badly if the entrance is not restricted by entrance closers at the proper time after the honey flow ceases in the late summer or early fall.

3. *A Study of Substitutes for Pollen.* —Suitable substitutes for pollen as food for colonies of honeybees are yet to be found. Many protein-containing materials have been supplied by investigators or gathered by adult honeybees and fed to the larvae; such food may become available to the larvae. The following experimental rations were fed to colonies as protein substitutes for pollen: (a) 1 quart of whole milk and 1 pound of sucrose; (b) 1 quart of whole milk, 1 pound of sucrose, and 1 egg yolk; (c) 2 quarts of sucrose syrup (1 part sugar to 1 part water) and 1 ounce of technical casein; and (d) 1½ pounds of fresh calf liver, finely ground, 500 c.c. of water, and 750 c.c. of sucrose. Colonies were transferred to full sheets of foundation and the protein reserve removed after which the experimental feeding began. Brood was

reared, capped, and then emerged when colonies were fed the experimental rations (a) and (b). Ration (b) appeared to show a slight advantage over ration (a). No brood was reared beyond the mass feeding stage of the larvae (2 days old) with rations (c) and (d). Technical casein and water extract of calf liver in a sucrose solution are evidently not available sources of protein to the honeybee larvae.

4. *Artificial Insemination of Queen Bees.* —Experimental work has been conducted with the artificial insemination of queen bees. Several laying queens have been produced. Improvements have been made in the standard or holding device, as used by Mr. W. J. Nolan of the Bureau of Entomology and Plant Quarantine, which is used for holding the queen and the micro-syringe. The insemination work is carried out under and with the aid of a wide-field binocular microscope.

[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 diseases, insects, and other pests injurious to plants are given on the following pages.

Cereal and Forage Crop Disease Investigations. —The phases of this project dealing with wheat flag-smut, wheat foot-rot, and the Pythium disease of milo were conducted in cooperation with the Division of Cereal Crops and Diseases, Bureau of Plant Industry, United States Department of Agriculture. The flag-smut studies were under the supervision of A. G. Johnson. The wheat foot-rot investigations herein reported are by Hurley Fellows and C. H. Ficke, while Miss Charlotte Elliott has cooperated in the studies of the Pythium disease of milo. The Department of Agronomy is cooperating in several phases of this project.

1. *Sorghum Disease Investigations.* —The relation of temperature to the growth and development of the kernel smut of sorghum, *Sphachelotheca sorghi*, on artificial media and the ability of the organism to infect young sorghum seedlings, has been studied. It has been found that:

a. The organism has a wide range of temperatures at which it grows on artificial media. Minimum, maximum, and optimum temperatures of 6, 48, and 26 degrees C., respectively, were obtained for the growth of the fungus.

b. Kafir seed inoculated with chlamydospores of sorghum smut was placed on moist paper in Petri dishes. Under these conditions chlamydospores germinate and some seedlings become infected at about 9 degrees C. as a minimum, and occasionally at 40 degrees C. as a maximum, although the exact maximum has not been determined. Heavy seedling infection occurs over a range of temperatures from 15 degrees to 27 degrees C. and possibly higher temperatures.

c. The organism will grow at a wider range of temperatures than seed of kafir will germinate. Infection in kafir seedlings in the greenhouse has been obtained at every temperature at which it has been possible to sprout the seed.

A study on the inheritance of resistance to the Pythium root rot (milo disease) in the seedling stage in the greenhouse shows that apparently resistance is inherited in a simple 3:1 ratio. The same results were obtained in the field at Garden City where F₂ hybrids were grown.

The strain of Dwarf Yellow milo which is resistant to the Pythium root rot has a "stable resistance" not subject to change because of environmental variations. Its resistance is not broken down by growing plants in infested soil at low or extremely high temperature, or soil moisture variations. About 50 per-

cent of the susceptible Dwarf Yellow milo plants when grown at a soil temperature of 34 to 36 degrees C., however, will escape infection.

This disease is not caused by a soil borne virus, as tests were made which prove that the filtrate from infested soil after passing through a Berkefeld filter no longer remain infectious. The organism causing this disease has been isolated, grown in culture, studied morphologically, and used for inoculation experiments. It has been identified as *Phythium arrhenomanes* Drechs. The common name of this disease has been changed from crown, root, and shoot rot of milo to the *Phythium* root rot of milo. This disease may be controlled by growing resistant strains of the susceptible sorghums, several of which have been developed at the Garden City Branch Experiment Station.

2. *Wheat Take-all*.— Up to the present time, no variety of winter wheat has been found resistant to the take-all disease. All of the varieties that have been tested have been found very susceptible; however, H-44, C. I. 8177, a spring wheat shows considerable resistance. Three common grasses, *Agropyron smithii*, *A. cristatum*, and *A. spicatum*, were found very susceptible to the disease. Further work on the storing of naturally infested soils under various combinations of moisture, compactness, and temperature indicate that coolness is the principal factor for the maximum retention of *Ophiobolus graminis* in the soil. The work indicates that the environment in which the soil has been, may affect the amount of disease on the current wheat crop.

3. *Dry-land Foot-rot*.— No lesions of the dry-land foot-rot are visible when winter wheat goes into winter dormancy. Isolations made at that time failed to reveal any fungous parasite. However, many common saprophytes were present in the crowns of seemingly healthy plants. As has been shown before, a retarded date of planting is effective in reducing the damage from dry-land root-rot. Irrigation and soil sterilization with formaldehyde also reduce the damage to some extent.

4. *Oat smut*.— During the summer of 1935 letters were sent to county agricultural agents in the main oat-growing region of the state, asking them to make oat smut collections from fields sown with seed purchased by the government seed-stock committee. As this seed came from various parts of the United States, it seemed desirable to learn whether new or different physiologic forms of oat smut were being brought into the state by the introduction of this seed. These smut collections are being run on 11 differential oat varieties. Preliminary results indicate that races of oat smut different from those previously known as occurring in Kansas have been introduced through the purchase of foreign seed oats. The smut reaction of six hybrid selections of the Marktown × Fulghum cross is being intensively studied. The results obtained indicate that several of these hybrids are not only highly resistant to smut, but they also possess very desirable agronomic characteristics.

The grey speck disease of oats, which seems to be physiological in nature, is being investigated, and various methods of soil treatment are being undertaken to control it.

5. *Bunt of Wheat*.— Several hybrid selections of the Oro × Tenmarq cross are being intensively tested for their reaction to bunt; some are very resistant and look very promising agronomically. The reaction of numerous hybrids, selections, and varieties of wheat toward bunt is being studied. The inheritance of bunt resistance is also being studied in several promising wheat crosses. It appears that resistance is inherited in a 3:1 ratio in two of the crosses studied, resistance being dominant.

6. *Flag Smut of Wheat*.— Many wheat varieties have been tested in the flag-smut nursery at Leavenworth, Kan., and the Turkey wheats as a group are highly resistant to flag smut. It would seem that the losses which are due to this disease can be almost totally eliminated by growing one of the adapted, highly-resistant varieties such as Kawvale.

7. *Alfalfa Diseases*.—A damping-off disease of alfalfa seedlings that is more prevalent on soil fallowed for several years has been found to be caused by a *Phythium* sp, and the results have been published. Methods of seed and soil treatment are being studied to discover a method of controlling

this trouble. Notes on the prevalence of bacterial wilt, the leaf spots, and black stem disease (*Phomo sp.*) of alfalfa have been taken, and selections of apparently resistant plants have been made. These will be further tested by artificially inoculating the selected plants and testing the cuttings from these plants.

[Project 76; Department of Botany. Leaders, L. E. Melchers and C. L. Lefebvre; state fund.]

Fruit and Vegetable Disease Investigations.— The investigations under this project concerned with the diseases of fruit, vegetable, and ornamental plants have been continued. This work included further studies on *Rhizoctonia* and scab diseases of the Irish potato and on diseases of the meet potato. Work is in progress on the diseases of black raspberries and on the development of mosaic resistant varieties of the cucumber. Foliage diseases of apples, tomatoes, and other crops were not severe during the biennium because of the hot and dry growing seasons; therefore, few data were obtained on their control.

Irish Potato Disease Investigations.— Studies of diseases of Irish potatoes were conducted as described below:

1. *Rhizoctonia Control.*— In the studies on the *Rhizoctonia* disease of potatoes, the effect of various treatments on earliness of sprout emergence, efficiency for controlling *Rhizoctonia*, and on yields was observed. The most satisfactory potato seed treatment was a 10-minute soaking in a solution of 6 ounces corrosive sublimate in 25 gallons of water, acidulated with 1 percent hydrochloric acid. This treatment caused little injury to the seed piece, prevented *Rhizoctonia* infection most effectively, and the potatoes thus treated yielded more than either untreated potatoes or plants from seed pieces treated with hot formaldehyde or with organic mercurials. Hot formaldehyde treatments were followed by lower yields because this fungicide does not effectively prevent *Rhizoctonia* infection, and the treatment injures the tubers and causes delayed emergence of sprouts especially when it is made a month or less prior to the planting date. Tests with yellow oxide of mercury were continued, but this treatment is less effective for controlling *Rhizoctonia* and for producing high yields than acidulated corrosive sublimate. A noteworthy characteristic of yellow oxide of mercury in the past two years has been its 10 pre-sevative effect on the planted seed pieces.

2. *Studies on Soil-borne Rhizoctonia.*— A continuation of the studies on the amount and importance of soil-borne *Rhizoctonia* in Kansas River Valley potato fields shows that this organism was practically eliminated from the soils during the hot, dry summers of 1933 and 1934. During the two seasons of 1934 and 1935, 2 and 1.5 percent, respectively, of the potato plants became infected with soil-borne *Rhizoctonia*. Following previous summers, when rainfall was more abundant, as many as one third to one half of the potato plants became infected by soil-borne *Rhizoctonia*.

3. *Potato Seed-piece Decay.*— Seasonal conditions in 1935 were conducive to a great amount of seed-piece decay and potato stands were greatly reduced thereby. Data on percentages of seed-piece decay obtained from tests in 17 potato fields resulted in 63 percent of the seed pieces decaying following non-treatment of the seed pieces, while only approximately 12 percent of the treated seed pieces had decayed by the last of May.

Sweet Potato Diseases.— Stem-rot resistant varieties, developed by the United States Department of Agriculture, were grown in order to determine their horticultural desirability. A variety, 47,442, having a yellow-colored skin and in orange-colored flesh, and which has proved highly resistant to the

stem-rot organism, may prove of value as a commercial variety, especially in fields that are infested with stem-rot organism. This variety, however, has not yielded well during the past two dry seasons. Single plant selections for stem-rot resistance have been made of the variety Nancy Hall, and the progeny of these selected plants are being studied under conditions favorable for stem-rot infection. Among Nancy Hall plants, there evidently occur strains that are highly resistant to the stem-rot organism. These studies indicate also that great variability in root type exists among Nancy Hall plants. Efforts are being made to isolate a desirable type of Nancy Hall that is highly resistant to the stem-rot organism.

Mosaic Resistant Cucumber Breeding Investigations.— A mosaic-resistant variety of cucumber obtained from Nanking, China, was crossed with large pickling, small pickling, and slicer varieties of mosaic-susceptible, American-grown cucumbers. The Chinese variety produces a longer and lighter colored fruit than is suitable for the demands in the United States. Efforts are being made to combine the mosaic resistance of the Chinese Long variety and the fruit type and dark green color of the American varieties. Progenies of the original crosses were back crossed to Chinese Long after which three generations of self-fertilized fruits have been produced from selected hybrid plants that bore desirable fruits and that seemingly were resistant to the mosaic disease.

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

Resistance of Winter Wheat to Leaf Rust.— The resistance of winter wheats to leaf rust (*Puccinia triticina*) is being studied under both field and green house conditions in cooperation with the Bureau of Plant Industry, United States Department of Agriculture. The principal phases of work have been the following:

1. *Testing of Varieties, Pure Lines, Introductions, and Hgbirds in the Rust Nursery.*— The material studied consisted of the most important commercial varieties of winter wheat, noncommercial varieties and selections, pure lines, and promising hybrid selections from state experiments; new varieties originated by private plant breeders; introductions of winter wheat from foreign countries; and hybrid lines originating in crosses made in the program of breeding for resistance.

Commercial hard red winter wheats such as Turkey, Kanred, Kharkof, Cheyenne, Cooperatorka, and Blackbull have proved to be highly susceptible. Tenmarq usually is only moderately rusted, apparently owing to a maturative type of resistance. Kawvale, a sermihard variety, has proved to be strongly resistant. Quivira, and other early hard-seeded segregates, from the Prelude × Kanred and Kanred × Hard Federation crosses also are highly resistant to leaf rust.

Among the soft red winter wheats, many selections of Mediterranean from Texas as well as certain selections from Fultz, Illini Chief, and Shepherd have shown high resistance. Many hybrid lines have exhibited strong resistance to leaf rust, especially lines from compound crosses such as (Kanred × Fulcaster) × (Kanred × Hard Federation) and (Kanred × Fulcaster) × Tenmarq. Many promising resistant lines have been isolated from Kanred × Kawvale, Hard Federation × Kawvale. Hope × Kawvale, Mediterranean × Hope, and Hope × Hussar crosses. All of the later have yielded some lines that possess resistance to both leaf and stem rusts. Selections from the last three crosses named are particularly outstanding in that respect.

The rust nursery contained 1,854 winter and 330 spring wheats in 1934 and 2,222 winter and 402 spring strains in 1935. Among the winter wheats there were 1,112 hybrid selections in 1934 and 948 hybrids in 1935.

2. *Testing of Varieties, Selections, Introductions, and Hybrid Lines with Known Rust Forms in the Greenhouse.*— As a supplement to the field studies,

a large number of wheats were tested with pure physiologic races of leaf rust in the greenhouse. The seedling rust reaction has been found to be a rapid and fairly accurate way to determine the relative susceptibility of wheats to the most important forms of rust of the central plains area.

3. *Breeding for Resistance and Studies on Its Inheritance.*— A total of 120 crosses has been made and studied to some extent in the past biennium. The crosses were made and the F1 plants grown in the greenhouse. All subsequent generations were grown in the field except for a few crosses in which genetic studies were being made. Attention is being given to the isolation of lines having leaf rust resistance combined with such characters as winter hardiness, strong straw, early maturity, high yield, and good grain quality as well as resistance to stem rust, bunt, Hessian fly, and flag smut. Studies on the inheritance of resistance in the past biennium have been mostly on inter-specific crosses. The two crosses Purple seeded (*Triticum turgidum*) X Prohibition (*T. vulgare*) and Prohibition (*T. vulgare*) X *T. dicoccoides* were studied in detail. Definite segregation was obtained in both crosses but ratios were very abnormal probably owing to sterility in F1 and F2 of these wide crosses.

4. *Physiologic Specialization and the Distribution and Prevalence of Physiologic Forms.*— To supplement studies on the resistance of winter wheat to leaf rust and to aid in the interpretation of results, a study has been made of the physiologic forms occurring in the central plains area. Forty collections yielded nine different forms in 1934 and thirty collections made in 1935 contained eight forms.

5. *The Effect of Leaf Rust Infection on the Yield and Protein Content of Winter Wheat.*— Three varieties of wheat, Turkey (susceptible), Tenmarq (moderately resistant), and Quivira (highly resistant), are being used in these experiments. Sulphur was dusted on one series of plots to control rust infection. Treated and nontreated blocks of each variety in each of six replications were grown end to end. Leaf rust infection was very light in 1934 and differences in yield between the treated and untreated plots were not significant. Seed from the rusted plots of Turkey and Tenmarq had lower protein contents than that from dusted plots. In 1935 severe lodging in Turkey and heavy infections of stem rust, which could not be prevented by either dusting or spraying with sulphur, rendered the results unreliable.

6. *Measurement of the Effect of Leaf Rust Injection on the Transpiration of Wheat.*— These studies were conducted under controlled conditions in the greenhouse. It was found that leaf-rust infection on a susceptible variety does not result in greatly increased transpiration in the daytime but does greatly increase the loss of water at night. For the two years of the experiment, rusted plants of the susceptible variety lost nearly 78 percent more water at night than did the rust-free controls. The increase seemed to be due principally to cuticular transpiration caused by rupturing of epidermal tissues by rust sori.

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

Climate and Injurious Insect Investigations.— The annual summaries of the more important insects of Kansas during the years 1934 and 1935 were prepared for publication and the former is now in print.

The year 1934 was the fourth in a series of increasingly hot, dry years. The winter of 1933-'34 was one of the mildest on record. There was marked deficiency of soil moisture, particularly in the subsoil; the spring was cold, dry and windy with heavy dust storms. The following insects were more plentiful than usual: Ants, pea aphid, green bug (*Toxoptera*), and other aphids, borers in shade trees, bot flies, canker-worms, cattle grubs, chinch bugs, green flea beetles, green June beetles, harlequin bugs, pentatomids in alfalfa fields, leaf-

hoppers, red spiders, red-bud leaf folder, hour-glass spider, stored grain insects, thrips (alfalfa), strawberry leaf roller, strawberry weevil, striped cucumber beetles, wax moth, and beet webworms. The following respects were scarce or nearly absent: Alfalfa caterpillar, box elder bugs, cabbage worms, cutworms other than the army cutworms, clover root curculios, biting flies on livestock, white grubs and May beetles, Hessian fly, maple worms, potato beetles, tarnished plant bugs, tomato worms, apple curculio, and wasps.

The year 1935 was the fifth year of drought of insufficient rainfall for crops, but there was an ample supply of moisture after September. For the year, there was 0.1 inch more than normal rainfall, but from an agricultural point of view it was badly distributed both as to time and localities. The year was characterized by outbreaks of the elm leaf aphid, tree borers, especially the flat-headed apple-tree borer, cankerworms, corn ear worms, biting flies on livestock, screw worm flies, green clover worms, red-bud leaf folder, walnut worms, and of red spiders on elms, garden truck, brambles and many other shade or fruit trees.

Temperature studies were continued during the summers of 1934 and 1935. The maximum soil temperature observed in 1934 was 161 degrees F. The usual soil surface temperatures experimented with ranged from 120 to 150 degrees F. A soil temperature of 118 degrees F. is scarcely lethal to the larger insects. It was observed that the respiration rate for grasshoppers increased greatly when exposed to hot soil. The normal rate for *Melanoplus differentialis* is about 33 times per minute. After exposure to a soil temperature of 144 degrees F. for 20 minutes, the respiration rate went to 93 to 111 times per minute. The rate then declined to only a few times per minute, which was followed by death. Chinch bugs were killed during migration from the wheat fields. Their eggs were killed at soil temperature of 145 degrees F. and the chinch bug population actually decreased during the summer. Temperatures of 105 to 115 degrees F. prevailed on hot days behind leaf sheaths of corn plants where young chinch bugs live, as was determined by a thermocouple.

Work carried out in the greenhouse with the greasy cutworm, *Agrotis ypsilon*, under controlled soil-moisture conditions indicates that for the particular soil in question the optimum soil moisture for the greasy cutworm ranges between 25 and 30 percent of the dry weight of the soil. At 58 percent the larvae develop normally, but all die in the prepupal and pupal stages. The minimum for this cutworm lies somewhere below 5 percent, which is much too dry for the growth of its host plants. These limits probably would not apply to soil with different water-holding capacities. From data obtained in laboratory and from the use of weather records, insect pest surveys, and the entomological literature, it may, be definitely stated that this cutworm is a potential pest throughout the United States. Since it is capable of maintaining itself under arid conditions, it will always be able to produce an outbreak whenever sufficient soil moisture is supplied by rainfall, overflow, or irrigation.

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

Hessian Fly and Other Wheat Insects.— The following phases of work have been actively followed during the biennium.

1. *Distribution of Hessian Fly in Kansas.*— In the fall and early spring of 1935-'36 it became evident that there was a heavy infestation by the fall generation of Hessian fly in some wheat fields in the eastern third of Kansas. The infestation in combination with winter drought and cold resulted in the death of infested plants. In some fields, especially about Marion and Parsons, as high as 70 percent of the plants were killed. Through at least the western part of the infested area the spring generation was greatly reduced by the effect of an April freeze or drought or both on fly, egg, or young larvae, all three of which apparently were present at that time. Areas of infestation still remained, in protected places, as far west as Abilene.

2. *Seasonal History of the Hessian Fly in the Field Near Manhattan.*—The number of flies present in local fields have been greatly reduced by the recent dry summers but the seasonal history has been followed as far as possible. There has been only about a 1-percent infestation in the early dates of seeding on the college farm. At the Hessian fly nursery, eggs were deposited normally on volunteer wheat about September 15, 1934. Eggs were first seen March 28, 1935, and adults at internals between April 6 and 19. On April 13 a count of the number of eggs on Ceres and Marquillo spring wheats showed 30 percent of the plants of the former variety and 7 percent of the plants of the latter infested. No evidence of a summer generation was seen. In 1935 there was an early and a late fall emergence. In the spring eggs were first seen April 11.

3. *Wheat Stem Maggot.*—Further data were secured on the life history and parasites of the wheat stem maggot. The data on this insect have been summarized and a manuscript on the subject prepared. A complex relationship has been found between the appearance of adults of the spring generation of this insect, and variety, date of planting, and date of first beading of wheat. There also appears to be a period of especial susceptibility in the life history of the plant. In 1935, as a result of the May and June rains, preceded by the early drought, a second growth of late culms appeared on many wheat plants. These were subject to a fairly heavy infestation of wheat stem maggot, and resulted in some upsetting of the usual relationship between date of planting and infestation by the spring brood of this insect. A heavy infestation occurred in the Manhattan spring wheat nursery where only 24 strains out of more than 500 had no blasted heads.

4. *Wheat Straw Worm.*—*Studies* are being continued on the relation of date and depth of planting and variety on infestation by the first generation of the wheat straw worm. A study has been made of the depth of the crown in different varieties planted at the same depth.

5. *Survey of Insects of the Wheat Field.*—These studies have continued along lines indicated in preceding reports. A number of insects were reared and will be submitted for identification by specialists later on.

6. *Chinch Bugs in Wheat.*—In the summer of 1934 an attempt was made to determine the factors affecting the distribution, egg-laying habits, and the migration of chinch bugs from wheat fields. Observations and accurate counts of bugs present in a six-acre field of Tenmarq wheat revealed the fact that the adult females deposited more eggs along the margin of the field and in areas on high ground where the wheat was thin than were laid in the reheat on low ground where the wheat lodged later. When the bugs began to migrate, they left these thin areas first and either migrated to adjacent corn and late oats or to greener wheat in the same field. The stubble of the lodged green wheat served to prolong the period of migration by furnishing succulent stubble in which the bugs could exist for a time. There was no evidence that the bugs frequent only the margins of the fields, but rather were generally distributed wherever the growth of the wheat plants was not so rank as to furnish a damp, dark environment at the bases of the wheat plant. Due to a scarcity of chinch bugs during the summer of 1935, no studies were made.

7. *Studies of Underground Insects Affecting Wheat.*—Through the assistance received from the National Youth Administration funds, a thorough study was begun to test the efficiency of 20 substances which might be used on seed wheat to repel the false wireworm when the seed is planted under soil conditions which are not favorable to rapid germination. While nothing has been found which is entirely satisfactory, some of the creosote derivatives show considerable repellent properties against the test insects, *Tenebrio molitor* which are very similar in feeding habit to the larvae of *Eleodes Opaca* Say. The sticky nature of some of the substances rendered them difficult to apply to the seed.

[Project 8; Department of Entomology. Leaders, R. H. Painter and H. R. Bryson; Hatch fund.]

The Corn Earworm and Other Insects Injurious to Corn.—
Studies during the biennium have consisted of work with three insects injurious to corn as follows:

1. *Corn Earworm.*—In the region of Manhattan, the percentage of injury to both sweet corn and field corn is very close to 100 percent though the extent of the injury to the individual ears varies greatly. It was thought that if some mechanical contrivance that was cheap, easily available, and simply applied could be found that would restrict the larvae to the tip of the ear, some progress would have been accomplished.

The first attempt was the use of a paper husk. In Texas and elsewhere it has been observed that corn with long silks protected by long tightly wrapped husks suffered considerably less injury from the corn ear-worm than other corn. Therefore strips of paper were wrapped about the ear and the silks leaving only the tips of the silks exposed. It was soon discovered that the growing ear pushed the paper away from its tip and left an excellent entrance for earworms to enter.

The second method tried proved to be much more successful. A stout cord was bound tightly around the ear just below the tip of the cob shortly after the silk emerged. This cord automatically tightened about the ear as the ear developed. In most instances the worms were retained above the corn, though in a few cases the cord became loosened and permitted the worms to go down. In the very early corn there was some side worm injury. Similarly a light flexible wire was used in place of cord.

2. *Corn-leaf Miners and Corn-leaf Blotch Miner.*— An extensive outbreak of the corn-leaf miner, *Ceradontha dorsalis* Loew and the corn-leaf blotch miner, *Agromyza parvicornis* Loew occurred at Manhattan during the spring of 1935. These flies attack the young corn plants when they are in the two- to four-leaf stage and destroy one or more of the leaves. The plants are retarded but rarely destroyed. A large series of parasites were reared from these miners.

3. *Chinch Bugs in Corn.*— Weather and other environmental conditions which prevailed two years prior to and during the early part of the 1934 season were conducive to building up a heavy infestation of chinchbugs. The presence of a concentrated population of chinch bugs in the general wheat fields and plots at the college farm presented an opportunity to study various phases of the chinch bug barrier problem. A comparison of various repellent materials with the creosote oil ordinarily used in the construction of chinch bug barriers in regard to effectiveness, cost, and ease of application. An experimental barrier, 39 rods in length, was maintained from June 5 to June 23, inclusive, between a heavily infested six-acre field of wheat and a field of corn. The ridge was laid off in sectors and a different repellent used on each to determine the effectiveness of each material. The materials used were pine tar trex, fuel oil plus creosote, naphthalene drain oil, naphthalene drain plus road oil No. 10, naphthalene drain oil on "Cyanogas" flakes, creosote oil, creosote plus chinch bug oil, road oil plus creosote and government chinch bug oil. Five parts of naphthalene drain oil were used in combination with 1 part of the other oils while 1 part of creosote was mixed with 5 parts of the other repellent in the combination.

The results obtained and the observations recorded concerning the activity of the bugs and maintenance of the barrier verify the following statements with respect to the construction of barriers.

a. The construction of a definite ridge with sloping sides increased the effectiveness of the creosote-posthole barrier. A dusty surface for the sloping side forced the bugs to crawl along the creosote line until guided into and caught in the postholes.

b. Posthole, 14 inches deep, retained longer the fumes emanating from the flake cyanide placed in the bottom of each hole than holes dug 7 inches deep. The maintenance of a flared dusty surface at the entrance to the hole increased the efficiency of the posthole as a trap.

- c. Repellents carelessly or accidentally poured into the posthole had a tendency to repel the bugs from the entrance to the hole.
- d. Less congestion of the bugs resulted along the barrier when the repellent was poured in a straight continuous line, than when irregularities occurred. With respect to repellents the following observations were made:
 - a. Creosote, pine tar, and naphthalene drain oil each proved more effective when used alone in the order named than when diluted with road oil, fuel oil, or other repellents used.
 - b. Pine tar; although more viscous than either creosote or naphthalene drain oil, was more difficult to pour on windy afternoons than were other repellents. Pine tar retained its effectiveness for a longer time than other repellents. Although the cost per gallon was greater, the total cost of maintaining a barrier was about the same as that of creosote because less material was required through less frequent applications
 - c. Naphthalene drain oil repelled the bugs effectively when first applied but lost its efficiency in about two hours on windy afternoons.
 - d. The effectiveness of the repellents in a mixture with pine tar, creosote, or naphthalene drain oil was determined by the proportion of each making up the mixture. Greater dilutions than 1 to 5 usually required two applications to hold the bugs.
 - e. A proprietary repellent of unknown composition was sprayed on stalks at the margin of the field as recommended. The material did not repel the bugs from the stalks.

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

Fruit and Vegetable Insects.— The work of searching for and testing insecticides suitable in the control of the codling moth in Doniphan county was continued from the last biennium. Substitutes for lead arsenate used in 1934 were several cryolites and manganese arsenate; those used in 1935 were calcium and manganese arsenates. These substitutes were compared with lead arsenate alone and with lead arsenate in combination with spreaders and stickers such as Vatsol, soap, and a summer oil. The cryolites under the weather conditions of 1934, gave slightly better control than did astringent lead arsenate and manganese arsenate. The incompatibility the cryolites and summer oil with the lime and fungicides limits their use to the latter part of the spray season. Calcium and manganese arsenates with a summer oil sticker; lead arsenate alone, with two spreaders of Vatsol, with pine tar soap, and with a sticker of summer oil were used in 1935. The lead arsenate-summer oil combination proved to be the best in codling moth control. The lead arsenate combinations of pine tar soap, Vatsol, and lead arsenate alone ranked in the order given and were followed by calcium and manganese arsenates.

Four papers dealing with the control of the codling moth have been published during the biennium.

During the spring and summer of 1934, the foliage of red-bud trees was destroyed by an insect known as the red-bud leaf-folder, *Gelechia cercerisella* Cham. (Lepidoptera, Gelechiidae). There has been some damage to the leaves caused by this insect during the past few years. In 1934, the damage was so serious that in some instances trees were killed. Severe injury to red-buds was also caused by this insect in 1935.

The characteristic injury caused by this insect is the folding of the leaf and fastening down the edges with strands of silk. Where the infestation is

heavy, there may be from two to four folded areas on the leaf. In the folded areas of the leaf the larvae of this insect eat off the epidermis or surface layer of the leaf. This brings about the drying out of the leaf and it turns brown. When the damage is severe, the leaves become useless and drop from the trees.

The adult is a small moth with dark brown wings which have 10 very small white spots. The length of this moth is 7 mm. and with a wing spread of 12 mm. Life history studies of this insect were carried on during 1934 and through 1935. It is hoped that this phase of the work can be completed during 1936. Hibernation takes place in the fall in the pupal form and in fallen leaves. There are two to four generations a year.

Larval parasitism was noticed during 1934 but life history rearings of the leaf-roller were impossible because of the extreme heat and dryness of the summer. During the summer and fall of 1935 a number of hymenopterous parasites were reared from the leaf-roller. These are being determined by specialists of the Bureau of Entomology and Plant Quarantine of the United States Department of Agriculture. The control for this insect is to spray the leaves during the latter part of April with a stomach poison to which is added a sticker or some adhesive to hold this poison in place. Another application should be made a month later. The best materials to use for the control are lead arsenate in combination with a summer oil.

The red-bud aphid (*Aphis pawnepae* Hottes) was first found in Kansas in 1934 on the Kansas State College campus. It again appeared in 1935 about one mile southwest of the first location. The apterous viviparous females have a peculiar colony habit of arranging themselves on the under side of the twigs and branches of the red-bud tree, and do not attempt to cover the upper half of the branches. Apparently they do not prefer the new, tender growth, but attack the older wood which is several years of age; namely, the branches of medium size. The smaller aphids are to the side and beneath the large apterous viviparous females. Due to dry soil conditions during 1934 and 1935 this insect probably was forced above ground.

A strawberry leaf-roller parasite, (*Macrocentrus ancylivorous*), has been liberated at North Topeka in Shawnee county, and at Wathena and Blair in Doniphan county, Kansas. This parasite has become established in Doniphan county. This parasite also attacks the Oriental fruit moth.

A codling moth parasite, (*Ascogaster carposopsae*), has been liberated in Doniphan and Wyandotte counties.

The woolly apple aphid parasite, (*Aphelinus mali*), has been liberated in Doniphan and Riley counties. The first shipments, which were made in the summer of 1935, arrived when the daily temperatures were 110 degrees F, or more. These decidedly unfavorable temperatures inhibited the establishment of this parasite and coupled with this factor was the lack of aerial forms of the host insect which had been destroyed by the hot dry weather conditions.

[Project 13; Department of Entomology. Leaders, R. L. Parker and P. G. Lamerson; Hatch and state funds.]

Insects Attacking the Roots of Staple Crops.— This project was started in the spring of 1915 for the purpose of studying the life economy of various subterranean insects such as white grubs, wireworms, false wireworms, corn root worms, etc., which attack the roots of staple crops.

A concentrated effort has been made during the past biennium to accumulate additional data regarding white grubs, wireworms, and other subterranean insects. The work consisted mainly in making excavations in cultivated areas, and in prairie sod in order to determine the effects of high and low soil temperatures, low soil moisture content, and the character of the vegetative covering upon the population of these insects.

The data obtained during both years indicate that the heaviest population of white grubs was found on areas where vegetation was most plentiful and where areas of soil were not exposed to direct rays of the sun throughout the

summer. The population in every instance was lower than those found in excavations during previous years.

A study of the average depths and the moisture content of the soil at which the beetles were taken showed that the grubs went down considerably deeper into the soil to pupate during August of 1934 and 1935 than was the case in previous seasons of greater rainfall and lower soil temperatures. Fifteen inches was the average depth at which white grubs were found during September and October on areas devoid of the covering necessary to protect the surface of the soil from excessively high temperatures.

Excavations during the winter of 1935-'36 revealed the fact that 15 percent of the grubs taken in the surface foot of soil were killed by freezing. The soil froze to a depth of 24 inches and remained in this condition for approximately two weeks.

The data show that the population of wireworms was reduced during the two dry summers of 1934 and 1935. The low soil temperatures of 1935-'36 were not detrimental to the wireworms found in the areas studied. The investigation in progress concerning the horizontal movement of wireworms in the soil was continued during 1935. The data obtained have been summarized and the following observations recorded:

- a. Wireworms do not travel great distances at random in the soil.
- b. The larvae probably travel no farther than is necessary for them to obtain food.
- c. The majority of the wireworms introduced into the soil at a given point were recovered within a radius of 2 feet from the point of introduction.

Because of the high temperatures and the low soil moisture content it was necessary to resow the bluegrass plots and to replant the strawberry plots which were to be used for the ecological studies of white grubs. This has been done so this phase of the project can be continued.

Attempts to determine the length of the life cycles of the common wireworms attacking corn and garden crops have shown that many of them require three years in which to complete their development. This is a significant fact when planning systems of crop rotations and farm practices designed to prevent or control wireworm infestations. Rearing studies conducted during the weeks when the daily maximum temperatures approached 105 and 113 degrees showed that newly hatched wireworms are unable to withstand such high temperatures for even a few minutes. This experimental evidence confirmed field observations that young larvae cannot withstand a dry soil environment. Wireworms started from the egg in 1930 were apparently full grown in 1934 and all of them have not pupated at this time. This variation in the length of life cycles of individuals of the same species makes difficult the task of accumulating authentic data regarding the average length of the life cycle. This ability to withstand adverse environmental conditions makes control measures difficult to plan.

Taxonomic studies of Elateridae and Scarabaeidae were continued. All of the available unidentified specimens of Elateridae were carefully labeled and made ready to send to a specialist for determination. Some excellent drawings of adult Elateridae have been made by H. C. Manis, a graduate student, and will be used in a future publication on the Elateridae of Kansas. Approximately 200 click beetles representing five genera were added to the working collection of Elateridae during the biennium. Many of these were specimens taken on staple crops.

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

Insects Injurious to Alfalfa, Grasses, and Allied Plants.— This project has included studies along two lines, each of which is discussed briefly below.

1. *Alfalfa, Vetch, and Clover Insects.*— The hot, dry seasons beginning in each of the two years in early July and lasting until the last of August were unfavorable to the development of most alfalfa insects.

Early adults of the migratory and the two-lined grasshoppers produced two generations in 1934. This is the first time the two-lined was observed to do this. Some damage in the state was done by these two species and the Packard grasshopper, but early bran-mash sowings, especially in western Kansas, reduced grasshoppers to less than normal numbers.

Experimental tests of various bran-mash formulas were made. Definite conclusions were not possible since the results vary widely with field conditions and were complicated by shifting populations. Oil bait has the advantage of being cheaper than Kansas bait, easy to mix, may be stored ready to sow for an indefinite period, spreads evenly, cannot be made to lump, and can be sown during the day. The disadvantages are that it is distinctly less palatable as shown by the fact that the largest initial kills resulted from the Kansas bait, and that being so light in weight, it is difficult to sow in even a light breeze. Cage tests over sown oil bait which had been laid two weeks before caged grasshoppers were exposed to it gave no kill whatsoever. There is no evidence that the oil bait will supplant the Kansas bait.

During the grasshopper fall survey in 1935, it was observed that the migratory and two-lined species oviposited in bare spots in alfalfa fields, field margins, stubble fields, and along roadsides; that the differential species oviposited in grass clumps; and that the Packard and red-legged species scattered their egg pods in fields and grasslands. Egg pods in many fields were heavily infested with bee flies and blister beetles. In general the fall survey indicated a much larger population of grasshoppers in 1936 than occurred in 1935. Spectacular flights occurred in counties near central Kansas in September, 1935.

The pea aphid was present in such small numbers during the spring of 1934 that control operations were not possible. A survey of alfalfa fields west and east of Manhattan on April 14, 22, and 23, 1936, revealed the almost complete absence of these insects on alfalfa and peas. Only three pea aphids were collected during the three days. All were taken in alfalfa fields around Lawrence.

The army cutworm (*Chorizagrotis auxiliaris*) did some damage during the spring of 1935 due chiefly to the concentration of normal population in green patches. The poor growing conditions for alfalfa and grass made a normal population appear to be an outbreak. Adults obtained from larvae were kept alive from May 16 until September 5 in the cave at the alfalfa insectary and 42 eggs were deposited. There has been conjecture as to how this species passes hot summers; the most plausible explanation being that the moths either hide in a damp cool place or fly to the Rocky Mountains, returning to lay eggs in September. The results this summer offer some support to the estimation as adults theory. Larvae were also collected and carried through to August. It developed that all the army cut-worms either died or pupated while the surviving larvae were all of a closely allied species, *Feltia subgothica*. This species was the dominant one in the spring of 1936, the army cutworm being almost absent.

The tarnished and field plant bugs were abnormally scarce during 1934. When 50 were caged over blooming alfalfa plants, nearly all the blossoms dropped as a result of their feeding and the seed set was markedly reduced. A count of the thrips in 71 alfalfa flowers on August 16, 1935, showed an average of 1.44 thrips per flower. About the same time, a count of the thrips in eight alfalfa blossom clusters showed an average of 19.9 thrips to the cluster. There were 59 open blossoms on the clusters, 20 closed blossoms, and 13 buds. A method of handling these microscopic forms in the field laboratory was worked out.

The beet webworm occurred in widespread outbreak in the western half of Kansas. It fed chiefly on Russian thistle and sugar beets but also damaged alfalfa where there were many thistles in the fields. The garden and alfalfa webworms were scarce.

The clover leaf weevil was plentiful during the spring of 1934 and less plentiful in 1935. Life history studies for rearing parasites were made. The clover root curculio was abnormally scarce during the year.

For the first time, *Diallagma angustiorata*, a geometer closely resembling and living with *Caenwigia erechtea*, the forage looper was reared, all stages

photographed and drawn and recognition features of both recorded. Both of the above species were numerous last July and August in alfalfa and sweet clover. Both were heavily parasitized also.

Alfalfa yellows, a disease spread by leaf hoppers, was exceptionally plentiful during the spring due chiefly to the delay in cutting because of heavy rains. Many of the seed pods were dry and brown, containing shriveled seeds. Fifteen pods from yellowed plants had 37 dark, shriveled seeds, and 22 normal seeds out of a total of 59, while 15 pods from normal plants had two dark, shriveled seeds and 92 normal seeds. Leaf hoppers were more plentiful than usual during the spring of 1936, it was observed during the spring survey.

The alfalfa seed chalcid was numerous again during the year. It was observed that when immature pods were opened that infested seeds could be recognized by their dull, grayish appearance. The interior is generally more or less eaten and the cavity filled with a gray larva.

2. *Insects on Grasses and Allied Plants.*— Semiweekly collections have been made throughout the growing season for the years 1933, 1934, and 1935, and are being continued during the present season from each of the following three stations in the animal husbandry pastures: a native prairie grass pasture; a Kentucky bluegrass pasture; and a brome and orchard grass pasture. Each collection consists of 25 measured sweeps with a specially constructed insect net. The insects secured are killed and taken to the laboratory where they are sorted and identified where possible or pinned, labeled, and sent to specialists for determination. It is believed that these collections represent an accurate cross section of the insect population for most of the groups of the insects of the grasslands from which they are taken.

Especial attention has been given during the past winter to summarize the data secured for the three previous growing seasons. Tables and bar charts of the insect populations of each of the areas studied and bar charts of the seasonal distribution of all of the important insect species have been constructed. These indicate the kind and quantity of insects taken, their seasonal history and their reaction to climatic conditions.

The Cicadellidae as a whole held to a remarkable uniformity of population during the three drought years but there were some outstanding shifts in quantity among the species. The most remarkable is found in *Laevicephalus striatus* whose population of 13,746 in 1934 dropped to 21 in 1935. On the other hand, *Cicadula divisa*, which is vector for the yellows disease of several plants, especially asters, increased from 267 in 1934 to 6,200 in 1935. The numbers of *Polyrnius inimicus*, one of the most important leaf hopper pests of the grasses, were practically uniform for each of the three years though there were considerable difference in seasonal distribution.

During the past biennium an intensive study of the insects hibernating in grass stems was started. The grass samples were secured by cutting the dead stems at the surface of the ground, care being used to separate different grass species. The grass samples were brought to the laboratory, subjected to severe wintering and then placed in shoe-box containers for rearing. As the insects emerged they were trapped in glass vials and were collected three times a week from these vials. The emergence period began in March and continued through June.

About 90 percent of the insects that emerged belong to the superfamily Chalcidoidea and consist of the genera Harmolita and Eurytoma and their parasites. The species of the Harmolita which includes the wheat straw worm and wheat joint worm are all gall formers or stem miners of grasses. A portion of the Eurytoma are plant feeders and the remainder are parasites. Other insects that emerged from the grasses include Chloropidae (Dipterous gall formers or plant feeders similar to the wheat stem maggot), Cecidomyidae (Dipterous predators and plant feeders similar to the Hessian fly), Coccidae (plant mealy bugs and scales), and various other Dipterous and Neuropterous predators. It is estimated that approximately 8,000 insects have emerged from the grass stems to date.

Leaf Miners.— An infestation of leaf miners in the leaves of *Tripsacum dactyloides* was discovered in Reno county and observed later in Stafford and McPherson counties in 1934. The miners emerged at the laboratory as beetles and were identified at the National Museum as *Anisostena bicolor*. This species was originally described from a single specimen secured from New Mexico nearly 50 years ago and has not turned up in collections since that time until the present series was taken. The larvae practically destroyed the leaves of grama grass. No infestations were discovered in 1935.

The insects most injurious to the culms of big and little bluestem grasses in the vicinity of Manhattan during the 1933 season were beetle larvae. Two of these emerged in 1934 from larvae brought to the laboratory. They were identified at the National Museum as *Centrinaspis furtiva*. The species was described from two female specimens from Missouri over 15 years ago and have not been collected since. The heavy infestation of 1933 at Manhattan was reduced in 1934 and absent in 1935.

[Project 115; Department of Entomology. Leaders, R. C. Smith and D. A. Wilbur; state and Hatch funds.]

Study of the Biology and Control of Fruit and Vegetable Insects.— During the past biennium major attention was devoted to the study of two insects as follows:

1. *Study of the Biology and Control of the strawberry Leaf-roller (Ancyliis comptana Froh.).*— This insect overwinters as a larva and changes to the pupa stage during the latter part of March and first part of April. During the last part of April the leaf-roller adults emerge and begin to lay eggs. The insect over-wintered with a small population in 1935. The rearing of 1935 was done under abnormal conditions such as cool weather in April and May and hot, dry weather during July and August. A long period of incubation due to cool weather occurred in the spring which did not appear to devitalize the insect in its development. A record of 100 individuals reared from eggs to adults of the first generation gave the following data: Incubation period, 30.88 days; larval period, 27.58 days; pupal period, 9.41 days; and total life cycle, 68.23 days. The second generation had to contend with hot, dry weather and starvation, due to the dying of the plants. A record of 19 individuals reared from eggs to, adults of the second generation gave the following average values: Incubation period, 5.5 days; larval period, 20.5 days; pupal period, 6.3 days; and the total life cycle, 32.3 days. No data were obtained in regard to the third generation due to the adverse weather conditions and the lack of adequate plant growing facilities under such weather conditions.

During 1934 four hymenopterous parasites, *Catolaccus aeneoviridis* (Gir.), *Perilompus fulvicornis* (Ashm.), *Spilochalcis torvina* (Cress.), and *Perisierola n. sp.* (Fam. Bethyilidae), new to the strawberry leaf-roller were reared and identified. These are in addition to the 17 known species reared by Mr. S. A. Summerland in 1928 at this station. *Macrocentrus ancyliivarous* was liberated and recovered in the vicinity of Blair, Kansas, in 1935. This parasite was also liberated in the vicinity of North Topeka. This latter parasite has become established in Doniphan county.

2. *Life History and Control Studies of the Strawberry Sawfly.*— Damage to strawberry plants by this insect (*Harpiphorus maculatus Norton*) has not been recorded in Doniphan county during the 20 years prior to 1933, when it caused severe damage to several strawberry fields in this county. During 1933 life history studies were started but none was carried through to completion because of the disappearance of the larvae from the rearing cages shortly after they had reached 3 mm. in length. During May, 1935, a severe infestation was located about 8 miles north of Blair. Organic insecticides—Cubor dust and Powell pyrethrum A dust—were applied to the infested plants on a misty foggy afternoon, May 22. One hour after the application of the dusts 50 larvae were collected from each test. These were retained for observation on

fresh strawberry leaves in jelly glasses. It was found that, Cubor dust is an effective means of control for this insert, whereas the Powell pyrethrum A dust is not. During May, 1936, in this same field, lead arsenate at the rate of 1½ pounds to 50 gallons of water was applied, which gave complete control of this sawfly. Life history studies are being carried on with this insect. A one-fifth acre plot of land has been rented for growing strawberry plants to carry out life history, plant resistance, and control studies of strawberry insects.

[Project 187; Department of Entomology. Leaders, R. L. Parker and P. G. Lamerson; Hatch and Purnell funds.]

The Resistance of Crop Plants to Insect Attack.— During the biennium studies were made of the resistance of sorghums and corn to chinch bugs; of corn to corn ear-worm; of wheat to Hessian fly; and of alfalfa to pea aphids.

At Lawton, Okla., in cooperation with the Bureau of Plant Industry, United States Department of Agriculture, over 800 varieties, selections, and hybrids of sorghum were under observation for resistance to chinch bugs. Especially noteworthy were a group of F3 hybrids of the cross, Sharon kafir × Dwarf Yellow Milo. Segregation for resistance and for other characters was observed. As a result of early migration of the chinch bugs and irregular or delayed germination of the grain the results obtained in the Manhattan chinch bug nursery were of little value. Some useful observations, however, were made in the variety and the breeding nurseries.

The work on the resistance of sorghums to chinch bugs has been summarized and a publication prepared. It reviews the work at the Kansas station since 1920 and that at the Lawton field station since 1930.

A duplicate planting of a number of F1 hybrid corn plants and their inbred parents were exposed to chinch bug attack at Lawton and Manhattan. The hybrids proved much more resistant than their parents indicating the importance of hybrid vigor in resistance. Brief notes on the results have been published.

As a result of the drought which killed the corn no records were taken on the infestation of corn ears by the corn earworm in 1934. A heavy first generation infestation in the breeding nursery both summers permitted valuable notes on the "ragworm" type of injury done by this generation to the curl of corn. In a group of new yellow F1 hybrids (1934) the injury ranged from 0 to 81 percent of the plants infested for individual hybrids. In groups of hybrids in which one parent was common to all combinations, the average percent of plants infested ranged from 7 to 50. There was a high correlation ($x = .67 \pm .07$) between the infestation in the parents and in the groups of hybrids. Notes were taken on the same group of hybrids in 1935. There was a high correlation between the percentage of plants infested in 1934 and 1935 in the same hybrids, $r = .73 \pm .06$.

The variety series of wheat in 1934-'35 consisted of 107 varieties, hybrids and selections which were examined for Hessian fly by dissection of plants. The infestation at Manhattan ranged from 2 to 84 percent of the plants infested. Twenty-two selections with purple straw color out of susceptible, yellow-strawed varieties were tested. These were selected from head- or plant-rows by staking and discarding susceptible plants. Most of the selections were more resistant than the parent variety and some had an unusually good record. Twelve hybrids involving Kawvale as the resistant parent were examined in 1934-'35. All of these had been selected over a period of three or four years by staking infested plants in space planted rows. All of these selections proved to be about as good as the resistant parent. Some of them are better than tile resistant parent and all are very markedly better than the susceptible one. Some of these are promising from an agronomic standpoint.

A group of F3 hybrids between the fly-resistant spring wheat, Marquillo, and the winter wheats, Tenmarq, Minturki, Oro, Kawvale, and Kanred ×

Hard Federation, were tested in 1934-'35 in both the hard and the soft wheat belts. Some of the hybrids have proved to possess the Marquillo resistance in both areas. A few of these resistant hybrids have also proved to be winter hardy and have other desirable agronomic characters.

The F₄ generation of these crosses was studied in 1935-'36 when a very heavy fall infestation occurred in the nursery at Springfield, Mo., at which time plants with only one tiller contained as many as 270 larvae. Under these conditions all the common winter wheat parents in the nursery had practically 100 percent of the plants infested. Only about 10 percent of the plants of these varieties in space planted rows survived the infestation and were alive when examined in March, 1936. The spring parent, Marquillo, had a plant infestation of 44 percent, but was entirely killed by the winter. Among over 260 F₄ lines of hybrids between Marquillo and various winter wheats, the infestation ranged from 32 to 100 percent. In the spring the survival of these Marquillo hybrids ranged up to 100 percent, indicating resistance to killing by both fly and winter conditions. It is evident that factors for resistance to fly of the soft wheat belt have been transferred from the fly resistant spring wheat, Marquillo, to segregates of the winter type.

In greenhouse studies of F₁ wheat hybrids involving resistance factors from Marquillo, susceptibility appeared to be dominant in several crosses. A group of 34 crosses between wheat varieties and selections involving the resistance to Hessian fly has been studied. These hybrid were in the F₃ generation in 1934-'35. Several different factors for resistance are evidently present. Forty-four different hybrid lines were found as resistant or more resistant than their resistant parent at Manhattan in 1934-'35. Many other lines were low in their infestation. Among these are a number which are also promising from an agronomic standpoint.

In the spring of 1935 at Parsons, Kan., a nursery of 381 rows of spring wheat varieties had a moderately heavy infestation by the fly. The average for the resistant Marquillo check was 17.5 percent of the tillers infested. There were 95 selections of various kinds of wheat with an infestation less than the average of the resistant Marquillo check. Seven of these were selection of Marquillo; of the remaining 88, 61 were of common bread wheat or interspecific hybrids of the common bread wheat type. Some of these hybrid selections have shown considerable promise for use as fly resistant parents for use in wheat breeding for the soft wheat areas of eastern Kansas and eastern states.

Some of the individual alfalfa plant selections made because of their resistance to the pea aphid in the field in the spring of 1934, were tested in the greenhouse. The method used has been to cage lots of five full-grown aphid nymphs on branches of alfalfa and at the end of 10 days count the progeny. These have ranged from 0 to more than 300. Apparently the aphid is unable to maintain a population on resistant plants. The general correlation between these tests and the field observation has been good. Some of the progeny of these resistant plants have also proved to be similar to their parents in resistance. The factors thus far studied, as indicated by the relatively few tests completed, may be summarized as follows:

- a. Under high temperatures the aphids become restless and may reproduce at a lower rate. The optimum temperature is about 60 degrees F.
- b. Under suboptimum temperatures reproduction is slow on all plants and the young nymphs do not develop quickly. On resistant plants these young nymphs do not die as they do at more optimum temperatures.
- c. On a branch bearing flower buck the aphids thrive better than they do on nonflowering branches.
- d. On susceptible plants injured by the feeding of many aphids, fewer aphids than usual are produced.

[Project 164; Departments of Entomology and Agronomy. Leaders, R. H. Painter and J. H. Parker; Purnell fund.]

Physiology of Reproduction and of Hibernation in Mammals.—Under this project studies have consisted of the following phases: (1) The physiology of hibernation—blood cell count, hemoglobin content, pH, and blood sugar content of the blood of hibernating and nonhibernating ground squirrels; (2) factors affecting rates of “waking” of ground squirrels from hibernation; (3) factors that influence precocious sexual development in fowls; (4) the effect of Antuitrin-S on development and function of the gonads of young and adult fowls; (5) the effect of large quantities of the theelin on the ovaries and pituitaries of fowls; (6) the effects of ablation of the pituitary and relation of the pituitary to light absorption in controlling egg production; and (7) the effect of androsterone on the vestigial testicular tissue of young female fowls.

The present studies have been running too short a time to give more than suggestions as to eventual results. Present developments are very encouraging, however. Results to date are as follows.

a. Apparently there is a difference in blood cell numbers between hibernating and nonhibernating ground squirrels. Other studies are in progress.

b. Whereas hibernating ground squirrels, when taken into a warm room, “awaken” through a rather fixed period of time, about one hour, hibernating squirrels injected with adrenalin develop a higher temperature and awaken more rapidly. More exact comparisons of normally awakening and adrenalin injected awakening ground squirrels are to be made.

c. The hormone from the adrenal cortex, Eschatin, as prepared by Swingle and Piffner apparently does not stimulate precocious sexual development in young fowls. Since this is in accord with other work on the rat, other preparations of adrenal cortex are to be tried.

d. Preliminary work indicates that gonads of young fowls are stimulated to develop at an early age after injections of Antuitrin-S, the gonadotrophic principle of human pregnancy urine. This work is to be continued with young and adult fowls.

e. The removal of the pituitary in fowls is being undertaken with the view of ascertaining if this gland is instrumental in stimulating the gonads upon exposing fowls to light. The difficult technique of removing the pituitary is believed to be almost mastered.

f. Androsterone (male sex hormone) is being extracted from male urine and injected into young female fowls to determine if the vestigial testicular tissue can be stimulated. One extraction of androsterone has been completed and the assay for potency is now being carried out.

[Project 191; Department of Zoölogy. Leader, E. H. Herricli; Purnell fund.]

PART III

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.— Investigations as to the value of ovarian extract in sterility in cattle, studies on infectious enteritis of cats, and also cooperative experiments with the Departments of Daily Husbandry, Animal Husbandry, and Chemistry have been carried on. Laboratory examinations of diseased animal tissues and fluids have also been carried on as in past years, a total of 16,589 such examinations being made. The work on infectious enteritis may be summarized as follows:

- a. The disease was found to be due to a specific filtrable virus. Secondary invaders are present but incapable of reproducing the disease.
- b. Formalized organ tissue suspensions produce a lasting immunity when inoculated into susceptible kittens.
- c. An homologous antiserum was developed and found to protect susceptible kittens against large doses of virus. It was also found to be beneficial as a curative agent.
- d. Over 200 cats have been used on the project. Of these almost 100 percent were found to be infested with some type of parasite.
- e. Dogs, rabbits, guinea pigs, rats, pigeons, foxes, and opossum are not susceptible to the virus.
- f. We were unsuccessful in preparing a heterologous antiserum.

Work on ovarian extract is still in progress. A method to produce the extract so that it will require a fewer number of treatments is being sought. The results of the use of ovarian extract still continue to be good in selected cases.

Examinations of swine have shown an increasing incidence of swine erysipelas.

During the past year the virus of equine encephalomyelitis has been demonstrated. The characteristic lesions were demonstrated in the affected brain, and filtered brain emulsions injected into guinea pigs gave positive results. The virus was carried through many guinea pigs on subsequent inoculations from guinea pig to guinea pig.

Some work done in the western section of the state demonstrated the presence of a disease in equines, especially and possibly in bovines, having all of the characteristics of selenium poisoning. Soil samples from various places showed a selenium content varying from one half part per million to eight parts per million. Obtainable history seemed to point to the fact that this same condition has been observed before and chiefly in years of drought.

A peculiar dermatitis in cattle has been seen this past year during the months of July, August, and September. Ulcers usually develop in the lower front portion of the lip. The nose, shoulders, and udder become inflamed, and these affected areas in time become more or less gangrenous and later slough off, wholly or in part. The dermatitis does not spread to large numbers in a herd and seems to be seasonal in occurrence. No fatalities resulted and no post mortem examinations were possible. The cause of the condition was not determined.

[Project 102; Department of Veterinary Medicine. Leaders, R. R. Dykstra and H. F. Lienhardt; state fund.]

Abortion Disease Investigations.— *Approximately 75,000* breeding cattle have been blood tested during the biennium ending June 30, 1936, for Bang's abortion disease and 15 percent reacted in a positive dilution for this disease. Thirty-three percent of all the herds contained no reactors on the initial test. One half of the herds containing reactors passed a completely negative test on the second test when the reactors were branded and shipped for slaughter soon after they were detected. In cooperation with the Department of Physiology it was discovered that Bang reacting cows have a higher pH value to their blood than Bang nonreactors. This difference is constant and measurable. Future work will be directed toward developing a practical diagnostic test suited to field conditions.

Data obtained in the study of certain herds following an "abortion break" have led to the conclusion that the susceptibility to Bang's abortion disease increases in direct proportion to the period of time that the herd has been free from the infection. This is particularly true in the case of the younger animals.

The first year of the biennium was devoted to an exhaustive study of a strain of *Brucella* variety *bovis* isolated and developed in this laboratory which not only seemed to possess but little virulence but also had lost the power to produce agglutinins following massive injections. Work has been started using 16 cows and a bull to test the vaccine in detail. The physical equipment for the study has practically all been accumulated. It is designed to project this study on two groups of cows over at least one pregnancy, one group to be vaccinated and the other group not vaccinated, exposure to infection to be similar for both groups. An exhaustive study has been made of the fate of 1,000 cattle reacting as suspects (1-50) to the rapid agglutination test for Bang's disease. Over a period of five months, 70.1 percent became negative 26.5 percent became reactors, and 3.4 percent remained suspicious for the five months. At the end of nine months, only one cow was still suspicious. Of the remaining 33 head, 24 became negative and nine became reactors. The percentage of Bang infection in the herd on the initial test was used as an indicator to forecast the probable course of the blood titration over the time period. When the initial herd infection was 15 percent or higher the suspects had a three to one chance to become reactors. This material will be prepared for publication in the *Journal of the American Veterinary Medical Association*.

[Project 135; Department of Veterinary Medicine. Leaders, H. F. Lienhardt and C. H. Kitselman; state funds.]

Blackleg Investigations.— The work in this project during the biennium has consisted in the production and distribution of anti-blackleg serum and blackleg filtrate, and of research work connected with the production of these products. Bacteriological examination of anaerobic diseases of horses, swine, and cattle were also carried out.

The action of several antiseptics on blackleg cultures was studied. It was observed that benzaldehyde, salicylaldehyde, and heptaldehyde in concentrations of 0.5 percent sterilized cultures of *Escherichia coli* and *Bacillus anthracis* in 24 hours, and cultures of *Clostridium chauvei* in 48 hours, but did not sterilize cultures of *Cl. septicus*, *Cl. novyi*, or *Cl. welchii*. Concentrations of 1 percent of these aldehydes, however, sterilized all the anaerobic and aerobic organisms tested with the exception of *Cl. welchii*. These studies confirm previous experiments on the greater resistance of anaerobic organ-

isms and show that there is a marked gradation of resistance among anaerobic species, *Cl. chauvei* being one of the least resistant anaerobic species.

The action of aldehydes and salts on the potency of blackleg filtrates and bacterins was studied. It was found that benzaldehyde, salicylaldehyde, and heptaldehyde did not increase the aggressive potency of blackleg filtrates and bacterins. The potency of blackleg filtrates treated with these aldehydes was no greater than that of filtrates containing no preservatives. In the case of bacterins, benzaldehyde apparently increased the potency to some extent. These results and experiments previously reported on the value of acetaldehyde and merthiolate suggest the possibility of substituting acetaldehyde or merthiolate for the formalin usually employed.

A study of the immunizing value of the supernatant fluid and the precipitate produced by treating blackleg filtrates and bacterins with potassium alum (aluminum-potassium sulfate) was made. It was found that blackleg filtrates and bacterins treated with potassium alum immunized a large proportion of guinea pigs injected with these products. The supernatant fluid obtained by centrifuging the alum treated products had little protective value. These experiments suggest the feasibility of concentrating blackleg filtrates and bacterins.

A study of the use of salts in culture media for the cultivation of blackleg organisms was made. It was found that neither sodium formate nor sodium hydrogen sulphite increased the growth of blackleg cultures. Neither copper sulphate nor zinc sulphate produced any increase in the growth or virulence of blackleg cultures.

A study of the keeping qualities of blackleg filtrates and bacterins containing formalin and acetaldehyde showed that formalized products produced in 1931 still had approximately the same aggressive potency of 65 units per dose. Products containing acetaldehyde maintained their potency for 12 months.

Studies were made of outbreaks of blackleg in which several pathogenic anaerobic organisms were isolated. In three cases in which polybacterial blackleg was diagnosed the cattle had been vaccinated for over three months with efficiently prepared commercial products.

[Department of Veterinary Medicine. Leader, J. P. Scott; state fund.]

Anaplasmosis Investigations.— During the past biennium the work on anaplasmosis conducted in cooperation with the Bureau of Animal Industry, United States Department of Agriculture, has consisted of routine examinations of experimental animals that have been “carriers” from two to seven years, particularly with regard to blood picture. Atabrin and plasmochin were used in an attempt to destroy the “carrier” state possessed by recovered animals. Cattle were treated with a 2 percent mercurochrome solution within two days after the initial temperature rise. Attempts were made to culture the anaplasma, to treat acute cases, and to stimulate the production of hemoglobin in a fairly recently recovered “carrier” case of anaplasmosis. Acute cases of anaplasmosis were produced experimentally in two instances and approximately 500 blood smears representing 12 different herds of cattle were examined for the presence of anaplasma bodies. Cattle that, have been “carriers” from two to seven years continue to show the presence of anaplasma bodies when blood smears are examined.

Attempts were made to cultivate the anaplasma under aerobic conditions and under vaseline seal. Bass medium was used which consists of normal blood plus 50 percent glucose solution. It was noted that anaplasma bodies

were quite numerous in the first generation under both aerobic conditions and when cultivated under vaseline seal. In the second generation the bodies were less numerous in those tubes cultivated under Vaseline seal. In the second generation the bodies were less numerous in those tubes cultivated aerobically than was observed in the first lot of tubes cultivated under vaseline paraffin seal. However, anaplasma bodies showed staining characteristics described for anaplasma marginals. Indications were that the bodies continued to grow through two generations, but could not be detected in blood cells after the third generation.

Acute cases of anaplasmosis were produced in two instances. First by inoculating a susceptible cow intravenously with 30 c.c. of a composite sample of citrated blood containing 10 c.c. from each of three suspect cows. In the second case a susceptible cow was inoculated intravenously with 30 c.c. of citrated blood taken from a cow that had been a "carrier" since October, 1928. Both cows were kept in a screened fly-proof enclosure with a susceptible cow as a contact animal. The contact animal did not at any time show symptoms of anaplasmosis or any other diseased condition. The second cow treated with "carrier" blood was treated intravenously three times per week with an anti-tomy compound "Fuadin," beginning two days after the first clinical symptoms of anaplasmosis. The red cell count on the first day of inoculation with Fuadin was 3,200,000 and after receiving 190 c.c. given in 10 to 20 c.c. doses over a period of 27 days the red cell count was estimated at 3,000,000. Anaplasma bodies were demonstrated in the blood cells of this animal three months after the the injection of Fuadin. Indications are that Fuadin was not of therapeutuic value.

Blood smears from cattle obtained from various places over the state were stained and examined for the presence of anaplasma bodies. In several instances the slides have shown well-defined marginal bodies that could not be distinguished from anaplasma bodies observed in slides obtained from cattle known to be infected with anaplasma bodies. Animal inoculations were not resorted to in an effort to substantiate these findings.

[Project 180; Department of Veterinary Medicine. Leaders, Herman Farley and H. F. Leinhardt; state fund.]

Feeder Cattle Disease Investigations.— During the biennium the work on this project has consisted of field investigations of diseases among cattle resulting from overfeeding, under nutrition, wheat poisoning, ensilage poisoning, or other cattle diseases of a questionable nature. In instances where food was regarded as suspicious in the causation of disease representative samples were brought to the laboratory and fed to small laboratory animals.

In one instance 30 head of calves that had been fed ensilage with no ill effects were transferred abruptly to a ration consisting of new alfalfa hay and a small amount of grain. Within three hours after "loading" on alfalfa hay three animals developed an "acute bloat" and died from asphyxiation. A decrease in the amount of alfalfa hay with addition of ensilage and grain apparently prevented further losses.

A second herd consisting of 150 head of aged, adult poor conditioned cows developed a diseased condition and several animals died. These cattle were purchased from a drought-stricken area in Arizona and were brought to Kansas in August, 1934. The entire herd was placed on a ration consisting of 1 1/2 pounds of cottonseed cake and wheat straw. During the winter those cows heavy with calf developed complications that are associated with malnutrition. The addition of alfalfa hay and grain to the ration stopped further losses. Vitamin A deficiency was probably the cause of the trouble.

In four herds losses were reported among calves fed ensilage taken from near the bottom of the silo. In these herds the food consisted almost entirely of ensilage. The diseased condition or malady was of an acute nature, as the

affected animals died within less than two hours after being detected as sick. In each of these herds a change to other types of feed apparently stopped the losses. In each of these cases samples of ensilage when fed to small laboratory animals did not produce any ill effects in these animals. Lesions observed on autopsy were acute gastro enteritis.

A herd of cattle consisting of 20 head of cows that were fed corn fodder and ensilage developed mineral deficiency, a disease which often develops among cattle fed on rations that are deficient in minerals, such as calcium and phosphorus, etc. On autopsy the bone tissue was found to be soft and spongy or extremely brittle.

One case of wheat poisoning was encountered. The animal died quickly. However, autopsy lesions were those encountered in cattle that had died as a result of toxemia.

During 1935-'36, there has been a paucity of cases consequently there are no new results to report. Several investigations have been made during the past year and the results of these investigations have been quite conclusive of starvation or overfeeding on coarse bulky feeds lacking in nutritive value. In other instances there was a relation between an inadequate water supply and the disease produced. The investigations thus seem to reveal troubles closely connected with the unusual climatic conditions prevalent throughout the state for the past few years.

[Project 194; Department of Veterinary Medicine. Leader, Herman Farley; state fund.]

Poultry Disease Investigations.— Because of the extreme drought, A-avitaminosis became a serious problem as early as late summer of 1935 and continued through the winter of 1936. Ordinarily little serious difficulty is encountered as a result of vitamin A starvation until late winter and early spring. Lack of vegetation as a source of vitamin A as well as the low vitamin A content of yellow corn and legumes which were produced in spite of the drought appeared to be the most important factor in the unseasonable and serious proportions of A-avitaminosis. Last year appears to be the worst on record in this respect.

D-avitaminosis as an apparent sequel to the drought and dust storms incident to the drought, has been unusually prevalent during the past year. Nervous symptoms as well as true rachitic Vitamin D starvation has been observed. In addition to diminished sunlight as a factor, direct injury from the inhalation of large quantities of irritating dust has undoubtedly played a significant predisposing role in disease production. Furthermore, in an attempt to lower feed costs, deficient quantities as well as inferior grades of cod-liver oil as a source of vitamin D have been incorporated in commercial and home-mixed rations. During the latter part of 1936 there was a marked increase in D-avitaminosis in birds fed on what was considered to be good grade cod-liver oil. It is quite evident from this that a great deal of low grade cod-liver oil is being sold in Kansas.

Several interesting and practical observations with regard to infectious laryngotracheitis have been recorded during further pursuit of studies on this problem. Not only was it shown that introduction of the virus into the yolk sack produced death of nine- to ten-day embryos with lesions of the chorio-allantois but introduction of the infection upon the latter tissues immediately beneath the inner shell membrane produced uniform and extensive lesions as well as embryo lethality. A strain of the Berkefeld filtered virus (8090) has been passed directly through more than 50 series of eggs without the necessity of intervening filtration and without encountering bacterial contamination. The virus was shown to undergo direct multiplication during egg passage while its capacity to infect susceptible chickens and the

chorio-allantoic membranes of the hen's egg did not appear to be altered as a result of continuous egg propagation. Comparative tests with the tracheal and the egg cultivated virus for cloacal vaccination have indicated that the number of "takes," and the degree of immunity, is similar with both products. It also appears that the egg-cultivated virus, as compared to that collected directly from the trachea, is a much more economical and safer source of vaccine.

Further observations on the results of vaccination of chicks against fowl pox indicate that the local "take" and the subsequent systemic reaction induced in three-week-old chicks is usually less severe than in day-old chicks. The immunity obtained from vaccination in chicks of both ages is similar in degree and duration and entirely adequate to protect against subsequent natural exposure. The cultivation of the pure virus upon the chorio-allantoic membrane of the developing hen's egg has been successful. The objective to be attained is to use the egg-propagated, bacteria-free, and standardized virus for vaccination purposes.

Additional studies of the use of copper sulfate solutions as substitutes for the drinking water of chickens to prevent and overcome worm infestation (ascariasis and taeniasis) have shown that (a) a 1:2000 solution may be given continuously to chickens from the age of three weeks to six months without harmful results; (b) such chickens, which were in confinement and not exposed to worm infestation, fed on the usual growing mash weighed approximately 25 percent more at the age of six months than did the control group; and (c) in field trials, of 52 birds from one flock kept on CuSO₄ from the age of two to six months, only 17.3 birds were parasitized as compared to 43.9 percent parasitism among 41 birds from the same premises not receiving CuSO₄.

The phase of the pullorum disease diagnostic problem in mature birds as it is concerned with the antigens employed in the agglutination test has been given further attention. In an effort to answer the following questions, antisera against *S. pullorum* and related pathogens of poultry were prepared from rabbits and chickens: (1) Do the sera of animals harboring rough (R) type pullorum infection react with smooth (S) type antigens employed in the agglutination test? (2) Do the sera of animals infected with smooth *S. aertrycke*, *E. coli*, and *S. gallinarium* give cross-agglutination reactions to the extent that discrepancies and irregularities arise in the agglutination test results? Chickens and rabbits were injected daily at alternate weekly intervals over a period of six weeks in order to produce high titer sera. S and R types of *S. pullorum*, and S types of the other organisms studied, killed by heat and by iodine, were employed for subcutaneous injection. Although the results with *S. pullorum* smooth antigens and the R and S types antisera were obtained with a limited number of antisera (20) it would appear that under ordinary conditions both R and S type pullorum infected, or carrier birds, would react to the routine agglutination tests. In answering question two, it would seem that carriers of *S. pullorum*, both R and S as well as those of *S. gallinarium* would react equally well to *S. pullorum* antigen; while few *S. aertrycke* and no *E. coli* carriers would be detected by the usual test employed for pullorum disease.

Fowl paralysis (*neurolymphomatosis gallinarium*) is rapidly assuming economic importance in Kansas. During the biennium of 1932-'34, there were diagnosed in this laboratory 23 outbreaks of the disease. During the past biennium we have examined birds from 214 outbreaks. The diagnosis commonly made in the field is on the basis of clinical paralysis. However, this is very likely to lead to error due to the fact that there are numerous other causes of paralysis. A positive diagnosis can be made only by laboratory examination and the demonstration of the peculiar cellular infiltration of the nervous tissue.

A study has been made for the past year on the types of paratyphoid bacteria present in the intestine of the chicken. The birds under observation are obtained from the poultry clinic at this college. Some of the organisms that it is desired to study are important poultry pathogens, while others are im-

portant in so-called food poisoning outbreaks of man. It is believed that a survey to determine their distribution in nature is important.

The problem was divided into two phases, one dealing with the preparation of a selective medium for the rapid isolation of such organisms, and the second a routine study of the organisms isolated. Three important groups of bacteria have been encountered. The most prevalent is the *S. aertrycke* type, which constitute nearly half the strains studied; the second an *S. paratyphi* type which is less prevalent, and a group of the so-called "slow lactose-fermenters" which perhaps belong to the colon group but which manifest many of the characters of the paratyphoid bacteria until they have been incubated for several days. This group constitutes a serious source of error in this type of investigation.

[Project 85; Department of Bacteriology. Leaders, L. D. Bushnell and C. A. Brandy; state fund.]

Parasitological Investigations.—During the past biennium the work has consisted of studies on four phases of the problems as follows:

1. *Studies on the Life Cycle of the Chicken Tapeworm (Raillietina cest icillus).*— A new intermediate host for the chicken tapeworm *Raillietina cest icillus* was found. The new host is a small black ground beetle *Amara basil laris* Say, an insect of wide distribution. Mature eggs of the fowl tapeworm, *Taillietina cest icillus*, fed to the ground beetles, *Amara basil laris* Say, developed into mature cysticeroids in 16 to 18 days. When these cysticeroids were fed to young chickens raised in confinement they developed into the adult tapeworms in 16 days. The control chickens kept in the same pen were without worms. From the work on this project another intermediate host is added for *Raillietina cest icillus* and the cysticeroid is described for the first time in this country.

2. *Study and Identification of a New Species of Nematode from the Domestic Cat at Manhattan, Kan.*— Twenty-three mature nematodes attached to the lining of the stomach and duodenum were taken from a domestic cat at Manhattan, Kan. They closely resembled superficially the common roundworm of the cat, but upon close examination were found to be a new species to which the name *Physaloptera felidis* Ackert has been given. Examination of the literature shows that this is the first record of a *Physaloptera* from the domestic cat in North America. The nematodes which are equipped with teeth and a large adhesive collar are probably detrimental to the host. The life cycle is unknown, but such nematodes normally require an invertebrate in which to grow the larval stage.

3. *Determination of a Safe and Efficient Dose of Carbon Tetrachloride for the Removal of the Large Roundworm, Ascaridia lineata (Schneider) from Growing Chickens.*— In connection with experiments on the resistance of chickens to *Ascaridia lineata* it was necessary to remove all the worms from the chickens. After some experimentation, it was found that carbon tetrachloride administered to chickens in gelatin capsules at the rate of 4 c.c. per kilo of chicken body weight was almost 100 percent effective. The administration of this anthelmintic, however, was found to seriously reduce egg production of pullets for a period of from seven to ten days following the administration of the drug. The results of the experiment also showed that carbon tetrachloride cannot be used at the dose rate of 10 c.c. per kilo of body weight as had been advocated. At that dose rate, 25 percent of the chickens treated died and all other birds were seriously affected.

4. *Studies in the Nutrition of Ascaridia lineata.*— A review of the literature including several foreign monographs on the physiology of the ascarids of man and domestic animals gave no conclusive evidence of the means by which these parasites obtain their food nor of the nature of the food they consume. Preliminary and regular experiments have been carried on here to ascertain the

method of nutrition of the fowl ascarid. *Ascaridia lineata*. The principal method of attack has been to parasitize chickens of the same age by giving them the same number of *A. lineata* eggs. After a week or more the chickens are divided into two groups, one to be nourished by intramuscular injections of glucose solutions, and the other group to be fed on regular rations. The results of experiments upon 141 chickens showed that during the first 18 days there was little difference between the groups in numbers of worms or their growth, but after this period when the worms have withdrawn from the intestinal wall into the gut lumen, the worms from the normally fed chickens were more numerous and longer than those from the fowls that received their nourishment by intramuscular injections of glucose. This indicates that these nematodes normally take some of the chicken's digested or partially digested food.

[Project 79; Department of Zoology. Leader, J. E. Ackert; Adams fund.]

Resistance of Chickens to Parasitism.— Three phases of this project have been actively carried on during the past biennium as follows:

1. *Studies on the Comparative Resistance of Four Breeds of Chickens and Two Varieties of a Fifth Breed to the Nematode Ascaridia lineata* (Schneider).—Evidence was presented for the first time on different degrees of resistance among breeds and varieties of one species to the same helminth. The data supporting the conclusions were derived from experiments on 1,351 chickens of four breeds and two varieties of a fifth breed given the same number of eggs from the nematode *Ascaridia lineata* (Schneider). The criteria for judging the resistance were the average number and length of the *Ascaridia lineata* from each group of chickens under comparison. Most resistant to the parasites were the heavy breeds and varieties; Rhode Island Reds, White Plymouth Rocks, and Barred Plymouth Rocks; the more susceptible were the White Leghorns, Buff Orpingtons, and White Minorcas. Factors in the differences in resistance appear to include greater utilization of nervous energy by the most susceptible breed, possible differences in strains within a breed, and the normality or tolerance of the host breeds. Very definite development of increased resistance to the worms developed in all the breeds and varieties of the chickens as they grew older. Chicks examined when about a month (33 days) of age had from four to nine times as many worms as did chickens on the same rations examined when about two months (65 days) of age. When more than two months of age the chickens which had been fed 50 embryonated eggs averaged not over two worms per bird. These results support the earlier findings, namely, that chickens kept free from worms until they were approximately 10 weeks of age may swallow considerable numbers of the eggs of this nematode without suffering therefrom.

2. *The Comparative Resistance of Two Strains of White Minorca Chickens to the Intestinal Nematode, Ascaridia lineata*.— The results of two tests on the resistance of 187 chickens to the intestinal nematode, *Ascaridia lineata* (Schneider), in 1932-'33 showed that White Minorca chickens were significantly more resistant to the growth of the *A. lineata* than were White Leghorn chickens. For example, the worms in the Minorcas averaged 19.03 mm. in length and those in Leghorns 23.83 mm., a difference of 4.80 mm. which was 9.72 times the probable error. On the other hand the results of two tests on 178 chickens during the following year showed that the White Minorcas from the same flock were significantly less resistant to the *A. lineata* than were the White Leghorns also from the same flock as before. Worms averaging 23.74 mm. occurred in the Minorcas and those averaging 20 mm. in the Leghorns, a difference of 3.74, which was 4.37 times the probable error.

Comparisons of the weights of the chickens showed that those of the Leghorns had remained approximately the same whereas the weights of the Minorcas showed those of 1932-'33 to be much heavier than the more suscep-

tible ones of 1933-'34. In fact, when the weights were examined, the first-year Minorcas averaged 523 grams and the second-year ones 373 grams. The only change in the White Minorca flock, according to the owner, was that new cockerels were provided for the second year. Whether or not the progeny from these two flocks can be considered as different strains, they do have different genetic constitutions and as the evidence indicates the first-year progeny were heavier and more resistant to the *A. lineata* than were the second progeny.

3. *Investigations on Resistant and Susceptible Strains of White Leghorn Chickens to the Viability and Growth of the Nematode, Ascaridia lineata (Schneider).*— In July, 1933, a group of chickens rather resistant to *Ascaridia lineata* was obtained. Several females and a male were grown to maturity and the resistance of their offspring compared with that of chicks of the same ages from the College Poultry Farm flock and from a local commercial flock. In each of these tests the offspring of the resistant group were more resistant to the viability and the growth of the *A. lineata* than were the offspring of either the College or of the local commercial flock.

Comparisons were then begun between the resistant group and a susceptible group secured from the local commercial flock. For the last two years, tests have been made on the F1 and F2 generations of the resistant and of the susceptible groups. In the F1 generation, tests on 110 chickens from the resistant group gave an average number of 2.6 worms per bird and an average length of 16.9 mm. Those from the susceptible group averaged 3.7 worms per bird and 20.5 mm. in length, showing that in both numbers and length of worms the F1 generation chickens from the resistant group were markedly more resistant than were the F1 generation fowls from the susceptible group.

The result of the experiments with the F2 generations follow: 133 chickens from the resistant group averaged 7.6 worms per bird with an average length of 25.27 mm. Ninety-nine chickens from the susceptible group averaged 12.5 worms per bird with an average worm length of 24.38 mm. From these results it is seen that the F2 generation of the resistant group had markedly fewer worms than did those from the susceptible group, while the growth of the worms in the two groups was about the same.

[Project 169; Department of Zoology. 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 the rural home have been conducted during the past biennium. Brief statements of the work done are given below.

Vitamin Content of Foods in Relation to Human Nutrition.

Three phases of work under this project have been studied during the biennium as follows:

1. *A Study of the Vitamin A Content of Selections of Yellow Corn.*— Co-operating with the Department of Agronomy, the vitamin A content of a promising Kansas selection of yellow corn has been studied, comparing it with a standard yellow corn and a standard white corn. The single-feeding method of Sherman and Todhunter has been used, each rat of the matched lots receiving a 20-gram portion of the ground corn, at the end of the customary depletion period. Negative control animals, receiving the vitamin A-free diet alone, have been fed. The positive control animals received single feedings of carotene. The new Kansas selection appears to be similar in vitamin A content to the standard yellow corn.

2. *A Study of Bean Sprouts as a Source of Vitamin C.*— Bean sprouts have been studied as sources of vitamin C. Several varieties of beans were ger-

minated in the laboratory and the sprouts, both raw and cooked, tested for palatability and also for ascorbic acid (vitamin C) content. A. K. soybeans and Mung beans (imported from China) produced the most satisfactory sprouts under the conditions of the laboratory. The sprouts of Blackeye cowpeas contained 0.22 mg. ascorbic acid per gram of raw sprouts, Red Kidney or haircot bean sprouts contained 0.18 mg. per gram and the sprouts of Mung beans and A. K. soybeans contained 0.17 and 0.13 mg. ascorbic acid per gram, respectively.

Bean sprouts cooked 3 minutes lost at least one fourth of the vitamin C content, with additional losses as cooking time was increased. The judges preferred the sprouts cooked 3 minutes and commented that the flavor of the raw sprouts was strong.

It appears that bean sprouts could be used as inexpensive sources of vitamin C. One cent's worth of dry Mung beans, at 15 cents per pound, would, when sprouted, produce 20 mg. of ascorbic acid equivalent in vitamin C content to 35 grams of lemon juice; while the same sum spent for A. K. soybeans at 2 cents per pound, would produce 71 mg. ascorbic acid equivalent in vitamin C content to 125 grams of lemon juice.

3. *A Study of the Vitamin A and C Content of the Milk of Dairy Cows Maintained Under Conditions Practiced in Kansas.*— Biological assay of the vitamin A potency of colostrum and milk of individual cows of the College dairy herd shows that the secretions of the first or second day were richest, from 8 to 19 times as potent as the milk produced later in the month. By the fourth day of lactation there was a considerable drop in the vitamin A activity per gram of sample with a further decrease by the seventh day. In general, the vitamin A content of the milk remained much the same from the seventh day until the end of the month. The richest samples of colostrum contained 25.5 and 27.4 International Units per gram while another sample tested only 8.8 International Units per gram. Several of the samples of milk contained about two International Units per gram while the least potent sample tested showed 1.4 per gram. Comparisons were also made on the basis of the vitamin A produced by a cow in one day. For each of the cows, the largest total output of vitamin A for one day was on the first or second day of lactation. The total daily outputs of vitamin A were distinctly lower by the fourth day of lactation and were near the same level for the remainder of the first month.

Biological assay of vitamin A potency is now being supplemented by chemical and physical methods developed for determining separately the vitamin A content and also the content of carotene, a precursor of vitamin A. The methods are now being applied to samples of butter prepared from colostrum and milk collected at definite intervals.

Determination of vitamin G (flavin) by the rat growth method shows that colostrum is distinctly richer than later milk. Milk produced on the fifth day of lactation is about twice as rich as the milk produced at the end of the first month of lactation and first day colostrum is approximately three times as potent as the milk of the same cow at the end of the first month. The vitamin G content of milk produced at the end of the first month of lactation resembled that of the composite college herd milk. Calculated total daily yields of vitamin G for the first day of lactation were similar for the cows studied. Total daily yields of vitamin G at least doubled or tripled by the fifth day of lactation and remained at about this same level at the end of the first month. This finding is in marked contrast to that for vitamin A, for total vitamin A yields were highest on the first or second day of lactation, with a rapid decrease to a lower level maintained throughout the first month of lactation.

[Project 158; Department of Home Economics. Leader, Martha M. Kramer; Purnell fund.]

The Utilization of Calcium and Phosphorus from Various Forms of Milk and Milk Products.— The work of the biennium has consisted of a study of the relation of the consumption of milk and milk products to the intake of protein, calcium, and phosphorus, as indicated by output. Young women, college students, have served as subjects for this study. Nitrogen, calcium, and phosphorus outputs of these subjects were determined to indicate protein, calcium, and phosphorus intakes (1) when the subjects were eating freely chosen diets; (2) diets with milk and cheese omitted, and (3) diets free of high-protein foods of animal origin. The subjects were to eat other foods desired and were urged to eat foods high in calcium and phosphorus.

Samples have been collected, analyses made, and results of analyses assembled and evaluated. With freely chosen diets, some subjects had figures for intake which were below the desired standards, suggesting that many were consuming less protein than is often advised and that some subjects were using insufficient high-calcium and high-phosphorus foods. The withdrawal of milk lowered the protein figures somewhat but had a more marked effect upon the calcium and phosphorus intakes, indicating that these college students are unlikely to meet calcium and phosphorus standards when milk is omitted. Calcium and phosphorus intakes became even more subnormal when all high-protein foods of animal origin were removed. As might have been anticipated, protein and phosphorus were more effected than was the calcium, this having already been reduced by the withdrawal of the milk. This project is to be discontinued.

[Project 159; Department of Home Economics. Leader, Martha M. Kramer; Purnell fund.]

An Investigation of the Effect Upon the Animal Body of Varying the Amount of Vitamins in the Diet.— The work during the biennium has been confined to an investigation of the effect upon the animal body of varying the amount of vitamin C in the diet. The first work undertaken was a study of the effects of vitamin C deficiency upon female guinea pigs. The Sherman, LaMer, and Campbell vitamin-C-free diet was used, with filter paper for additional roughage. Greens were given to the positive control animals and orange juice to the experimental animals as supplement.

Investigation is now in progress to determine the effect upon the female guinea pig of varying the amount of vitamin C in the diet, with special reference to reproduction and the development of the embryo. The growth of the animals, the vitamin C content of tissues, and the structure of the teeth are also receiving attention. Growth and reproduction are seriously interfered with unless the vitamin-C-free diet is generously supplemented. Neither 5 c. c. nor 10 c. c. orange juice per 300 grams of body weight (given by pipette) was adequate supplement for pregnant animals. Supplements usually considered adequate are apparently less than optimum, as they produced subnormal growth and reproduction.

The direct titration method of Bessey and King is used for estimating the vitamin C content of tissues of animals of these experiments. The kidneys of these animals showed distinct increase in ascorbic acid content with the amount of orange juice fed. In the case of the hearts there appeared to be little variation due to supplements here used. The adrenal showed marked variation. The average ascorbic acid content, in mg. per gram, for the young animals on the smallest amount of orange juice, the 5 c. c. portion, was a little over half

the Bessey and King figure for normal guinea pigs. The larger portions of orange juice brought distinct increases in the vitamin C content of the adrenal. No animal of these series had in the organs studied sufficient vitamin C to be regarded as a reserve store. It is suggested, however, that the ascorbic acid content of the tissues, particularly of the adrenal, may increase with increased well-being of the young animals receiving supplements above the recognized protective portion.

A diet supplying as much as 1 c. c. orange juice per 100 grams of body weight per day appears to be insufficient for reproduction although various workers have reported that this amount of antiscorbutic is enough to provide adequately for the vitamin C requirements of the guinea pig. Animals now being studied receive a vitamin-C-free diet, amply supplemented with vitamin C, until they reach the age of two weeks, one month, two months, or three months. At each of the age levels indicated, some animals are killed as controls, some are maintained on the basal diet as negative controls, and others are given the basal diet with an additional supplement of 1 c. c. orange juice per 100 grams of body weight and are so maintained for one, two, or three months. Effort has been made to secure pregnancy at this level of vitamin C intake, but this is difficult. At the end of the experiment, tissues are retained for examination. The teeth are particularly valuable for study as vitamin C deficiency produces abnormal structures.

[Project 188; Department of Home Economics. Leader, Martha M. Kramer; Purnell fund.]

A Study of Factors Affecting the Service Qualities of Certain Textile Fabrics.— Five phases of this project were studied during the biennium as follows:

1. *The Effect of Light of Different Wave Lengths on Service Qualities of Unweighted and Weighted Silks.*— An undyed, unweighted silk crepe and portions of this crepe which were weighted to 35 percent and 60 percent by the tin-phosphate-silicate method and to approximately 50 percent by the tin-lead method by the United Piece Dye Works were used. Physical measurements, such as thread count, tensile strength, stretch, weight per square yard, thickness, set, covering, and power, were made for each fabric. Effective thickness was measured with the Randall-Stickney thickness gauge and body or gross thickness with a microscope.

Measurements of yarn diameter and set indicate that the kind and amount of weighting cause variations in covering power and thread count. Specimens of the unweighted and weighted silks were exposed to the entire spectrum of an S-1 sun lamp and to limited regions of the spectrum. Glass filters were used to eliminate undesired rays. Tensile strengths of specimens before and after exposure to light rays were used as indicators of changes in the silks. X-ray diffraction patterns of the silks were studied also. Lead-weighted silk gave a typical powder pattern; 50 percent tin-weighted silks showed slight evidence of fibering; 43 percent tin-weighted gave a much stronger fiber pattern. Diagrams of the unweighted silk before exposure to the light source and after exposure to the entire spectrum appear similar, but photometric analysis indicated that exposure of silk to light results in a decrease in fiber orientation, causing the long fiber arc to expand toward the character of a powder pattern.

2. *A Study of Service Qualities of Fabrics as Affected by Laundering.*— Six popular brands of unbleached and of bleached sheeting were chosen for this study. Portions of each fabric were laundered 20 times in an electric machine, agitator type, and pressed in a mangle. The hardness of the water and the temperature of suds and rinse waters were carefully regulated. With one exception, six ounces of ivory soap flakes dissolved in eight gallons of water was used in the machine. Before each laundering, lengths of the brown sheetings were treated with bleaching agents. These applications were repeated until the fabric attained the same whiteness as the commercially bleached material—the degree of whiteness being measured with a Bausch and Lomb color an-

alyzer. In one series of 20 washings Oxydol was substituted for ivory flakes. Tensile strength, stretch, thread count, effective and gross thickness, weight per square yard, and whiteness were determined before laundering, after one, and after 20 launderings. Data obtained indicate that:

a. Thread count increased after the first laundering.

b. Effective thickness, measured by the Randall-Stickney thickness gauge, was greatest after the first laundering, then gradually decreased with repeated launderings with soap alone or with bleaching agents and soap.

c. The first laundering caused a loss in breaking strength, greater loss occurring in bleached than in unbleached fabrics.

d. After 20 launderings the unbleached fabrics were stronger than the bleached ones. Unbleached fabrics which were bleached and laundered registered approximately the same breaking strength as commercially bleached fabrics of the same brand.

3. *Comparison of Blanket Materials.*— During the past biennium the following articles including data on this project have been published: "Blankets Worth Their Weight in Wool," *Christian Science Monitor*, August 10, 1934; and "Blanket Weakness Shown by Analysis," *Laundry Age*, January, 1935. Work is progressing on a popular bulletin which will include the results of this study.

4. *A Study of the Service Qualities of Fabrics as Affected by Laundering.*— The purpose of this study was to determine the effect, on certain cotton textiles, of variations in methods of laundering by power and home laundries. Work already completed on this problem included a comparison of the effect on certain cotton textiles of one power and one home laundry. The percentage loss in strength and loss and change of color were the means of comparison. Johnson's test of 20 launderings was used, a loss of less than 10 percent in tensile strength for 20 launderings serving as a standard for efficient laundering. A summary of results indicated that, in three fourths of all specimens, home methods caused a greater loss in strength than power methods. Six cotton fabrics, all in plain colors, were selected for further testing. The results of this work are similar to those of the first part of the study. The figures indicate that clothes sent to the power laundry would not wear out more rapidly than those laundered at home. The power laundries handled the white clothes more satisfactorily than the home laundries but they caused a greater change in the colored fabrics as shown by visual tests.

5. *A Comparison of the Absorptive Qualities of Certain Fabrics.*— Seven types of Terry-woven towels have been studied and compared. It is hoped that the results of such study will determine the structure of Terry fabric best suited for use as toweling. The important items being studied are the breaking strength of the ground and the pile; the weight of the fabric; the structure including the weave of the ground, number of picks and ends, single or double loop, length of loop, number of filling for each loop and method by which loop is held in ground; the rate and amount of absorption; and the resistance of the loop to being pulled out of the cloth. Preliminary work has been done on resistance of the loop to pull but so far these data have not been analyzed.

The following articles, including preliminary work done on this project have been published: "The Determination of Absorption of Water by Fabrics," *American Dyestuff Reporter*, December 31, 1934; "Speedy and Accurate Weighing," *Journal of Home Economics*, February, 1935.

[Project 161; Department of Home Economics. Leaders, Esther Bruner, Katharine Hess, and Alpha Latzke; Purnell fund.]

A Comparison of Cooking Equipment for the Farm Home.

— The purpose of the experiment this year was to obtain information concerning efficiencies and temperature distribution of heat with regard to star-shaped giant burners by varying the total port areas and redistributing the individual flames. The giant burner used for tests contained 52 open ports. Tests were

made by using the burner with 52, 44, 36, and 28 ports open and by closing the others. The results showed that, when using gas at 8 and 11 cubic feet per hour, a greater thermal efficiency was obtained with the fewer number of ports open, and that less time was required to heat the water used for making the tests. Other correlations are being made.

A direct heated oven was tested for efficiency, heat distribution, and recovery of normal temperature after opening the door at stated intervals when loaded with 54 pounds of sand. The thermal efficiencies were greater when the oven contained larger loads than the smaller ones. The time for recovery of normal closed-door temperature was more rapid when the door was open for short periods of time than the longer ones, and the amount of gas required when the door was opened short periods of time. Data on effect of drop in temperature with regard to various loads have not been correlated. Tests on indirect heated ovens have been reported previous years. Data from these tests are being studied and prepared for publication. The project will be terminated.

[Project 174; Department of Home Economics. Leader, Mary F. Taylor; Purnell fund.]

A Study of Factors Affecting the Expenditures for Family Living of Kansas Farm Families.— This study started this year is based on the expenditures of farm families that were members of the Farm Bureau-Farm and Home Management Association in Kansas in 1934 and 1935. The data from 87 home account books in 1934 and 144 home account books in 1935 have been tabulated and are in the process of analysis.

[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 the work 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 cooperative assistance is obtained at the Fort Hays branch station from the following agencies of the United States Department of Agriculture: Forest Services 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 Engineering with wheat siorage problems.

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, 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, consisting of an area of 3,440 acres, was established on the old Fort Hays Military Reservation by legislative enactment in 1901. Approximately 2,000 acres are under cultivation, the remainder being pasture, campus, feed lots, and roads. The station is equipped to conduct experimental work with soils, crops, livestock forestry, and horticulture. Brief statements about the more important projects follow:

Dry Land Agriculture.—The tillage and rotation work was conducted in cooperation with the Division of Dry Land Agriculture of the Bureau of Plant Industry, United States Department of Agriculture. Investigations consisted largely of a continuation of experiments in methods of production of the principal crops adapted to this section. The work includes: Continuous cropping, using numerous methods of seedbed preparation; alternate cropping with fallow; rotations of crops; alfalfa and brome grass as sod crops in rotation; green-manure crops, barnyard manure, and commercial fertilizers; various width of row spacing for the production of row crops in rotation; the effect upon the crop resulting from stover of the previous crops being left on the ground; the effect of different tillage machines when used for the first operation in the preparation of a seedbed for wheat; the effect of the use of different types of drills on the yield of wheat; the effect of various methods and amounts of work on fallow and of chiseling, deep plowing, dynamiting, and subsoiling upon yields; the effect of timely tillage upon the storage of moisture in the soil and resultant yields; of various methods and amounts of tillage upon the storage of moisture in the soil; of various methods of seedbed preparation upon the development of nitrates in the soil; and of tillage methods and crop rotations on the protein content of wheat.

Bulletin 273 recently published by the station is a treatise on "Soil Moisture and Winter Wheat with Suggestions on Abandonment," which incorporates much of the information obtained from soil moisture investigations carried on at this station for the past 25 years. These results show that the amount of moisture in the soil at seeding time determines very largely the yield of wheat that can be expected at the next harvest.

Although soil moisture studies show that there has been sufficient precipitation in most years at the Fort Hays station to permit the storage of enough water in the soil to carry a crop through frequent periodical droughts, the prolonged drought of 1934 and 1935 was entirely too severe to provide sufficient water for storage by the most efficient tillage methods to enable crops to grow to maturity. The only plot on this project to mature a crop in 1935 was one which had been fallowed for three years in succession, that is 1932, 1933, and 1934. This plot produced 23 bushels of wheat per acre and soil moisture studies indicated that this crop actually used stored water to a depth of and including the ninth foot. This illustrates the great depth to which winter wheat roots can penetrate the soil for water. Wheat grown on a similar plot in 1934 also utilized stored water down to and including the ninth foot. [A. L. Hallsted, in charge.]

Cereal Investigations.— These investigations were conducted in cooperation with the Division of Cereal Crops and Diseases, Bureau of Plant Industry, United States Department of Agriculture. The object of these investigations is to improve the quality of the sorghum and cereal crops and assist in the development of better methods of producing these crops through time and rate

of planting experiments, varietal tests, hybridization, and selection. Results obtained from a rate and date of seeding experiment with four varieties of winter wheats indicate that date of planting has a greater influence on yield than varietal differences in the length of growing season. The varieties under investigation listed in Table V in order given, range in maturity from extremely early to late. The average yields in bushels per acre were obtained for the four-year period, 1932 to 1935, inclusive.

TABLE Y.—YIELD OF FOUR VARIETIES OF WINTER WHEAT SEEDED AT WEEKLY INTERVALS IN A DATE OF SEEDING EXPERIMENT

VARIETY	September.				October.		
	8	15	22	29	6	13	20
Early Blackhull	8 9	13 7	16.4	17 6	19 6	18.6	16 4
Quivira. . .	11.0	14 3	15.8	14.9	18 4	18 6	17.4
Kanred. . . .	12.7	15.2	16.7	17.4	19.9	19.8	17 0
Oro.	14 4	15 6	16.9	17.7	18.2	18.0	16.3

The low yield of Early Blackhull on September 8 was due to failure of the variety in 1932 to survive a fall drought after emergence, whereas the other three varieties did not germinate until after late rains. The peculiar seasonal conditions which prevailed during the fall preceding the 1932 crop demonstrated that some varieties of wheat can germinate at a lower soil moisture content than others. The continued drought of 1934 and 1935 greatly retarded all progress in hybridization and selection work.

Work is now progressing on material obtained from a cross between smooth-awned Flynn barley and the stiff-strawed Vaughn barley from which it is hoped to secure a selection embracing all the good qualities of the Flynn and the stiff straw of the Vaughn in order that a more desirable variety for harvesting with the combine may be made available.

The production of an early white seeded juicy forage sorghum for the northern sorghum belt is now in process of development, with Leoti red used freely as one of the parents. The Leoti red has an attractive appearance, is resistant to the red-leaf blotching while the stalks are among the sweetest and juiciest known. Leoti red, however, is susceptible to kernel and head smuts. A Leoti red-feterita cross has given white seeded strains highly resistant to the above smuts and the strains have juicy stalks. For grain-sorghum production selections from two crosses: Day mile, Club and Club X (Backcross) are being extensively tested for types suitable to combine methods of harvesting. Strains having earliness, dwarfness and grain with either the yellow or white color are sought. The cross, Weskan X Greeley, received as F material from the Kansas station, offers possibilities for an improved early grain sorghum for the northern sorghum belt. [A. F. Swanson, in charge.]

Bindweed Control Investigations.— This project was started July 1, 1935, in cooperation with the Division of Cereal Crops and Diseases of the United States Department of Agriculture on a 90-acre tract of land which the station has leased from the Fort Hays Kansas State College. The experiments now under way include: (1) Time of beginning fallow; (2) frequency of cultivation; (3) depth of cultivation; (4) competitive and smother crops; (5) time of applying sodium chlorate, dry; (6) methods of applying sodium chlorate, dry; (7) rate of applying sodium chlorate, dry; (8) time and rate of applying sodium chlorate spray in comparison with dry applications; (9) the effect of chlorate on succeeding crops; (10) the effect of bindweed on the yield of different crops, and (11) the trend of food reserves in bindweed roots in untreated areas and under different treatments.

The plan is to establish a new set of treatments each year for a period of years under each experiment. This should give the information necessary for determining the relation of seasonal differences to the effectiveness of the various control methods. Each set of experiments will be carried to completion, which in some cases will probably require three or four years. Emphasis will be placed on the fundamental phases of the problem such as physiological, soil, and climatic relationships involved, in order that the results secured will be better understood and can be applied to different sets of conditions. Other phases of the problem which will be studied include: (1) The rate of spread of bindweed patches, (2) the relation of the size and age of bindweed patches to the difficulty with which they are eradicated, (3) the effectiveness of other chemicals than sodium chlorate, and (4) the various angles of the bindweed seed and seedling problem. [F. L. Timmons, in charge.]

Forage Crops Investigations— These studies are conducted in cooperation with the Division of Forage Crops and Diseases, Bureau of Plant Industry, United States Department of Agriculture. Early in the biennium the studies were mainly concerned with testing and developing improved strains and methods of establishing or producing forage sorghums, sweet clover, alfalfa, and grasses. During the latter part of the biennium major attention has been directed to selecting and testing domestic and imported grasses, perfecting methods for establishing them, and studying the effect of drought and grazing on native grasses on different types of soil in western Kansas.

Results of these investigations indicate that even the most hardy native grasses have suffered severe injury from a combination of severe drought, intense heat, soil blowing, and close grazing. Buffalo grass and blue grama escaped with the least injury among the native species. Grazing, unless carried to drastic extremes or accompanied by severe and prolonged drought, appeared to favor the spread of buffalo grass by eliminating or reducing the competitive effect of the taller and less hardy species.

The indications are that cultivated land may be satisfactorily reestablished with native grass by a combination of transplantings and reseedings. Further evidence was obtained in substantiation of previously reported results in successfully reestablishing buffalo grass by transplanting methods. Sods dropped onto the surface of deeply cultivated land and pressed into the soil with a heavily weighted packer during the hottest and driest part of 1934 have successfully withstood adverse conditions and spread an average distance of 18 inches from the original clump. Transplanting small pieces of sod in this manner at wide intervals was done in a practical manner without much expense except for labor. This provides a basis for an ultimate cover of the best adapted grass available.

After transplanting and packing, the land is in excellent condition for re-seeding blue grama and western wheat grass, which supply some pasturage and protective cover while the widespaced buffalo grass sods are slowly spreading. Many promising selections of native and introduced grasses have been made. These include *Agropyron pungens*, *A. semicostatum*, *A. Sibericum*, *A. smithii*, *Bromus erectus*, *Bouteloua gracilis*, and *Panicum virgatum*.

Several new and promising strains of sweet clover were included among a comprehensive list of selections and introductions. Those which have been under test long enough to merit special consideration include Madrid White, Madrid Yellow, Chantlands, Downs, Madison County, Redfield, Siberial, and Alpha. Seed of these new strains is not yet available for distribution.

Alfalfa has been successfully reestablished on bottom land by fallowing long enough in advance to completely replenish the subsoil moisture, and seeding in August at the rate of 12 to 15 pounds to the acre on well prepared and firmly packed seedbed. Fall seedings on fallow have been equally successful and decidedly more productive than spring seedings on fallow. [D. A. Savage, in charge.]

Soil Erosion and Water Conservation Investigations.— Investigations in soil erosion and water conservation which were formerly carried in cooperation

with the Bureau of Chemistry and Soils and the Bureau of Agricultural Engineering, United States Department of Agriculture, were transferred on April 1, 1935, to the Soil Conservation Service, United States Department of Agriculture. The nature of the work was not altered by the transfer from one bureau to the other.

These studies consist of comprehensive and detailed measurement under carefully controlled conditions of soil and water losses from terraced and unterraced land having different degree of slope and upon which various tillage and cropping systems are being employed. In connection with the above studies, much time and effort have been given towards the development of an attachment for a lister, which will make dams in lister furrows. Such an attachment which does a very creditable job of making dams has recently been perfected by this station. A limited amount of work has also been done on the development of a pasture-contouring machine. As an additional check on the efficiency of the different practices in conserving soil and water, an intense soil moisture penetration study has been conducted on all conditions represented in the work.

Results obtained in 1935 showed unusually high loss of both soil and water from pasture land. The chief cause of these abnormal losses was the silting in and sealing over of the grass land by wind-blown material deposited from dust storms in March and April. Soil and water losses were approximately four times and 21 times greater, respectively, in 1935 than for the average of the five preceding years. Results also indicate that soil and water losses from land with no cover were 50 and 600 percent greater, respectively, as compared with land cropped continuously to wheat. Losses from wheat land were 700 and 300 percent greater for soil and water, respectively, when compared with closely clipped buffalo grass. These results show convincingly the value of a good permanent vegetative cover in conserving soil and water.

Results obtained thus far from terraced crop land indicate that level terraces on the heavy soils common in this region tend to impound water, which results in some loss of crops in the basins and prevents tillage when other parts of the field can be tilled. Short terraces with a uniform grade, and long terraces with a variable grade, with the maximum not exceeding 5 inches, have proved most satisfactory. The lowest soil and water losses have resulted from terraces having a uniform grade of 4-inch fall per 100 feet and a vertical spacing of 3 feet. With the use of the basin lister attachment, where rows are on the contour, it has been found possible to retain on the land all of the water that fell during a 3-inch rain, with 1 inch of the rain falling in 30 minutes. No water has been lost from land tilled in this manner during a period of two years that this implement has been used. [F. G. Ackerman, in charge.]

State Forest Nursery.— The work for the biennium has been a continuation of the work of previous years in the experimental planting of new untried varieties of shrubs, ornamental, and forest and tree fruits; and in the propagation and distribution of hardy types adapted to western Kansas conditions. Coöperative work with the Cheyenne Horticultural Field Stations, Cheyenne, Wyo., for the trial of many new species of trees and ornamental shrubs was started in 1935 with plans made to expand this work each year. Coöperative relationship was also carried on with the Southern Great Plains Field Station at Woodward, Okla., in the planting of introductory material and in the study of causes and effects of chlorosis in horticultural plants.

The number of ornamental trees and shrubs sold in the spring of 1935 was 11,392 units, going to 5.5 counties. In the spring of 1936, 11,897 units were distributed in 55 counties. In the forest seedling service, 79,897 units were distributed in 74 counties in 1935. In 1936, 91,680 forest tree seedlings were distributed in 64 counties. The distribution of forest tree seedlings is carried out in cooperation with the Forest Service of the United States Department of Agriculture. The addition of an extension forester to the staff at Kansas State College aided in the distribution of seedling nursery stock to farmers in 1936. Conditions in western Kansas were unfavorable for planting nursery stock in 1935 and 1936, but there was much interest despite the drought.

The vineyard, demonstration cherry and plum orchards, and the testing blocks of trees and shrubs were maintained as in previous years. A total of 482 kinds of trees and shrubs were under observation in the testing blocks.

Opportunity was afforded to gather notes on the effects of the most prolonged drought in the experience of Kansas agriculture. Notes and tabulations on the reactions of various species to drought and dust were recorded. The irrigation system installed in 1932 and extended in 1935 to cover the entire nursery prevented the loss of thousands of trees and shrubs during the drought seasons of 1934 and 1935.

A commercial cherry crop was produced in the terraced farm orchard in 1935 and was readily disposed of to focal purchasers. The 1936 crop was practically destroyed by late spring freezes. The drought caused the loss of most of the cherry and plum trees set out on land above the top terraces, but all trees below the level terraces on land approximating a 10-percent slope are in a healthy, vigorous condition, indicating that the rainfall caught and held by the level terraces has penetrated deeply into the soil and is benefiting tree growth. [Fred P. Eshbaugh, in charge.]

Beef Cattle Feeding Investigations.— The beef cattle feeding investigations, as usual, were concerned largely with the utilization of western Kansas feeds for the maintenance of beef cattle. The drought of 1934 brought on a shortage of roughage, making it necessary to supplement home-grown feeds with shipped-in feeds of various kinds. Russian thistles were available in large quantity in western Kansas, thereby making it possible to carry on investigations with Russian thistles in various forms and in comparison with and supplementary to sorghums in various forms.

The results of the 1934-'35 feeding experiments emphasize the fact that ground, more or less mature, Russian thistle hay supplemented with 1 pound of cottonseed cake per head daily will bring calves through the winter in a satisfactory condition and that the same kind of ground Russian thistle hay without cottonseed cake is not a satisfactory wintering ration for stock cattle. Ground Russian thistle hay proved to be worth considerably more than Russian thistle silage, when each was supplemented with cottonseed cake, as a roughage for stock cattle.

Kafir fodder silage and 1 pound of cottonseed cake produced more than four times as much gain as silage made from Russian thistles supplemented with 1 pound of cottonseed cake. In case of necessity, results indicate that ground Russian thistle hay can replace satisfactorily nearly one half of the full silage allowance in the ration when fed together as a winter ration for stock cattle. Kafir or Atlas sorgho hay produced 30 percent more gain than ground Russian thistle hay when each was fed with 1 pound of cottonseed cake daily. Ground Russian thistle hay plus 4 pounds of blackstrap molasses per head daily is considerably better than ground Russian thistle hay alone, but not so good as the ground thistles supplemented with 1 pound of cottonseed cake per head daily. Ground Russian thistle hay plus 4 pounds of blackstrap molasses and 1 pound of cottonseed cake per head daily is an excellent stock cattle wintering ration. In these experiments no laxative effect was observed in any of the cattle receiving Russian thistles.

Russian thistles should be looked upon as a last resort emergency feed because of their low feeding value, low yield compared to sorghum crops, and high cost of harvesting.

The 1935-'36 feeding experiments were conducted to determine the comparative value of eight protein supplements in stock cattle winter rations. Five heifer calves and five steer calves were used in each lot in this experiment. Each lot received the same kind and amount of silage daily. The protein supplements and amounts fed were as follows: Cottonseed meal, 1 pound; linseed meal, 1 pound; soybean meal, 1 pound; peanut meal, 1 pound; corn gluten meal, 1 pound; tankage, 1 pound; wheat bran, 3 pounds; alfalfa hay, 4 pounds. There were no significant differences between the weight gains of the first six supplements, results from all being very satisfactory, but wheat bran and alfalfa hay were measurably better than the six other supplements used. Four pounds of alfalfa hay proved as valuable as 3 pounds of wheat

bran. The weight gains in the tankage lot were not so great as in the first five lots and not so great as has been obtained in experiments at other stations. The tankage fed in this experiment seemed normal in color, texture, and odor and showed an average tankage analysis. All of these protein supplements were eaten readily by the calves. [L. C. Aicher and C. W. McCampbell, in charge.]

Pure Seed Distribution.— The drought of 1934 seriously handicapped the sorghum seed-producing phase of the station's activities for that season. However, the station had a large reserve of Pink kafir carried over from the previous year's crop and this was quickly distributed. The sorghum distribution embraced 25,752 pounds of Pink kafir and 3,205 pounds of Western Blackhull kafir, with a few experimental shipments of miscellaneous varieties totaling almost 1,000 pounds. Tenmarq wheat again proved in demand and 106,680 pounds, all the seed produced that could be spared, was distributed. Kanred also was distributed, but only to the amount of 30,375 pounds. Flynn, a new smooth-awned barley of good yielding ability, was released for the first time this year. Only 2,008 pounds could be supplied, however. Seed shipments for the 1934-'35 season reached 52 counties, 9 states, and 1 foreign country, and embraced 239 orders.

The season of 1935 was again one of disappointment with all crops excepting alfalfa seed and a small amount of Atlas sorgo, the latter having been produced on a small area which Big Creek flooded when it overflowed its banks during a period of high water in June. There was a tremendous demand for seed, but the station was only able to supply 24,135 pounds of Atlas sorgo. Alfalfa seed sales reached a total of 5,252 pounds, and Flynn barley a total of 6,720 pounds. The two years of drought seriously depleted the seed-wheat reserves of this area and the station was able, because of stored reserves, to supply 790,417 pounds of Kanred in an attempt to meet the demand. This seed as mostly from the 1932 and 1933 crops. The distribution of all seed stocks in the 1935-'36 season reached a total of 826,991 pounds and was distributed in 68 counties, in 11 states, and embraced 468 orders. [L. C. Aicher, in charge.]

GARDEN CITY BRANCH EXPERIMENT STATION

The Garden City Branch Experiment Station contains 320 acres of upland soil and is located five miles northeast of Garden City. The experimental work is divided into two main projects: Dry-land agriculture and irrigation agriculture. Lambs are fed experimentally each winter also.

Dry Land Agriculture.— The Division of Dry Land Agriculture, United States Department of Agriculture, is cooperating with the station in conducting experiments in crop rotation, seedbed preparation, and tillage methods under unirrigated conditions. Many different crop rotations are used in a study of time and method of seedbed preparation, value of summer fallow for both wheat and row crop, and in a study of crop sequence.

The calendar year 1934, with a total precipitation of 7.08 inches, was the driest on record. The year 1935 was but little better, and crops on unirrigated land were a total failure. Available data are little different, therefore, than that given in the biennial report of 1932-'34.

A set of soil boxes 2 1/2 feet by 15 feet have been established for the purpose of studying the rapidity with which moisture penetrates the soil on three different soil types and to study rate and extent of evaporation losses from the same soils. Sandy loam, fine sandy loam, and silt-loam soils are being used in the experiment. Two different soil surfaces—(1) a roughened, corrugated surface that is intended to approximate contour listing, and (2) a comparatively smooth surface to approximate onewayed or lightly harrowed land, are to be maintained for each of the three soil types. It is expected that some valuable information will be secured from this work.

Another experiment inaugurated in cooperation with the Division of Dry Land Agriculture is one designed to study lateral, as well as vertical, root development of Dwarf Yellow milo in rows variously spaced from 44 inches to 16½ feet apart. It is now known that Dwarf Yellow milo in every second- and every third-row plantings can exhaust the available moisture from the intervening areas if necessary, but little is known about the maximum distance to which sorghums can feed laterally.

The work on unirrigated land includes variety testing of corn, sorghums, and small grains and date-of-planting experiments with those crops. A pasture grass project in which numerous varieties were to be planted in an effort to find suitable grasses for reseeding land taken out of cultivation was planned for 1935 and again for the spring of 1936. The dry conditions due to the long continued drought and accompanying dust storms have made it impossible to make the plantings.

Contour listing of native pastures as an aid to natural resetting to grass is being widely advocated by different interests. Check plots embodying different listing and chiseling combinations are being started on experiment station pastures this spring. All old plants of buffalo grass have died during the past two years. Many seedlings came in 1935 but the continued drought killed most of them before the close of the season. A few new seedlings of both buffalo and blue grama are coming this season (1936). [F. A. Wagner and H. J. Haas, in charge.]

Irrigation Agriculture.— Reduction in funds available for station operation beginning in 1932 has necessitated a reduction in the amount of irrigation experimental work that was being carried. Irrigated rotations, rate of watering, and season of watering experiments with alfalfa were among those discontinued. Variety testing work with alfalfa and seed production of varieties showing resistance to bacterial wilt have been materially increased. The fact that irrigation water is available as needed makes this station the most suitable location in the state for alfalfa seed increase work with new strains and selections of which it is desirable to increase seed supplies as rapidly as possible. Bacterial wilt has destroyed stands on thousands of acres of alfalfa in Kansas and surrounding states during the past 10 years and the development of varieties and strains resistant to the disease is the only known means of reducing the losses. That phase of work is, therefore, of more than passing interest since the results being obtained from the cooperative project are of high value, not alone to farmers of western Kansas but to farmers of the entire state of Kansas and, in fact, to growers in most alfalfa producing sections of the United States.

Shoot, crown, and root-rot disease of milo is another major problem that has received intensive study in cooperation with the Division of Cereal Crops and Diseases, United States Department of Agriculture. The problem originated here in 1926, since which time the scope of work has been rapidly increased until during the past two seasons it has been a major problem under irrigation. The disease is 100 percent fatal to Dwarf Yellow milo and to most milo derivatives. The disease is soil borne and is caused by the organism *Pythium arrhenomanes*, isolated and recently identified. Crop rotation and soil treatments have not been effective in controlling the disease and, as with bacterial wilt of alfalfa, the use of resistant varieties and strains is the only definite means of control known at the present time. Resistant strains of Dwarf Yellow milo, Wheatland milo, Beaver milo, and Day milo have been developed at this Station and seed will soon be available for distribution to farmers. These new strains are apparently fully resistant to the disease and can be grown satisfactorily on the most heavily infested soils.

A bluestem grass project is being carried which is of interest to stockmen. When grown under natural conditions bluestem, both big and little, are light seed producers in most seasons. Also, seed that is produced is usually low in vitality so that there is no satisfactory way of propagating these grasses. A few hundred plants of both big and little bluestem were set on irrigated land in 1932 for observation and it was found in 1933 that seed production was

greatly increased when soil moisture conditions were kept at a high level and that the viability of the seed was also greatly improved. Increased plantings were accordingly made in 1934 and the experiment is being continued on an enlarged scale.

Three different pasture-grass mixtures, involving eight varieties of cultivated grasses, were seeded in adjoining areas for demonstrational and experimental purposes in the fall of 1934. The pastures will be grazed by dairy cattle. Soil drifting in from an adjoining farm covered the grasses deeply enough to kill out some of the varieties. *Bromus inermis* was apparently uninjured and show a full stand. There also remains some Kentucky bluegrass and Crested Wheat grass. [F. A. Wagner, in charge.]

Lamb Feeding Investigation.— A double-deck car of lambs has been fed each winter for the past three years. The lambs have been divided into five or six lots for experimental feeding. Feed comparisons have been planned so as to secure information upon the comparative feeding value of alfalfa and Dwarf Yellow milo. Atlas, and sumac roughages either with or without by-products of the sugar beet industry of the Arkansas Valley. Many livestock feeders have felt that corn and alfalfa are necessary in the feed lot. Results thus far obtained in the lamb feeding trials indicate that milo grain is a satisfactory fattening ration and that the sorghum roughages, with ground limestone added, are satisfactory substitutes for alfalfa whenever the price differential justifies their use.

Lambs fed during the winter of 1934-'35 made average gains for the full 120-day period of .28 pound to .37 pound, depending upon feeds used, and they showed a high degree of finish when slaughtered. Lambs fed during the 1935-'36 winter season were on feed for 100 days and averaged from .35 to .44 pound daily gain for the full period. The lambs fed Dwarf Yellow milo grain and alfalfa hay produced gains at a feed cost of \$5.93 a hundredweight; lambs fed milo grain and ground sumac fodder plus ground limestone produced gains at a cost of \$6.18 a hundredweight; and lambs fed milo grain and dried beet pulp in equal amounts and milo fodder produced gains at \$6.03 a hundredweight. All lambs carried satisfactory finish, and sold, at the close of the experiment, at \$9.85 a hundredweight, which was market top for the day at Kansas City. [F. A. Wagner and Rufus F. Cox, in charge.]

COLBY BRANCH EXPERIMENT STATION

The Colby Branch Experiment Station, consisting of 274 acres of land, is located on the west edge of Colby, Thomas county. The work of the station is divided into three major projects: Dry-land agricultural investigations, crop adaptation, and dairy herd improvement. Minor projects consist of variety tests of fruits, shrubs, and trees.

Dry Land Agriculture.— The experimental work in cultural methods in cooperation with the Division of Dry Land Agriculture, United States Department of Agriculture, was continued without change or addition during the biennium. Climatic conditions were so unfavorable in both 1934 and 1935 that practically no crops were produced on this project. Winter wheat failed on all methods in 1935 and the 1936 crop will also be a failure. These two failures will materially reduce the average yield of winter wheat on all methods. The 1935 crop season demonstrated that there is no sure way of producing a crop under the extreme drought conditions such as were experienced at that time. There are 270 plots in this project, with very few duplications in method of tillage. These were planted to 10 different types of crops, yet no plot produced enough in 1935 to warrant its being called a yield. [J. B. Kuska, in charge.]

Crop Adaptation.— Studies in varieties of the various field crops were continued as outlined in the last report. Because of the severity of the season, no spring small grains were planted in 1935. All varieties of winter wheat failed in both 1935 and 1936. This was also true of wheat planted in the

date and drill tests. The spring small grains planted in 1936 show some promise of returning a yield. The row crops, corn, and sorghums, made some vegetative growth but neither was able to produce grain in 1935. [E. H. Coles, in charge.]

Dairy Herd Improvement.— The dairy herd improvement project, that of breeding up a herd of grade cattle by continued use of purebred sires, was continued as previously outlined. The average production of the 16 cows milked during the biennium was 9,628 pounds of milk and 371.85 pounds of butterfat in 1934, and 8,794 pounds of milk and 357.56 pounds of butterfat in 1935. The severe dust storms and lack of pasture lowered the production in 1935. One cow in the herd, No. 29, received national recognition when she was exhibited at the Topeka and Hutchinson State Fairs, the National Dairy Cattle Congress at Waterloo, Iowa, and the National Dairy Show at St. Louis, Mo., in the fall of 1935. She was shown as the first grade cow in the world to have produced 100,000 pounds of weighed milk on a twice-a-day milking schedule. She has been in production since February 20, 1925. Her total production to June 1, 1936, is 119,133 pounds of milk and 4,556.19 pounds of butterfat. A second-grade cow in the project, No. 30, has recently passed the 100,000-pound production mark. She is also a 11-year-old cow. [E. H. Coles, in charge.]

TRIBUNE BRANCH EXPERIMENT STATION

The Tribune Branch Experiment Station is located in Greeley county, near the town of Tribune. The results secured on this station apply to the high-plains area extending from the Smoky Hill river to the Arkansas river. The work is planned to study variety responses, seedbed preparation, and date of seeding of the principal adapted crops—wheat, oats, barley, corn, and sorghums. Limited studies are also made of the adaptation of various varieties of legumes, grasses, garden crops, flowers, and trees.

The climatic conditions in this section of the state have been very severe during the last biennium. The total precipitation in 1934 was 7.76 inches, which was 9.27 inches below normal, and that of 1935 was 8.83 inches, which was 7.78 inches below normal. While soil blowing has been a contributing factor to the failure of the crops on many fields in the county in both 1934 and 1935, soil blowing has been prevented on the station by using approved methods of soil cultivation.

Wheat planted on early fall plowed land gave the highest yield, and that drilled in the stubble gave the lowest on the wheat seedbed preparation plots in 1934. The yields on the seedbeds prepared by early Ming, early one-waying, and late one-waying were intermediate. No yields were secured from the project in 1935. The yield on the wheat variety plots was too low to be significant in either 1934 or 1935. Kanred made a higher yield than either Turkey or Blackhull over a 14-year period. Early Blackhull made the highest average yield, 13.1 bushels per acre, over a 7-year period.

All of the spring cereals made low yields in 1934, and were complete failures in 1935. Reward spring wheat made a yield of 7.7 bushels per acre in 1934, which was only slightly less than that of the best yielding winter wheat variety. Bruncker oats made a yield of 16.6 bushels and Kanota 15.4 bushels in 1934. The yield of these two varieties is practically the same over a 12-year period. Flynn was the highest yielding barley variety in 1934 and over a 6-year period.

No grain yields were secured from the corn or sorghum variety plots in 1934 and 1935. Cassel White corn has made an average yield of 14.4 bushels per acre and Hays Golden 13.1 bushels over a 10-year period. Other varieties have made lower yields. Greeley, an early-maturing sorghum, developed at this station, has made a higher grain yield than any other grain sorghum over an 8-year period. Kansas Orange has made a higher forage yield than any

other variety of sorghum. The forage of earlier-maturing varieties, such as Leoti Red or Early Sumac, is better quality than that of the later-maturing varieties. Sorghum planted on June 5 produces a higher grain and higher forage yield than that planted on May 20.

Sudan grass has proved to be a good supplementary pasture crop on this station. In 1934, 2.5 acres of Sudan grass drilled on cropped land furnished 42 days pasture for two cows and two calves. In 1935, 5.5 acres of Sudan grass listed, on corn ground, furnished pasture for two cows and three horses from August 1 to August 29. Sudan grass drilled on cropped land has produced an average of 72 days of pasture per year over a 13-year period. The average carrying capacity was one cow per acre.

Irish Cobbler potatoes, on summer fallowed land, produced 38.9 bushels per acre in 1934, and made a 15-year average yield of 65.2 bushels per acre. The Red River Ohio variety produced no marketable potatoes in 1934, and made a 15-year average yield of 59.6 bushels per acre. The Early Triumph and Rural New York varieties have each made lower yields than either Irish Cobbler or Red River Ohio.

The garden work on the station shows that some vegetables can be produced by means of irrigation even under such severe conditions as those of 1934 and 1935. The early-maturing varieties of radishes are better adapted than those of later maturity. Early Curled Simpson and Black-seeded Simpson lettuce both proved to be good varieties on this station. All varieties of beans and peas failed to produce crops. Beets and carrots made a fair yield in both years. Extra Early Evergreen proved to be the best yielding variety of cucumbers.

Flowers can be produced in this area with proper care as to selection and cultivation. Zinnias, marigolds, four o'clocks, petunias, dahlias, and portulacas have produced well during the last two years. Tulips and sweet peas are likely to be damaged by wind and dust unless they are well protected.

Tree plantings made near the buildings on the station indicate that red cedar, western yellow pine, plum and cherry trees are most likely to withstand the wind and drought of this section. New plantings should be made only when a good supply of moisture is available. All trees need to be protected from rabbit damage and from the fire hazard caused by Russian thistles drifting among the trees.

Sod was broken on the north side of the station in the spring of 1935 in order to establish a study of supplementary pasture crops. The rotation to be used is fallow, winter wheat, and Sudan grass. Both the winter wheat and Sudan grass will be used for pasture. [T. B. Stinson and A. L. Clapp, 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. Six bulletins were printed during the biennium.

Circulars.— Brief popular reports of experimental results and popular discussions on various agricultural problems are published as circulars. Five circulars were published during the biennium.

BIENNIAL REPORT OF DIRECTOR

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				
<i>No.</i>	<i>Title</i>	<i>Edition</i>	<i>Pages</i>	<i>Total pages</i>
	Seventh Biennial Report of the Director	1,750	147	257,250
TECHNICAL BULLETINS				
38	Effect of Burning on Kansas Bluestem Pastures	3,000	65	195,000
39	Seasonal and Short-time Fluctuations in Wheat Prices in Relation to the Wheat Price Cycle	3,000	52	156,000
40	Twenty Years of Soil Fertility Investigations	2,500	57	142,500
41	Phosphorus Requirements in the Ration of Growing Pigs	2,500	86	215,000
GENERAL BULLETINS				
269	Field Bindweed and Methods of Control	35,000	26	910,000
270	Hardy Trees and Shrubs for Western Kansas	15,000	32	480,000
271	Pasturing Winter Wheat in Kansas	15,000	30	450,000
272	Management of Kansas, Pastures	20,000	44	880,000
273	Sod Moisture and Winter Wheat With Suggestions on Abandonment	10,000	46	460,000
274	Capon Production	15,000	35	525,000
CIRCULARS				
174	Commercial Fertilizers for Potatoes in the Kansas River Valley	4,500	12	54,000
175	Information on Recent Publications	15,000	3	45,000
176	Cleaning and Sterilizing Dairy Farm Utensils	10,000	16	160,000
177	Grape Growing in Kansas	15,000	32	480,000
178	Poultry Management	50,000	77	3,850,000

SOME INFORMATION REGARDING EACH PUBLICATION ISSUED

BIENNIAL REPORT

Seventh Biennial Report of the Director: For the Biennium July 1, 1932, to June 30, 1934.— This biennial report outlines the scope of the work of the Agricultural Experiment Station for the period. Brief summaries of the results on some projects are given and brief progress reports made on the others. The annual financial statements and a list of the publications of the station and of contributions to other scientific publications by members of the station staff are included. (By L. E. Call, Director, Agricultural Experiment Station. 147 pages; 3 figures; 3 tables.)

TECHNICAL BULLETINS

Technical Bulletin 38: Effect of Burning on Kansas Bluestem Pastures.—The experiments which furnished the information for this bulletin were conducted on two areas of bluestem pastures near Manhattan. Big bluestem (*Andropogon furcatus*) and little bluestem (*Andropogon scoparius*) are the dominant grasses on both pastures. Experimental plots were burned annually in the late fall, early spring, medium spring, late spring, and unburned.

Burning decreased the yield of the mature vegetation. The yield was the least on the plots burned in the late fall. The plots burned in the early spring were next, followed by the plots burned in medium spring. Burning was of little value in controlling weeds and brush unless it was done in the late spring when the organic food reserves were at a low point. The grasses were more leafy during the early part of the growing season on the burned than on the unburned plots. In early June of each year, the protein content of the grass was highest on the plots burned in the late spring, followed by that on the unburned plots. The grass from the medium spring burned plots ranked third and that from the fall and early spring burned plots had the lowest protein content. The moisture of the soil was higher on the unburned than on the burned plots but burning had no influence on the nitrogen and organic

content of the soil. The plant population was greatest on the plots burned in the late fall and least on those burned in the late spring. Burning decreased or eliminated Kentucky bluegrass. Early growth of grasses in the spring was stimulated by burning. (By A. E. Aldous, Department of Agronomy. 65 pages; 12 figures; 23 tables.)

Technical Bulletin 39: Seasonal and Short-time Fluctuations in Wheat Prices in Relation to the Wheat-price Cycle.— Indices of seasonal variation for cash wheat prices at Kansas City are characteristically different in a period of advancing prices from what they are in a period of declining prices. These differences make it possible to forecast with reasonable accuracy the trend of wheat prices or the position of the wheat-price cycle. This is particularly true in certain strategic months. (By R. M. Green, Department of Agricultural Economics. 52 pages; 14 figures; 15 tables.)

Technical Bulletin 40: Twenty Years of Soil Fertility Investigations.— This bulletin reports the results obtained on the soil fertility project during the 20-year period ending in 1930. The project consists of several different cropping systems, including numerous fertilizer and other soil treatments.

Rotations including alfalfa have produced higher yields of corn and wheat than have those including soybeans or only grain crops. Wheat produced higher yields after brome grass than after alfalfa but corn produced slightly higher yields after alfalfa. Wheat yields have been higher when the crop is grown continuously than in rotation with soybeans and corn. Phosphates have been of value in alfalfa and wheat production but little increase has been obtained from their use on other crops. Potassium sulfate has given only slight increases. Complete fertilizer have increased the yield of all crops to some extent but in general the increases have not been economical. Manure has increased the yield of all crops. Sulfur has not increased the yield of alfalfa but has increased the acidity of the soil. The test weight of wheat has not varied greatly with different cropping systems or soil treatments. The brome-grass rotation produced wheat having the highest weight per individual kernel. The highest protein content of wheat has been obtained when the crop is grown in rotation with alfalfa and corn. Phosphates decreased the protein content of wheat in all cropping systems. Brome-grass land produced wheat having the lowest percentage of protein. (By R. I. Throckmorton and F. L. Duley, Department of Agronomy. 57 pages; 5 figures; 30 tables.)

Technical Bulletin 41: Phosphorus Requirements in the Ration of Growing Pigs.— This bulletin reports a three-year investigation of the feeding of different levels of phosphorus in the rations of young pigs. Data are presented (1) to show the effect of deficient amounts of phosphorus in the ration on the growth and development of pigs, and (2) to determine the minimum amount of phosphorus necessary in a ration for their normal growth and development.

The results show that a low-phosphorus diet caused a loss of appetite, a poor utilization of feed and storage of energy, a failure to make normal growth and to develop bone and muscle normally, a lowering of inorganic phosphorus in the blood, and a marked increase in thirst with a corresponding excretion of urine. The minimum requirements of phosphorus in the ration of growing pigs were found to be between 0.27 and 0.3 percent. (By C. E. Aubel, Department of Animal Husbandry, J. S. Hughes, Department of Chemistry, and H. F. Lienhardt, Department of Veterinary Medicine. 86 pages; 23 figures; 34 tables.)

BULLETINS

Bulletin 269: Field Bindweed and Methods of Control.— A description of field bindweed and comparisons with other weeds which may be mistaken for it are presented. The seriousness of the weed, its influence upon crop yields, and means by which it is spread are fully discussed. Detailed directions are given for three methods of killing bindweed; namely, the sodium-chlorate spray method, the fallow-smother-crop method, and the salting method. Pasturing with hogs and other livestock is considered briefly. Suitable equipment for spraying and for cultivation is described and illustrated. Sodium chlorate and calcium chlorate are compared as to effectiveness and danger from fire in han-

dling. (By J. W. Zahnley, Department of Agronomy, and W. F. Pickett, Department of Horticulture. 26 pages; 12 figures.)

Bulletin 270: *Hardy Trees and Shrubs for Western Kansas.*— Information about the selection of the proper species of trees and shrubs for western Kansas, together with instruction for their planting and subsequent care, is presented in this bulletin. Forty-nine species and horticultural varieties of deciduous and evergreen shrubs and twenty-three species of trees are discussed. Special mention is made of the species of trees and shrubs for southwestern Kansas. (By E. W. Johnson, former forest nurseryman at the Fort Hays Agricultural Experiment Station, Hays, Kan. 31 pages; 17 figures.)

Bulletin 271: *Pasturing Winter Wheat in Kansas.*— This bulletin includes discussions of the various practices of farms and the results of experiments in pasturing winter wheat in Kansas. The times at which wheat can be pastured without a consequent reduction in yield of grain, the amount of grazing wheat will withstand, the gains made by livestock, and the value of dry feeds used in connection with wheat pasture are among the numerous questions given consideration. (By A. F. Swanson, Division of Cereal Crops and Diseases, United States Department of Agriculture, Fort Hays Agricultural Experiment Station. 29 pages; 8 figures; 8 tables.)

Bulletin 272: *Management of Kansas Permanent Pastures.*— The main problems arising in the utilization of native pastures are discussed in this publication. The data presented include a classification of Kansas pastures, growing requirements of pasture plants, methods for controlling weeds and brush in pastures, poisonous plants, effect of burning in pastures, methods of grazing to increase the production of pastures, temporary pasture crops, salting livestock, stock watering places, runoff and erosion in pastures, use of commercial fertilizers, and revegetation of depleted perennial pastures. (By A. E. Aldous, Department of Agronomy. 44 pages; 20 figures; 1 table.)

Bulletin 273: *Soil Moisture and Winter Wheat with Suggestions on Abandonment.*— The influence of varying amounts of soil moisture at seeding time on the yield of wheat is shown in this bulletin and conclusions drawn are supported by data obtained on the branch agricultural experiment stations at Hays, Colby, and Garden City. The relative value of different tillage methods for the storage of soil moisture is discussed. The depth of penetration of water into the soil at seeding time is shown to be a reliable indication of the probable yield of wheat. (By A. L. Hallsted and O. R. Mathews, Associate Agronomists, Division of Dry Land Agriculture, Bureau of Plant Industry, United States Department of Agriculture. 46 pages; 4 figures; 8 tables.)

Bulletin 274: *Capon Production.*— In this publication a general introduction to capon production is followed by a discussion of breeds, identification of sex, age, and size to caponize for best results, and a detailed description of the operation accompanied by appropriate illustrations. Some new theories are advanced regarding the causes of hemorrhage, wind puffs, and slips. Rate of growth, cost of production, marketing, and profits are discussed. Turkey and guinea capons are treated briefly though there seems to be no justification for canonizing turkeys and guineas. (By Loyal F. Payne, Department of Poultry Husbandry. 35 pages; 18 figures; 2 tables.)

CIRCULARS

Circular 174: *Commercial Fertilizers for Potatoes in the Kansas River Valley.*— This circular gives the results secured from the use of commercial fertilizers in the production of potatoes on farms of Kansas river valley potato growers. The fertilizers used were nitrogen and phosphorus alone and in combination, and potash in combination with the other two. The work was conducted over a four-year period, 1931 to 1934. Since rainfall and temperature varied greatly during this time, the tests give information on results which may be expected in years both of low and of high yields. (By A. L. Clapp, H. E. Myers, and F. L. Timmons, Department of Agronomy. 12 pages; 1 figure; 4 tables.)

Circular 175: Information Regarding Recent Publications.— This circular gives brief statements regarding the content of the following popular publications of the station: Bulletins 265 to 271 and Circulars 172 to 174. (Office of Director. 3 pages.)

Circular 176: Cleaning and Sterilizing Dairy Farm Utensils.— Instructions are given for cleaning and sterilizing milk cans and pails, milking machines, milk bottles, and cream separators. The use of a lye solution as a disinfecting agent is discussed. Plans for a milking machine teat cup rack and directions for the preparation and use of lye and chlorine disinfecting solutions are presented in the circular. (By W. J. Caulfield and W. H. Riddell, Department of Dairy Husbandry, and A. C. Fay, Department of Bacteriology. 15 pages; 10 figures.)

Circular 177: Grape Growing in Kansas.— This circular, a revision of Circular 134 of the same title, records results of experimental work with the American grape and observations of practices followed by successful growers in Kansas. Special emphasis is placed on choice of varieties, management of vineyard soils, and pruning the vines. (By R. J. Barnett, Department of Horticulture. 32 pages; 12 figures.)

Circular 178: Poultry Management.— This circular covers in a general way all important phases of poultry production, including the size of flocks; selection of a breed; houses and equipment; reproducing the flock; incubation and brooding; poultry nutrition; culling; production and marketing of poultry products; and poultry parasites, diseases, and sanitation. An outline of poultry improvement work is presented in the appendix; also a proposed educational program for poultry associations. The circular is a revision, with many changes and additions, of circular 122. (By Loyal F. Payne, Department of Poultry Husbandry. 77 pages; 27 figures; 5 tables.)

PUBLICATIONS BY DEPARTMENTS

The following table contains a list, classified by departments, of the regular publications of the Agricultural Experiment Station, and also the technical articles contributed to scientific journals by members of the station staff:

LIST OF PUBLICATIONS BY DEPARTMENTS

Department of Agricultural Economics

<i>Serial No.</i>	<i>Year of issue</i>	<i>Title, author, and publication</i>
86	1935	Seasonal and Short-Time Fluctuations in Wheat prices in Relation to the Wheat-Price Cycle. R. M. Green. Kan. Agr. Expt. Sta. Tech. Bul. 39:1-52.
87	1934	Determining Agricultural Areas in the United States. W. E. Grimes. Amer. Statist. Assoc. Proc. 29:19-20.
90	1934	Size of Farm and the Business Cycle. J. A. Hodges. Jour. Farm Econ. 16:711-714.
...	1935	Planning, Control, and Research in Agriculture After Recovery. J. D. Black (Discussion by W. E. Grimes). Jour. Farm Econ. 17:37-38.
91	1935	Agricultural Planning and Farm Management in the Wheat Belt. W. E. Grimes. Jour. Farm Econ 17:547-552.
92	1935	Judging Future Wheat Supplies by Rainfall Distribution. H. J. Henney. Mo. Weather Rev. 63:185-187.
93	1935	Some Factors Affecting Butter Consumption. John B. Roberts. Jour. Farm Econ. 17:735-738.
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117	1934	Bacterial Leaf Spot of Peach. G. A. Filmger. Kan. State Hort. Soc. Bien. Rpt. 42:118-121.
118	1934	Experiments for the Control of Frog-eye. W. F. Pickett. Kan. State Hort. Soc. Bien. Rpt. 42:60-64.

<i>Serial No.</i>	<i>Year of issue</i>	Title, author, and publication
120	1934	Ground Cover Lessens Chance of Frost Damage. R. J. Barnett. Amer. Fruit Grower. 34:7.
121	1934	Leaf Areas in Relation to Apple Production. W. F. Pickett. Kan. State Hort. Soc. Bien. Rpt. 42:107-111.
122	1934	The Spray Residue Problem in Kansas. G. A. Filinger. Kan. State Hort. Soc. Bien. Rpt. 42:126-130.
124	1934	Control of Two Fungous Diseases of Apples. T. R. Rertz. Kan. State Hort. Soc. Bien. Rpt. 42:121-126.
125	1934	Field Bindweed and Methods of Control. J. W. Zahnley and W. F. Pickett. Kan. Agr. Expt. Sta. Bul-269:1-26.
126	1934	A Tenderfoot Visits the Southwestern Mum Grower. W. B. Balch. Jour. Chrysanthemum Soc. Amer. 2:12-16.
129	1935	Photosynthetic Activity and Internal Structure of Apple Leaves are Correlated. W. F. Pickett. Amer. Soc. Hort. Sci. Proc. 32:81-85.
130	1935	Two Problems Facing Teachers of Horticulture. R. J. Barnett. Amer. Soc. Hort. Sci. Proc. 32:192-195.
131	1935	Greenhouse Soil Treatments. W. B. Balch. Market Growers Journal. 56:118-119.
132	1935	Grape-Growing in Kansas. R. J. Barnett. Kan. Agr. Expt. Sta. Circ. 177:1-32.
134	1936	The Laboratory in Elementary Horticulture. R. J. Barnett. Amer. Soc. Hort. Sci. Proc. 33:704-706.
135	1936	The Comparison of Three Methods of Measuring Photosynthetic Activity of Apple Leaves. W. F. Pickett. Amer. Soc. Hort. Sci. Proc. 33:152-154.
136	1936	Variations in the Effectiveness of Chemically Treated Codling Moth Bands. G. A. Filinger. Amer. Soc. Hort. Sci. Proc. 33:191-194.

Department of Milling Industry

...	1934	The Determination of the Water Absorbing Capacity of Flour by Means of the Super Centrifuge. E. B. Working. Cereal Chem. 11:567.
...	1934	Farm Storage of Wheat as a Factor in Quality. C. O. Swanson. Northwest. Miller (Production Annual). 180:10.
...	1934	Moisture in Wheat and Mill Products. C. O. Swanson. Northwest. Miller (Production Annual). 180:12.
...	1934	The Living Wheat. C. O. Swanson. Northwest. Miller (Production Annual). 180:64.
...	1935	Atmospheric Factors in Milling: Conditions Which Neutralize the Effects of Tempering. C. O. Swanson and J. E. Anderson. Northwest. Miller. 181:792.
...	1935	Atmospheric Factors in Milling: A Study of Certain Factors as a Help in Maintaining Optimum Conditions for Milling. C. O. Swanson and J. E. Anderson. Northwest. Miller.. 182:198.
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...	1935	Atmospheric Factors in Milling: Factors Which Influence Evaporation from Wheat and Mill Stocks. C. O. Swanson and J. E. Anderson. Northwest. Miller. 182:790.
...	1935	Quality in Wheat. C. O. Swanson. Proc. World's Grain Exhib. and Conf., 1933. 2:375.
...	1935	Some Factors Which Affect the Diastatic Activity in Wheat. C. O. Swanson. Cereal Chem. 12:89.
...	1935	Hardness in Wheat. R. O. Pence. Bul. Assoc. Oper. Millers. July, 1935, pp. 651-653.
...	1935	Absorption of Water by Wheat and Some Aspects of Tempering. C. O. Swanson and J. E. Anderson. Northwest. Miller. 183:530.
...	1935	Principles Which Make Possible the Establishment of Any Desired Humidity. C. O. Swanson and J. E. Anderson. Northwest. Milk. 183:798.
...	1935	The Story of a Grain of Wheat from Ripening to Bin. C. O. Swanson. Northwest. Miller (Production Annual). 184:12-13.
...	1935	Factors That Influence the Protein Content of Wheat. C. O. Swanson. Northwest. Miller (Production Annual). 184:26-28.
...	1935	The Wheat-Meal-Time Fermentation Test. C. O. Swanson and J. H. Parker. Northwest. Miller (Production Annual). 184:14-16.
...	1935	Determination of Moisture in Wheat and Its Products. J. E. Anderson. Northwest. Miller (Production Annual). 184:25.
...	1935	Wheat the Flow Sheet May Reveal. R. O. Pence. Amer. Miller. 63(11):28 and (12):19.
...	1936	Meaning of Atmospheric Control. C. O. Swanson. Bul. Assoc. Oper. Millers, May, 1936. pp. 703-706.

Serial No.	Year of issue	Title, author, and Publication
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49	1936	Physical Tests to Determine Quality in Wheat Varieties. C. O. Swanson. Cereal Chem. 13:179.
50	1936	Effect of Harvest Conditions on a Few Quality Factors in Wheat. C. O. Swanson. Cereal Chem. 13:79.
51	1936	Measurement of Respiration in Flour. E. B. Working. Cereal Chem. 13:234.
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79	1934	Inheritance of Age at Sexual Maturity in the Domestic Fowl. D. C. Warren. Genetics. 19:600-617.
80	1934	Management of Leghorn Hens and Pullets With and Without Artificial Lights. L. F. Payne and L. J. Sunmons. Poultry Sci. 13:323-332.
81	1934	The Effect of Gonadectomy on the Secondary Sexual Characters of the Bronze Turkey (<i>M. gallopavo</i>). H. M. Scott and L. F. Payne. Jour. Expt. Zool. 69:123-136.
82	1934	Ovulation in the Domestic Hen. D. C. Warren and H. M. Scott. Science. 80:461-462 (Abstract).
83	1935	The Vitamin A Content of Eggs as Related to Rate of Production. Myra C. Koenig, M. M. Kramer, and L. F. Payne. Poultry Sci. 14:178-182.
83-a	1935	The Time Factor in Egg Formation. D. C. Warren and H. M. Scott. Poultry Sci. 14:195-207.
85	1935	An Attempt to Produce Turkey-Chicken Hybrids. D. C. Warren and H. M. Scott. Jour. Heredity. 26:105-107.
86	1935	Adaptation of the Introductory Course in Poultry Husbandry. L. F. Payne. Poultry Sci. 14:342-345.
87	1935	The Sequence of Appearance, Mole, and Replacement of the Juvenile Remiges of Some Domestic Buds. D. C. Warren and C. D. Gordon. Jour. Agr. Research. 51:459-470.
88	1935	Physiological Factors Influencing the Rate of Egg Formation in the Domestic Hen. D. C. Warren and H. M. Scott. Jour. Agr. Research. 51:565-572.
90	1936	Poultry Management. L. F. Payne. Kan. Agr. Expt. Sta. Circ. 178:1-77.
91	1936	Capon Production. L. F. Payne. Kan. Agr. Expt. Sta. Bul. 274:1-35.
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...	1934	Feline Infectious Enteritis. E. E. Leasura, H. F. Lienhardt, and F. R. Taberner. North Amer. Vet. 15:30-45.
59	1934	Bang's Abortion Disease of Cattle C. H. Kitsekamn. Lederle Vet. Bul., Pearl River, N. Y. 3:3-8.
...	1935	A Live Germ Vaccine for Bang's Abortion Disease of Cattle. C. H. Kitzelman. Jour. Amer. Vet. Med. Assoc. 39:(n. s.) 526. and Science. 81:363.
62	1936	The Effects of Low-phosphorus Rations Growing Pigs. C. Aubel, J. S. Hughes, and H. F. Lienhardt. Jour. Agr. Research. 52:149-159.
...	1935	Gas Edema Diseases J. P. Scott. Twelfth Internatl. Vet Cong., 168-187.
63	1936	Influence of the Ration on the Vitamin C Content of Milk. W. H. Reddell, C. H. Whitnah, J. S. Hughes, and H. F. Lienhardt. Jour. Nutrition. 11:47-54.
...	1934	Investigations of Two Outbreaks of Laryngotracheitis. J. P. Scott and C. A. Brandy. Ohio State Vet. Quart. 22:23-31.
Department of Zoölogy		
155	1935	Comparative Resistance of Bronze Turkeys and White Leghorn Chickens to the Intestinal Nematode, <i>Ascaridia Lineata</i> (Schneider). J. E. Ackert and L. L. Eisenbrandt. Jour. Parasitol. 21:200-
156	1935	Age Resistance of Chickens to the Nematode <i>Ascaridia lineata</i> (Schneider). J. E. Ackert, D. A. Porter, and T. D. Beach. Jour. Parasitol. 21:205-213.
159	1934	The Life History of <i>Leidynema appendiculata</i> (Leidy), A Nematode of Cockroaches. C. G. Dobrovoly and J. E. Ackert. Jour. Parasitol. 26:468-
160	1934	The Skeletal Development of the Anterior Limb of the Guinea-pig, <i>Cavia cobaya</i> Cuv. from the Twenty-five-day Embryo to the 161-day Post Natal Guinea-pig. Mary T. Harman and Olga Saffry. Amer. Jour. Anat. 54:315-331.



Serial No.	Year of issue	Title, author, and publication
161	1935	Factors in the Resistance of Chickens to the Nematode <i>Ascaridia lineata</i> (Schneider). J. E. Ackert. Trans. on the Dynamics of Development. U. S. S. R. 10 : 413-421. (Volume dedicated to the late Prof. M. M. Zawadowsky, Moscow, Russia.)
162	1935	Polyradiate Tapeworms from a Dog. C. G. Dobrovolny and Marjorie P. Dobrovolny. Amer. Micros. Soc. Trans. 54 :22-27.
163	1935	Absorption of Soluble Volatile Fatty Acids. R. H. Hughes and E. J. Wimmer. Amer. Jour. Biochem. 108: 141-144.
164	1935	The Efficacy of Carbon Tetrachloride in Round Worm Control. J. E. Ackert and G. L. Graham. Poultry Sci. 14:228-231.
165	1935	Comparative Resistance of Five Breeds of Chickens to the Nematode <i>Ascaridia lineata</i> (Schneider). J. E. Ackert, L. L. Eisenbrandt, J. H. Wilmoth, B. Glading, and I. Pratt. Jour. Agr. Research. 50:607-624.
...	1934	Resistant and Susceptible Strains of White Minorca Chickens to the Nematode, <i>Ascaridia lineata</i> (Schneider). J. E. Ackert and J. H. Wilmoth. Jour. Parasitol. 20:323-324 (Abstract).
...	1935	The Thoracic Sclerites of a Trichopterous Pupa, <i>Dicosmoecus atripes</i> Hagen, (Limnophilidae). A. L. Goodrich. Amer. Micros. Soc. Trans. 54:57-64.
...	1933	On the Comparative Resistance of Six Breeds of Chickens to the Nematode <i>Ascaridia lineata</i> (Schneider). J. E. Ackert, L. L. Eisenbrandt, B. Glading, and J. H. Wilmoth. Jour. Parasitol. 20:127 (Abstract).
167	1936	The Effect of Injections of Antuitrin-S on the Sexually Inactive Male Ground Squirrel. Burton L. Baker and G. E. Johnson. Jour. Endocrinology. 20: 219-223.
...	1936	Species from the Genetic Standpoint. R. K. Nabours. Amer. Nat. 70:191-192.
169	1936	The Cysticercoid of the Fowl Tapeworm <i>Raillietina cesticillus</i> . J. E. Ackert and W. M. Reid. Amer. Micros. Soc. Trans. 55: 97-100.
171	1936	<i>Physaloptera felidis</i> n. sp., A Nematode of the Cat. J. E. Ackert. Amer. Micros. Soc. Trans. 55 :250-254.
...	1935	Studies on Ascarid Nutrition. J. E. Ackert and J. H. Whitlock. Jour. Parasitol. 21:428 (Abstract).
175	1935	Parthenogenesis in the Ovaries of Guinea Pigs. Mary T. Harman. Trans. Kan. Acad. Sci. 38:319-320.
176	1935	Some Effects of Experimental Diets Upon the Reproduction and Growth of the Guinea Pig (<i>Cavia cobaya</i>). Mary T. Harman and Isabelle Gillum. Trans. Kan. Acad. Sci. 38:321 (Abstract).
177	1935	Some Observations on the Development of the Teeth of <i>Cavia cobaya</i> . Mary T. Harman and Arlene Smith. Trans. Kan. Acad. Sci. 38:323 (Abstract).
Director's Office		
52	1934	Seventh Biennial Report of Director, Kansas Agricultural Experiment Station, 1932-'34. L. E. Call.
53	1935	Information Regarding Recent Publications. Kan. Agr. Expt. Sta. Circ. 175 :1-3.
55	1936	Cultural Methods of Controlling Wind Erosion. L. E. Call. Jour. Amer. Soc. Agron. 28:193-201.
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...	1934	Methods of Reestablishing Buffalo Grass on Cultivated Land in the Great Plains. D. A. Savage. U. S. Dept. Agr. Circ. 328:1-20.
15	1934	Hardy Trees and Shrubs for Western Kansas. E. W. Johnson. Kan. Agr. Expt. Sta. Bul. 270:1-31.
16	1935	Pasturing Winter Wheat in Kansas. A. F. Swanson. Kan. Agr. Expt. Sta. Bul. 271:1-29.
...	1935	Beef Cattle Investigations, 1934-'35, Fort Hays Branch Experiment Station. C. W. McCampbell and L. C. Aicher. 23d Ann. Rpt. Beef Cattle Investigations, 1934-'35, Fort Hays Branch Expt. Sta.
18	1935	The Development of Sorghum Culture in Kansas. A. F. Swanson. Kan. State Bd. Agr. 29th Bien. Rpt. 34:165-174.
...	1935	The Killing Effect of Heat and Drought on Buffalo Grass and Blue Grama Grass at Hays, Kansas. D. A. Savage and L. A. Jacobson. Jour. Amer. Soc. Agron. 27:566-582.



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Kansas Agricultural Experiment Station

Serial No.	Year of issue	Title, author, and publication
19	1935	A Field Aspirator for Emasculating Sweet Clover Flowers. D. A. Savage. Jour. Amer. Soc. Agron. 27:774-775.
...	1935	Curbing the Wind. L. C. Aicher. Kan. State Bd. Agr. 29th Bien. Rpt. 34:67-71.
...	1935	"They Came Through"—Survey Shows Where Drought Met Most Resistance. D. A. Savage. Soil Conservation. 1:4-5.
20	1936	Soil Moisture and Winter Wheat with Suggestions on Abandonment. A. L. Hallsted and O. R. Matthews. Kan. Agr. Expt. Sta. Bul. 273:1-46.
...	1936	Beef Cattle Investigations, 1925-'36, Fort Hays Branch Experiment Station. C. W. McCampbell and L. C. Aicher. 24th Ann. Rpt. Beef Cattle Investigations, 1935-'36, Fort Hays Branch Expt. Sta.
...	1936	The Fort Hays Basin Lister. L. C. Aicher. The Kansas Agr. Student. 15:101-102.

FINANCIAL STATEMENT, 1934-'35

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

	Federal appropriations	State appropriations and receipts	Totals
Main station	\$90,000.00	(a) \$48,295.84	\$138,295.84
Branch stations, appropriations		(b) 54,243.32	54,243.32
Branch stations, sales		67,818.49	67,818.49
Totals	\$90,000.00	\$170,367.65	\$260,367.65
Personal services	\$82,254.28	\$84,009.64	\$166,263.92
Supplies and materials	2,404.38	29,136.68	31,541.06
Communication service	41.55	2,383.34	2,424.89
Travel expenses	708.50	4,517.77	5,226.27
Transportation of things	4.00	1,901.39	1,905.39
Publications	35.13	1,144.62	1,179.75
Heat, light, water, and power	20.94	5,241.20	5,272.14
Contingent expenses	4.00	357.62	361.62
Equipment	3,856.60	16,349.58	20,206.18
Buildings and land	670.62	5,511.09	6,181.71
Balance		19,804.72	19,804.72
Totals	\$90,000.00	\$170,367.65	\$260,367.65

(a) Includes a balance on hand June 30, 1934, of \$10,406.84.

(b) Includes a balance on hand June 30, 1934, of \$5,438.36.

FINANCIAL STATEMENT, 1935-'36

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

	Federal appropriations	State appropriations and receipts	Totals
Main station	\$102,512.74	(a) \$55,330.28	\$157,843.02
Branch stations, appropriations		(b) 70,553.78	70,553.78
Branch stations, sales		66,382.53	66,382.53
Totals	\$102,512.74	\$192,266.59	\$294,779.33
Personal services	\$91,828.16	\$86,278.18	\$178,106.34
Supplies and materials	5,755.96	25,626.75	31,382.71
Communication service	39.82	2,476.11	2,515.93
Travel expenses	467.03	5,312.85	5,779.88
Transportation of things	53.38	1,532.62	1,586.00
Publications	46.05	1,525.39	1,571.44
Heat, light, water and power	20.11	6,350.05	6,370.16
Contingent expenses	11.00	560.97	571.97
Equipment	2,511.79	34,575.96	37,087.75
Building and land	1,779.44	12,172.42	13,951.86
Balance		15,855.29	15,855.29
Totals	\$102,512.74	\$192,266.59	\$294,779.33

(a) Includes a balance on hand June 30, 1935, of \$5,741.28.

(b) Includes a balance on hand June 30, 1935, of \$3,803.78.