

KANSAS  
AGRICULTURAL EXPERIMENT  
STATION

KANSAS STATE AGRICULTURAL  
COLLEGE

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**DIRECTOR'S REPORT**  
**1917-18**

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MANHATTAN, KANSAS

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AGRICULTURAL EXPERIMENT STATION  
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MANHATTAN, KANSAS

KANSAS STATE PRINTING PLANT  
W. R. SMITH, STATE PRINTER  
TOPEKA. 1918

# KANSAS AGRICULTURAL EXPERIMENT STATION

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\* In cooperation with the United States Department of Agriculture

† On leave

KANSAS AGRICULTURAL EXPERIMENT STATION

OFFICE OF THE DIRECTOR

June 30, 1918

*To His Excellency, Arthur Capper, Governor of Kansas:*

I have the honor to present herewith the report of the Kansas Agricultural Experiment Station for the fiscal year ended June 30, 1918. It includes a brief statement of the work completed or in progress, and the principal changes which have occurred since the issuance of the last report.

L. E. CALL, *Acting Director*

(3)

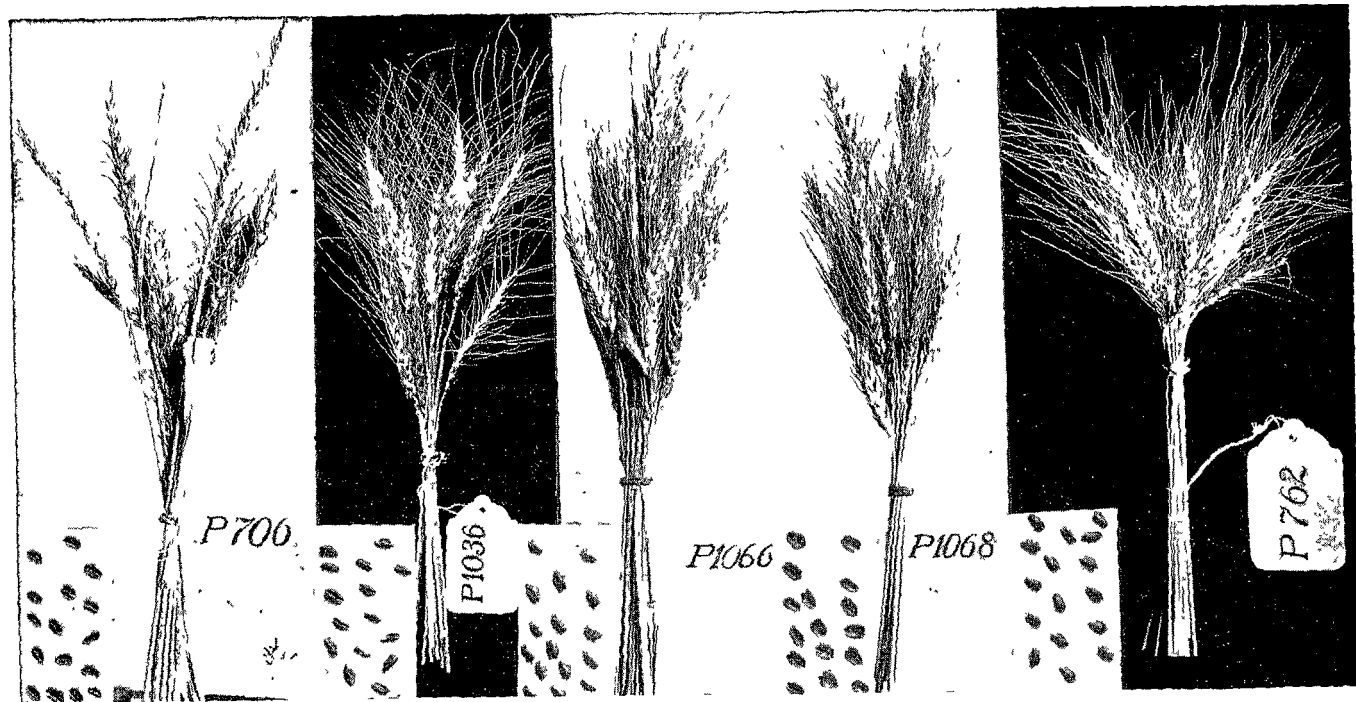


FIG 1—Five hard winter wheats showing contrast in their resistance to the common black stem rust (*Puccinia graminis tritici*). Three of these varieties—P762 (Kanred), P1066 and P1068, show marked resistance. Note the absence of rust pustules on the “necks” of these varieties as compared with those of P1036 and P706 (Improved Turkey). The behavior of P1036 and P706 is typical of the common hard winter wheats in Kansas. The effect of the rust is shown on the grain. (See “Plant Disease Investigations,” page 30.)

## THE DIRECTOR'S REPORT

### INTRODUCTION

The conditions affecting the work of the Kansas Agricultural Experiment Station during the fiscal year 1917-18 were a continuation of those which began to develop when this country entered the war, and which were described in some detail in the annual report for the previous fiscal year. Briefly, these conditions involve a shortage of trained men; a shortage of skilled and unskilled labor; materially increased costs of operation, and an augmented demand for members of the station staff to render service outside their regular duties.

These conditions have materially increased the difficulties of continuing the work on the various scientific projects. Nevertheless, through their devotion to their scientific work, backed by a keen appreciation of the far-reaching importance of agricultural investigations to the national welfare, it has been possible for the members of the staff to keep a large part of their work going, and at the same time to attend to their numerous other patriotic duties. In this connection it is important to recognize the great immediate value of most of this scientific activity. It has been found that with some slight modifications of method or with increased attention to particular features, the results of most of the regular investigational projects can be made immediately applicable as rapidly as they are secured, and thus have a distinct value in the national war program. This has been shown repeatedly in the work of the station during the past year. It has, however, been impossible to maintain all lines of work at peace-time strength.

During recent months the thought of members of the station staff has been directed to an increased extent to postwar problems. It is not unlikely that the agricultural problems following the war will be at least as difficult of solution as those which have been encountered during the war. In this connection the Agricultural Experiment Station may be expected to take a leading part, as it has during the war, and the work of the station already has received some attention with this in view.

Following the resignation on February 28, 1918, of Director W. M. Jardine, who was made president of the college, Professor L. E. Call served as Acting Director for the remainder of the fiscal year.

The following pages contain brief statements of the more important features of the work performed by the Kansas Agricultural Experiment Station during the fiscal year 1917-18.

### PERSONNEL

The following changes in the personnel of the station staff have taken place during the year:

#### APPOINTMENTS

H. H. Amos, B. S. A., Superintendent of Poultry Farm  
 John J. Bayles, B. S. A., Superintendent of Colby Branch Station  
 C. E. Buchanan, Assistant in feed control  
 L. E. Call, M. S., Acting director  
 J. W. Crumbaker, B. S. A., Superintendent of land and livestock  
 W. R. Davis, B. S., Assistant in dairying  
 L. H. Fairchild, B. S., Assistant in dairy husbandry  
 G. C. Gibbons, B. S. A., Assistant to superintendent of Fort Hays Branch Station  
 J. B. Gingery, D. V. M., Instructor in veterinary medicine  
 Mrs. Elizabeth Harling, Seed analyst  
 M. W. Kirkpatrick, Superintendent of Tribune Branch Station  
 H. F. Lienhardt, V. M. D., Assistant in poultry disease investigations  
 C. W. Oaks, Miller  
 John H. Parker, M. S., Assistant professor of farm crops  
 Gee. H. Phinney, Foreman of Agronomy Farm  
 H. A. Pratt, B. S., Greenhouse foreman  
 Lena L. Price, Research assistant to director

#### RESIGNATIONS

H. H. Amos, Superintendent of Poultry Farm  
 W. C. Calvert, Assistant in horticulture and greenhouse foreman  
 Stanley P. Clark, Superintendent of Colby Branch Station.  
 W. R. Davis, Assistant in dairying  
 NT. L. Harris, Superintendent of Poultry Farm  
 Gee. S. Hine, State Dairy Commissioner  
 John G. Jackley, Assistant in poultry disease investigations  
 Wm. M. Jardine, Director  
 M. W. Kirkpatrick, Superintendent of Tribune Branch Station  
 R. W. Kiser, Assistant professor in animal husbandry

James Machir, Assistant in poultry department  
 Fred S. Merrill, Assistant professor of horticulture  
 O. C. Miller, Inspector of feedingstuffs  
 N. E. Olson, Assistant in dairying  
 T. H. Parks, Specialist in entomology  
 Hagan Phlegar, Miller  
 Lena L. Price, Research assistant to director  
 Robert Schmidt, Seed analyst

### PUBLICATIONS ISSUED

Four bulletins, one director's report, and ten circulars were published and distributed during the fiscal year ending June 30, 1918. They were as follows:

BULLETINS				
No.	Title	Edition	Pages	Total pages
218	Growing Sorghum in Kansas .....	35,000	54	1,890,000
	Director's Report, 1915-16 .....	2,500	49	122,500
TECHNICAL BULLETINS				
3	The Influence of the Ration Upon the Intestinal Flora of Swine .....	3,000	54	162,000
4	A Study of the Etiology of Roup in Birds.....	3,000	23	69,000
5	Some Nutritive Properties of Corn.....	3,000	39	117,000
CIRCULARS				
61	Chicken Houses .....	25,000	15	375,000
62	Feeding Work Horses .....	30,000	16	480,000
63	Potato Seed Diseases and Their Treatment.....	10,000	2	20,000
64	The Home Vegetable Garden.....	35,000	8	280,000
65	Insects and Plant Diseases Attacking Garden Crops..	15,000	12	180,000
66	Spraying Fruit Trees .....	15,000	8	120,000
67	Pedigreeing Poultry .....	10,000	16	160,000
68	Another Strain of Puccinia Graminis .....	3,500	4	14,000
INSPECTION CIRCULARS				
5	Feed Registration under the Kansas Feedingstuffs Law .....	5,000	63	315,000
6	Kansas State Livestock Registry Board Report No. 7,	7,000	159	1,113,000
Totals .....		202,000	522	5,417,500

### SUMMARIES OF PUBLICATIONS

#### BULLETINS

218. *Growing Sorghum in Kansas*, C. C. Cunningham and Ralph Kenney. This bulletin deals with the various sorghum crops grown in Kansas. The adaptability of the sorghums to Kansas conditions; their place in crop rotations; varieties; methods of seedbed preparation, planting, cultivating, and harvesting; seed selection; utilization for feed and sirup; and diseases and insect pests are treated in detail.



**REPORT**

*Director's Report, 1915-16*, W. M. Jardine. A brief summary of the work of the Kansas Agricultural Experiment Station during the fiscal year ending June 30, 1916, is given. The main features of the report are as follows: (1) Changes in the personnel of the station staff; (2) a statement of station publications and a partial list of articles contributed by members of the station staff to scientific journals; (3) statements of the most important lines of research supported by Adams, Hatch, and State funds, respectively; (4) a brief statement of the control work, and demonstration work carried on by the station; (5) brief reports of the work of the branch experiment stations; (6) a financial report covering all receipts and expenditures of the station for the fiscal year; and (7) a short technical paper on "Methods of Controlling Blackleg Developed by the Kansas State Agricultural College."

**TECHNICAL BULLETINS**

3. *The Influence of the Ration Upon the Intestinal Flora of Swine*, L. D. Bushnell and J. J. Frey. Since the lack of certain elements in the diet causes great difference in the development of the animal body, it was thought possible that the intestinal flora might be so modified by diet that it, also, would influence the growth of the animal. This bulletin contains a brief historical review of the literature upon this point. The facts presented show that the individual variation in the various groups of animals masks any variations due to different feeds; and that small variations in diet affect the intestinal flora but little. An examination of the bacterial flora of the intestinal contents and excreta from different animals did not show differences great enough to explain the differences in growth.

4. *A Study of the Etiology of Roup in Birds*, J. G. Jackley. This publication gives the results of investigational work on roup in chickens. Certain facts concerning etiological relationships of a bacterium of the Pasteurella group to this disease are reported. Results are given which show that the organism causing roup, if not the same as *B. avisepticus*, is very closely related to it. Fowls immune to roup also seem to be immune to cholera. Birds can be protected against roup by prolonged treatment with a bacterin made from the roup organism.

5. *Some Nutritive Properties of Corn*, J. S. Hughes. This bulletin reports a number of experiments in which corn, corn bran, cornmeal, pearl hominy, corn germ, kafir grain, and corn supplemented with unpurified casein, casein purified by extraction and casein autoclave at various temperatures, were used as feeds for pigeons, chickens, and rats. From the experiments reported in detail the following conclusions are drawn: (1) Corn alone is an adequate diet for adult pigeons for maintenance, at least during a period of one year. 2) Corn bran contains relatively large amounts of antineuritic substances, or substances similar to those contained in rice polishing, called "vitamines" by Funk, and "water-soluble B" by McCollum 3) Five grains of corn a day will supply the requirement of an adult pigeon for this substance or these

substances. (4) Corn germ contains some of the food accessories called "fat soluble A" by McCollum. (5) A fairly rapid but abnormal growth can be induced in young chickens by force feeding them on a diet of corn and salt mixture. (6) Some of the benefit derived by adding unpurified casein to a diet of corn and salt mixture is due to the fat-soluble A which it contains. This may be removed by thoroughly extracting, or destroying by autoclaving at 45 pounds pressure for two hours. (7) Autoclaving the casein does not destroy its efficiency as a protein for producing growth in young rats.

### CIRCULARS

61. *Chicken Houses*, Ross M. Sherwood. The location, size, and ventilation of chicken houses as well as suitable floors and fixtures are discussed. Attention is called to methods of disinfecting the house and keeping it free from mites and illustrations are given showing a number of satisfactory types of chicken houses found on various Kansas farms.

62. *Feeding Work Horses*, C. W. McCampbell. This publication is an abridged edition of Bulletin 186 published in 1912. It deals with the results of the horse feeding investigations conducted at Ft. Riley, Kan., in 1911 that apply particularly to Kansas conditions. It includes comparisons of corn with oats; oats with corn bran and linseed oilmeal; and alfalfa hay with prairie hay. It also gives a brief discussion of the use of alfalfa hay for horse feeding purposes.

63. *Potato Seed Diseases and Their Treatment*, L. E. Melchers. This publication is a postcard circular describing the most commonplace potato diseases which are spread through infected seed; namely, blackleg, black scurf (rhizoctonia), dry rot or "wilt," and scab. The chemical treatment of seed for the control of each disease is described from a commercial standpoint. Other disease control measures besides chemical treatments are advocated, such as the rotation of crops for a certain period of time.

64. *The Home Vegetable Garden*, M. F. Ahearn. This circular contains brief directions for the location, care, and arrangement of a home vegetable garden. Cropping systems to promote intensive gardening and maximum yields from a limited area, are presented in some detail. The construction and care of hotbeds and coldframes is treated briefly, and the control of vegetable insect pests is discussed in a general way.

65. *Insects and Plant Diseases Attacking Garden Crops*, J. H. Merrill and L. E. Melchers. This circular includes a "Calendar for the Control of Insect Pests and Plant Diseases," which presents, in tabular form methods of preventing damage from the most common insects and plant diseases which attack garden crops. Full directions are given for the preparation and application of the insecticides and fungicides necessary to use in the various control measures recommended.

66. *Spraying Fruit Trees*, J. H. Merrill. This circular discusses the subject of spraying, the reasons for spraying, and gives directions for the preparation of spraying materials. Since spraying has a two-fold purpose, namely, the control of insects and plant disease, considerable atten-

tion is given to directions for preparing the fungicides—concentrated lime sulphur, self-boiled lime sulphur, and bordeaux mixture. The dormant or winter spray is used similarly on all fruit trees, but the summer sprays differ according to the kind of tree being treated; therefore, separate spraying schedules are given for treating apple, pear, peach, cherry, and plum trees.

67. *Pedigreeing Poultry*, William A. Lippincott. A simple and comprehensive method of pedigreeing poultry is described. It includes pedigree hatching, methods of marking chicks, trapnesting, and recording. Sample flock breeding records, chick indices, egg records and pedigree blanks are shown.

68. *Another Strain of Puccinia graminis*, Leo E. Melchers and John H. Parker. This circular is a preliminary report on the discovery of a new biologic form of stem rust of wheat. The name assigned to this new form of rust is *Puccinia graminis tritici-inficiens*. It has been found that this new rust behaves differently on some varieties of wheat from the ordinary black stem rust of wheat, *Puccinia graminis tritici*. This new biologic form of stem rust is new to science and is opening the way for the discovery of numerous other biologic forms. Three varieties of hard winter wheat; namely, Kanred (P762), P1066, and P1068 which have been shown to be remarkably resistant to *Puccinia graminis tritici* are very susceptible, in the seedling stage, to this new form of stem rust and at least partially susceptible in the heading stage when grown under field conditions,

**INSPECTION CIRCULARS**

5. *Feed Registration Under the Kansas Feedingstuffs Law*, L. A. Fitz and A. E. Langworthy. This circular summarizes important features of the State Feedingstuffs Law; defines the common commercial feeds; gives results of, and uses of samples; and lists the firms registering feeds.

6. *Kansas State Livestock Registry Board Report No. 7*, C. W. McCampbell, Secretary. This publication contains a list of all stallions licensed by the State Livestock Registry Board to stand for public service in Kansas during the year 1917. It also contains a discussion of "Colt Losses—Causes and Prevention."

**PAPERS APPEARING IN SCIENTIFIC JOURNALS**

In addition to the official publications heretofore listed, the staff members have prepared numerous papers along the various lines of applied science which make up the research activities of the station. Many of these papers have been presented at meetings of the respective scientific associations; many have appeared in leading scientific periodicals. A partial list of these publications is given herewith:

"The Influence of Cold Shock in the Sterilization of Canned Goods," L. D. Bushnell, *Journal of Industrial and Engineering Chemistry*, vol. 10, pp. 431-443. 1918.

"The Bacteriological Examination for Menigococcus Carriers," L. D. Bushnell, *The Journal of Medical Research*, vol. 33, pp. 1-10. 1918.

"Examination of Canned Salmon for Bacteria and Tin," L. D. Bushnell, and C. A. A. Utt, *Journal of Industrial and Engineering Chemistry*, vol. 9, pp. 678-680. 1917.

"Relation of Weed Growth to Nitric Nitrogen Accumulation in the Soil," L. E. Call, and M. C. Sewell, *Journal of the American Society of Agronomy*, vol. 10, pp. 35-44. 1918.

"Habits of the Magpie in Southeastern Washington," Lee R. Dice, *The Condor*, vol. 19, pp. 121-214. 1917.

"Effect of Paraffin on the Accumulation of Ammonia and Nitrates in the Soil," P. L. Gainey, *Journal of Agricultural Research*, vol. 10, pp. 355-364, 1917.

"Some Factors Affecting Nitrate-Nitrogen Accumulation in the Soil," P. L. Gainey and L. F. Metzler, *Journal of Agricultural Research*, vol. 11, pp. 43-64. 1917.

"Studies on the Life History of Two Kansas Scarabæidæ (Cleop.)," W. P. Hayes, *Journal of Economic Entomology*, vol. 11, pp. 136-144. 1918.

"Nutritive Properties of Kafirin," A. G. Hogan, *The Journal of Biological Chemistry*, vol. 33, pp. 151-159. 1918.

"Microorganisms and Heat Production in Silage Fermentation," O. W. Hunter, *Journal of Agricultural Research*, vol. 10, pp. 75-83. 1917.

"The Colon-Aerogenes Group from Silage," O. W. Hunter, *The Journal of Bacteriology*, vol. 2, pp. 635-639. 1917.

"A Further Study of the Etiology of Roup in Fowls," J. G. Jackley, *Journal of the American Veterinary Medical Association*, vol. 52, pp. 853-858. 1918.

"The Agronomist of the Future," W. M. Jardine, *Journal of the American Society of Agronomy*, vol. 9, pp. 385-390. 1917.

"A New Wheat for Kansas," W. M. Jardine, *Journal of the American Society of Agronomy*, vol. 9, pp. 257-266. 1917.

"The Case of the Blue Andalusian," William A. Lippincott, *The American Naturalist*, vol. 52, pp. 95-115. 1918.

"The Factors for Yellow in Mice and Notch in Drosophila," William A. Lippincott, *The American Naturalist*, vol. 52, pp. 364-365. 1918.

"Notes on False Wireworms with Especial Reference to Eleodes Tricostata Say," J. W. McColloch, *Journal of Economic Entomology*, vol. 11, pp. 212-224. 1918.

"Relation of Kinds and Varieties of Grain to Hessian Fly Injury," J. W. McColloch and S. C. Salmon, *Journal of Agricultural Research*, vol. 12, pp. 519-527. 1918.

"Notes on the Migration of Hessian Fly Larvæ," J. W. McColloch and Hachiro Yuasa, *Journal of Animal Behavior*, vol. 7, pp. 307-323. 1917.

"Three Varieties of Hard Red Winter Wheat Resistant to Stem Rust," L. E. Melchers and J. H. Parker. *Phytopathology*, vol. 8, p. 79. 1918.

"Further Data on the Relation Between Aphids and Fire Blight *Bacillus amylovorus* (Bur.) Trev.," J. H. Merrill, *Journal of Economic Entomology*, vol. 10, pp. 45-46. 1917.

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"Daily Variation of Water and Dry Matter of the Leaves of Corn and the Sorghums," E. C. Miller, *Journal of Agricultural Research*, vol. 10, pp. 11-45. 1917.

"Comparative Transpiration of Corn and the Sorghums," E. C. Miller, *Journal of Agricultural Research*, vol. 13, pp. 579-604. 1918.

"A Device for Sowing Grasshopper Poison," T. H. Parks, *Journal of Economic Entomology*, vol. 10, pp. 524-525. 1917.

"Relation of Density of Cell Sap to Winter Hardiness in Small Grains," S. C. Salmon, *Journal of Agricultural Research*, vol. 13, pp. 497-506. 1918.

"Why Cereals Winterkill," S. C. Salmon, *Journal of the American Society of Agronomy*, vol. 9, pp. 353-380. 1917.

"The Effect of Prolonged Growing of Alfalfa on the Nitrogen Content of the Soil," C. O. Swanson, *Journal of the American Society of Agronomy*, vol. 9, pp. 305-314. 1917.

"Enchytræidæ (Oligochaeta) from the Rock Mountain Region," Paul S. Welch, *Transactions of the American Microscopical Society*, vol. 36, pp. 67-81. 1917.

"Entomological Notes," Paul S. Welch, *Transactions of the American Microscopical Society*, vol. 36, pp. 97-100. 1917.

"Entomological Notes," Paul S. Welch, *Transactions of the American Microscopical Society*, vol. 36, pp. 274-280. 1917.

"The Enchytræidæ (Oligochaeta) of the Woods Hole Region," Paul S. Welch, *Transactions of the American Microscopical Society*, vol. 36, pp. 119-138. 1917.

"An Extra Molt in the Nymphal Stages on the Chinch Bug," Hachiro Yuasa, *Entomological News*, vol. 29, pp. 233-234. 1918.

"Some Constituents of the American Grapefruit (*Citrus Decumana*)," H. F. Zoller, *Journal of Industrial and Engineering Chemistry*, vol. 10, pp. 364-373. 1918.

### INVESTIGATIONAL WORK

A brief summary of some of the more important lines of investigation, showing the progress that has been made during the fiscal year is given herewith. The projects are grouped according to the funds from which they receive their chief financial support.

#### ADAMS FUND PROJECTS

**Animal Nutrition Investigations.**—These investigations have been continued with the purpose of applying the information obtained by the experimental work of recent years on the uses of food in the animal body. Three phases of the subject have been studied during the year.

(a) *Deficiencies of Corn for Feeding Pregnant Sows.*—This phase of the experiment was begun 1916-17. Fifteen purebred Duroc-Jersey gilts were placed on different rations to study the effect of such rations on foetal development of the litter and on the development of the pigs from birth to weaning time (60 days of age). Ten of the gilts used in the experiment in 1916-17, and four gilts farrowed in the spring of 1917 were used in a continuation of the experiment this year. These ten sows and four gilts were divided into four lots. A tabulation, showing briefly the rations used and results obtained is given in Table L.

The ration fed lot 46, in which no live pigs were farrowed, furnished approximately the same amount of protein as that fed lot 45, but it was much lower in ash. Only one dead pig was farrowed in lot 45, and the others in that lot were about average in size and strength. The greatest average number of live pigs per sow 10 days after farrowing were obtained in lot 45, which averaged seven live 10-day-old pigs per litter. The heaviest pigs at birth were obtained in lot 46, in which the average birth weight was 2.27 lbs., but this lot farrowed only dead pigs. The lightest pigs were farrowed by lot 44B, in which the average birth weight was 1.92 lbs. Chemical analyses are being made of the carcasses of pigs in these lots, but the complete results are not yet available.

(b) *The Effects of the Addition of Protein and Ash to the Rations of Fattening Hogs Under Practical Conditions.*—Sixty-six Duroc-Jersey pigs of uniform type and breeding secured from the Fort Hays Branch Experiment Station were used in this experiment, six pigs in each of the 11 lots. Seven lots were fed on alfalfa pasture and four in dry lots for a period of 100 days. The methods used (whether the feeds were fed separately or mixed), the rations fed, and the results secured are indicated in Table II.

TABLE I.—FEEDING OF PREGNANT SOWS, 1917-18

Lot No.	Sow No.	Ration, 1917-18	Pigs farrowed			Average weight at birth
			Live	Dead	Raised (a)	
44 A	19	Ground corn and tap water.....	2	1	2	} 2.19
44 A	28	“ “ “ “ .....	5	1	0	
44 A	38	“ “ “ “ .....	4	4	0	
44 A	2	“ “ “ “ .....	2	0	2	
44 B	12	Ground corn and distilled water.....	5	2	0	} 1.92
44 B	54	“ “ “ “ .....	9	4	0	
44 B	78	“ “ “ “ .....	10	2	0	
44 B	1	“ “ “ “ .....	2	0	2	
45	23	Corn 70 percent, shorts 24 percent, tankage 6 percent.....	3	0	3	} 2.19
45	3	“ “ “ “ “ “ .....	5	0	5	
45	4	“ “ “ “ “ “ .....	3	1	3	
46	60	Corn 90 percent, gluten meal 5 percent, blood meal 5 percent.....	0	15	0	} 2.27
46	97	“ “ “ “ “ “ .....	0	6	0	
46	5	“ “ “ “ “ “ .....	0	0	0	

(a) Pigs killed accidentally, or for analysis are included in this table.

TABLE II.—THE EFFECTS OF ASH AND PROTEIN IN THE RATIIONS OF FATTENING PIGS

(Experiment to determine profitable methods of fattening pigs for early market)

RATION	Dry Lot				Pasture	
	Lot 16 <i>Mixed</i>	Lot 17 <i>Mixed</i>	Lot 18 <i>Mixed</i> Reducing protein ration	Lot 19 <i>Free-choice</i>	Lot 20 <i>Mixed</i>	Lot 21 <i>Free-choice</i>
	Gr. corn 70 percent, shorts 24 percent, tankage 6 percent	Gr. corn 60 per cent, shorts 32 percent, tankage 8 percent	Gr. corn 40-80 percent, shorts 48-16 percent, tankage 12-4 percent	Gr. corn, shorts, tankage	Gr. corn 80 percent, shorts 16 percent, tankage 4 percent, alfalfa pasture	Sh. corn, shorts, tankage, alfalfa pasture
Number of pigs in lot.....	6	6	6	6	6	6
Average initial weight.....	53 lbs.	54 lbs.	54 lbs.	54 lbs.	53 lbs.	54 lbs.
Average daily gain per pig.....	1.33 lbs.	1.33 lbs.	1.43 lbs.	1.45 lbs.	1.51 lbs.	1.50 lbs.
Days to gain 150 pounds per pig....	112	112	105	104	99	100
Concentrates consumed daily per pig.	5.73 lbs.	6 05 lbs.	6 26 lbs.	6.37 lbs.	6.00 lbs.	5.46 lbs.
Concentrates consumed per 100 pounds gain						
Corn.....	299 lbs.	271 lbs.	279 lbs.	301 lbs.	317 lbs.	307 lbs.
Shorts.....	103 lbs.	145 lbs.	127 lbs.	125 lbs.	68 lbs.	50 lbs.
Tankage.....	26 lbs.	36 lbs.	32 lbs.	16 lbs.	16 lbs.	7 lbs.
Total.....	428 lbs.	452 lbs.	438 lbs.	442 lbs.	396 lbs.	364 lbs.



TABLE II.—THE EFFECTS OF ASH AND PROTEIN IN RATIONS (CONCLUDED)

RATION	Pasture				
	LOT 22 <i>Mixed</i> Gr. corn 94 percent, tankage 6 percent, ash free-choice, alfalfa pasture	LOT 23 <i>Free-choice</i> Sh. corn, tankage, ash free-choice, alfalfa pasture	LOT 24 <i>Mixed</i> Gr. corn, alfalfa pasture	LOT 25 <i>Mixed</i> Gr. corn 100 percent, bone ash 2.5 percent, alfalfa pasture	LOT 26 <i>Mixed</i> Gr. corn, ash free-choice, alfalfa pasture
Number of pigs in lot.....	6	6	6	6	6
Average initial weight.....	53 lbs.	53 lbs.	54 lbs.	54 lbs.	54 lbs.
Average daily gain per pig.....	1.55 lbs.	1.48 lbs.	1.45 lbs.	1.43 lbs.	1.40 lbs.
Days to gain 150 pounds per pig.....	97	101	104	104	107
Concentrates consumed daily per pig.....	5.74 lbs.	5.49 lbs.	5.36 lbs.	5.59 lbs.	5.42 lbs.
Concentrates consumed per 100 pounds gain					
Corn.....	349 lbs.	360 lbs.	371 lbs.	379 lbs.	386 lbs.
Shorts.....					
Tankage.....	22 lbs.	10 lbs.		Ash 9 lbs.	
Total.....	371 lbs.	370 lbs.	371 lbs.	388 lbs.	386 lbs.

The most rapid gains were made by lot 22, which had access to alfalfa pasture supplemented with ground corn, tankage, and ash, and which averaged 1.55 lbs. gain per pig per day. The slowest gains were made by lots 16 and 17, which received corn, shorts, and tankage in dry lot. The lowest quantity of concentrates consumed per 100 pounds of gain (349 pounds) was in lot 22. At the prices then obtaining, the cheapest gains were made by lot 21 in which 100 pounds of gain cost \$9.68.

(c) *Protein and Ash Deficiencies of Corn and Sorghum Grains.*—The mineral and protein deficiencies of corn as the sole ration for young animals have been studied for several years. It has been shown that the mineral deficiency is largely remedied by the use of calcium, and that the protein deficiency is due largely to the quality of the proteins in the cereal. During the fiscal year, 1916-1917, experiments were started to determine the feeding deficiencies of kafir, by methods similar to those previously employed with corn. Rats were used as experimental animals. Some of the conclusions reached are as follows:

When kafirin, the protein most abundant in kafir, formed the sole source of protein, the diet was a nutritive failure. The addition of gelatin alone enabled the rats to grow slowly; the addition of gliadin alone barely sufficed to maintain the live weight of the animals. When both proteins were added the animals grew more rapidly than when gelatin alone was added. The tentative theory that there are at least two limiting factors in kafirin as a source of protein has been suggested. Gelatin supplies the one, and gliaden the other. Gelatin contains a larger percent of lysine than gliadin, but it lacks tyrosine, cystine, and tryptophane. Gliadin, while deficient in Iysine contains these three amino acids in fairly satisfactory proportions. On the basis of these facts it is assumed that lysine is the first limiting factor in kafirin and that the three other amino acids, tyrosine, cystine, and tryptophane, constitute the second.

To investigate the deficiencies in kafirin more definitely the amino acids mentioned were added to the basal ration. The addition of tryptophane or tyrosine to the basal ration containing Iysine did not increase the rate of growth. When cystine was superimposed on this ration the animals grew somewhat more rapidly.

When kafir forms the sole diet of white rats, it has about the same nutritional value as corn. Kafir is seriously deficient in calcium, but when this element (Calcium lactate) is supplied, the animals grow and attain maturity, though the growth period is considerably prolonged. Growth on kafir and ash mixture is apparently more rapid than on corn and ash mixture. The proteins of kafir seemed to have a biological value equal to that of corn in inducing growth.

Kafir is probably deficient in one of the accessory substances. A comparison of the data obtained by feeding kafir and by feeding corn indicates that the fat soluble A, as described by McCollum, is a limiting factor. The experiments have also shown that the water soluble accessory is deficient in kafir. This was discovered in a study of the proteins of milo, feterita, and kafir as compared with the proteins of corn. All these grains, except kafir, have an abundance of the water soluble accessory and some authors have made the assertion that all grains have an abundance of this accessory.

**Sex Type as Related to Functional Development and Performance.**—This investigation was inaugurated in the spring of 1915 in cooperation with the Bureau of Animal Industry of the United States Department of Agriculture. Each of the 20 Shorthorn cows purchased had shown her ability to transmit beef characteristics to her offspring. The cows were assembled at the Kansas Agricultural Experiment Station, September 1, 1915. The investigation is planned to run 20 years. No cow is to be retained that does not demonstrate her ability to produce good beef calves. The cows are bred only to beef bulls of exceptional merit whose dams were high milk producers. Their feeding and care promote maximum milk production. It is hoped by long investigation to determine the relation of beef type in the parent to the transmission of beef characteristics and milking ability—to obtain some positive information on the proper standards for the selection of females in the beef breeds.

Thirteen of the cows in the original herd are still in the experiment. The Scotch-bred cow, Pride's Bessie (fig. 2) has been admitted to the Shorthorn Registry of Merit on her milk and butterfat record. She is the first purebred Scotch Shorthorn to be admitted to the Shorthorn Registry of Merit.

Several young cows have been put into the experiment to take the place of those dropped because of the failure of their offspring to meet the standards. The number is thus kept up to the original number—20. Of the 19 calves, born during the year, 13 were sired by Matchless Dale and 6 by Narcissus Type. A bull calf sired by Matchless Dale and out of Daisy 4th was sold when 15 months old for \$1,000. He will head a large Shorthorn herd.

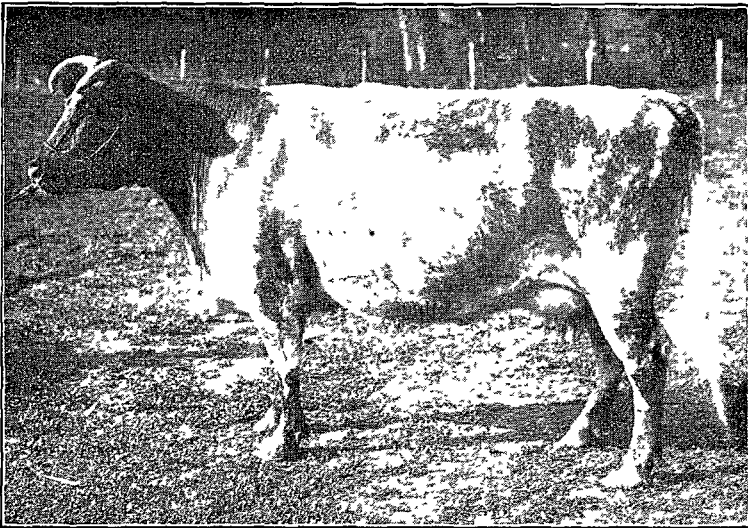


FIG. 2.—Pride's Bessie, Purebred Scotch Shorthorn

**Alfalfa Hay Investigations.**—Experimental tests on work horses with alfalfa hay cut at different stages of maturity were discontinued. The field and chemical work, however, was continued for the purpose of studying the results of cutting alfalfa at different stages of maturity, on the annual yield and on the permanence of stand for a period of years; also for the purpose of continuing the study of the effect of cutting at different stages of maturity on the chemical composition of the hay.

The average yields of four years show that the full bloom stage yielded 4.88 tons per acre or 0.29 tons higher than the one-tenth bloom. The bud and the seed stages each averaged 0.98 tons per acre less in yield than the full bloom and 0.69 tons less than one-tenth bloom. The stand of alfalfa in the bud stage plots is deteriorating rapidly, the plants being replaced by grass and weeds.

**Breeding Investigations with Orthoptera.**—Life history studies under controlled temperature and moisture conditions have been continued. An electric motor has been installed which makes the air conditioner more efficient. In the breeding of the parthenogenetic *apotettix* in controlled chambers indications have been found that certain characters of form may be affected by temperature and moisture. It will require several seasons to determine the effect.

To demonstrate fully the parthenogenesis of this genus, large numbers have been bred, some to the fourth generation without male parents. With only four exceptions in several thousand, all the parthenogenetic offspring are females. Not only do the pure lines produce by parthenogenesis, but the heterozygotes as well. There is also "crossing over" or "linkage" in this group, and their method of developing young without fertilization makes them excellent material for the study of this important phenomenon. Three papers, the results of the work of this project, two dealing with inheritance in *Paratettix*, by Nabours, and another presenting results of breeding *Tettigidea*, by Bellamy, were published in the October, 1917, number of the *Journal of Genetics*, Cambridge University Press.

**Climate and Injurious Insect Investigations.**—Life history studies under controlled conditions have heretofore been made on a number of insects, especially the Hessian fly and the chinch bug egg parasite. These studies have been correlated with others made under natural conditions.

A study has also been made of the corn leaf-aphis, *Aphis maidis*, under controlled conditions. Fifty-five generations of this species were reared and interesting data were secured regarding the effect of temperature upon development. At temperatures of from 84° to 90°F., no winged forms appeared. At 72°F., only one winged form appeared among many hundreds of wingless ones. At from 60° F. to 70° F., large numbers of winged forms appeared. In the entire 55 generations, no males appeared.

Studies are now being carried on with another species of aphid, *Macrosiphum granaria*, to determine the effect of temperature and moisture conditions upon its rate of development and upon the appearance of the winged forms and of the sexual forms. The installation of an electric motor makes the air con-

ditioner thoroughly efficient in the control of temperature and moisture conditions in the laboratory.

**Parasitology Investigations.**—This work has been pursued during the year along two lines as follows:

(a) *Life Histories of Chicken Tapeworms.*—Extensive investigations indicate that the common cricket (*Gryllus* sp.), so abundant about poultry yards, may not serve as an intermediate host of fowl tapeworms. Similar results have been obtained by feeding fowls earthworms that had been either given tapeworm embryos, or removed from infected poultry yards.

The technique for feeding tapeworm embryos to house flies, and for keeping the latter alive long enough to permit the formation of larval tapeworms in their bodies was worked out, and the fowl tapeworm, *Davainea cesticillus* (Molin), has been transmitted to chickens by feeding them house flies, *Musca domestica*, which had been given embryos of this cestode. Among the tapeworms transmitted, two were sexually mature. These results which furnish the first experimental evidence on the life cycle of this parasite have been accepted for publication in the *Journal of Parasitology*. It is planned to continue the investigation of the house fly as an intermediate host of fowl tapeworms.

(b) *Fowl Nematode Transmission.*—It has been demonstrated that fowls may become infected with the nematode, *Heterakis papillosa* Bloch, by the feeding of the dung earthworm, *Helodrilus gieseleri hempeli* Smith. (Ackert, James E. 1917. "A Means of Transmitting the Fowl Nematode, *Heterakis papillosa* Bloch." *Science*, n. s., 46:394.) Studies of the life history of this parasite begun this year will be continued.

#### HATCH FUND PROJECTS

**Soil Fertility Investigations.**—This project includes various cropping systems, the application of barnyard manure in different amounts, and the use of green-manuring crops and of commercial fertilizers on various crops.

Because of adverse climatic conditions corn yields in 1917 were very light, but some interesting variations in yield were obtained. Plots that have been growing corn continuously since 1910 yielded 22.6 bushels per acre while plots that grew corn in rotation with wheat and alfalfa yielded 44.9 bushels.

Corn grown in rotation with cowpeas and wheat yielded 32.8 bushels per acre and a system in which corn is grown two years and wheat one gave a yield of 22.7 bushels of corn in 1917. Applications of commercial fertilizer had little or no effect on the yields of corn grown in rotation but marked differences were obtained where corn was grown continuously. It appears that phosphorus may be applied with profit to Kansas soils that are in a low state of fertility and are growing corn continuously without applications of manure. Manure applied at the rate of 2.5 tons annually has increased the average yield of corn 7.93 bushels per acre.

The severe winterkilling of wheat during the months of January and February resulted in low yields. The effect of cropping system on the yield of wheat is brought out by Table III.

TABLE III.—EFFECT OF CROPPING SYSTEM ON YIELD OF WHEAT

CROPPING SYSTEM	Yield in bushels per acre—							
	1911	1912	1913	1914	1915	1916	1917	Av.
Alfalfa four years, corn two years, and wheat one year..	18 00	10 97	11 43	32 60	19 52	18 47	10 10	17 3
Corn, cowpeas, and wheat .	15 83	9 04	9 95	29 8	15 27	16 73	13 63	15 73
Corn two yrs., wheat one yr.	12 66	7 59	5 17	29 6	12 41	16 31	9 96	13 38
Wheat continuously.	25 84	5 73	17 64	23 50	12.75	6 86	11 85	14 88

It will be noted that the average increase due to rotation is quite marked, but that the differences in 1917 were very slight, due to the extreme winterkilling.

Applications of manure on wheat continue to have a decided influence on the yield, especially when wheat is grown continuously. In 1917 the yield on the plot cropped continuously to wheat without manure was 11.85 bushels per acre, and on the plot cropped continuously to wheat but receiving 2.5 tons of manure per acre annually, 20.5 bushels.

Each ton of manure that has been used in growing wheat continuously has given an average increase of 2.9 bushels of grain. The increase has not been so great when wheat has been grown in rotation.

Commercial fertilizers did not have as much influence on the yields of wheat during 1917 as they had the two years previous. In several cases in the rotation work the fertilized plots gave lower yields than the check plots. In the continuously cropped wheat plots all those receiving commercial fer-

tilizers gave a higher yield than the check plots. Phosphorus has increased the average yield of wheat in the three-year rotation 3.49 bushels per acre, while the complete fertilizer has increased the average yield 7.07 bushels per acre. However, the results indicate that the best fertilizer for wheat is one high in phosphorus and containing some nitrogen. Potassium has not proved beneficial.

Alfalfa yields were low because of the dry condition during midsummer. The yields on the series growing alfalfa in rotation were much higher than those secured from the continuous series. Applications of manure at the rate of five tons every three years produced an increase of approximately half a ton of hay during the season of 1917.

Commercial fertilizers increased the yield of alfalfa in all cases, but the increase due to applications of potassium was so small as to be negligible. An application of 180 pounds of acid phosphate per acre on alfalfa grown in rotation increased the yield 986 pounds in 1917, and the average yield since 1911, 878.9 pounds. The complete fertilizer has increased the average yield 1477.5 pounds.

Excellent yields of cowpea hay were secured during 1917. The highest yielding plots were those receiving complete commercial fertilizer and barnyard manure.

In the alfalfa, kafir, corn, and oats rotation, the highest yield of alfalfa hay was secured from the plot receiving manure and rock phosphate. On the kafir series the check plot yielded 18.1 bushels per acre, the plot receiving fresh manure yielded 23.8 bushels, the plot receiving fresh manure and rock phosphate yielded 23.4 bushels, while the one receiving leached manure yielded 25.7 bushels.

**Tillage Investigations.**—This work has been pursued the past season along three lines as follows:

(a) *Seedbed Preparation for Wheat.*—The results of seedbed preparation investigations agree with those of previous years in showing a direct correlation between the yield and the date and depth of a seedbed preparation (to 7" in depth) for wheat on continuously cropped plots, and between the yield and the date of preparation on the plots cropped in rotation. The highest yields were secured from the earliest preparation and, in the case of the plots cropped continuously to wheat, from plots plowed 7 inches deep.



Nitrification varied with the available moisture in the soil during the period of preparation. The available moisture appeared to be dependent upon the amount of weed growth. The different methods of seedbed preparation have had little, if any, influence upon the potential efficiency of the organisms concerned in the formation of nitrates. Any difference in the rate of nitrate formation was, therefore, due to differences in the activity of those organisms concerned in the decomposition of organic matter. The differences in the rate of decomposition of organic matter are due to environmental conditions which render activity of the bacterial flora difficult, and not to differences in the flora. The principal environmental factors responsible for variations in the rate of organic decomposition are distribution of organic matter and availability of moisture. Vitrification was as great in the surface 3 inches of soil as in the 3- to 6-inch section. In the 6- to 12-inch section, however, vitrification was less than in the upper layers.

Determinations of the amount of weed growth on the late-prepared plots and of the amount of nitrogen contained in the weeds, lead to the conclusion that vitrification was as rapid on these plots as on those receiving early tillage.

The average yields indicate that if wheat stubble cannot be plowed immediately after harvest (July 15), the best system to practice is to double disk immediately and plow 6 or 7 inches deep when convenient, but not later than the fore part of September. Cultivation should be sufficient to keep down the weeds and produce a firm seedbed.

(b) *The Soil Mulch.*—Studies on the effect of soil mulching with different soil types were begun during the season. The soil types employed were silt loam, fine sand, and clay. Eight plots each 12 by 12 feet were used. On four of them the surface foot was removed and the space filled, in two of them with fine sand, and in the other two with clay. A bare surface and a 3-inch cultivation were compared for each soil type. In addition weeds were allowed to grow throughout the season on two plots. The average percent of moisture to a depth of 6 feet in each of the eight plots for the period from April 1 to October 1, 1917, is shown in Table IV.

The table shows that the cultivation was not effective in conserving moisture, except possibly in the case of the sand. The difference in that instance was 0.8 percent in favor of the cultivation.

TABLE IV.—MOISTURE EXPRESSED AS PERCENT OF DRY WEIGHT

Clay		Sand		Silt loam		Weeds	
Three-inch cultivation	Bare surface	Three-inch cultivation	Bare surface	Three-inch cultivation	Bare surface	Plot No. 1	Plot No. 2
22.4	23.0	17.2	16.4	19.9	20.4	17.5	17.0

The average nitrates in a depth of 3 feet for the same period, April 1 to October 1, are expressed in Table V.

TABLE V.—NITRATES EXPRESSED AS POUNDS PER ACRE-FOOT

Clay		Sand		Silt loam		Weeds	
Three-inch cultivation	Bare surface	Three-inch cultivation	Bare surface	Three-inch cultivation	Bare surface	Plot No. 1	Plot No. 2
74.5	57.67	91.4	126.1	219.2	220.3	57.0	114.5

Except with clay, nitrification was evidently as great in the bare surface as in the cultivated soil.

(c) *Crop Sequence of Sorghums.*—By four different sets of water cultures with wheat seedlings using soil solutions obtained by leaching, filtering, and centrifuging, it has been definitely determined that kafir and milo do not have a toxic effect upon the soil. This applies even during seasons when kafir has affected the wheat growth injuriously as shown by comparison with corn.

Nutrient solutions were used in conjunction with the water cultures and these indicate that kafir soil is lacking in available nitrogen. Oats were grown in field soil previously cropped to corn, kafir, and mile, respectively, and fertilized with combinations of nitrogen, phosphorus, and potassium. Applications of nitrogen alone on kafir soil produced a growth of oats exceeding the untreated corn soil or corn soil with nitrogen.

Soil moisture and nitrate determinations at the time of planting fall wheat showed there was less moisture and nitrates in the soil from the kafir plots than from the corn plots. This may be accounted for by the fact that the kafir produced about twice as much dry matter as the corn.

**Cereal Crop Improvement.**—The experimental work of this project was conducted much the same as in previous years. The nursery and technical breeding work has been in charge of Professor John H. Parker since September, 1917, while the other phases of the work have been under the same leadership as in previous years.

Kanred, the new and improved wheat developed by the station, has continued to demonstrate its superiority to other varieties. Its average yield for the seven years during which it has been grown in field plots at Manhattan is 4.5 bushels per acre higher than Turkey and 4.7 bushels higher than Kharkof. It appears to be markedly resistant to cold and to certain strains of black stem rust. Two other varieties known as Kansas Nos. 2414 and 2415 have also proved very resistant to cold and to rust.

Nebraska Hybrid No. 34 proved to be much less winter hardy than other varieties of wheat and for this reason is considered unsuited to Kansas conditions.

In cooperation with the Entomology Department 87 varieties of small grain, mostly wheat, were compared as to their susceptibility to injury from Hessian fly. Remarkable differences were found (1) in the attractiveness which different varieties appeared to have for the fly, and (2) in the ability of the fly to develop normally on different varieties. It was found that the fly seldom lays eggs on oats, barley, einkorn, spring emmer, and durum wheat, and less abundantly on soft winter wheats than on hard winter wheats. It was also found that on certain varieties, especially Illini Chief, Dawson Golden Chaff, Beechwood Hybrid, and Currell Selection, very few flaxseeds were developed although eggs were laid on the plants in abundance.

A new strain of Red Texas oats, Kansas No. 5179, has been giving especially good results. Its outstanding characteristic is its earliness, as it usually ripens with Kherson and Sixty-Day oats.

The furrow method of seeding wheat continues to give promising results. Unfortunately the time of seeding or the location of the plots for this test was unusually favorable and practically no winterkilling occurred although most of the varieties in the variety test were badly injured. As a result the grain sown in the usual manner came through the winter

in good condition. The average yield for wheat in furrows was 2.0 bushels per acre higher than for the usual method. As in previous years the north and south seeding has given better results than east and west.

Variety, method-of-cultivation, time-and-method-of-planting, and hybridization tests on corn were conducted on upland. The method-of-cultivation test was conducted on fall plowed and non-plowed land; the rate-of-planting test on both upland and bottom-land. The ear-to-row test with Pride of Saline was continued and a few rows of pedigreed corn, which has been self-pollinated in the greenhouse for a number of years, were added for field trial.

The method-of-cultivation test continued to show that weeds are the principal factor to consider in cultivation. The average yields on the plots which were not cultivated but in which the weeds were kept out with a hoe were only 1.1 bushels per acre less than the plots cultivated in the usual way. The plots cultivated during the summer gave the lowest yields of all.

In the rate-of-planting test 20-inch spacing gave the best yields on upland and 16-inch spacing on the bottom-land, as an average for four years.

**Forage Crop Improvement.**—A study of Sweet Clover was undertaken in cooperation with the Office of Forage Crop Investigations, United States Department of Agriculture, to find out the best rate, date, and method of seeding, and the relation of the stage of cutting and length of stubble to the yield of hay and seed. Experiments were also conducted on grazing the second year's growth in the spring as a substitute for cutting where the second crop was desired for seed.

In a five-year test Kansas Orange sorghum yielded 19.2 tons, Blackhull White kafir 12.6 tons, and corn 12.1 tons of silage per acre. Some of the less important varieties of the sorghums were omitted from the variety test, while other new ones were introduced for trial.

**Hessian Fly Investigations.**—In the phase of the study to determine the period of emergence of the Hessian fly it is not uncommon to find flies emerging from 18 to 24 months after the collection of wheat infested with the flaxseeds. In one case the fly was reared from wheat collected 36 months before the emergence of the adult.

Cold weather early in the fall of 1917 prevented a large main fall brood of the fly. The first spring brood although normal in size was retarded or killed by the cold weather during April and May. Many of those that survived did not reach the flaxseed stage until shortly before harvest. Because of these climatic conditions the second spring brood was very light. The central part of the state was the only area infested by the fly this year—Harvey, McPherson, Saline, and Dickinson Counties having the heaviest infestation. The winter killing of much of the wheat, especially in Western Kansas, is at least partly responsible for this reduction of the infested area.

A test was begun in the fall of 1916 in cooperation with the Agronomy Department to determine relative resistance or immunity of different varieties of small grain to Hessian fly injury. Eighty-seven varieties of small grain were under observation. Eggs were found on practically all varieties in large numbers, although there was a slight preference shown for the hard wheats. There was no correlation between the number of eggs laid on a variety and the subsequent infestation. Varieties bearing few eggs often had a large number of flaxseed, while other varieties bearing a large number of eggs had a light infestation. Illini Chief, a variety of soft wheat, showed complete immunity. The standard varieties of hard wheat had a much higher infestation than the standard varieties of soft wheat. The problem resolves itself into a study of: (1) The relative infestation and injury of different kinds, varieties, and strains of various small grains, and (2) why certain kinds and varieties are resistant or immune, or why they escape injury in some cases where others are badly injured.

**Corn Earworm Investigations.**—This study was continued along the same lines as during recent years. The cold months of April and May, 1917, seriously delayed early germination of the seed and the heat and drouth of July and August so seriously injured the development of the crop that the time-of-planting experiment showed little variation, either in yield per acre or percent of ears injured by the earworm.

In the variety test 18 varieties were grown and complete data were secured on tasselling, silking, and maturity, together

with data on percent of earworm injury and yields. Bloody Butcher and Silver King had the lowest percent of ears injured.

**Fruit Insect Investigations**—The study of the relation between aphids and blight infection was continued. A large number of apple seedlings were grown in the field insectary. Aphids transferred to these seedlings from blight infected leaves or pure cultures of bacteria produced blight infections.

Data were secured on the value of nicotine sulphate as a summer spray on fruit, vegetables, and field crops. The substance is so soluble in water that rain readily washed it from the leaves of fruit trees and the sprayed trees were as badly damaged by insects as the unsprayed. While it was very efficient in the destruction of aphids on various crops it was not found satisfactory in controlling cucumber beetles, cabbage worms, tomato worms, potato beetles, or corn earworms.

#### STATE FUND PROJECTS

**Farm Management Investigations.**—The farm management investigations during this year included farm surveys in three counties and detailed labor records on five farms. The surveys were made in Allen, Cowley, and Jackson Counties, complete records of a year's business being obtained. In the Allen County survey 57 farms were included; in Cowley County, 124; and in Jackson, 250. This was the third year's work in Allen and Cowley Counties and the first in Jackson. In Cowley County 100 of the records were for farms from which records had been obtained in both of the preceding years. The records for these three years, viz., 1914, 1915, and 1916, were combined for each of these 100 farms and the average of the three taken. These averages were then tabulated and studied to ascertain if the principles previously discovered in one-year studies, held true for a period of years. It was found that the profit-limiting factors were accentuated when three-year averages were considered, Size of business as measured in total area of farm, area in crops, or total capital, had no consistent effect on the profits. The following outstanding conclusions may be noted:

1. The principal factors limiting profits were: (a) The organization of the farming business with reference to diversity; (b) the number and productivity of livestock; and (c) the crop yields.

2. The farm of the average size was large enough to return good profits where other things were favorable. A few farms were so small as to be seriously handicapped by their size. This could usually be remedied by renting additional land.

3. Many farmers had too much of their capital invested in land, leaving too little working capital.

4. Additional capital should be invested in either more or better livestock according to the needs of the individual farmer.

5. More attention should be given to the conservation and utilization of barnyard manure so that soil fertility and crop yields will be maintained.

**Grazing Experiment.**—This experiment was begun in 1915 to determine the possibilities of improving native pasture land by a deferred and rotation system of grazing. Four separate fields are now included in the investigation. A field of 1120 acres is grazed as Mr. D. D. Casement, the owner of the land, desires; 140 acres was protected in 1915 and 1916 until seed-stalk maturity, grazed lightly until July 10, 1917, and then to capacity to October 16, 1917; 200 acres was grazed to its maximum carrying capacity each year; a fourth pasture of 120 acres which was grazed throughout the season of 1915, was handled by the deferred system of grazing in 1916 and 1917. Although the 1120-acre area was grazed throughout each season, it was not grazed to capacity and consequently has shown some improvement in the past three years. The percent of vacant ground in representative meter-square areas over the pasture has decreased 10.5 percent in the three years; the pure grass has increased 22.6 percent; weeds and grass mixed have decreased 3.4 percent; and the weeds have decreased 18.7 percent.

The 140-acre area, pastured by the deferred system of grazing during 1915 and 1916, showed a decrease in vacant ground of only 6.5 percent, but as there was 6.9 percent less vacant ground at the start of the experiment this area has reduced its vacant ground to a lower minimum than the 1120-acre field. The percent of pure grass has increased 28.8 percent, the weeds and grass mixed have decreased 9.9 percent, and the weeds alone have decreased 12.7 percent. Thus the vacant ground has decreased to a marked degree, the pure grass increased over 25 percent, and the weeds and grass mixed and the weeds alone have decreased on the protected area.

All tests with seeding tame plants have failed with the exception of that with sweet clover. This has been successful when planted in the fall or early spring if the pasture is to be grazed by the deferred system. In those fields which have been grazed continuously throughout the season sweet clover has been unsuccessful. The protection of an area during the early portion of the season for two years gives the clover a chance to become established and also to reseed, a factor of prime importance with biennial species. Detailed investigations are being continued to find out the factors which must be considered in burning native grass pastures. The effect of burning on soil temperatures, moisture, and the various grass and weed species is being carefully studied as well as the rate of growth of the grasses on burned and unburned areas.

**Effect of Alfalfa Upon Soil Fertility.**—This is the third year of work on this investigation to determine the effect of prolonged production of alfalfa upon soil fertility elements. Results thus far obtained indicate that while fields in the western part of the state, cropped to alfalfa for a period of years, contain a relatively larger percent of nitrogen than similar alfalfa fields in the eastern part of the state, yet as a rule, where alfalfa is grown continuously for hay and the entire crop removed, the nitrogen in the soil is not increased. The analytical work is only well begun and will later include determinations for phosphorus, calcium, and total carbon.

**Silage Investigations.**—During the year a study was made of the chemistry of sweet clover silage in comparison with alfalfa silage. Bacteriological studies were continued on the effect of adding a carbohydrate supplement to alfalfa for silage. It was found that good silage can be made from sweet clover with less difficulty than from alfalfa. Alfalfa siloed alone undergoes a typical fermentation but the final product is of poor quality. However, when a carbohydrate supplement was added to alfalfa it fermented with a good quality of silage. The alfalfa silage contained a much higher content of amino-acids and ammonia than the alfalfa silage with the carbohydrate supplement. The fermentation in each case is caused by the same group of microorganisms, but their metabolic processes are influenced by the composition of the silage. In the alfalfa silage available carbohydrates are limited, and as a result the microorganisms utilize protein as a source of food and energy.



However, when a carbohydrate is added to the alfalfa, the organisms preferring the carbohydrate utilize it for energy and thereby spare the protein from decomposition, and the silage from undesirable flavors and odors.

### **Physiological Investigations with Drouth-Resistant Plants.**

—In the work of this project it has been previously shown that under severe climatic conditions the sorghums, and particularly mile, can absorb water from the soil and transport it to the leaves more rapidly in proportion to the loss of water from the plant than can corn. As a result of this ability the sorghums, during the periods of drouth can produce more dry matter for each unit of leaf area than can corn. These studies were continued during the season, 1917, the following plants being used in the experiment: Corn, (1) Pride of Saline, (2) Sherrod's White Dent, and (3) Freed's White Dent; sorghums, (1) Blackhull's kafir, (2) Dwarf Blackhull kafir, (3) Dwarf mile, (4) Red Amber sorgo, (5) Freed's sorgo, and (6) feterita.

The amount of water transpired per plant in a given period stood, with the exception of Dwarf Blackhull kafir, in the same relative order as the extent of leaf surface. The amount of water transpired per plant, however, was not proportional to the extent of leaf surface. Blackhull kafir and Dwarf Blackhull kafir always had the lowest rate of transpiration per unit of leaf surface in the experiments in which these plants were used. All the varieties of corn used always transpired more water per plant during any given period than any of the sorghums. Their rate of transpiration per unit of leaf surface was, with the exception of the kafirs, always much lower than that of sorghums. The rate of transpiration per unit of leaf surface for feterita, Dwarf mile, Freed's sorgo, and Red Amber sorgo was much higher than that of the corn plant under the same conditions. This difference in the transpiration rate of corn and the sorghums was more marked when the plants had reached their full leaf development and the difference in leaf surface of these plants had reached a maximum. The difference in the transpiration rate per unit of leaf surface was also more evident under severe climatic conditions than under conditions where the evaporation was low.

The results of these experiments with corn and the sorghums seem to indicate that in most cases a small leaf surface is the most important factor in reducing the loss of water

from these plants. The corn plant is not capable of supplying its large extent of leaf surface with a sufficient amount of water to satisfy the evaporating power of the air, and as a result its rate of transpiration per unit of leaf surface falls below what it would be if the needed amount of water was supplied. The sorghums, on the other hand, with their small leaf surface are able to supply water in amounts sufficient to satisfy the evaporating power of the air and, as a result, their rate of transpiration per unit of leaf surface is higher than that of the corn.

The results of this work were published in the *Journal of Agricultural Research*, 13:579-604. (June 10, 1918.)

**Nutrients in Forage Crops.**—The object of this experiment is to determine, for the leading forage crops, the chemical composition, changes in composition, and losses of chemical constituents as affected by maturity and methods of harvesting and curing. While corn, the sorghums, including Sudan grass, and alfalfa are included in the study, the only completed results obtained to date are from alfalfa, stacked green. The most significant figures on this phase-of the work are as follows:

Amount of dry matter put into stack. . . . .	80,116	pounds
Amount of dry matter taken from stack. . . . .	48,806	"
Loss of dry matter. . . . .	31,310	"
Percent of loss. . . . .	39	

Some of the material in the stack was badly spoiled. The chemical analysis of the best black silage showed the following: (1) The moisture content was practically the same as when the material was put into the stack. (2) The ash content was considerably increased showing a large loss of organic matter.

(3) The percent of protein in the black alfalfa was greater than in the original hay, showing that the loss of protein was relatively less than that of other compounds. (4) The percent of nitrogen-free extract, crude fiber, and ether extract was less than in the original material showing a large loss of these compounds.

The work on different methods of curing alfalfa is showing definite results. It is planned to pursue this work one more season. Proteolysis is produced by the prolongation of the process of drying. Samples dried slowly contain a larger percent of nitrogen in the form of amino acids and amids than samples dried rapidly.

**Milling Investigations.**—A study is being made of the chemical changes which take place during the process of tempering wheat. These can be accurately measured by the electro-chemical apparatus. However, practically all the chemical work on wheat and flour is in a virgin field and progress is necessarily slow. It is hoped to secure some information on the factors which determine the gluten quality of wheat. Such factors as enzymes, electrolytes, and the products of protein hydrolysis are being studied.

The Agronomy Department submitted 74 samples of wheat for milling in the continuation of the study for the determination of the effect of seedbed preparation, soil fertility, and variety upon the milling and baking qualities of wheat. War conditions have seriously interfered with the rapid progress of this work. Figures and comparisons for a period of five years, however, will soon be available and it is probable that some definite information will be obtained.

**Milling Grain Sorghums.**—The milling and baking tests of kafir which were begun last year were continued. Larger amounts of kafir were manufactured into a rather fine meal. The best product was obtained by using blank sieves in the upper tiers of the 1st, 2d, and 4th break sections of the sifters and a No. 30 wire sieve in the top of the 3d break section. A 60-scratch roll was used on the 4th break and the stock from the last break was sent through the bran duster clothed with No. 28 wire. This process removed the coarse bran or hull which had not previously been removed by thorough scouring.

The product secured makes a quite satisfactory substitute for cornmeal and has much the same properties and characteristics. However, it is darker in color than white cornmeal and contains many specks. It also has a characteristic kafir flavor amounting almost to a bitterness in some cases. This bitterness is very noticeable when the meal is made from kafir containing appreciable percentages of immature or green kernels. The bitter flavor is not noticeable when some form of jelly, preserves, or sirup is eaten with these hot breads. Kafirmeal is being used to some extent as a substitute, many families preferring part kafirmeal to all cornmeal. More kafirmeal would undoubtedly be used during the enforced use of substitutes were the people as familiar with it as they are with cornmeal.

A very satisfactory mixed flour can be obtained by grinding a blend of 35 percent of kafir and 65 percent of wheat into a product corresponding to whole wheat flour. This mixed flour can be used very successfully in making muffins, gems, pancakes, waffles, and Parker house rolls. When used in making light bread enough white flour should be added to reduce the percentage of kafir to 20 percent. Less shortening should be used with kafir or kafir mixtures than with pure wheat.

**Garden Crops.**—Because of the importance of tomatoes, both as a kitchen crop and as a market garden crop, the work of the year consisted largely in determining the best methods of their production. On the tests to determine the value of pruning and staking, results for three seasons are now available. These show clearly that it is impractical to prune and stake tomatoes when growing them on a commercial scale. Increase of production is possible but the cost of pruning and staking will more than offset this increase. In the experiment pruning to three stems gave the maximum yields.

**Potato Investigations.**—This season's work confirms the wisdom of using some crop, usually either wheat or corn, which makes a heavy demand on the soil, between alfalfa and potatoes. Fall plowing has proved to be helpful in the control of potato diseases, possibly because of the fact that the soil is in better condition and better germination is secured.

**Orchard Management Investigations.**—This work is conducted for the purpose of determining the best methods of Kansas orchard management for the stimulation of maximum fruit production. During the year the study has been continued along two lines, as follows:

(a) *Soil Management.*—Continued experimentation in orchard soil management justifies the conclusion that alfalfa and permanent sodding must be abandoned in order to control the buffalo tree hopper (*Ceresa bubalis* Fab.). Serious washing of the glacial soils, even where cultivation is along the contour lines, indicates the need of cover crops, however, and cowpeas and oats are being tested for this purpose.

(b) *Orchard Pruning.*—The superiority of two prunings, summer and winter, over a single pruning or neglected pruning continues to be apparent, and a very large number of fruit buds were produced on 5-year old and 6-year old apple trees that were pruned for the two years preceding. Bad weather

at blossoming time prevented a satisfactory set of fruit of most varieties and the pruning tests will be continued. A check will be possible as younger trees come into bearing.

**Forest Tree Investigations.**—The station is emphasizing the desirability of increasing the planting of red cedar and black walnut, these species having shown under Kansas conditions their superiority as windbreaks, ornamental, and shade trees. The nuts of the black walnut, though incidental are a valuable by-product. These two species have also given greater returns, when they have reached timber size, than other species. The demand of the government for black walnut timber for airplane propellers, is further emphasizing the importance of black walnut trees in the future. The serious recent winter-killing of the *Arbor vitae* also emphasizes the importance of red cedars for windbreaks and ornamental plantings. Recent investigations also show the bull pine to be a valuable ornamental tree which has heretofore received too little attention in Kansas.

**Plant Disease Investigations.**—Plant disease investigations in cooperation with the Office of Cereal Investigations, Bureau of Plant Industry, United States Department of Agriculture, have been continued. The work of the year has been confined chiefly to three plant diseases, vitally affecting three crops of great economic importance to the state.

(a) *Wheat Stem Rust Investigations.*—More than 150 varieties of winter wheat have been tested for their resistance toward the ordinary black stem rust of wheat, *Puccinia graminis tritici*. The testing was undertaken both in the field and in the greenhouse. For four successive seasons, epidemics of stem rust were secured in the field, so that thorough tests of all varieties could be made. Of the varieties grown, three hard winter wheats have been definitely proved to be remarkably resistant to stem rust. These are P762 (Kanred), P1066, and P1068 (fig. 1); the first hard red winter wheats which are known to have this resistance towards *Puccinia graminis tritici*. Out of hundreds of inoculations in the seedling stage, not a single infection was secured.

Various selections of these three varieties have been made in the Kansas rust nursery. These have been sent to different cereal producing states in the Union, for the purpose of testing them for their hardiness and rust resistance under various

environmental conditions. Their resistance towards *Puccinia graminis tritici*, is as marked as the most resistant emmer or durum. All three are, or promise to be, of great commercial value.

About 120 hybrids between Kanred, P1066, and P1068 as the winter parents, and Minn. 188 (Preston) and C. I. 3641 (Marquis) as the spring parents, were made. This seed was planted in the cereal greenhouse and the F generation was successfully grown to maturity. These hybrids will be inoculated in the heading stage of the F generation.

A new form of stem rust of wheat, heretofore unreported to science, has been discovered. A preliminary publication appeared in station Circular 68, "Another Strain of *Puccinia Graminis*." This is a biologic form of *Puccinia graminis tritici* and on account of its infectious qualities, has been given the name *Puccinia graminis tritici inficiens*. It has been shown that Kanred, P1066, and P1068 are susceptible to the new rust, although they are highly resistant to *Puccinia graminis tritici*. Detailed physiological and morphological studies of the new form are being made.

(b) *Corn Smut Investigations*.—On account of unfavorable weather conditions and the use of a hybrid which had a peculiar anatomical leaf structure unfavorable to isolation experiments, little additional evidence was obtained concerning the life history of the corn smut fungus. Experiments to date, however, on the ecological studies of the corn smut organisms, show that the corn smut is carried from the soil by the wind to the axils of the leaves of the corn plant. Cultures are readily obtained from the leaf axils. It has been found that a virulent culture in a topmost leaf axil may serve as a source for infecting several nodes below thereby giving a plant the appearance of a systemic infection.

The use of fungicides on a large scale show, that under Kansas conditions at least, they are neither practical nor effective. Bordeaux mixtures and formaldehyde sprays in some cases reduce the percent of corn smut, but they likewise proportionately reduce the yield, even more so than the loss brought about by the smut.

In a variety test and a date-of-planting test in which four standard varieties of corn have been grown for four years, both at Manhattan and Hays, Kan., Kansas Sunflower has

shown consistently less corn smut. it has also been observed in the greenhouse when natural infection occurred, that Kansas Sunflower had less smut.

(c) *Varietal Resistance of Sorghums to Kernel Smut.*—A variety test of about 38 varieties of the sorghums grown both at Manhattan, Kan., and Amarillo, Tex., shows that a great difference exists in the different varieties as to their susceptibility to kernel smut. The percent of smut varied from 0 percent in the case of milo, feterita, white durra and Brown kaoliang, to 38 percent in the sorgo group. Although milo and feterita are stated in the literature as being immune to smut, investigations show that by artificially injuring the sprouting seed and dusting them with smut spores, infection can be secured. The problem as to what constitutes their natural resistance as compared to the other sorghums is being investigated at present.

**Plant Disease Survey.**—Field data on plant diseases must precede and accompany all research and intelligent application of control measures. The state plant disease survey in cooperation with the Office of Plant Disease Survey, Bureau of Plant Industry, United States Department of Agriculture, has been under way for four years. A large number of diseases previously unreported have been found in the state, and a large fund of information which will be helpful in controlling them has been secured, Nine of the diseases which have been located are new to science.

**Heifer Development Experiment.**—Definite data which are being secured on the relative cost of growth and milk production in dairy heifers raised on alfalfa alone, on alfalfa and silage, and on alfalfa silage and grain will be valuable to dairymen. The work was begun in 1914 with 18 heifer calves divided into three lots and fed as follows:

- Lot 1, alfalfa hay alone.
- Lot 2, alfalfa hay and silage.
- Lot 3, alfalfa hay, silage, and grain.

Lot 4, consisting of another six heifer calves, was added to the experiment the following year. These heifers were fed alfalfa hay, silage, and grain the same as those in lot 3, but were bred to calve at the age of 24 months. The heifers in the other lots were bred to calve at the age of 30 months. The ration of each lot is to be the sole ration until each cow has completed at least three lactation periods.

A few of the cows in lots 1, 2, and 3 have completed their first lactation periods. Cow No. 51 (fig. 3 A) from lot 1, produced 5,823 pounds of milk and 224 pounds of butterfat in one year. This cow had nothing to eat but alfalfa hay and con-

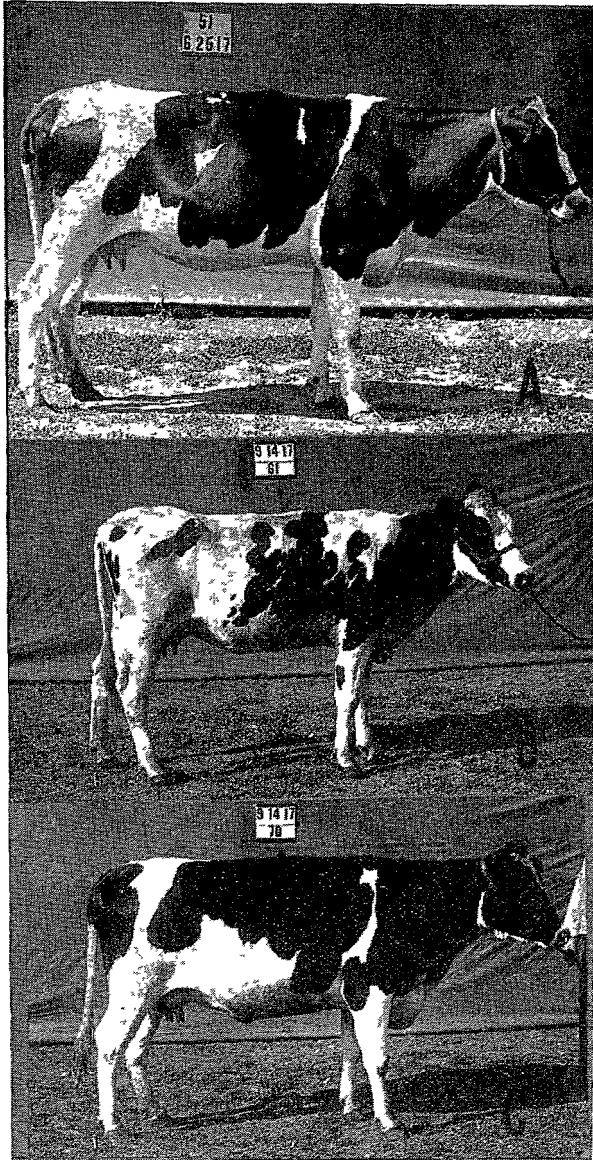


FIG. 3.—Representative cows from lots 1, 2, and 3 (A, B, and C, respectively)—Heifer Development Experiment



sumed, during maximum milk production, as much as 45 pounds per day. Her average daily consumption was about 35 pounds.

Cow No. 61 (fig. 3B), from lot 2, produced 6,047.2 pounds of milk, 211.1 pounds of butterfat during one year of her first lactation period. Cow No. 70 (fig. 3C), from lot 3, produced 5,831 pounds of milk and 221 pounds of butterfat during the first lactation period of only 10 months.

Complete records of all feeds, weights, measurements, and production are kept so that a complete report can be issued at the proper time.

**Cattle Feeding Investigations.**—Continuing the policy of the preceding five years, the Animal Husbandry Department fed for five months during the winter of 1917-18, 50 head of calves from the Fort Hays Branch Experiment Station. Most of these calves were produced by the use of White Shorthorn bulls on Aberdeen-Angus and Galloway cows. The calves were shipped to Manhattan early in December. From the time of their arrival until a week before they were put into the feedlot they were fed an average daily ration of 2 pounds corn and cob meal, 1/4 pound linseed meal, 1.2 pounds alfalfa hay, and 4 pounds silage. One week before the experiment started the calves were divided into five lots of ten each. The factors considered in making this division were: (1) All lots were made as nearly equal in weight as possible. (2) Six steers and four spayed heifers were placed in each lot. (3) Eight blue-greys and two red calves were placed in each lot. At the time of separation into lots each lot was put on a preliminary feed of the ration which it was to receive during the experiment, so that all lots had an equal advantage.

This experiment was conducted for the purpose of studying the efficiency of different Kansas grown feeds in finishing baby beef. Only feeds available to the Kansas cattlemen were used. The rations fed to the various lots were as follows:

Lot 30, shelled corn, linseed meal, alfalfa hay, immature corn and kafir silage.

Lot 31, shelled corn, linseed meal, and alfalfa hay.

Lot 32, shelled corn and alfalfa hay.

Lot 33, shelled corn, alfalfa hay, cottonseed meal, and immature corn and kafir silage.

Lot 34, ground corn, linseed meal, alfalfa hay, and immature corn and kafir silage.

Comparisons may be made as follows: (1) Between shelled corn and ground corn fed with linseed meal, alfalfa hay, and silage, as shown in lots 30 and 34. In this experiment the lot receiving ground corn made slightly larger daily gains, a little more expensive gains due to the fact that 10 cents per hundred weight was charged for grinding the corn, but the calves showed more finish and as a result were valued 25 cents per hundred higher than those receiving shelled corn. The calves fed ground corn returned slightly more profit per head. The results were so close, however, that the individuality of the calves could easily turn the profit the other way. (2) Between linseed meal and cottonseed meal, as shown in lots 30 and 33. This experiment, not unlike others heretofore conducted at this station, shows that linseed meal is superior to cottonseed meal as a protein supplement in finishing baby beef. Until the end of the third month the calves receiving cottonseed meal had gained more than any other lot and showed as much finish, but from that time on cottonseed meal did not seem to stimulate the appetite as did linseed meal with the result that they would not eat as much feed and could not make the gains. The profits in lot 30 were \$4.19 a head greater than the profits in lot 33, and this difference is attributed to the greater efficiency of linseed meal in finishing baby beef. (3) Between shelled corn, linseed meal, and alfalfa hay, fed with immature silage and without immature silage as shown in lots 30 and 31. In this experiment silage gave cheaper gains, more rapid gains, and a great deal more profit per head. While lot 31 returned the least profit per head, yet if it had been fed by itself so that no other lots could be compared with it, it would be considered that a very good profit had been made. (4) Between shelled corn and alfalfa hay, fed with linseed meal and without linseed meal as shown in lots 31 and 32. Lot 32 made smaller gains per day than lot 31 and did not show as much finish, but they made cheaper gains and returned slightly more profit per head. Here again the results were so close that the individuality of the calves could easily reverse the profits.

Table VI gives detailed information regarding the results secured.

All of the rations fed proved to be very satisfactory. With the valuation placed on the various lots by commission men from Kansas City, Wichita, and St. Joseph it can be seen that all five lots were above the average in finish. Each lot returned a large profit per calf, with no credit being given for manure or for the pork produced by hogs following the calves.

TABLE VI.—CATTLE FEEDING EXPERIMENT

(December 17, 1917, to May 16, 1918)

	Lot number and ration				
	Lot 30 Shelled corn, linseed meal, alfalfa hay, silage	Lot 31 Shelled corn, linseed meal, alfalfa hay	Lot 32 Shelled corn, alfalfa hay	Lot 33 Shelled corn, alfalfa hay, cottonseed meal, silage	Lot 34 Ground corn, linseed meal, alfalfa hay, silage
	<i>Pounds</i>	<i>Pounds</i>	<i>Pounds</i>	<i>Pounds</i>	<i>Pounds</i>
Initial weight.....	473.3	471.6	489.6	476.8	477.4
Final weight.....	845.3	827.8	833.3	844.3	854.2
Total gain.....	372.0	356.2	344.7	367.5	376.8
Average daily gain.....	2.48	2.37	2.30	2.45	2.51
Average daily rations:					
Corn.....	9.87	9.88	10.46	9.71	9.89
Linseed meal or cottonseed meal.....	1.68	1.68	.....	1.68	1.68
Alfalfa hay.....	4.53	9.79	10.30	4.70	4.49
Silage.....	10.31	.....	.....	10.35	10.35
Cost of feed per day.....	\$0.401	\$0.413	\$0.383	\$0.399	\$0.411
Cost of 100 pounds gain.....	16.20	17.40	16.68	16.29	16.36
Cost of feed per calf.....	60.25	61.99	57.50	59.76	61.76
Initial cost per calf at \$8.75.....	41.41	41.26	42.87	41.72	41.77
Total cost per calf.....	101.66	103.25	100.37	101.48	103.53
Final value per cwt.....	16.50	16.25	16.00	16.00	16.75
Value per calf.....	139.47	134.42	135.33	135.09	143.08
Profit per calf.....	33.58	37.03	28.79	29.89	35.18

There were ten calves in each lot. Cost of grinding corn, 10 cents per hundredweight. Fifty cents per hundredweight was deducted from profits for cost of marketing.

Price of feeds: Corn, \$1.50 per bushel; linseed meal and cottonseed meal, \$60 per ton; alfalfa hay, \$20 per ton; silage \$8 per ton.

**Feeding Western Lands.**—Three hundred lambs from New Mexico were purchased on the Kansas City market, the fore part of December, 1917. They were fed on rough feed until December 29, then divided into five lots of 60 each, and fed five different rations as shown in Table VII, which also shows the results secured.

**Inheritance Investigations in Swine.**—The object of this study is to determine the method of inheritance of fertility, color, shape of face, shape of ear, mammae pattern, differences in size, rate of growth, and time of maturity in swine.

TABLE VII.—LAMB FEEDING EXPERIMENT

(December 29, 1917, to February 27, 1918—60 days)

	Lot number and ration				
	Lot No. 15	Lot No. 16	Lot No. 17	Lot No. 18	Lot No. 19
	Shelled corn, alfalfa hay (crowded)	Shelled corn, alfalfa hay	Shelled corn, sweet clover hay, silage	Shelled corn, alfalfa hay, silage	Whole kafir, alfalfa hay
Average initial weight.....	<i>Pounds</i> 60.5	<i>Pounds</i> 61.2	<i>Pounds</i> 61.2	<i>Pounds</i> 60.4	<i>Pounds</i> 59.9
Average final weight.....	36.3	37.8	33.7	33.9	34.8
Gain.....	25.8	26.6	22.5	23.5	24.9
Average daily gain.....	.43	.44	.37	.39	.41
Average daily ration:					
Grain.....	1.46	1.42	1.37	1.37	1.39
Hay.....	1.54	1.76	1.02	.95	1.74
Silage.....			.81	.81	
Feed per 100 pounds gain:					
Grain.....	340	320	365	351	335
Hay.....	358	398	272	242	421
Silage.....			215	205	
Cost of 100 pounds gain.....	\$14.67	\$14.56	\$15.22	\$14.37	\$16.98
Cost of feed per lamb.....	3.78	3.87	3.41	3.37	4.22
Initial cost of lamb.....	9.68	9.79	9.79	9.66	9.58
Marketing expense.....	.39	.39	.39	.39	.39
Market grade.....	Choice	Prime	Choice	Choice	Good
Market price.....	\$17.30	\$17.45	\$17.30	\$17.30	\$17.15
Final value of lamb.....	14.06	14.45	13.61	13.65	13.69
Profit per lamb.....	.21	.40	.02	.23	.50
Value per bushel of grain consumed.....	1.81	1.94	1.69	1.84	1.62

Price of feeds: Shelled corn, \$1.68 per bushel; kafir, \$3.50 per hundredweight; alfalfa hay, \$25 per ton; sweet clover hay, \$25 per ton; silage, \$8 per ton. (Kafir at \$1.62 per bushel costs \$2.90 per hundredweight.)

During the past year the following crossings have been made: (1) Tamworth sow with wild boar. (2) Tamworth sow with crossbred Tamworth-wild boar. (3) Berkshire sow with wild boar. (4) Tamworth sow with Berkshire boar. (5) Duroc Jersey sow with Berkshire boar. The following tendencies have been noted: (1) The wide Berkshire forehead is dominant over the medium forehead of the Duroc Jersey and the narrow forehead of the Tamworth and the wild hog. (2) The Berkshire dish of face is recessive to the straight face of the Tamworth and the wild hog. (3) The Berkshire short face is completely recessive to the Tamworth long face. (4) The erect ear of the Berkshire is dominant over the drooping ear of the Duroc Jersey. Apparently there are distinct hereditary differences between the Berkshire and Duroc Jersey with respect to size, rate of growth and early maturity.

**Improvement and Conservation of Farm Poultry.**—A continuation of use of standard-bred males from high producing strains in grading up mongrel flocks constituted an important

part of the work of the year. The yearly egg production record of the third generation was secured. Barred Plymouth Rock, Single Comb White Leghorn and White Orpington males were used with different groups of mongrel pullets. Pullet offspring from the respective groups were mated the following year to cockerels of the same breed as their sires. This was repeated the third year.

A full report on this work is in preparation. The following results, taken from incomplete tabulations, are of interest: (1) The Barred Plymouth Rock third generation grade females which completed a full year's laying gave an average first year's production of 207.33 eggs as compared with an average first year's production of 104.5 eggs by their mongrel great-granddams. One of these third generation grade pullets, with

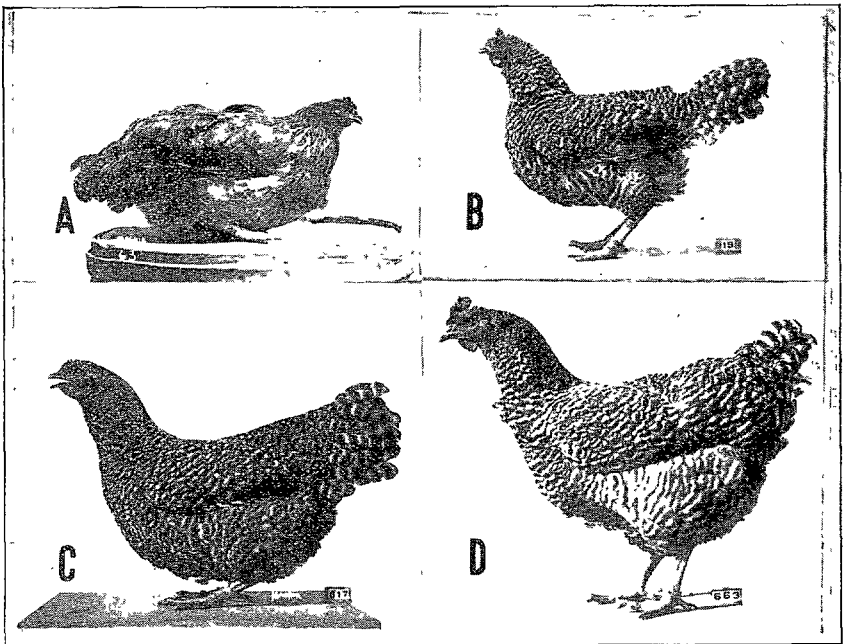


FIG. 4.—A grade Plymouth Rock pullet (D) of the third generation and her dam (C), granddam (B), and mongrel great-granddam (A). The first year's egg production record of each was as follows: A, 101 eggs; B, 120 eggs; C, 175 eggs; and D, 250 eggs

her dam, granddam, and great-granddam, is shown in figure 4. (2) The Single Comb White Leghorn third generation grade females which completed a full year's laying gave an average

first year's production of 198 eggs as compared with an average first year's production of 74.5 eggs by their mongrel great-granddams. (3) The results with White Orpingtons have not been as favorable though the same care in selecting males was exercised. The White Orpington third generation grade females completing a full laying year gave an average first year's production of 111.25 eggs as compared with an average first year's production of 123.5 eggs by their mongrel great-granddams.

A check pen of mongrels has been kept. through the three years, the pullet offspring being mated each year in turn to mongrel cockerels. The average first-year production of the third generation mongrel pullets completing a full year's laying was 129.60 eggs as compared with an average first-year production of 101.66 eggs by their mongrel great-granddams. The improvement noted may have been due to more systematic care during the growing period than their granddams received, though it would appear that this should have led to the same result in the care of the White Orpington grades.

The work of selecting for high egg production within the standard breeds most common on Kansas farms is being continued with success. Considerable numbers of eggs and breeders from high producing families have been sent out to farmers during the past year.

A study of the inheritance of Andalusian blue is also being carried on under this project. During the past season more than eighteen hundred chicks have been hatched, recorded, and described. From the evidence at hand it appears that at least four factors are responsible for the feather color of Blue Andalusians; namely, (1) black pigment, (2) a restrictor of black pigment which makes it appear bluish gray, (3) an extender which carries pigment to all the feathers of the body, and (4) lacing, which is responsible for the black edging of many of the contour feathers of both. males and females. Shank color is also being studied but the data are as yet insufficient to warrant a statement.

**Poultry Disease Investigations.**—This work has been continued during the year along the lines of previous investigation. A station circular on "Poultry Diseases" has been prepared and presented for publications. It will be available in the near future.

That the cause of roup in fowls is due to a bacterium of the pasteurella group (as previously reported by the station), has been further verified.

**Marketing of Dressed Poultry.**—On account of the shortage of help only a small amount of work was done on this project during the year. The work was carried out along two lines: (1) A study of decomposition in the hope of finding some method of preventing the formation of volatile putrefactive products. (2) An attempt to find some standard, other than odor, whereby it could be said spoilage had occurred.

Both bacteriological and chemical examinations were made. The work thus far indicates the following conclusions: (1) Quantitative bacteriological determinations are not an index to spoilage. (2) The most important accumulations of bacteria are in the intestinal tract and the skin. There is evidence that the skin flora plays a more important role than was formerly considered. (3) The intestinal tract gives rise to bad odors and volatile products most rapidly; the liver next, the skin next, if kept moist, and the muscles last. Nothing has been found to keep down the development of bad odors without injuring the appearance and texture of the skin.

**Insects Injurious to Sample Crops.**—Six phases of this work have been pursued during the year as follows:

1. The study of the life history, economy, and control of the kafir ant under laboratory and field conditions was completed and manuscripts prepared for the publication both of an illustrated station circular dealing especially with control measures and an illustrated technical bulletin, "A Biological Study of *Solenopsis molesta* Say." These publications will be available within a few months.

2. The study of the life history, economy, and control of the maize bill-bug under both laboratory and field conditions was completed. A manuscript for an illustrated circular on "Controlling Maize Bill-Bugs" and another for an illustrated technical bulletin on "The Maize Bill-Bug or Elephant Bug, *Sphenophorus maidis* Chittn." have been prepared for publication. It is hoped these publications will be available in the near future.

3. Flea-beetles were especially injurious to corn in Southeastern Kansas in the spring of 1917. Considerable time was spent in the infested fields studying the life history of the insects and giving advice to farmers on control measures.

4. The study of insects injurious to alfalfa was continued, more extensive work being done on some of the most important species. The alfalfa hay worm was given special attention. In the course of the investigation a new parasite was discovered, one probably new to science, since no parasite of the alfalfa hay worm has heretofore been known in this country. Studies were begun on the importance of insects as pollinators of alfalfa.

5. Considerable work was devoted to a study of the effect of repellents on germinating seeds. More than two thousand individual germination tests were conducted, most of them under field conditions. Among the most promising repellents are, bordeaux, turpentine, kerosene, black leaf 40, and lime-sulphur. Further careful and adequate tests will be made along lines that promise valuable results.

6. The study of insects injurious to roots of staple crops has included the May and muck beetles and closely related species, the wireworms and false wireworms.

Of the May beetles, 23 species have been found in the state, the data secured showing the period of flight, relative number and food habits of each species. Two species and the female of another species, not heretofore recorded from Kansas, are included in this data. The life histories of five species have now been worked out and a large amount of data have been obtained toward working out the life economies of several other species.

Of the muck beetles, two species occur in Kansas; namely, *Ligyris gibbosus* and *Ligyris relictus*. The life history of the former was repeated and considerable data was obtained on the latter.

In the study of the species closely related to the May beetles and muck beetles, the life histories of two species (*Cyclocephala villosa* and *Anomala binotata*) have been worked out and data prepared for publication. Rather extensive notes have been collected on *Diplolaxis*, *Euphoria*, *Catalpa*, *Pelidnota*, and *Pollyphylla*.

A complete biological study is being made of the various species of wireworm occurring in the state. There are at least eight species of great economic importance and data are being collected on all points in the life economy of each.



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The life histories of two species of false wireworms (*Eleodes opaca* and *Eleodes tricostata*) were repeated during the year. These confirmed the results of the previous year and gave considerable additional field data. At least nine more species occur in Kansas and a study of these will be begun in the near future. The parasite of *Eleodes tricostata*, which was common in 1916, did not appear in 1917, although every effort was made to find it.

**Termite Investigations.**—Further data were secured on habits, natural checks, and insect enemies of termites. The first true kings and true queens secured at this station were raised from swarming individuals. Winged forms were found in the nests in midwinter, indicating that these forms acquire their wings some time previous to swarming and that they are ready to swarm whenever conditions outside the nest are favorable.

**Shade-Tree Insect Investigations.**—No additional data were secured on the life histories of either the elm borer or the cedar scale. It was also found to be impossible to make any further observation on the chalcid parasite which has heretofore been found to be a valuable check on the increase of the cedar scale. In the study of the life history and methods of control of the cankerworm, the following data of interest and value were secured:

On the college campus 17 trees were banded with tanglefoot and examined daily until the cankerworms ceased to emerge. The first cankerworms caught on these bands were secured on November 28, 1917, the last ones were found April 16, 1918. The total number caught on the bands on these 17 trees was 795. The greatest number emerged on March 29, 1918. At the time of the maximum emergence, the temperature was 51.

A tree-banding material which has been used by the Gypsy Moth Commission in New England was made and given a trial. Owing to the climatic conditions found at Manhattan, this tree-banding material did not remain sticky during the cold nights and for that reason but few moths were captured by it.

Some trees were banded with celluloid, others with tin, and others with paper, to which had been applied a coat of enamel. The idea was that these materials would be too smooth for the

cankerworms to crawl over. These bands seemed to check the number of moths passing over, but further data are desired on this point.

**Bee Investigations.**—The study of the bee problems and their relation to Kansas conditions was undertaken as a definite and separate project in October, 1917.

To obtain some data on the methods of wintering bees, six colonies, as nearly uniform as possible, all having been given new queens from the same stock on the same date, were selected for an experiment. The amount of honey and the number of bees in each colony, were determined on the day the experiment started. All six of these hives were placed on scales and daily readings were made of the weight of each colony. Three of these colonies were placed in a position that was sheltered from the wind, while the other three were placed in an exposed position. In each set of three there were one single-story hive, one two-story hive, and one hive in an insulated packing case. Interesting data were secured from these readings which will be valuable when the experiment has been continued for a few winters.

**The Bacteriology of Canning.**—An investigation of methods of canning was made in the summer of 1917 for the purpose of improving the present methods of canning vegetables in such a way that they will be more uniformly successful. The tests were made in large test tubes fitted with rubber stoppers, since the use of such tubes promoted the making of a large number of tests in a limited laboratory space. The tubes also gave similar results to those obtained from the use of ordinary jars. The vegetables used were peas, beans, beets, sweet potatoes, and carrots. The results indicated: (1) Blanching did not aid in the sterilizing process; (2) proper sealing aided greatly in preventing spoilage of canned foods; (3) salt, except in amounts too large to be allowable, was of little value in preserving canned vegetables; (4) small amounts of acetic acid (such as vinegar) aided in keeping canned vegetables.

**Investigations of Injurious Mammals.**—The work of eradicating noxious mammals from the campus and farms of the college has been carried nearly to completion. The problem now becomes largely one of devising methods to prevent re-invasion. The amount of poison shipped and the amount of

correspondence with farmers during this year have increased considerably over previous years.

**Embryology of Cestodes.**—An investigation was begun during the year 1916-17 to ascertain the method of development in certain embryological stages of cestodes (tapeworms) found in domestic and wild animals. It was ascertained that the larval form of the dog tapeworm *Tænia pisiformis* Bloch, may develop in the domestic kitten and that the evagination of the cysticerco occurs in the duodenum of the cat.

**Investigations of Outbreaks of Animal Diseases.**—During the fall of 1917 numerous losses occurred among cattle pastured in cornfields. This disease has commonly been called corn-stalk disease, forage poisoning, and hemorrhagic septicemia. Numerous specimens from animals which have died with this disease have been received. From an exceedingly small percent of specimens, *Bacillus septicus bovis* has been isolated and from numerous others organisms have been isolated which are pathogenic to guinea pigs and rabbits. Thus far it has not been possible to show that either of these groups or organisms are pathogenic to cattle. It is quite possible that these organisms enter the tissues through secondary invasion from the digestive tract. On account of these irregularities it is essential that this work be further conducted in order to reach a more definite conclusion as to the role which these organisms may play in the production of this disease.

**Blackleg Investigations.**—The germ-free fluid blackleg vaccine has continued to stand practically 100 percent efficient in protecting against blackleg. Demands for it have steadily increased since it was first produced at this station. The demand for the blackleg serum is decreasing as it has been shown that its use, followed by the use of the virus pellets, does not produce as high a degree of active immunity against blackleg as does the use of the germ-free vaccine. The immunity produced by the germ-free vaccine is also of longer duration.

This station is now engaged, and has been for much of the past year, in the production of a blackleg filtrate made by the filtration of cultured media after the organisms have grown upon it as long as they will grow. Preliminary experiments show that this filtrate is fully as efficient in immunizing cattle against blackleg, as the germ-free vaccine, and it is a less expensive produce. Investigations of methods of determining

immunizing properties, or standardizing, blackleg vaccines are also under way.

**Cooperation in Kansas.**—The investigation of cooperation as applied among farmers in Kansas has been completed and a bulletin on the subject will be available in the near future. This work has been delayed for a year on account of the leave of absence of the officer in charge.

**Value of Cream Grading.**—This work consisted of a survey and a series of tests in a limited but typical area, for the purpose of determining the value of cream grading from a commercial standpoint. The Dairy Division of the Bureau of Animal Industry and the Kansas Creamerymen's Improvement Association cooperated with the Kansas Agricultural Experiment Station in carrying out the project. While most of the work was done during the fiscal year 1916-17, the work was not completed and results made available until December, 1917.

A thorough survey was made of a typical Kansas dairying community (a community in which the farmers are engaged in dairying on a small scale). The community selected was in the vicinity of Herington, Kan. The survey covered 69 farms from which cream was being delivered to two receiving stations at Herington. The number of cows milked on these farms in August, 1916, varied from 2 to 26, the average being 8. A large fund of information was secured in the survey with reference to the conditions which contribute to the deterioration of cream and to methods whereby these conditions can be improved. The investigation included a study of such factors as cleanliness, bacteria, temperature and the frequency of cream delivery.

The results of this investigation indicate: (1) That there is no necessity of second grade cream being delivered at cream receiving stations with the exception of that which may be second grade on account of forage flavors. (2) That a special grade of cream of higher quality than the present first grade can be obtained throughout Kansas, for a small additional remuneration, that will be mutually advantageous to farmer, creameryman and consumer. In connection with the paying of a premium for special grade cream it is recommended that the relative price for second grade cream be lowered. (3) The necessary methods for the production of a high-grade cream include the use of small-top milk pails and clean sterilized

utensils. For steaming utensils a simple farm sterilizer is recommended. The cream after production must be immediately cooled and held in an efficient cooling tank, and the dairyman can secure a type of tank which can be successfully used throughout the entire year. It should be possible for the farmers to deliver cream to the stations, even during the warm months of the year, at a temperature not higher than 65° F. (4) The creameries can aid in the improvement of the quality of cream by taking care of it properly while it is in their hands. More attention should be given to the temperature of the cream from the time it is received in the receiving stations until it is to be used for butter making at the plant. Creameries can further assist by improving their methods of washing, steaming, and drying the cans and covers both in the receiving stations and in the creamery. All cans and covers should be thoroughly washed in warm water and washing powder, steamed for 30 seconds, and dried with hot air for 2 minutes.

**Cooperative Experiments with Farmers.**—Because of the variation in soil and climatic conditions it is desirable to extend the studies made at the regular experiment stations to all parts of the state before the results of these studies can be considered conclusive and directly applicable in farm practice. This state-wide testing of methods which the experiments at the regular stations have shown to be desirable is accomplished through the conduct of cooperative experiments with practical farmers. This cooperative experimental work was begun in 1911. During the season of 1917 this work was under way in 80 counties of the state, and included 190 variety tests of corn; 140 variety tests of sorghums; 76 variety tests of wheat; 51 seed tests with wheat; 92 fertilizer tests with wheat, corn, oats, and alfalfa; 5 rotation and fertilizer experiments; 46 miscellaneous tests in crop production, and 188 plantings of improved varieties of crops for the production of seed for distribution throughout the state. The results of this work include: Conclusive evidence that acclimated varieties of corn are superior to introduced varieties; the determination of the local adaptations of a number of varieties of corn and sorghums; demonstrations of the superiority of Kanred wheat for all soil types throughout the hard wheat growing section of the state; demonstrations of the efficacy of phosphatic fertilizers on shale and sandstone soils

for such crops as winter wheat, alfalfa, and clover, but that relatively little benefit is secured by applying phosphatic fertilizers to the same soils for oats, kafir, or corn.

### PUBLIC SERVICE

The experiment station is responsible for the enforcement of certain state regulatory laws in addition to its primary function as a scientific investigational agency; and certain other work growing out of the regular investigational activities and of value in demonstrating improved agricultural practices is carried on. The more important features of this work during the fiscal year 1917-18 are briefly referred to below.

**Fertilizer Control.**—The use of commercial fertilizers in the state has increased materially during recent years. In 1908, approximately 2,400 tons of commercial fertilizers were sold in the state as compared with a total of almost 13,000 tons during the year 1917. The experiment station is charged with the inspection of all commercial fertilizers offered for sale in the state. In this connection one extended trip is made in the spring and another in the fall of each year for the purpose of securing one or more samples of each brand of fertilizer sold in Kansas. During the fiscal year 1917-18, 26 towns were visited in the fall, and 22 in the spring. ON these visits a total of 68 samples of fertilizers, representing 19 brands, were secured. All fertilizer samples taken are analyzed and the results are published periodically for the information of Kansas farmers. In this way the interests of the farmers using commercial fertilizers are safeguarded.

**Livestock Feed and Remedy Control.**—The experiment station, through its Feed Control office, has charge of the registration and inspection of commercial feeds and livestock remedies. In this work during the past year special attention has been paid to shipments of cottonseed products coming into the state. In a number of cases it was possible to secure rebates for the consumers of these products on account of deficiencies in protein or because of short weight, Considerable difficulty has been experienced with manufacturers of poultry feeds, who have attempted to sell products consisting largely of weed seeds and screenings under misleading names or brands. Owing to the urgent demand for wheat flour, the wheat shorts on

the market has been of poor quality. As there was a differential in price for the different grades of shorts, the station was called upon to classify a large number of samples of this feed and to see that the product was properly labeled. The following table shows something of the activities of the Feed Control office during the fiscal year 1917-18:

Inspections made . . . . .	1,346
Firms visited . . . . .	1,305
Towns visited . . . . .	222
Feeds registered . . . . .	1,855
Firms registering feeding stuffs. . . . .	768
Inspection samples of feedingstuffs analyzed . . . . .	186
Feeds not up to guarantee in one or more constituents . . . . .	107
Feeds deficient in protein . . . . .	39
Feeds deficient in fat . . . . .	21
Feeds excessive in fiber . . . . .	47
Federal samples analyzed . . . . .	20
Commercial samples analyzed . . . . .	216
Citations issued but prosecution for violation held in abeyance . . . . .	7

During the fiscal year 1917-18, 44 livestock remedies were added to the number previously registered, and on June 30, 1918, a total of 431 livestock remedies were registered with the experiment station, representing total of 168 firms. The experiment station issues publications from time to time to inform the trade and the general public regarding the requirements of the law with reference to feedingstuffs and livestock remedies.

**State Livestock Registry Board.**—In order to inform the farmers of the state as to the breeding of the stallions used, the experiment station is charged bylaw to maintain a stallion registry in which all stallions in service in the state must be registered and licensed. During the fiscal year 1917-18 a total of 5,044 licenses were issued. Of these, 3,260 were for purebred stallions and 1,784 were for grades and scrubs. Under the operation of the stallion registry law the number of grade and scrub stallions is decreasing. The purebreds registered for service in the spring of 1918 represent a larger proportion of the total number licensed than they did the year previous, and more grade and scrub stallions have been retired from public service during the past year than ever before in recent years. The number of Percheron stallions in service has increased, this breed now representing 71 percent of the purebred stallions in service in the state. Each year sees a decline in the number of standard-bred stallions, the number during the past

year decreasing from 286 to 194. Fewer cases of deception and attempted fraud on the part of stallion dealers have been reported this year than for several years.

**State Dairy Commissioner.**—The state dairy commissioner has continued his work in the inspection of dairy manufacturing plants and the examination and licensing of milk and cream testers. The policy of the state dairy commissioner is to assist in stimulating dairy production as well as to improve the quality of dairy products by promulgating reasonable rules and regulations from time to time. A numerical statement of the character and extent of some of the more important activities of the dairy commissioner during the past fiscal year follows:

Town visits . . . . .	575
Cream station inspections . . . . .	804
Creamery inspections . . . . .	110
Ice-cream station inspections . . . . .	78
Dairy farm inspections . . . . .	44
Condensery inspections . . . . .	8
Receiving station inspections . . . . .	8
Dairy establishments closed because of insanitary conditions. . . . .	34
Ice-cream sales room inspections . . . . .	80
Test scales condemned . . . . .	10
Applicants examined for cream buyers' permits . . . . .	1,888
Percent of applicants receiving permits . . . . .	88

**Seed Inspection and Distribution.**—The experiment station has continued the distribution of small quantities of pure seed from the central farm at Manhattan. Such distribution during the fiscal year 1917-18 included the following:

Wheat . . . . .	3,640	bushels
Kafir . . . . .	393	"
Sorghums . . . . .	349	"
Corn . . . . .	261	"
Oats . . . . .	115	"

In addition to the distribution of these small quantities of pure seed, the station has been particularly active during the past year in connection with the general commercial seed supply of the state. Following the extensive winterkilling of wheat during the winter of 1916-17 which resulted in the destruction of a large part of the potential supply of seed of the best hard winter wheat, the experiment station inspected fields in 26 counties in the south central part of the state in order to locate satisfactory seed for planting in the fall of 1917. In this connection, a total of 4,817,950 bushels of seed wheat was located and a seed list giving the name and address of the grower and other necessary information was prepared and issued as Circular No. 5 of the State Council of Defense. Fur-



ther activity in connection with the seed supply during the past year involved the testing of 16,836 samples of seeds of field crops to be used by Kansas farmers. This seed included corn, kafir, milo, and practically all the other common field crops of the state, and represented every county in the state. Upon the receipt of these samples from the farmers, the experiment station determined the germination in all cases, and in many cases the purity, and made appropriate reports of the results.

**Improvement of Dairy Cattle.**—One of the duties specifically delegated by law to the agricultural college is that relating to the general supervision of the dairy herds at the various state institutions by the Dairy Department. Regular visits are made to these institutions by representatives of the Dairy Department who furnish expert assistance in connection with the



FIG. 5.—Maid Henry Pontiac, the leading milk and butter producer in Kansas. Year's record at a 5 years of age: Milk, 18,377 pounds; butterfat, 695 pounds

selection, feeding, management, and breeding of the dairy stock. This work is closely associated with the dairy cattle improvement work at the experiment station, where one of the best college dairy herds in the country is being developed. Of the 80 producing cows in this herd, 54 have yearly production records averaging 410 pounds of butterfat per cow. One of these cows, Maid Henry Pontiac, is shown in figure 5. It is

hoped that the association of the dairy cattle improvement work at the experiment station with that at the other state institutions will be a strong factor in accelerating the improvement of dairy stock throughout the state.

### **BRANCH EXPERIMENT STATIONS**

The branch stations at Hays, Garden City, Colby, and Tribune are maintained for the purpose of supplementing the investigational work conducted at the main station at Manhattan, with particular reference to testing under Western Kansas conditions the results secured at Manhattan, and to investigate agricultural problems peculiar to the four Western Kansas districts in which the branch stations are located. The work of these branch stations was continued during the fiscal year 1917-18 without material modification in the general plans. The Department of Agriculture continued to cooperate in conducting dry-land agriculture investigations at the Fort Hays, Garden City, and Colby stations, and in the forage crop and cereal investigations at the Fort Hays Station. Something of the character and extent of the work of these branch stations is indicated briefly below.

#### **FORT HAYS BRANCH EXPERIMENT STATION**

The Fort Hays Experiment Station consists of 3,600 acres of land equipped for investigational work with both crops and livestock.

**Crop Investigations.**—The crop investigations are conducted primarily on 1,689 experimental plots and on somewhat larger fields used for the forest nursery and garden work. The dry-land agriculture investigations occupy approximately 300 plots upon which studies are made of various crop production methods including continuous cropping, alternate cropping, rotations, various tillage methods, and studies of the relationship of moisture, nitrates, and temperature to crop production. The crops grown include wheat, alfalfa, corn, sorghums, and other crops grown in Western Kansas. The results of this work are of increasing value to the agriculture of the western part of the state, particularly in that they show the relative value of a large number of different crop production methods, as, for example, that early plowing has yielded during the past six years

an average of 6 bushes per acre of wheat more than has been produced by late plowing. The forage crop production work includes tests of new varieties and new crops like Sudan grass; studies of various methods of producing alfalfa and other forage crops, and breeding work for the improvement of forage crops adapted to Western Kansas conditions. The forage crop work occupies in the neighborhood of 400 experimental plots each year. Some of the recent accomplishments of this work include the development of Western Orange cane and Pink kafir, and much assistance in the introduction of Sudan grass in the western part of the state. Six years' results are now available on a comprehensive test of growing alfalfa in rows various distances apart as compared with ordinary planting. A report of these results is now being prepared for publication. The cereal investigations include the introduction and testing of various new cereal varieties and the selection and breeding of new strains of cereals, as well as the testing of various methods of seeding, including a test of the furrow-drill method compared with the ordinary seeding method. The state forest nursery which is included in the crop work at the Fort Hays station occupies about 25 acres of land and includes approximately 250,000 trees and plants of various ages and sizes. These are grown for the purpose of observing and recording their behavior under Western Kansas conditions, and those which are found suitable for those conditions are distributed at cost among farmers in the western part of the state.

**Livestock Work.**—The station owns approximately 1,000 head of livestock. Each year a large number of these cattle are used in specific livestock investigations including 17 experimental lots of beef cattle and a number of lots of sheep and hogs. These animals are used primarily in feeding work to determine profitable methods of utilizing the feeds grown in Western Kansas. In addition to the above, a herd of 56 grade Holstein cattle are used in the experimental dairy project. In addition to this feeding work which is carried on each year, the livestock kept are used in developing practical methods of herd improvement with particular reference to beef cattle for Western Kansas ranges.

**Application of Experimental Results.**—In order that the results secured in the breeding work with crops and in the similar stock-feeding experiments may be tested out on a practical

scale, the farm produces about 300 acres of alfalfa; from 300 to 400 acres of grain and forage sorghums; 100 acres of corn and 600 to 650 acres of wheat, annually. These acreages make it possible to test out on a commercial scale the varieties produced in the experimental work and also the methods of production which the experimental work indicates are worthy of large scale application. Six silos, a grain elevator, and a seed barn make it possible for the station to handle its feed and seed situation satisfactorily. These large scale operations supplement admirably the small scale experimental work of the station, and at the same time are conducted at a profit.

**Public Service.**—During the past year the station has been called upon to render a large amount of public service in the way of information and expert advice regarding various agricultural problems in the western part of the state. One important feature of these public service activities is the annual farmers' round-up, which in the spring of 1918 was attended by 2,500 people. The annual sorghum and wheat days, held under the auspices of the branch station, have been commanding constantly increasing interest.

### GARDEN CITY BRANCH EXPERIMENT STATION

The work of the Garden City Branch Experiment Station is concerned both with irrigation agriculture and dry-land agriculture as these two are important in the district represented by the station. The work conducted during the fiscal year 1917-18 was substantially a continuation of the projects already under way. The principal lines of work include dry-land crop rotation and tillage experiments, variety tests of crops both with and without irrigation, investigations of the use of water in irrigation, and the keeping of a dairy herd.

**Climatic Conditions.**—Climatic conditions during the crop season of 1917 were unfavorable to the growth of all dry-land crops. In 1917 no wheat survived the conditions of the preceding winter and no yields were obtained from unirrigated spring wheat under any treatment. Sorghum crops withstood dry conditions much better than other grains and a light yield was secured from these crops in 1917.

**Dry-Land Agriculture Investigations.**—The work in the dry-land agricultural project was continued on substantially the same lines as in 1916. This work includes the testing of a large

number of crop rotations, the continuous production of dry-land crops on the same land under various methods of tillage, and determinations of the adaptability of crops for dry-land conditions in Southwestern Kansas. The year 1996 was so unfavorable that only small yields were secured from any of these crops.

**Irrigation Investigations.**—This work was continued in 1917 on practically the same plans as were outlined in 1914. It includes 11 different field crops grown with irrigation for comparison with the same crops grown under the same cultural treatments but without irrigation. A number of these crops are also grown under various rates of watering based on the moisture content of the soil. It is being found in this work that most of the sorghum crops respond markedly to increased applications of irrigation water, but that the cereal crops do not respond to an equal degree. One of the most striking and important features of the irrigation work is that in which it was found that profitable yields of several of the field crops grown in Southwestern Kansas can be secured if one copious irrigation is applied to the land in the fall of the year even if no summer irrigation is practiced. The results of this work have been particularly striking during the past two years, both of which have been dry. It appears likely that the application of this fact in practical farming in Southwestern Kansas might be of value in two directions: (a) In distributing the available water on a given tract of land over a large proportion of the land in a single irrigation in the fall of each year, and (b) in distributing the labor requirement of crop production through the application of the irrigation water during the late fall and early winter when the labor requirements of the farm are less pressing.

In addition to the irrigation work above mentioned, the station is doing a large amount of work with reference to best methods of installing and operating irrigation pumps. Information is being secured regarding the efficiency of a number of different types of pumps and pump engines, and this information is being made available to the farmers in Southwestern Kansas who are interested in irrigation by pumping.

**Diary.**—The dairy herd which was transferred from the Dodge City Branch Experiment Station in April, 1917, is now maintained at the Garden City station. This herd is used in

connection with the utilization of some of the feed crops produced at the experiment station and, incidentally, in some dairy cattle breeding work. It is planned to investigate the possibilities of developing from the original herd of inferior stock a herd of good producing animals through the use of high class purebred bulls.

#### COLBY BRANCH EXPERIMENT STATION

The Colby Branch Experiment Station occupies 320 acres of land near the town of Colby in Thomas County. The work of this station includes investigations of crop production, tillage methods, conservation of moisture, and general farm management. These investigations are of great importance in Northwestern Kansas and they are being carefully studied in an effort to determine what are the best methods to follow in that locality for a series of years.

**Dry-Land Agriculture.**—The investigations in dry-land agriculture include a large number of experiments in crop rotation and tillage methods. One of the important accomplishments of this work during the past two years is that relating to the use of the furrow drill. The practice of using the furrow drill instead of the ordinary grain drill has proved decidedly beneficial at the Colby station. The yields secured in practically every instance have been materially higher where the furrow method of seeding was followed than those secured from ordinary seeding methods. The results of the use of the furrow drill have been so satisfactory that this method of seeding is now used on the greater part of the experiment station, and to a considerable extent on the commercial farms in the vicinity.

**Irrigation.**—A small pumping plant with a capacity of about 400 gallons per minute, and a reservoir with a capacity of about 1 acre-foot are maintained at the Colby station for the purpose of investigating the feasibility of small irrigation plants as a supplement to the dry-land agriculture operations in Northwestern Kansas. During the past season irrigation water was applied to about 5 acres of land, most of which was seeded to alfalfa, and very satisfactory returns were obtained from the water applied. It is planned now to increase this irrigation work somewhat so as to include a greater variety of field crops, and thus to secure more information of value to

farmers in Northwestern Kansas both with reference to the production of field crops by supplemental irrigation and also with reference to the development of better home surroundings.

**Dairy.**—Several years ago it seemed advisable to attempt to develop practical methods of stabilizing the agriculture of Northwestern Kansas by introducing the dairy industry into the agriculture of that section. With this in view a herd of high-grade Ayrshire cows and a purebred Ayrshire bull have been maintained at the Colby Branch Station since October, 1915. This herd now numbers 13 producing cows. They, together with the young stock, are maintained on native pasture during the greater part of the year, the pasture being supplemented partly with silage produced on the farm and partly with concentrated feeds. The gross income from this dairy herd is now in the neighborhood of \$2,000 per year. The concentrated feeds used are purchased, but all the rough feeds are produced on the station. Three silos are used and enough feed is carried over each year to last through a year of total crop failure. The excellent results which have been secured in this dairy enterprise suggest a method whereby the farmers in Northwestern Kansas can secure much in the way of stabilization in their agriculture. These results indicate that it would be entirely practical for a farmer having from 320 to 640 acres of land to maintain a dairy herd of from 10 to 20 cows. Practically all the feed required by these cows could be produced on the farm, and the income from the cows would assure the farmer a living even during years when the climatic conditions were so adverse as to make wheat production unprofitable.

#### TRIBUNE BRANCH EXPERIMENT STATION

The work of the Tribune Branch Station was conducted on substantially the same lines as during the previous year. This work includes the production of varieties of various crops to test their adaptation to Southwestern Kansas conditions, with particular reference to the beef cattle industry which is the major industry in that locality. Particular attention is being paid to the production of silage crops for use in winter feeding of range stock. In this connection experiments are conducted not only with various crop varieties but also with different

rates of seeding, crop rotation, and seedbed preparation. The results secured already are indicating the suitability of such crops as dwarf mile, dwarf kafir, and freed sorgo. Fairly satisfactory results have also been secured with millet and Sudan grass. The sorghum crops produced at the station are placed in silos and are later fed out during the winter to livestock and in this way much useful information is being secured with reference to wintering livestock in the extreme southwestern districts of the state.

### FINANCIAL STATEMENT

The Kansas Agricultural Experiment Station in account with federal and state appropriations, 1917-18

	Federal appropriations	State appropriations and receipts	Totals
Manhattan station.....	\$30,000 00	\$48,241 89	\$78,241 89
Branch stations.....		46,214 70	46,214 70
Branch station farm products.....			43,683 53
			\$168,139 62
Salaries.....	\$16,510 76	\$17,956 74	\$34,467 50
Labor.....	6,903 75	39,368 63	46,272 38
Publications.....	16 07	21 62	37 69
Postage and stationery.....	101 44	695 00	796 44
Freight and express.....	27 67	1,563 29	1,590 96
Heat, light, water, power.....	38 82	2,031 89	2,070 71
Chemicals, laboratory supplies.....	1,026 98	707 81	1,734 79
Seeds, plants, sundry supplies.....	907 77	10,216 98	11,124 75
Fertilizers.....	23 00		23 00
Feedingstuffs.....	3,139 37	16,986 01	20,175 38
Library.....		26 65	26 65
Tools, machinery, appliances.....	609 54	4,828 02	5,437 56
Furniture and fixtures.....	12 20	353 50	365 70
Scientific apparatus, specimens.....	172 13	25 33	197 46
Livestock.....	10 70	2,604 25	2,614 95
Traveling expenses.....	225 04	2,745 72	2,971 76
Contingent expenses.....	31 50	9,531 11	9,562 61
Buildings and land.....	192 26	6,370 89	7,063 15
Balance.....		21,606 18	21,606 18
<b>Totals.....</b>	<b>\$30,000 00</b>	<b>\$138,139 62</b>	<b>\$168,139 62</b>

We, the undersigned, duly appointed auditors of the corporation, do hereby certify that we have examined the books and accounts of the Kansas Agricultural Experiment Station for the fiscal year ending June 30, 1918; that we have found the same well kept and classified as above, and that the receipts for the year from the treasurer of the United States are shown to have been \$30,000.00 and the corresponding disbursements \$30,000.00, for all of which proper vouchers are on file and have been by us examined and found correct.

And we further certify that the expenditures have been solely for the purposes set forth in the acts of Congress approved March 2, 1887, and March 16, 1906.

E. W. HOCH  
C. W. GREEN  
WILBUR N. MASON