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A G R I C U L T U R A L E X P E R I M E N T
S T A T I O N

KANSAS STATE AGRICULTURAL
COLLEGE

DIRECTOR'S REPORT
1916-17

MANHATTAN, KANSAS

KANSAS
AGRICULTURAL EXPERIMENT STATION
KANSAS STATE AGRICULTURAL COLLEGE

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MANHATTAN, KANSAS

KANSAS AGRICULTURAL EXPERIMENT STATION

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KANSAS AGRICULTURAL EXPERIMENT STATION

OFFICE OF THE DIRECTOR

June 30, 1917

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, 1917. 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.

W. M. JARDINE, *Director*

THE DIRECTOR'S REPORT

INTRODUCTION

The work of the Agricultural Experiment Station of the State Agricultural College during the closing months of the year 1916-17 was necessarily interwoven with that of the Kansas State Council of Defense. The station had been found to be the natural agency through which changes in the agriculture of the state might be effected. Eighteen members of the station staff rendered active services in the work of the Committee on Agricultural Production of the Council of Defense. At times the attention of entire departments was centered upon the problem of determining the most effective means for increasing food production. Of the 8,887,000 acres of winter wheat planted in Kansas in the fall of 1916, 4,908,000 acres were destroyed by winterkilling, drouth, and soil blowing. The first task of the Committee on Agricultural Production was to get the maximum amount of this acreage into spring crops. A preliminary survey was made of the state's agricultural resources and information was obtained on the amount of idle land, the best crops to plant, the labor situation including man, horse, and machine power, and the available seed supply including names and addresses of farmers having seed for sale, the counties lacking seed, and the kinds needed. A seed list containing this information was issued and given wide distribution. This list was of great practical value to farmers and aided materially in getting the maximum acreage of idle land into spring crops.

The destruction of the wheat crop in at least 35 counties where hard red winter wheat is usually grown, and the questionable quality of much of the wheat which was produced, made it essential that fields of pure hard red winter wheat be located if an adequate supply of pure seed was to be available for fall planting. A personal inspection of fields of wheat was determined upon. A force of twenty men, thirteen of whom were members of the station staff, were maintained in the field from two to three weeks in June when the wheat was in condition for inspection. A total of 229 days of the time of members of the station staff were spent in this work. Practically all of

the fields of good wheat in 26 counties in the south central part of the state were personally inspected. The results of the inspection were tabulated and published in the form of a circular, giving the names and addresses of the farmers having seed for sale, and the variety, quantity, and purity of the same. The list included a total of about 4,763,866 bushels of seed of hard red winter wheat suitable for planting. This list was of great aid to farmers in securing seed wheat. Many farmers ordered their seed supply direct from other farmers in the state whose names and addresses were given in the seed list.

The experiment station staff appreciates the opportunity afforded to prove its capacity for constructive, practical effort, and the national needs will continue to receive first attention. In the preoccupation in the present great emergency, however, we must not forget the future. The service the experiment station is now able to render is due to the fundamental and continuous research work which has been done since the station was established. To overlook the necessity for continued scientific investigation and experimentation respecting the principles and applications of agricultural science as a preparation for the great reconstruction period which must follow the war, will be to endanger the foundation of national welfare.

Many different influences are now tending to disrupt experimental work. Since war was declared April 6, 1917, members of the station staff have resigned to accept commissions in the national army; to enter government service; to accept positions with commercial firms; and to accept appointments with other state agricultural colleges and experiment stations. A number have been granted leave of absence for the duration of the war, or as long as their services are needed, and others have been permitted to devote part time to government service. The high cost of living furnishes an additional influence tending to disturb research work. The natural desire of station members to remain with studies they have initiated and advanced is often overcome by consideration for family duties and demands, in the face of attractive financial offers.

The experimental work of the station has already suffered serious interference. Some projects have been closed until such time as the workers may return. Others are being carried forward by assistants. Still others are being continued

in modified form with the help available. The Director of the station wishes to call attention to the serious situation and to urge that every effort be made to retain an efficient, working station force. Otherwise the agriculture of the state will suffer deterioration at a time when the state and nation are least able to withstand it.

The station worker should consider carefully whether by making a change he can render a greater public service, and whether professional progress will be furthered by such action. He should be willing to make a temporary sacrifice in the interest of service in a great crisis. On the other hand, when serious deterioration of research work would result from the resignation of a member, those in authority should not permit reasonable financial considerations to stand in the way of his retention.

PERSONNEL

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

APPOINTMENTS

M. C. Tanquary, Ph. D., assistant entomologist; A. E. Lawson, B. S. A., assistant in animal husbandry; Harold P. Wood, B. S. A., hog herdsman; R. K. Bonnett, M. S., assistant professor in agronomy; Cecil Elder, D. V. M., assistant in veterinary medicine; F. E. Fox, B. S. A., assistant in poultry husbandry; Armin Doerner, B. S. A., assistant in landscape gardening; Dora M. Otto, B. S., research assistant to the director; John Patterson, D. V. M., instructor in veterinary medicine; Hagan Phlegar, miller; Roy Kiser, B. S. A., assistant professor in animal husbandry and superintendent of land and livestock; M. N. Levine, M. S., assistant in plant pathology; James W. Crumbaker, B. S. A., assistant in agronomy and superintendent of Agronomy Farm; J. R. McClung, A. M., assistant in bacteriology; Jos. P. Scott, D. V. M., assistant in veterinary medicine.

RESIGNATIONS

R. Page Bledsoe, instructor in farm crops; O. M. Franklin, assistant in veterinary medicine; L. G. Hepworth, feedingstuffs inspector; Frank E. Mussehl, assistant in poultry husbandry; Edith E. Jones, research assistant to the director; A. E. McCly-

monds, assistant in agronomy and superintendent of the Agronomy Farm; J. W. Benner, instructor in veterinary medicine; T. P. Haslam, assistant professor in veterinary medicine; Ralph Kenney, assistant professor of farm crops; John Patterson, instructor in veterinary medicine; T. S. Townsley, assistant in poultry husbandry; L. L. Leeper, miller; F. S. Schoenleber, head of the Department of Veterinary Medicine; John L. Bayles, assistant in agronomy, Garden City Branch Station; Kurt Peiser, assistant in bacteriology.

PUBLICATIONS ISSUED

Five bulletins, one director's report, and nine circulars were published and distributed during the fiscal year ending June 30, 1917. They were as follows:

BULLETINS				
No.	Title	Edition	Pages	Total pages
213	The Time to Seed Wheat in Kansas.....	35,000	16	560,000
214	The San José Scale.....	10,000	28	280,000
215	Methods of Controlling Grasshoppers.....	25,000	30	750,000
216	The Marketing of Kansas Butter.....	40,000	79	3,160,000
217	Alfalfa Silage	20,000	19	380,000
	Director's Report, 1914-15.....	5,000	69	345,000
CIRCULARS				
56	Cream Production and Grading in Kansas.....	100,000	4	400,000
57	Growing Draft Colts.....	4,000	16	64,000
27	Capons for Kansas (Revised).....	30,000	8	240,000
58	The Woodlot	5,000	37	185,000
59	A Preliminary Report on Two New Methods of Preventing Blackleg by Means of an Anti-Blackleg Serum and an Aggressin.....	4,000	7	28,000
60	Chicken Management on the Farm.....	50,000	23	1,150,000
INSPECTION CIRCULARS				
2	Some Important Essentials in Profitable Horse Production	15,700	4	62,800
3	Analyses of Inspection Samples of Fertilizers, 1915-16,	4,000	17	68,000
4	Analysis of Inspection Samples of Fertilizers, Fall, 1916	3,000	11	33,000
Totals		350,700	368	7,705,800

SUMMARIES OF PUBLICATIONS

BULLETINS

213. *The Time to Seed Wheat in Kansas.* (L. E. Call, S. C. Salmon, and C. C. Cunningham.) This bulletin points out the relation between time of seeding and injury from Hessian fly, winterkilling, and drouth. The best time to seed in different parts of the state is discussed.

214. *The San José Scale.* (L. M. Peairs and J. H. Merrill.) Attention is called to the seriousness of San José Scale, and information necessary for its recognition and treatment is furnished. The discussion includes (1) a brief and concise history of San José Scale in the United States and in Kansas; (2) a life history of the insect; (3) the extent of its distribution and injury; (4) an outline of preventive measures; (5)

directions for control in infested orchards; and (6) a description of spraying materials and methods of spraying.

215. *Methods of Controlling Grasshoppers.* (F. B. Milliken.) Control measures for grasshoppers, covering the destruction of the eggs, the young, and the adults, are given. Natural checks on grasshopper multiplication; predaceous and parasitic enemies; and the most injurious species of grasshoppers together with their life histories and habits are subjects of discussion.

216. *The Marketing of Kansas Butter.* (Theodore Macklin.) The different methods of marketing farm and creamery-made butter are described. The relation of quality of farm butter to volume of butterfat production, to methods of butter making, and to prices obtained by Kansas farmers is indicated by accurate, representative statistics. Different methods of delivering butterfat to centralizers and the special conditions which necessitate centralizers in the state are discussed and the results compared with local creamery results in the representative sections.

217. *Alfalfa Silage.* (O. E. Reed and J. B. Fitch.) This bulletin explains in detail the plans followed in conducting experiments in making silage from alfalfa, covering a period of two years. The character of silage resulting from combining with alfalfa, different materials containing a high percent of carbohydrates such as corn meal, molasses, and sweet sorghum stover, is described. Results of palatability tests and chemical analyses are given.

REPORTS

Director's Report, 1914-15. (W. M. Jardine.) A brief summary of the work of the Agricultural Experiment Station during the fiscal year ending June 30, 1915, is given. The main features of the report are: (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 discussion of control work, cooperative experiments, and demonstration and extension work carried on by the station; (5) brief reports of the work of the five branch experiment stations; and (6) a financial report covering all receipts and expenditures of the station for the fiscal year.

CIRCULARS

56. *Cream Production and Grading in Kansas.* (Geo. S. Hine.) This publication deals with the essentials necessary to the production of first grade cream on the farm. Special emphasis is given to the proper method of cooling cream. The different methods in general use are compared for efficiency. The objectionable flavors and odors common to cream are discussed, and the advantages and results of cream grading are set forth.

57. *Growing Draft Colts.* (C. W. McCampbell.) An experiment conducted for the purpose of studying the rate and cost of development of

draft colts, and covering a period of two years, is reported in this circular. The plan of the experiment is described and the results given.

27. *Capons for Kansas*. (Revised) (Wm. A. Lippincott.) The desirability and practicability of raising capons in Kansas is discussed. Methods of operation are described in detail and the different steps of procedure are made clear by illustrations.

58. *The Woodlot*. (Chas. A. Scott.) The different types of timber land found in Kansas are described. Suggestions for improving the present stands are offered and desirable species are recommended for future planting.

59. *A Preliminary Report on Two New Methods of Preventing Blackleg by Means of an Anti-Blackleg Serum and an Aggressin*. (F. S. Schoenleber, T. P. Haslam, and O. M. Franklin.) This circular describes the methods used by the Kansas Agricultural Experiment Station during the past year in making blackleg serum and pellets and blackleg germ-free fluid vaccine, or aggressin. Results of the use of the two vaccines are given. The conditions under which each form of vaccine should be used are stated briefly.

60. *Chicken Management on the Farm*. (R. M. Sherwood, Wm. A. Lippincott, F. E. Mussehl, N. L. Harris, and F. E. Mixa.) The breeds of chickens best suited to general farm conditions are discussed. The general management of the farm flock is treated in detail, covering such subjects as breeding, housing, feeding, incubation, and marketing.

INSPECTION CIRCULARS

2. *Some Important Essentials in Profitable Horse Production*. (C. W. McCampbell.) This publication, issued in accordance with chapter 318, Laws of 1913, contains suggestions relative to profitable horse production and a list of stallions licensed to stand for public service in Kansas for the year 1916. These stallions are listed on a county unit basis and are classified under three heads—purebred, grade, and scrub.

3. *Analyses of Inspection Samples of Fertilizers, 1915-16*. (J. T. Willard and R. C. Wiley.) The results of analyses of 76 inspection samples of fertilizers, not previously reported, are tabulated. While a number of deficiencies are indicated, the table shows that the manufacturers are apparently attempting in good faith to conform to the provisions of the law. A statement showing the receipts and expenditures of fertilizer fees from July 1, 1914, to June 30, 1916, is given. A reprint of the Kansas fertilizer law is included.

4. *Analyses of Inspection Samples of Fertilizers, Fall 1916*. (J. T. Willard and R. C. Wiley.) A report of the analyses of 57 inspection samples of fertilizers taken from stocks offered for sale in the open market during the fall of 1916 is presented. An explanation of fertilizer terms and a list of Kansas dealers handling fertilizers are included. In regard to the quality of the fertilizers, the report indicates a distinct tendency to shortage in the potassium content.

PAPERS APPEARING IN SCIENTIFIC JOURNALS

In addition to the official publications listed above, 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:

"On the Effect of Selection in Paramecium," James E. Ackert, *Genetics*, vol. 1, pp. 387-405.

"The Soil Mulch," L. E. Call and M. C. Sewell, *Journal of the American Society of Agronomy*, vol. 9, pp. 49-61.

"Results of Ten Years of Experimental Wheat Sowing to Escape the Hessian Fly," George A. Dean, *Journal of Economic Entomology*, vol. 10, pp. 146-159.

"The Strength and Composition of Blackleg Vaccines," O. M. Franklin and T. P. Haslam, *The Journal of Infectious Diseases*, vol. 19, pp. 408-415.

"Studies on the Life-History of *Ligyris Gibbosus* DeG. (Coleopters)," William P. Hayes, *Journal of Economic Entomology*, vol. 10, pp. 253-261.

"The Nutritive Properties of Corn," Albert G. Hogan, *The Journal of Biological Chemistry*, vol. 28, pp. 193-208.

"Corn as a Source of Protein and Ash for Growing Animals," Albert G. Hogan, *The Journal of Biological Chemistry*, vol. 29, pp. 485-493.

"The Effect of High Temperatures on the Nutritive Value of Foods," Albert G. Hogan, *The Journal of Biological Chemistry*, vol. 30, pp. 115-123.

"Wind as a Factor in the Dispersion of the Hessian Fly," James W. McColloch, *Journal of Economic Entomology*, vol. 10, pp. 162-168.

"A Method for the Study of Underground Insects," James W. McColloch, *Journal of Economic Entomology*, vol. 10, pp. 183-187.

"Relation of Aphids to Fire Blight," J. H. Merrill, *Journal of Economic Entomology*, vol. 10, pp. 45-47.

"The Relation of Winter Temperature to the Distribution of Winter and Spring Grains in the United States," S. C. Salmon, *Journal of the American Society of Agronomy*, vol. 9, pp. 21-24.

"Nitrogen in Amino Form as Determined by Formol Titration in Relation to Some Other Factors Measuring Quality in Wheat Flour," C. O. Swanson and E. L. Tague, *Journal of the American Chemical Society*, vol. 39, pp. 482-491.

"Chemical Composition of Alfalfa as Affected by Stage of Maturity, Mechanical Losses and Condition of Drying," C. O. Swanson and W. L. Latshaw, *Journal of Industrial and Engineering Chemistry*, vol. 8, p. 726.

"The Sulphur Content of Some Typical Kansas Soils, and the Loss of Sulphur Due to Cultivation," C. O. Swanson and R. W. Miller, *Soil Science*, vol. 3, pp. 139-148.

"Another Cestode from the Young Cat," J. E. Ackert and A. A. Grant, *Transactions of the American Microscopical Society*, vol. 36, pp. 93-96.

"Ecological Observations on *Ustilago Zeæ*" A. A. Porter and L. E. Melchers, *Phytopathology*, vol. 7, pp. 73-74.

"The Black Spot of Pepper," L. E. Melchers and E. E. Dale, *Phytopathology*, vol. 7, p. 63.

"*Puccinia triticina* Erikss. Leaf Rust of Winter Wheat Causes Damage in Kansas," L. E. Melchers, *Phytopathology*, vol. 7, p. 224.

"The Significance of Nitrification as a Factor in Soil Fertility," P. L. Gainey, *Soil Science*, vol. 3, pp. 399-416.

"The Effect of Time and Depth of Cultivating a Wheat Seedbed upon Bacterial Activity in the Soil," P. L. Gainey, *Soil Science*, vol. 2, pp. 193-204.

"Daily Variation of Water and Dry Matter in the Leaves of Corn and the Sorghums," E. C. Miller, *Proceedings of the National Academy of Science*, vol. 3, pp. 427-431.

EXPERIMENTAL WORK

A brief summary of the more important lines of investigation, showing the progress which has been made during the course of the year, is given herewith. The projects are grouped for the most part in accordance with the funds from which they receive their financial support.

ADAMS FUND

Physiological Effect Upon Work Horses of Alfalfa Hay Cut at Different Stages of Maturity.—During the summer of 1916, alfalfa hay was harvested at the following stages of growth—bud, one-tenth bloom, full bloom, and seed. This was the third season of the experiment. The yield of hay was smallest from the plots cut in the bud stage and greatest from those cut in the full bloom stage. Determinations of stand showed that the plots cut regularly for the three seasons in the bud stage had lost 70 percent of the original number of plants; those cut in the tenth bloom stage had lost 51 percent; those cut in full bloom had lost 49.3 percent; and those cut in the seed stage, 42.6 percent.

One digestion trial was conducted with six Percheron fillies, to determine the comparative effect of feeding alfalfa hay cut at different stages of maturity with corn as a grain ration. When the experiment had been in progress three months, fire destroyed the specially prepared feeds. The animals were then placed together and given the same treatment. During the three months, the greatest gain in live weight was made with alfalfa hay cut in the bud stage, and the least gain re-

sulted from that cut in the seed stage. However, it would appear from subsequent results under identical treatment that the character of gain made from the use of hay cut in the bud stage was different from that made from the use of hay cut in the more mature stages of growth. When the animals were given identical treatment, the gain of the fillies previously fed the hay cut in the bud stage was less than one-half the gain of the fillies previously fed on hay cut in the more mature stages. During the progress of the experiment, there was every evidence that a ration of corn and alfalfa hay was insufficient to meet the needs of the horses fed. An abnormal appetite was indicated, probably due to deficiency of crude fiber in the ration.

Animal Nutrition Investigations.—The records of six years' experiments in the study to determine the uses of food in the animal body have been prepared in a form suitable for technical publication. The information obtained has great scientific value, but its practical applications have not been sufficiently demonstrated. Therefore, additional experiments are being conducted on different phases of the subject. During the past year three supplementary studies have been under way, as follows:

(a) *The Effects of Feeding Ash and Protein to Fattening Hogs Under Practical Conditions*—Ninety Duroc-Jersey pigs of uniform breeding were divided into 15 lots of six pigs each and fed cornmeal with ash and protein supplements in different rations. The experiment was continued until each lot had made an average gain of 150 pounds per pig. Among the outstanding results secured from the use of different rations, it was shown that a ration of corn and alfalfa pasture does not supply all of the mineral required for growth in a young fattening pig. Pigs fed this ration practically ruined the stand of alfalfa by rooting. In all cases where tankage was used, the addition of bone ash was a handicap to the ration. In other rations it proved beneficial. The value of self-feeders in fattening young pigs was also studied in connection with the experiment. It was found that in dry lots, the free choice system of feeding is valuable as showing faster gains and more economical use of feeds. In pasture lots, the reverse was true. Results indicated that when full fed on alfalfa pasture, the pig's appetite is not the most efficient guide for balancing his ration.

His appetite for alfalfa prevents a proper consumption of concentrates for his needs.

(b) *The Deficiencies of Corn for Feeding Pregnant Sows.*—Fifteen purebred Duroc-Jersey sows, farrowed in the spring of 1916, were bred in December and January and placed on different rations to study the effect on foetal development and the growth of the litters. The allotments and rations were as follows: Lot 40, 6 sows, ground corn; Lot 41, 3 sows, ground corn 70 percent, shorts 24 percent, and tankage 6 percent; Lot 42, 3 sows, ground corn, wheat gluten, and blood meal in such proportion as to make the ration slightly higher in protein and much lower in ash than the ration of Lot 41; Lot 43, 3 sows, ground corn 70 percent, shorts 24 percent, tankage 6 percent, and ash—the ash being increased from 1 to 3 parts during gestation period.

One sow in Lot 40 died 37 days after farrowing. Another has been unable to get up although she has been fed ground corn, shorts, tankage, milk, and green alfalfa or rape since getting down. One sow produced a litter of only one pig. The sows in Lot 42 had to be taken off the regular ration soon after farrowing and were put on a good ration of ground corn, shorts, tankage, and milk. One sow, replaced on the original ration, did not do well and died 36 days after farrowing. Of the other two sows, one has been partially paralyzed and unable to walk since farrowing, and the second was unable to stand for seven days after farrowing. The pigs in Lot 42 were very fat at birth, inactive, and weak in the hind legs. The pigs in Lot 43 were somewhat thinner than the average but strong and active. The average weights of the pigs are shown in Table I.

TABLE I.—AVERAGE WEIGHTS OF PIGS.

LOT NUMBER	Number of pigs		Average weight	
	At birth	At 30 days	At birth	At 30 days
40.....	21	10	<i>Pounds</i> 2.20	<i>Pounds</i> 8.90
41.....	30	18	2.23	13.72
42.....	23	12	2.52	10.50
43.....	30	17	2.23	12.11

(c) *Protein and Ash Deficiencies of Corn and Sorghum Grains.*—This study has shown that when corn constitutes the entire ration of young animals the supply of inorganic constit-

uents is inadequate for normal growth. The mineral deficiency is almost entirely remedied by the addition of calcium. It has also been shown that the slow growth of animals when fed corn alone is largely due to the poor quality of the proteins of this cereal. Rats were used as experimental animals in studying corn proteins. Marked improvement in the rate of growth occurred when tryptophane was added to corn proteins and after a further addition of lysine, their efficiency for growth production was greatly increased. The nutritive properties of kafir are now being studied by the methods applied previously to corn. It has developed so far that the deficiencies of kafir are very similar to those of corn.

Alfalfa Breeding Investigations.—In these investigations the breeding plot was moved to a new and more favorable location. Thirty-six crosses were made between pedigree *sativa* and pedigree *falcata* strains of alfalfa, and ten crosses between different *falcata* strains. Individual mother strains of ordinary alfalfa have been isolated which are unusually heavy seed bearers, a highly important matter for alfalfa growers in Eastern Kansas. Individual strains of alfalfa have been isolated which are immune to leaf-burn, a physiological trouble due to too high temperatures.

Climate and Injurious Insect Investigations.—Life history studies have been made of several insects, more especially the Hessian fly and the chinch bug egg parasite, under controlled temperature and moisture conditions. These studies have been correlated with others made under natural conditions. Further studies were also made with regard to the influence of temperature and moisture on the life history of the Hessian fly. From the data at hand, it seems that 85° F. and 75 percent humidity are optimum for fly development. A study of the behavior of Hessian fly larvæ shows that the direction of migration is predetermined by the orientation of the egg. The degree of inclination of the leaf has nothing to do with the direction of larval migration. The larvæ are capable of locomotion on either an ascending or descending incline. That the wind is an important factor in the distribution of Hessian fly has been further indicated. By the use of upright screens, adult flies were caught at points as far distant as two miles from any infested fields. One fly was taken five miles from any infested field. An investigation of the effect of seedbed preparation on

the emergence of the adult fly indicated that the earlier the ground was worked, the fewer the flies that emerged.

Parasitological Investigations.—Further evidence was secured that chickens may become infected with the nematode, *Heterakis papillosa* Bloch, by being fed the dung earthworm, *Helodrilus gieseleri hempeli* Smith, taken from infected poultry yards. It was discovered that the eggs of this nematode hatch in moist earth. The study of the relation of this nematode to the earthworm in the transmission is continued.

Breeding Investigations.—Several new characters have been studied. It has been definitely determined that there are two classes of characters in orthoptera—one class in which each pattern is allelomorphic to each of the others, there being fourteen patterns in this class; and another class in which the character is allelomorphic only to its absence, never to any other character. It has been discovered that there is a kind of parthenogenesis in one group of these grasshoppers. This matter is being further studied and tested. Through the use of the temperature and moisture control chambers, a whole generation has been gained in a year—five generations being produced instead of four as in the ordinary greenhouse.

Sex Type as Related to Functional Development and Performance.— During the past year, sixteen of the Shorthorn cows in this experiment produced calves, of which nine are heifers and seven are bulls. With the exception of one heifer and one bull, all of the calves are sired by Matchless Dale 291609. Milk and butterfat records are being kept for all of the cows except one which has successfully resisted being milked. One cow died and three were removed. A Scotch-bred cow, Pride's Bessie, has been secured to add to the herd, and heifers from cows not in the herd will be added when they calve, to make a total of twenty cows.

HATCH FUND

Soil Fertility Investigations.— Soil fertility investigations including various cropping systems and fertilizer tests, have been continued as previously outlined. The effect of cropping systems is becoming more pronounced. Plots that have been growing corn continuously, yielded 28.15 bushels per acre in 1910 and 23.00 bushels in 1916, while the plots growing corn in rotation with cowpeas and wheat yielded 29.59 bushels per

acre in 1910 and 42.25 bushels in 1916. In 1916 the wheat grown in the various rotations was far better than that grown continuously, and this in spite of the fact that in 1911 when the work was begun, the continuously cropped plot was the highest yielder of the project.

The effect of barnyard manure on the various crops is becoming even more pronounced than the effect of cropping systems. Application of manure on corn in the rotation of corn, cowpeas, and wheat, had a marked effect on the succeeding crop of wheat. However, the average yields of plots receiving all the manure on corn are almost identical with the yields of wheat on plots receiving one-half the manure on corn and one-half on wheat. The use of manure on alfalfa grown in rotation with corn and wheat, gave increases in yield that were very noticeable. The most outstanding effect of manure was on alfalfa grown continuously. This treatment has always given marked results, but the effect was especially great in the season of 1916.

In corn grown in rotation, commercial fertilizers have not given increases in yield sufficient to pay for the fertilizer. However, where corn has been growing continuously since 1911, commercial fertilizers are showing marked increases in yields. It has been only during the last two years that fertilizers have given any marked increase on these plots, and the big factor in increasing yields has been phosphorus. On wheat grown continuously, application of fertilizer gave a higher yield than the check plots during the season of 1916. The use of potassium gave only a very slight increase over the check plots, but the application of phosphorus alone or in combination resulted in a test weight of two or more pounds per bushel above the other plots of the series. Commercial fertilizers have had no marked effect on the yields of alfalfa grown in rotation, but where alfalfa has been grown continuously, the effect has been quite pronounced.

Seedbed Preparation for Wheat.— The yields at harvest, 1916, were quite low. The summer of 1915 brought so much precipitation that the ground was too wet for optimum nitrification conditions. Consequently the early summer cultivation did not occasion the usual accumulation of available nitrogen although the nitrate formation varied as usual with the date

of preparation. The stands were poor owing to considerable winterkilling. The highest yield of 8.25 bushels per acre was produced on the plot listed July 15 with the ridges subsequently worked down. As a result of the seasonal moisture and nitrate studies it was found (1) that nitrification is correlated with the available moisture during the summer period; (2) that the available moisture is controlled by cultivation treatments through the prevention of weed growth; and (3) that the growth of weeds not only wastes the soil moisture but utilizes the nitrates developed, preventing a nitrate accumulation for the fall growth of wheat.

Investigations concerning the effectiveness of soil mulches have been conducted systematically since 1911. As a result of three years' determinations, it is concluded (1) that a cultivated soil surface is no more effective than a bare surface in checking moisture evaporation; (2) that nitrification may take place at the same rate on uncultivated soils with a bare surface, as on cultivated soils; (3) that weeds cause a depletion of the soil moisture and plant food; and (4) that, as regards cultivation, the aim should be to keep soil in a receptive condition to absorb rainfall and to prevent weed growth.

Cereal Crop Improvement.—The work in cereal crop improvement was continued with no material changes. The new wheat, P-762, has been named Kanred. Its yield the past season exceeded all past records in comparison with the standard varieties, Turkey and Kharkof. It produced nearly 11 bushels more to the acre than Turkey and 8.5 bushels more than Kharkof. Its average yield for the six years in field tests is 31.1 bushels to the acre as compared with 26.5 bushels for Turkey and 25.9 bushels for Kharkof. A promising strain of oats has been isolated which is much earlier than the Red Texas usually grown and which appears to be more productive. The rate and date of seeding test with wheat, and the rate, date, and seedbed test with oats, were continued and gave results comparable with those of previous seasons. The research work on causes of winterkilling was continued and gave some interesting and valuable results. It was found that the kind of soil and its moisture content have a very definite though complex relation to temperature of soil and winterkilling of grain crops. Seeding in furrows was found to give marked protection to grain during the winter.

The work with corn was continued as in the previous season except that the methods-of-cultivation test on bottom land was abandoned and one on unplowed upland substituted. The plots which were scraped to remove weeds and the plots which were cultivated in the ordinary way, gave practically the same yields, while the plots that were cultivated every ten days after the corn was laid by, gave the lowest yields of any. The test with hybrid seed gives erratic results. Sometimes the hybrid yields considerably higher than either parent and again very much lower. On the average the hybrid strains yield better than the average of the parents, but not enough higher apparently to justify the extra cost.

Forage Crop Improvement.— In forage crop improvement, a study of over 3,000 heads of kafir with respect to the relation of number of whorls to the weight of the heads, revealed that heavy heads had fewer whorls than light heads, and that the heavy heads threshed the higher percent of grain. A comparison of corn, kafir, and Kansas Orange sorghum for silage for five years, places Kansas Orange in the lead with an average yield of 18 tons per acre. In the general forage test, it was found that soybeans yield from a third to a half more hay per acre than cowpeas, and from two to three times as much seed. Several varieties of soybeans have produced an average yield of 25 bushels per acre or more during the past three years. A study of local adapted strains of Kentucky blue grass and of introduced strains, show that the former is much the better, indicating that the plants gradually become adapted to local conditions.

Corn Ear-Worm Investigations.— This study was conducted along several lines. In the variety test of corn with regard to immunity to corn ear-worm injury, twenty-five varieties of corn were grown and complete data obtained on tasselling, silking, and maturity, and on the percent of ear-worm injury and yields. Colby Bloody Butcher and Iowa Silvermine had the lowest percent of ears injured and the highest yield. Experiments were made with dust sprays with regard (1) to the number of applications necessary to control the ear-worm, and (2) a comparison of the cheesecloth bag and the dust gun in applying the spray. Results indicated that the injury decreases with the increase in the number of applications, and

that the dust gun is more effective than the cheesecloth bag in application.

Fruit Insect Investigations.— There was no outbreak of apple-leaf skeletonizers during the summer of 1916; consequently no work was done with them. Studies with apple blight show that there is a direct relation between the infestation with aphids and the infection of blight. Attempts to bring about blight infection during August when the average maximum temperature was 96.5° F. and the rainfall, 0.71 inch, failed, showing that trees are not susceptible to blight during a period when no growth occurs. In September, when weather conditions resembled those of spring and the trees had begun to put forth new growth, aphids carrying blight bacteria were placed on twigs and confined there by cheesecloth sacks. Every case of blight which developed was on these aphid-infested trees.

STATE FUND

Farm Management Investigations.— Records of farm business for 1915 on 633 farms were obtained in cooperation with the Extension Division. In addition, detailed records of all farm operations and transactions were obtained from three farms. The farm surveys show that the average Kansas farm is lacking in well organized diversity. The tendency of many farmers has been to invest too large a proportion of their capital in land, leaving insufficient capital to equip their farms properly. The studies on tenancy substantiated the results obtained in 1914 for cash, share-cash, and crop-share tenants. Stock-share leased farms were included in the results for 1915, and it was found that these gave the largest returns. The study showed that cash tenancy is the least profitable and the most objectionable type of tenant farming. Except in the case of the farms leased on a stock-share basis, the averages of the rented farms show a less desirable type of agriculture than the averages of the owned farms. Stock-share leased farms compare very favorably with the owned farms and the system of farming followed in many instances was more desirable than that found on the average owned farm. The stock-share method of leasing is the most practicable and satisfactory solution of the tenancy problem in Kansas at the present time.

Grazing Experiment. — The work was continued as originally planned except for a few minor changes. In 1914, 140 acres protected until September 2, furnished feed for 80 cows and 70 calves for 68 days. This did not injure the pasture and supplied more forage than was secured on a similar area grazed through the season. In 1916, this area was not grazed until September 1. It then supplied feed for 50 cows and their calves for over 70 days. It was found that more seed matured on the protected portion in both seasons than where the cattle were grazed throughout the season. Also, the seed produced on the protected area in 1915 on the average germinated twice as well as the other. Germination tests for 1916 are not completed.

Sweet clover and several kinds of tame grasses have been seeded in the native sod to determine the practicability of improving pastures in this way. Sweet clover only has proved promising. The yellow type seems to predominate over the white. A thorough study is being made of the effects of burning. Data so far indicate that burning early in the spring does not injure the grass as far as its immediate effect is concerned.

Effect of Alfalfa Upon Soil Fertility.— The object of this experiment is to determine the effect of prolonged production of alfalfa upon soil fertility elements. Samples taken from fields which have been growing alfalfa for a long term of years have been classified into, (1) those taken in the eastern or humid part of the state where the rainfall is 30 inches or more; (2) those taken in the west-central or semi-humid part where the rainfall is less than 30 inches but more than 20 inches; and (3) those taken in the western or semi-arid part of the state. It has been found that soils in alfalfa in the semi-arid portion of the state have as great a percent of nitrogen as the soils in the native sod, and the difference in nitrogen content between the cultivated soils and the soils in native sod is small. In the humid region, all the soils in native sod contain a larger percent of nitrogen than the soils in alfalfa. Also with a few exceptions, the soils in alfalfa contain a larger percent of nitrogen than those continuously cropped. Alfalfa fields in the humid region are on the average two-thirds as old as the fields in the semi-arid section. In the semi-humid section, the results resemble those of both the semi-arid and the humid sections.

That is, alfalfa soil has in some cases more nitrogen and in other cases less nitrogen than the native sod.

Silage Investigations.—The work on making silage from alfalfa has been completed and is reported in Bulletin 217. The chemical work of previous years on silage from corn and kafir has been continued. The work has consisted for the greater part of moisture, acidity, and feed analysis in connection with feeding experiments. Bacteriological investigations with silage have shown, (1) that acid production is the principal fermentation; (2) that all forage contains the proper organisms for a desirable silage fermentation; and (3) that the controlling factors for the production of good silage are, proper forage, and correct methods of siloing.

Work has been done in determining the weights of silage and capacities of silos. From the figures thus far obtained, it is concluded that the average weight for silage in silos from 30 to 40 feet high is approximately 38 pounds per cubic foot. The average weight in the first foot of silage has been found to be about 30 pounds per cubic foot.

Experiments in Feeding Dairy Cattle.—An investigation is under way to determine the comparative feeding value of silage made from (1) kafir heads and butts; (2) kafir butts, the grain from the same being ground and fed to the animals separately; and (3) kafir butts alone, no grain being used. Similar work is also under way to determine the value of silage made from corn with and without grain. One test has been completed and a second test is under way. Sudan hay and alfalfa hay were compared by feeding two lots of cattle for a period of three months during the past winter. It has been found that Sudan hay makes good feed for dairy cows and compares favorably with alfalfa hay. The hay used thus far has contained from 9 to 10 percent protein. This work will be continued next year.

Heifer Development Experiment.—This experiment is being continued as originally planned except that the twenty-four heifers have been divided into four lots instead of three. All received milk until six months old and in addition, the first lot received alfalfa hay alone; the second lot, 'alfalfa hay and silage; and the third and fourth lots, alfalfa hay, silage and grain. After six months of age the rations specified shall constitute the sole rations of the cows until each has had at least three calves. Lots 1, 2, and 3 were bred to calve at 30 months of age;

Lot 4 were bred to calve at 24 months of age. About half of the heifers have freshened and records are being kept of the milk and butterfat produced. The purpose of the experiment is to secure information regarding the relative value of the rations used, their effect on the cattle, and the relative cost of growth and production.

Physiological Investigations with Drouth-Resistant Plants.—

The work on the variation of water and dry matter in leaves of corn and the sorghums has been carried through three seasons and concluded. Altogether, the water content and dry matter of the leaves were determined every two hours for 22 days and 10 nights. During a drying day the percent of water decreases much more rapidly in the leaves of corn than in the leaves of milo. This would seem to show that the milo plant can absorb water from the soil and transport it to the leaves better than can the corn plant. Under severe climatic conditions corn leaves do not increase perceptibly in dry weight after 10 a. m. while milo leaves continue to manufacture food through the hottest portion of the day. The results of this work were published in the *Journal of Agricultural Research*, vol. 10, pp. 11-47.

Breeding Corn for Drouth Resistance.— The summer of 1916 was one of long continued drouth. Official records show a moisture deficiency for the season of 6.26 inches, all of which occurred in the months of July and August. During these two months, corn was subjected to a severe drouth test and the results obtained may be considered as throwing some light on the behavior of the hybrids under drouth conditions. Thirty-five strains of corn belonging to hybrid family No. 58 were grown at Manhattan. As a result of the season's work, nearly three bushels of seed were obtained from strains of corn which stood the drouth successfully and which seem to be superior to ordinary corn in drouth resistance. Two of the strains had large ears as the farmer would judge them. Nine of the hybrid strains showed superior drouth resistance. One of the hybrids was grown at Garden City in pot experiments and proved to be nearly as economical as kafir and dwarf milo in water requirements.

Nutrients in Forage Crops.— In the season of 1916, maize, and several of the sorghums including Sudan grass, were studied to determine the effect of maturity and methods of harvest-

ing and curing upon the nutrients in forage crops. At the time of tasseling, pollination was prevented on a portion of the corn by covering the silk. The barren corn was then harvested at the same time as the normal corn. Results showed that the barren corn had a higher percent of protein and smaller percent of crude fiber than the normal corn. With Sudan grass the percent of protein is very closely related to yield. When the percent of protein is high, the yield is small, and when the yield is high, the percent of protein is small. The largest amount of total nutrients per acre was obtained when the grass was cut in full bloom. With the sorghum plant as a whole, the percent of protein and crude fiber decreases and the percent of nitrogen-free extract increases as the plant matures.

Soil Survey.— The results of the analysis of the soils from Montgomery County were tabulated and presented in a form suitable for publication. The soil types in Montgomery County show the same general deficiencies as the soil types in South-eastern Kansas usually show; namely, a deficiency in calcium compounds, a low phosphorus content, and less potassium than the average for good soils of the state.

Milling Investigations.— The work of this project consists of tests on wheat produced on the Agronomy Farm from plots used in seedbed preparation, soil fertility, and variety tests. Approximately 165 milling tests, 350 baking tests, and 5,200 chemical determinations were made. Results of tests to date have been summarized with a view to making a general summary and drawing conclusions. It is expected by this means to discover which determinations should be continued and which abandoned.

Milling Grain Sorghums.— Approximately 20 milling tests and 75 baking tests were made with kafir. It would appear that a somewhat coarse meal, rather than a fine flour, produces best results when used as a partial substitute for wheat flour. Indications are that a sufficiently satisfactory product can be obtained by blending 20 to 25 percent kafir meal with a good, strong wheat flour. Much will depend upon individual taste in deciding what proportion of kafir meal is desirable. Some conclusions as to the type of mill equipment best suited to milling of kafir have been reached.

Potato Investigations.—Potato investigational work has been conducted along three lines—(1) variety tests, (2) disease

control, and (3) fertilizer tests. The variety tests included most of the standard varieties and in some cases, checks were made on seed from the Colorado and Red River districts, as compared with Kaw Valley seed. Irish Cobbler and the Early Rose (northern) made the best yields. Colorado seed was less productive than either the northern grown or Kaw Valley seed. In controlling disease, comparisons were made of dry and liquid sprays. It was found that dry sprays could be applied more rapidly and more cheaply than liquid sprays. They were also as effective in controlling Colorado potato beetle as liquid sprays. Liquid sprays of bordeaux mixture were much more effective in controlling early blight. The results from the application of commercial fertilizers have shown that in years of favorable conditions, the yields may be increased by the application of fertilizers. The results of two tests showed that potash had the greatest influence on increased yields.

Fruit Bud Formation.— The soil management factors considered show, to date, the following results: (1) That the use of alfalfa as a companion crop may encourage the work of the buffalo tree hopper (*Ceresa bubalis* Fab.). (2) That a more vigorous wood production results from thorough cultivation than from growing trees in sod, or in alfalfa plots where the alfalfa is allowed to grow within three and a half feet of the trees.

In pruning investigations the effects of summer pruning, winter pruning, and lack of pruning were studied. It was found that summer pruning produced more evenly developed and better balanced tops than either winter pruning or no pruning. Summer pruned trees produced fruit spurs and a few blossoms on the current season's growth. None of the others produced any blossoms. Summer pruned trees were less affected by the severe winds that followed several hard fall rains than the other trees, which, offering more resistance to the wind, were in many cases blown over.

Small Fruits and Garden Crops.— The best varieties of the more common vegetables and some special kinds have been grown in the trial plots in order to discover the varieties best suited to Kansas conditions. New varieties when introduced are given a thorough test in the trial garden. Particular emphasis has been placed on the tomato experiments due to the importance of this crop, both as a kitchen crop and as a market

garden crop. Different methods of pruning tomatoes have been tried. The yield was greatest from plants allowed to grow without pruning or training, but there was a much larger percent of sunburned tomatoes. The work so far indicates that pruning to three stems will give the best results. Insect control has been an important feature of the garden work; Standard remedies have been tried with varying degrees of success.

Poultry Disease Investigations.—The Cause of roup in fowls has been demonstrated to be due to a bacterium of the pasteurella group. A control method based on the use of a bacterin prepared from this organism has shown itself, under experimental conditions, to be absolutely effective. The work of Mack at the Nevada Agricultural Experiment Station on a protective bacterin treatment for chicken cholera has been verified by work at this station. Results have been obtained recently which indicates that fowls immune from roup are also immune from cholera. This will be studied further.

Improvement and Conservation of Farm Poultry Products.—The work on this project was confined to the study of standard-bred males from high producing strains in grading up mongrel flocks. From the standpoint of egg production chickens may be divided into three classes; namely, (1) the mongrel fowl of whose egg production nothing is known; (2) the purebred fowl which is bred for shape and color, but of whose egg production nothing is known; and (3) the purebred fowl which is bred for high egg production.

Marketing of Eggs and Poultry.—A study was made of the keeping quality of eggs and dressed poultry shipped by parcel post. A large number of fowls were dressed by different methods and shipped to a town about 50 miles distant. From there they were returned to the Bacteriology Department for examination. The results of this phase of the investigation, lead to the conclusion that it is not feasible in Kansas to ship poultry by parcel post during the summer. Attempts to use preservatives such as cane sugar, sodium nitrate, and sodium chloride, have not been successful because of the foreign flavors added with these substances.

Cooperation in Kansas.—The work of this project has been completed and a manuscript prepared entitled, "The Funda-

mental Principles of Cooperation," which will be published as a station bulletin.

Marketing of Kansas Butter.—This project has been completed and the results published as Bulletin 216.

Shade-Tree Insect Investigations.—In 1915, the borers in elm trees were found to be heavily parasitized by a nematode, the life history of which was worked out. Cages were placed around the trunks of several of these trees in order to make studies of the life histories of the elm borers that emerged. During 1916, no borers emerged from any of the trees around which cages had been placed.

Twelve trees were banded with tanglefoot and examined daily in order to secure data as to the date of the earliest emergence of the canker-worm moths. January 5 was the date of earliest emergence, April 21 the last date. The maximum emergence occurred from March 17 to 21 inclusive. These facts indicate the period during which danger may be expected from the canker-worms;

Cedar scale (*Aonidia juniperi*) was discovered working on the cedars on the campus in the spring of 1915. By the spring of 1916 it had nearly destroyed those trees which it infested. A life history of this scale was begun and thoroughly worked out. Two chalcid parasites were found to be a valuable check on the increase of the scale.

Insects Injurious to Staple Crops.—Four phases of this work have been pursued during the year as follows:

(1) Considerable new data were collected on the life economy of the kafir ant in the field. Colonies and nests were found to be numerous about Manhattan. Many large nests were found in corn fields early in the spring.

(2) A close study was made of the outbreak of green bug in Southern Kansas. The oats crop throughout the area of infestation was a total failure and there was considerable injury to wheat, corn, and sorghums. Several attempts were made to introduce parasites and although many millions were successfully imported, they failed to reduce the number of green bugs.

(3) A study has been made of May, muck, and closely related beetles, also of wireworms. The work consisted in collecting adults and grubs and working out the life histories of the different species of economic importance.

(4) A study of insects-injurious to alfalfa was begun at the beginning of the fiscal year, July, 1916. The first year's work consisted largely of making a survey of the problem and starting life history studies on forms of economic importance. In all, 830 specimens of various species have been collected and recorded. These include the alfalfa hay worm, clover leaf weevil, clover root curculio, clover seed chalcid, and the alfalfa caterpillar.

Termite Investigations. —The study of the life history and habits of the termite was continued and valuable data were secured on the swarming habits, reproductive period, and longevity. A neoteinic (complimentary) queen was found, showing that the termites are not dependent upon the true queens for establishing or continuing a colony. Data were secured on the parasitic nematode (*Diplogcder serivora*) of the termites.

Injurious Mammal Investigations.— The iron base and wood base snap rat traps have been found about equally effective and more so than the wire cage rat trap. Cornmeal and rolled oats have proved effective baits. Arsenic has proved a successful poison in the following formula : One part arsenic, eight parts corn meal, and eight parts sugar, mixed dry. The Hooker trap for gophers has proved too small to take the large gopher of this vicinity. A new method of setting the No. 0 steel trap is giving excellent results. A survey of the mammals of Riley County has been made. Seventy-two mammals have been taken by trap lines and records are being made of feeding habits, breeding period, number of young, and parasites in the different species.

Cattle Feeding Investigations.— Eighty-four grade Hereford calves from the Fort Hays Branch Station were full-fed for the production of yearling beef. The details of the experiment and the results are given in Table II.

TABLE II.—CATTLE FEEDING EXPERIMENT
(December 1, 1916, to May 30, 1917)

	Lot number and ration					
	Lot No. 24 Ground barley, oil meal, alfalfa hay, (brown) silage	Lot No. 25 Shelled corn, oil meal, alfalfa hay, (brown) silage	Lot No. 26 Shelled corn, oil meal, alfalfa hay, (good color)	Lot No. 27 Shelled corn, oil meal, alfalfa hay, (brown)	Lot No. 28 Shelled corn, oil meal, sweet clover hay	Lot No. 29 Shelled corn, oil meal, alfalfa (black)
	<i>Pounds</i>	<i>Pounds</i>	<i>Pounds</i>	<i>Pounds</i>	<i>Pounds</i>	<i>Pounds</i>
Average initial weight	338.6	341.1	334.5	334.7	342.6	338.6
Average fiscal weight	719.9	682.4	688.3	684.8	698.8	600.7
Average total gain	381.3	340.3	353.8	350.1	356.2	262.1
Average daily gain	2.12	1.89	1.96	1.94	1.97	1.45
Average daily ration:						
Grain	7.32	6.63	7.39	7.39	7.38	6.65
Oil meal	1.32	1.19	.49	.49	.49	.49
Hay	4.05	4.05	7.82	7.82	7.32	14.45
Silage	7.75	7.75
Cost of feed per day	\$0.24	\$0.202	J.216	\$0.216	\$0.212	\$0.18
Cost of 100 pounds gain	11.34	10.68	11.01	11.10	10.71	12.36
Cost of feed per steer	43.20	36.36	38.88	38.88	38.16	32.40
Initial cost of steer at \$8.50	28.78	29.07	28.43	28.45	29.12	28.78
Total cost of steer	71.98	65.43	67.31	67.33	67.28	61.18
Final cost per cwt	10.01	9.59	9.77	9.83	9.62	10.10
Final value per cwt	10.20	10.35	10.25	10.35	10.50	9.60
Final value of steer	73.43	70.63	70.55	70.88	73.37	57.67
Profit per steer	1.45	5.20	3.24	3.55	6.09	3.51

Fourteen steers were in each lot. They were fed 180 days. Alfalfa hay used in Lots 24, 25, and 27 was brown (stack burnt) medium coarse; that used in Lot 26 was of good color, same quality otherwise. Sweet clover hay used in Lot 28 was the first year's growth, of very fine quality and excellent color. Black alfalfa used in Lot 29 was stacked immediately after cutting without being cured. Cottonseed meal was used the first three months. Linseed meal was used the last three months.

Prices used for feeds—own. \$1.12 per bushel; barley, \$1.06 per bushel; alfalfa hay, \$15 per ton; sweet clover hay, \$15 per ton; black alfalfa, \$5 per ton; silage, \$5 per ton; linseed and cottonseed meal, \$45 per ton.

Feeding Western Lambs. —For a lamb feeding experiment 283 lambs were bought in Denver. Three were discarded. The remainder were separated into four lots of 70 lambs each and fed to compare the value of shelled corn, whole kafir, and whole barley when fed with cottonseed cake, alfalfa hay, and silage; also to determine the value of silage when fed with shelled corn, cottonseed cake, and alfalfa hay. After 30 days of feeding, lambs began to die in several of the lots. At the end of 45 days the lambs remaining were marketed. No comparable results were secured and the experiment will be repeated.

Value of Cream Grading. —A study of the value of cream grading was begun in August, 1916, the Dairy Division of the Bureau of Animal Industry, the Kansas Agricultural Experiment Station, and the Kansas Creamerymen's Improvement Association, cooperating. The principal object of the work is

to determine the value of grading cream from a commercial standpoint, the price received for butter made from special cream sold in competition with butter made from the general run being taken as an index to the value. The work of the year was largely devoted to a study of the condition of the cream produced in the vicinity of Herington, Kan., involving an examination of the physical conditions under which it is produced, as well as its condition at time of delivery, with a view to determining methods of improving the quality of cream. Results of the work to date indicate that it is possible by relatively simple means to greatly improve the quality of centralizer cream in Kansas.

Plant Disease Investigations.— Plant disease investigations in cooperation with the Bureau of Plant Industry have been continued. A marked freedom from stem rust (*Puccinia graminis tritici*) in field and greenhouse tests has been found in three varieties of hard winter wheats developed by the Kansas Agricultural Experiment Station. One of these, Kanred, showed an average of 10 percent rust in the nursery, and two other promising commercial varieties showed only 5 percent. None of these varieties had enough stem rust to affect the yield and quality. All other varieties which proved susceptible in the same plots took as high as 85 percent rust with the quality of seed very poor. The distribution and percent of bunt in wheat in the crop of 1917 was given more than usual attention in connection with a systematic inspection of wheat fields made by the State Council of Defense. Bunt was found in the following counties: Reno, Stafford, Rice, Pratt, Harper, Dickinson, Barber, Norton, Chase, McPherson, and Sumner. The majority of fields showed from 2 to 5 percent, but many ran higher and one or two showed 25 percent. The names of the owners of the fields were secured and letters and special literature urging seed treatment were sent out in August. As a summary regarding cereal rust in the state in the season of 1917, it might be said that leaf rusts of cereals were slightly less than the average, and the stem rusts, although present on all the cereals, were very slight.

Investigations with corn smut show that the organism is carried from the soil to the young corn plant by means of wind. The organism has been isolated, grown in pure culture, and healthy plants inoculated with positive results. Various fungi-

cides used in sprays seem to reduce the amount of corn smut, but in practically every case the yield is likewise reduced. It has been shown that infection from corn smut is local and that infection through the developing seedling is a negligible factor. Corn smut was very abundant in the field, 50 to 75 percent infection occurring in fields in the eastern and southern part of the corn belt. Sorghum smut (kernel smut) was present in sufficient quantities to cause considerable damage. Sorghum seed treatment is coming into more general use. Physoderma was found in the vicinity of Manhattan and in Labette, Bourbon, Allen, Anderson, and Marshall Counties.

Severe loss in the potato crop was caused by *Rhizoctonia* or blackleg. None of the leaf diseases were apparent. Tip burn brought about by the dry conditions in July caused a great deal of damage. A conspicuous disease in the tomato crop was the so-called blossom drop. This disease is more or less prevalent every year, but in many districts was very noticeable the past season.

Cooperative Experiments with Farmers.— Soil and climatic conditions in Kansas vary greatly. It is therefore necessary to extend the studies conducted at the Manhattan station to all parts of the state before results can be considered conclusive. Through the cooperative experiments with farmers, begun in 1911, fertility and tillage requirements and crop adaptations of the various soil types are determined, with respect to the existing climatic conditions.

In 1916 the Agronomy Department cooperated with farmers in 85 counties in conducting the following experiments: 185 variety tests of corn; 84 variety tests of grain and forage sorghums; 73 variety tests of wheat; 4 date-of-seeding tests of wheat; 50 fertilizer tests of wheat, oats, corn, and alfalfa; 8 rotation projects; 116 miscellaneous tests in crop production; and 90 tests in which improved varieties of crops were grown for the production of seed for increase planting. Results of variety tests with corn demonstrate decisively that acclimated varieties of corn are superior to introduced varieties and that the longer a variety has been grown in a given environment, the greater is its superiority over introduced varieties, other things being equal. As a result of variety tests with corn and the sorghums, the adaptations of the various varieties of each crop has been determined. Definite recommendations regard-

ing the growing of sorghums can be made for all parts of the state. In the variety tests with wheat, it was demonstrated that Kanred is a superior variety for growing on all soil types throughout the hard wheat belt of Kansas. In 54 cooperative tests with farmers, extending over a period of three years, Kanred gave an average increase of 4.4 bushels an acre over the local variety. Results of fertilizer tests show that the fertilizer requirements of Eastern Kansas soils differ. Fertilizers that prove effective on one soil type in a locality, may or may not produce favorable results on other soil types within the same locality.

PUBLIC SERVICE

The experiment station has been made responsible for the enforcement of different state regulatory laws, in addition to the work of conducting investigations for which it was originally established. Practical demonstration work is done by several departments of the station. The different lines of public service rendered, briefly presented, are as follows :

REGULATORY WORK

Fertilizer Control.—The inspector in charge of fertilizer control work made two extended trips through the sections of the state in which the bulk of the fertilizer business is transacted, taking samples of the various brands found on sale. The results of the analyses of samples taken during the fall inspection are published in Inspection Circular 4. The high price of potassium compounds is reflected in the fact that there is a notable tendency to a deficiency in the potassium content of the fertilizers on sale in the state. Farmers are advised to claim damages for deficiency in potassium below the manufacturer's guarantee.

Livestock Feed and Remedy Control. —The following report covers the work done in enforcing the feedingstuffs and livestock remedy laws:

FEEDINGSTUFFS	
Inspections made	1,427
Firms visited	1,358
Towns visited	327
Fees registered	1,838
Firms registering feedingstuffs	865
Inspection samples of feedingstuffs analyzed	421
Fees found not up to guarantee in one or more constituents	155

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Feeds deficient in protein.....	31
Feeds deficient in fat.....	59
Feeds excessive in fiber.....	113
Federal samples analyzed.....	72
Commercial samples analyzed.....	229
Citation issued but prosecution for feed violation held in abeyance,	14
Information relative to feed violation filed with county attorney...	12
Settled out of court.....	3
Seizures under federal law.....	6

LIVESTOCK REMEDIES

Remedies registered	32
Firms registering livestock remedies.....	17
Total number of remedies registered.....	387
Total number of firms registering remedies.....	148
Inspection samples of livestock remedies analyzed.....	8
Office samples of remedies analyzed.....	3
Federal samples of remedies analyzed.....	2
Citation issued but prosecution for livestock remedy violation held	
in abeyance	3
Settled out of court.....	1
Information relative to livestock remedy violations filed with county	
attorney	5

State Livestock Registry Board.— Stallion licenses issued for the year 1917, totaled 5,440, an increase of 150 over the number issued for 1916. Of this number, 3,363 were for purebreds, an increase of 203, and 2,077 for grades and scrubs, a decrease of 53 during the year. Further analysis of the work shows that the number of purebred draft stallions standing for public service has increased 269, while the number of stallions of the light breeds has decreased 66. Percheron stallions have increased 251 in number, while standardbreds have decreased 70. At present, 61.8 percent of all the stallions standing for public service are purebreds as compared with 41.2 percent in 1910. The stallion owner is given every possible opportunity to comply with the law before prosecution is begun. The splendid assistance and cooperation of county attorneys enabled the board to secure almost complete compliance with the law at a very small cost. Each year greater appreciation of the work done by the board is manifested on the part of the horse producers of the state. Only seven wilful and persistent violators of the law were found, each of whom was prosecuted, convicted, and fined.

State Dairy Commissioner.—Examinations for cream buyers were held in 44 cities throughout the state by a representative of the department. Final examinations were given to 1,418

applicants in addition to 791 temporary examinations. Approximately 90 percent of those taking the examinations received permits. Nine hundred thirty-two cities were visited and inspections made of 1,267 cream stations, 131 creameries, 65 ice cream factories, 3 condenseries, 44 milk stations, 93 dairy farms, and 17 receiving stations. Sixty-nine dairy establishments were closed because of unsanitary conditions and four prosecutions were made and won by the state.

Fifteen days were spent in extension work. Seven meetings of the Kansas Creamerymen's Improvement Association were attended upon request. The department assisted in the organization of the Kansas Ice Cream Manufacturing Association, making possible the closer cooperation with these manufacturers. Five meetings of the Association were attended upon request. Five cities were cooperated with and encouraged to adopt suitable milk ordinances for protecting consumers. Considerable time was spent in the Government cooperative work. The dairy farms were scored by a representative of the department and frequent conferences with the men engaged in carrying out the plans were found necessary. A special report covers the cooperative work.

The policy of the department is to stimulate the production, as well as improve the quality, of dairy products. Reasonable rules and regulations are passed from time to time. The requiring of the immediate washing of dairy utensils and the return of the same clean to the owner has saved thousands of dollars to the dairymen of the state. The local demand for dairy products is daily increasing, notwithstanding high prices. Tested herds are proving a decidedly valuable investment for their owners and there seems to be no tendency on the part of the dairymen of the state to dispose of their dairy herds, regardless of the movements of this character in the eastern states. During the year Kansas farmers were paid \$8,735,237 for milk and cream by creameries, condenseries, and ice cream manufactories. The total number of pounds of creamery butter made from Kansas cream was 33,514,602.

DEMONSTRATION WORK

Pure Seed Work.— In the seed laboratory, 334 purity tests, 534 germination tests, 18 examinations, and 2 identifications were made from samples of seeds received including the fol-

lowing crops: Alfalfa, alsike, clover, sweet clover, red clover, white clover, Kentucky bluegrass, red top, timothy, millet, Sudan grass, meadow fescue, flax, corn, sweet corn, wheat, oats, sweet sorghums, feterita, milo, kafir, and broom corn. Germination tests were made of 67 samples of flower, vegetable, and fruit seeds.

The Agronomy Department published lists from time to time, giving the names of farmers in the state who had seed of good quality for sale and the variety and quantity available. These lists also included any pure seed which the department had for sale. The lists published included a total of 90,833 bushels of seed grain of the various crops available for planting. Four hundred thirty bushels of improved high-yielding seed of corn, wheat, and the sorghums from the station were sold and distributed to farmers.

Department of Entomology.—The beekeeping laboratory was made available for the use of beekeepers in preparing their hives and in caring for their honey. During the spring of 1917, a series of meetings was held at Chapman, Kan., for the benefit of the beekeepers of that section. Lectures were given on practical beekeeping subjects and demonstrations made on the manipulation of bees. Such subjects as swarm prevention, transferring to modern hives, and artificial increase, were discussed and demonstrated. A representative from the Department of Entomology attended the meetings of the Kansas Beekeepers' Association and took part in discussions and demonstrations. The work of the Entomological Commission in the northern half of the state was continued under the supervision of the department. The inspectors examined colonies for bee diseases, gave practical advice, and conducted demonstrations.

Department of Horticulture.—Demonstrations in pruning, spraying, and grading and packing were held at the orchards of different fruit growers. The most extensive demonstrations of the general value of spraying for the control of insects and diseases were made in the Pugh orchard in Wabaunsee County and the Mayfield and Winne orchards near Manhattan.

Department of Veterinary Medicine.— Little demonstration work was done by the Veterinary Department during the year, owing to the absence of serious epidemics of animal diseases in the state. Some demonstration work in vaccinating hogs for

cholera was done in Nemaha, Dickinson, and Cowley Counties in cooperation with the government. The potency and reliability of the germ-free fluid vaccine for blackleg was demonstrated in a number of localities. A number of cases of necrotic stomatitis of both pigs and cattle, and catarrhal fever in calves, were investigated.

Department of Dairy Husbandry.—Cow testing associations were organized and put into operation by the department at Wichita and Mulvane and in Montgomery County. Members of the department aided farmers in selecting cattle for their herds. Six carloads of high class dairy stock were shipped into the state during the year through the instrumentality of the Dairy Department. In March, 1917, three members of the department spent one week each on the "Cow and Hen Special" operated over the Santa Fe Railway in the eastern half of Kansas.

MISCELLANEOUS SERVICE

Approximately 50,000 copies of station bulletins and circulars were mailed during the year in response to miscellaneous requests received. This is an increase of five thousand over the number sent out last year, and is in addition to the publications supplied to the twenty-one thousand persons whose names appear on the regular mailing lists. Fifty thousand letters were written by members of the station staff, giving advice and information on every conceivable phase of agriculture in reply to inquiries received. Approximately 750 days of the time of the staff members were occupied in field work in compliance with requests for speakers at farmers' institutes, association meetings, and livestock conventions, as well as for judges at fairs, and for personal assistance in landscape gardening, farm management, and similar activities. The members of the station staff took an active part in the spring campaign of the State Council of Defense for increased food production. Staff members rendered effective service on important committees dealing with crops, livestock, dairying, poultry, plant and animal diseases, insects and injurious mammals, and gardening and canning.

IMPROVEMENTS

REFRIGERATION PLANT

At the beginning of the fiscal year, 1916-17, the refrigeration plant installed in the basement of the Dairy Building at a total cost of \$4,940.70, was in complete operation. The ice machine has a capacity of 8 tons a day. Four cold storage rooms are maintained, two of them being double in capacity. These are used for storing the perishable products, such as meats, milk, butter, cream, eggs, and serums, of the Animal Husbandry, Dairy, Poultry, and Veterinary Departments. Storage capacity is rented to other departments. Ice is sold to all other departments of the institution. A sales counter is maintained in connection with the plant, at which the food products of the departments concerned are sold to the public. The sale of ice and rent of storage room furnish receipts which make the plant practically self-supporting during six months of the year. More than half of the expenses are made during the other six months. When the expenses are greater than the receipts, the difference is borne by the Animal Husbandry, Dairy, Poultry, and Veterinary Departments.

OTHER IMPROVEMENTS

A modern machine shed and a hay shed were constructed on the Agronomy Farm. A hog house of unglazed hollow tile was built by the Animal Husbandry Department for use in the swine inheritance studies. The Dairy Husbandry Department built an experimental dairy barn for use in the heifer feeding experiment. A glazed hollow tile silo of 200 tons capacity was constructed as an addition to the stone horse and cattle barn. A stave silo of 80 tons capacity and a heating plant were added to the equipment of the animal nutrition barn. A two story rock horse barn was constructed on the Horticulture Farm and a storage room of rock was built over the storage cave. The Poultry Husbandry Department added to its equipment a Tolman laying house, 20 by 20 feet, with a capacity of 100 hens. An addition was built to the office building at the Fort Hays Branch Station, more than doubling the office room, and a cottage was built for the forester. A modern cottage for the superintendent is under construction at the Garden City Branch Station.

BETTER BREEDING LIVESTOCK

Eleven purebred Belgian horses, including one stallion, four mares, and six colts, were added to the herds of the Animal Husbandry Department. Five purebred Guernsey cattle were purchased from the best breeders in the East. Two heifers came from England, two from the Isle of Guernsey. A young bull, Langwater Benefactor, was purchased from one of the best Guernsey herds in the United States. It is expected that the addition of these Guernseys will make the station Guernsey herd the best in the West.

BRANCH STATIONS OF THE KANSAS AGRICULTURAL EXPERIMENT STATION

The branch stations at Hays, Garden City, Colby, and Tribune, have continued in operation with no radical changes in the plan of their work. The Department of Agriculture has continued to cooperate in conducting investigations in dry-land agriculture at the Fort Hays, Garden City, and Colby stations; irrigation investigations at the Garden City station, and cereal and forage crop investigations at the Fort Hays station. The branch station at Dodge City continued in operation until May, 1917, when it was abandoned, no appropriation having been made by the recent state legislature for its support. All livestock, feedstuffs, and other property belonging to the state were removed from Dodge City to the Garden City station. The land used by the station reverted to Ford County under the terms of the lease.

FORT HAYS BRANCH EXPERIMENT STATION

Administration.—The station came under the supervision of a new superintendent in the spring of 1916. The different enterprises were continued in much the same order as formerly. One of the higher class workmen was made foreman, relieving the superintendent of routine duties as far as possible, giving him opportunity to keep in touch with the station as a whole and to become acquainted with the people of Western Kansas and their needs. The business of the station was centralized in the office and a detailed system of office records initiated. Special effort is being made to secure better records of work done by the men in the field, of the use of machinery and loss

of tools, and to assemble other information contributing to improved management. The superintendent, assistant superintendent, foreman, nurseryman, and the government representatives in charge of cooperative experimental work, form a staff which meets at intervals for the discussion of problems of vital importance to the station.

Climatic Conditions.—Only 16.01 inches of rainfall occurred from September, 1915, to September, 1916, compared with an average precipitation for forty-eight years of 23.16 inches for the period. Of the total rainfall, 5.88 inches fell in June as compared with the average precipitation for that month of 3.24 inches. The timely moisture occurring in June insured the production of a large crop of wheat. From July to September, 5 inches of rain fell as compared with a normal precipitation during the period of 12 inches. The extreme drouth through July, August, and September made it possible to harvest, thresh, and market wheat with entire absence of damage from moisture.

Commercial Crops.—The area devoted to the production of wheat in 1916 was 572 acres. The total of all wheat grown on the station, exclusive of small experimental plots, was 13,854.33 bushels at an average yield per acre of 24.2 bushels. The best yield, 34.3 bushels per acre was secured on land which had been prepared for sorghum in 1915 but which was practically fallowed because of the poor stand of sorghum secured. It cost an average of \$8.03 an acre, or 33 cents a bushel, to produce this wheat. Other crops grown on the station were: Alfalfa, 305 acres; Sudan grass, 19.4 acres; drilled cane, 44 acres; feterita, 33 acres; kafir, 222.5 acres; corn, planted in the ordinary manner, 125 acres; corn planted in alternate rows (partial summer fallow), 111.5 acres.

Cattle.—Investigations in livestock feeding methods for Western Kansas were continued for the fifth year, the main object of the experiments being as formerly—the profitable utilization of by-products of grain farming that would otherwise have no value. The experiment conducted the previous year with Hereford heifers to determine the effect of feeding and time of breeding upon the development of the heifers and the calves produced was repeated with some variations in the plan and rations. Eighty Hereford heifers were used. These

were divided into Lots 1 and 2 according to rations fed, and these subdivided into Lots A and B according to time of breeding. Table III indicates the plan of the experiment and gives the average daily rations, the average gain per head, the average cost of feed per head, and the feed cost per pound gain.

TABLE III.—DEVELOPMENT OF BREEDING HEIFERS
(December 2 to March 31—120 days)

	Lor 1 A Bred to calve at 2 yrs. (a)	Lor 1 B Bred to calve at 3 yrs.	Lor 2 A Bred to calve at 2 yrs.	Lor 2 B Bred to calve at 3 yrs.
Average daily ration—	<i>Pounds</i>	<i>Pounds</i>	<i>Pounds</i>	<i>Pounds</i>
Alfalfa hay	9.27	9.27	9.13	9.13
Silage	13.4	13.4	13.4	13.4
Wheat straw	4.47	4.47	4.47	4.77
Corn	3.0	3.0		
Cottonseed cake	1.0	1.0		
Average gain per head	177.6	183.6	88.8	99.6
Average cost of feed per head (b)	\$15.83	\$15.83	\$6.94	\$6.94
Cost of feed per pound gain	0.089	0.086	0.078	0.069

(a) The heifers in Lot 1 A had less trouble in calving than the heifers in Lot 2 A.

(b) Feeds were given the following values: Alfalfa hay, \$8 per ton; silage, \$3 per ton; wheat straw, \$0.00 per ton; pound corn, \$1 per bu.; cottonseed cake, \$40 per ton.

In a test to determine cost of wintering, 50 Hereford calves were each fed an average daily ration of alfalfa 8.8 lbs., corn silage 10.45 lbs., and straw 1.69 lbs. At the end of the 120-day period, the calves had made an average gain per head of 99 pounds at an average feed cost per head of \$5.13. The average cost per head per day was \$0.043.

Feeding tests were also conducted to determine the cost of the following: Wintering breeding cows; wintering cows with calves at side compared with cost for dry cows; and wintering herd bulls.

Dry-Land Agriculture Investigations.—The number of plots in the dry-land agriculture investigation has grown from 100 to 237. Studies are being made on (1) climatic conditions; (2) crop production, including continuous cropping, alternate cropping, and rotations; and (3) soils with relation to moisture, nitrates, and temperature. Daily readings are taken and recorded of air temperature, humidity, wind velocity, sunshine, precipitation, evaporation, and soil temperature at various depths. Precipitation records kept at Fort Hays for a long period of years and continued by the station since its establishment, indicate that the amount of rainfall varies from

year to year, but that the average annual precipitation remains practically constant.

Wheat and other cereals are grown on plots continuously, all conditions remaining the same each year except the method of preparing the seedbed. In the studies in alternate cropping groups of plots are divided into pairs, each of which is used for an experiment in alternating winter wheat with fallow or with cultivated crops. Extensive studies are made in the rotation of crops. Studies in soil moisture covering a period of four years and reported in Bulletin 206, proved that the average yield of winter wheat is in direct proportion to the amount of available moisture stored in the ground at seeding time. Further investigations are being made to determine (1) the amount of moisture stored by various methods of seedbed preparation for winter wheat, corn, and kafir; (2) the influence of fallow, green manure crops, and barnyard manure upon the storage of water in the soil; (3) the effect of early plowing, late plowing, frequency of plowing, listing, subsoiling, deep tilling, and dynamiting upon moisture content; and (4) how much of the stored moisture is used by the crop during its growth and development.

Cereal Crop Investigations.—Investigations with cereal crops have been conducted along two lines: (1) The introduction of new and better varieties; and (2) the selection and breeding of new strains. A large number of varieties of wheat from many countries have been grown in small plots in an effort to find those best adapted to Western Kansas. This work has shown that in this section, hard red winter wheat is much more productive than any other tested. Among the hard winter wheats that have proved best adapted to Western Kansas are Kharkof, Turkey, Crimean, and Malakoff. Many selections have been made from the different varieties to obtain more drouth-resistant and higher-yielding, pure strains. Several hundred strains from the adapted varieties are now being tested on typical upland prairie loam soil. Several strains of Crimean, Kharkof, Turkey, and Malakoff wheat have been developed that consistently outyield the check variety by as much as 4.5 bushels per acre. The best of these are now being increased on the station for distribution to the farmers of Western Kansas.

Special attention is being given to the development of grain

sorghums, chief of which are kafir, milo, and feterita. Sorghum grain is now quoted regularly on all the large markets in the West at prices equal to and often higher than that paid for the same grade of white corn. This is because of the increased use of sorghum meal in food products. In the sorghum crop experiments at the Fort Hays Station, selections are being made from strains introduced from other countries and from strains developed in the Great Plains, to establish desirable characters, such as early maturity, heavy yields, drouth resistance and nonsuckering habits. The effect of different rates and dates of seeding and different methods of seedbed preparation, planting, cultivation, and harvesting, are being studied.

Varieties of corn commonly grown in Western Kansas are being tested in comparison with varieties grown in eastern and northern states. Efforts are being made to improve and establish a typical Western Kanas corn.

Forage Crop Investigations.—Forage crop experiments are designed, (1) to improve such crops as the common sorghums in quality, purity, and yield; (2) to discover and test new crops like Sudan grass; and (3) to furnish the farmer with facts about forage crops of uncertain merit which are widely advertised, as, for example, the African kafir which was brought to Kansas several years ago. In 1916, 378 plots of varying sizes were used in tests on the sorghums (including Sudan grass), alfalfa, sweet clover, annual legumes, and millet. Single row tests were also made of 175 varieties or lots of alfalfa, and 50 new selections, or recently acquired lots of sorghum. Notes were taken at intervals during the growth of the crops. The material on each lot was cut, cured, and weighed separately. Every variety of sorghum which matured seed was threshed to obtain the grain yield.

Feeding tests with the principal hay and silage crops are conducted extensively each winter by the Animal Husbandry Department of the station.

Seed Wheat Distribution.— During the summer of 1916, orders were filled for seed wheat ranging from one bushel to carlots, and totaling 4,679 bushels. This was sold at the prevailing market price and gave the people of Western Kansas an opportunity to secure low priced seed.

Dairy Farming.—The dairy farm is maintained as a demonstration project. During the year 26 head of dairy animals were purchased and added to the herd, and 50 head of stock were sold. Fifty-nine pigs were purchased early in the year at a total cost of \$164.40. They were fed the by-products of the dairy farm and later sold for \$758.30. Wheat, alfalfa, and the sorghums were grown on the land devoted to the dairy project, 154.5 acres being devoted to these crops. The sorghum produced was put into the silo.

State Forest Nursery.—The forest nursery has grown from 1 acre, five years ago, to 25 acres at the present time, containing approximately 250,000 trees and plants of various ages and sizes. Between 75,000 and 100,000 trees and plants will be ready for spring distribution.

The forest nursery does three things for Western Kansas: (1) Furnishes acclimated stock; (2) secures hardier and more drouth resistant varieties; and (3) furnishes these to planters at cost of production. It is of special advantage to Western Kansas to be able to secure acclimated stock since a tree grown under native climatic conditions is better enabled to withstand the hardships of the climate than one produced under foreign conditions. Charts for each of the past five years, indicating points to which trees have been shipped, show that the western section of the state is receiving a larger proportion of the orders each year. Sales during the year 1916 amounted to 56,950 trees and 408 plants and shrubs. The sales of trees included 24 varieties. Osage Orange led with 18,238 trees; Tamarix was next with 8,729 trees. Sales of other trees reaching into thousands were of poplar, Chinese arborvitae, white elm, hackberry, honey locust, red cedar, ash, catalpa, and Russian mulberry. The total number of orders was 471, distributed as follows: Kansas, 459; Texas, 3; Oklahoma, 2; Utah, 2; Georgia, 1; Illinois, 1; and Colorado, 3. Of the trees sent out from the nursery each year, the number reported living after the first season's growth has increased from 76 to 91 percent.

Public Service.—Great progress was made during the year in acquainting the people of Western Kansas with the work of the station. Thousands of visitors were received. A rest room was provided for their comfort. Members of the station staff participated in public meetings in all parts of the western half

of the state, throughout the year. Information was given out on all phases of crop and livestock production. Members of the staff also cooperated actively in farmers' institute work. Some farm survey work was done in cooperation with the district agricultural agent. Moving pictures of different operations of the station were prepared and shown at different points in the state. These proved of great educational value in informing the public of the work of the station.

GARDEN CITY BRANCH EXPERIMENT STATION

Climatic Conditions.—General climatic conditions throughout the season were very adverse to the growth of all crops. The total rainfall for the season was 15.53 inches, and for the period from April 1 to October 1, 1916, 12.66 inches. Eighty-two percent of the total rainfall occurred during the growing season, yet but little of it was of use to the growing crops, owing to the heavy run-off or the isolated character of the showers. The evaporation from the free water surface of an 8-foot tank was 57.46 inches, which, with the exception of that of 1911, is the highest record since the establishment of the station. Wind velocity during the spring and fall months was very high at times, the 2-foot anemometer registering as high as 30 miles an hour for short intervals. No trouble was experienced from soil-blowing, however.

Dry-Land Crop Investigations.—With the exception of two new sorghum rotations the outline of the work on this project was the same as that in 1915. On account of the continued dry weather, fallow and green manure plots of winter wheat were practically the only ones that produced crops worth harvesting. The best yield was 14 bushels an acre, while the average yield for all tillage methods and rotations was 5.4 bushels an acre. Spring wheat, oats, and barley were not worth harvesting. Corn stood the drouth well until July 15 when it began to fire badly. It was harvested the early part of August. No grain was produced on any of the plots. The average yield of stover was 2,100 pounds an acre. Sorghums made but little growth during the summer and the rains came too late, and in insufficient amounts, to permit of the production of grain except on fallow. The average yields of stover for all plots of kafir and milo, were about 1,900 and 1,800 pounds an acre respectively.

Irrigation Investigations.—This work was continued as outlined and begun in 1914. The experiments include 11 different crops and in most instances, four rates of watering based on the moisture content of the soil. All plots are planted in duplicate. In the season of 1916 a greater difference in yields was produced by different amounts of water applied, than at any time since the work was started. This difference was more marked with the sorghum crops than with the small grains. The first series of milo, receiving 21.3 inches of irrigation water, yielded 58.6 bushels an acre; the next series, receiving 14.3 inches, yielded 41.5 bushels an acre; the third series, receiving 11.3 inches, yielded 16.3 bushels an acre; the fourth series, receiving 5.2 inches, yielded 7.5 bushels an acre. The difference was not so marked with the forage sorghums but there was in every instance a marked increase in the yield with an increase in irrigation water. Small grains did not respond as readily to the application of water and in several instances the series receiving the second rate of watering produced more grain than that receiving the highest rate. Millet, cowpeas, potatoes, and sugar beets showed some response to the application of water, but hardly in proportion to the amount applied.

Irrigation Pumping.—During the season of 1916 the pumping plant was run 821 hours, pumping 102 acre-feet of water at a cost of \$328.49 for fuel, oil, and repairs, exclusive of labor. This is a considerable increase in hours of operation over any previous season the plant has been run. The pump is old and worn and considerable trouble was experienced in keeping it in running order. At times during the summer it was impossible to supply enough water for some of the field crops.

Improvements.—Four grade cows and an Ayrshire bull were purchased as the beginning of a dairy herd. The construction of a modern cottage for the superintendent was begun. A shed was built for the cattle. The land devoted to the dry-land investigations was fenced rabbit-tight.

COLBY BRANCH EXPERIMENT STATION

Climatic Conditions.—The dry weather beginning the first of September, 1915, extended into the spring of 1916. The season of 1915, previous to September, was very wet and sufficient moisture was conserved in the soil to promote a good

growth of wheat in the fall and to bring it to maturity the following June. The dry spring of 1916 was accompanied by unusually cool weather, lasting until the middle of June. This resulted in unfavorable seeding conditions for spring crops. Germination was slow and the final stand of the sorghums was poor. The last frost in the spring occurred May 15; the first frost in the fall, September 14, giving a short growing season of 122 days. Owing to late frost, cherries were the only fruit that matured. These were of first-class quality.

Variety Tests.—**Variety** tests were conducted with winter wheat, spring wheat, spring oats, corn and the sorghums. Six varieties sent from the station at Manhattan and one local variety were included in the test with winter wheat. Table IV gives the results of the experiment :

TABLE IV.-VARIETY TESTS OF WINTER WHEAT, 1916

VARIETY	Yield per acre	
	Pounds of straw	B shels of grain
Kanred.....	3,307	42.55
Pedigree 706.....	3,386	36.88
Nebraska No. 28.....	3,354	32.60
Kharkof.....	2,585	31.64
Turkey.....	3,260	29.51
Local Turkey.....	2,583	28.78

As will be noted from the table, Kanred wheat outyielded the local strain of Turkey wheat by 13.77 bushels an acre. Kanred was planted in increase plots the fall of 1916, so that pure seed is now available for distribution from the station. Unfavorable results were secured in the tests with spring wheat and oats, owing to dry, cool weather during the spring and the dry fall and winter preceding. The spring wheat also suffered from grasshopper ravages and black stem rust.

Eighteen varieties of corn, sixteen sent out from the Manhattan station, and two local strains, were used in the variety test with corn. Owing to the dry growing season and hot winds at pollinating time, none of the varieties matured grain, so that only fodder yields were secured. In the variety test with the sorghums, 22 varieties were planted. Yellow milo and Red Amber made the best grain yields. From field observations, Yellow milo has proved itself to be the most promising grain sorghum for Western Kansas,. Stock prefer it to any of

the other sorghums when fed as grain and relish it when fed either in the head or as a ground feed. In case a stand is not secured from the first planting and the season is too late for replanting, either Freed sorgo or feterita is a good second choice. For a forage crop, either as silage or dry feed, Red Amber has yielded the largest tonnage and matured the best. It makes excellent silage, first class dry feed, and is reasonably sure of maturing seed.

Irrigation.— Sixteen one-tenth acre plots were used in a comparative test between irrigation and non-irrigation. Table V shows the crops used and the results:

TABLE V.—YIELDS OF IRRIGATED AND NON-IRRIGATED PLOTS, 1916

CROP	Yield per acre	
	Irrigated	Non-irrigated
Potatoes	65.2 bu.	16.16 bu.
Red Amber silage	17.2 tons	5.3 tons
Red Amber dry fodder	8.1 "	.5 "
Red Amber seed	1070.0 lbs.	450.0 lbs.
Corn silage	8.0 tons	2.9 tons
Corn dry fodder	2.0 "	.65 "
K fir dry fodder	4.5 "	1.5 "
Milo	3.5 "	1.9 "
Sudan grass	.9 "	.35 "

In order to encourage better and more extensive gardens in Northwest Kansas, a small plot of ground 30 by 60 feet, was set aside for garden. This was located near the cottage, convenient for daily use, and so that the overflow from the windmill could be used for irrigation. A hydrant was installed in the pipe leading from the pressure tank to the house, and the garden irrigated through 100 feet of three-quarter inch hose and a spray. In the spring the ground was given a heavy dressing of manure, irrigated and plowed deeply. A dozen roots of rhubarb, the same number of asparagus, a half dozen of horseradish, and 100 everbearing strawberry plants were planted. The following produce was harvested from the garden:

Green peas	25 lbs.	Rhubarb	15 lbs.
Green beans	15 "	Cabbage	25 heads
Tomatoes	210 "	Sweet corn	25 ears
Beets	120 "	Summer squash	4
Carrots	50 "		

As an example in beautifying the farm home, flowers, rose bushes, and other shrubs were planted about the cottage and office.

Dairy.—Six Ayrshire cows and a purebred Ayrshire bull were delivered to the station, October 2, 1915, the purpose being to furnish a means of utilizing the by-products of the farm as feed for livestock, and also to demonstrate the place of livestock in dry-land farming. The cows were fed corn silage, sorghum fodder, and a concentrate mixture of wheat bran, ground barley, and oil meal. From October 10, 1915, to July 1, 1916, the cost of concentrates fed was \$137.70. During the same period, the sales of milk amounted to \$567.24. During the four months, September to December inclusive, 1916, milk sales amounted to \$288.97.

TRIBUNE BRANCH EXPERIMENT STATION

The work of the station was Continued from the previous year on a similar experimental basis. The extremely wet season of 1915 was followed by an unusually dry fall and winter and drouth conditions continued through the spring and summer of 1916. Winter wheat made a complete failure, was plowed out, and the ground seeded to Sudan grass. The small spring grains did fairly well through June, but continued dry weather resulted in their making only hay. From January 1 to August 1, only three good rains were received and these at wide intervals. Three inches of rain were received the last ten days of August. Practically all crops except corn showed an immediate, marked improvement. Fair yields were secured from dwarf milo, dwarf kafir, and Freed sorgo. Some plots of dwarf milo yielded 20 bushels to the acre. Sudan grass made over 2½ tons an acre where broadcasted and about 1½ tons an acre where planted in 42-inch rows. Some of the corn varieties produced 20 bushels an acre. Millets and Sudan grass sowed on July 15 yielded better than 1 ton an acre. Sufficient feed was produced on the station to carry the livestock through the winter, with a considerable surplus for sale.

DODGE CITY BRANCH EXPERIMENT STATION

During the last year of the existence of the Dodge City branch station, all experimental work with crops was discontinued and the farm put on as nearly a self-supporting basis

as possible. About 55 acres were in cultivation. During the season of 1916, this land was devoted to crops as follows: Winter wheat, 30 acres; Western Orange sorghum, 15 acres; Sudan grass, 5 acres; and Pink kafir, 5 acres. The wheat made an average yield of 17 bushels an acre. Only light showers occurred after June 12. Sudan grass was practically a failure. The sorghums made only forage and this was put into the silo, making 30 tons of silage. The wheat ground was replanted to winter wheat in the fall of 1916. A good stand was secured, but it was destroyed by winterkilling.

The dairy herd, developed from six scrub cows and a pure-bred Ayrshire bull, consisted of 19 heifers and calves and a bull at the time the station was discontinued. Six registered Duroc-Jersey sows were purchased at the beginning of the year, the object being to utilize the skim milk from the dairy herd as the principal feed for hogs. From these sows, 39 pigs were sold. When the station was abandoned, the following property was transferred to the Garden City station: 19 heifers and calves and 1 bull; 6 sows and 15 pigs; and 73.5 bushels of wheat.

Cash receipts for the station from April 1, 1916, to May 1, 1917, were as follows:

228.5 bushels wheat	\$328.62
39 pigs	236.50
1 boar	25.00
3 cows	180.00
1 bull	75.00
3 steer calves	45.00
Cream	219.28
Machinery, labor, seed.....	39.75
Total	\$1,149.15

FINANCIAL STATEMENT

The Kansas Agricultural Experiment Station, in account with federal and state appropriations, 1916-17

	Federal appropri- ations	State appropri- ations	Totals
Manhattan station	\$30,000.00	\$43,791.71	\$73,791.71
Branch stations.....		36,510.90	36,510.90
Cooperative experiments.....		7,535.03	7,535.03
Branch station farm products.....			54,122.66
			\$171,960.30
Salaries	\$15,216.63	\$26,220.80	\$41,437.43
Labor.....	8,173.45	32,908.59	41,082.04
Publications.....	109.35	33.41	142.76
Postage and stationery.....	80.96	1,437.07	1,518.03
Freight and express.....	40.99	1,507.17	1,548.16
Heat, light, water, power.....	120.34	1,748.92	1,869.26
Chemicals, laboratory supplies.....	855.79	1,004.30	1,860.09
Seeds, plants, sundry supplies.....	592.81	9,830.92	10,423.73
Fertilizers.....	13.50	19.26	32.76
Feeding stuffs.....	3,058.13	8,448.68	11,506.81
Library.....	130.20	264.09	394.29
Tools, machinery, appliances.....	341.23	6,206.43	6,547.66
Furniture and fixtures.....	114.63	714.71	829.30
Scientific apparatus, specimens.....	163.01	445.91	608.92
Livestock.....	477.64	2,939.34	3,416.98
Traveling expenses.....	319.83	3,707.05	4,026.83
Contingent expenses.....	59.08	2,226.15	2,285.23
Buildings and land.....	132.33	7,609.01	7,741.34
Balance.....		34,688.49	34,688.49
Totals	\$30,000.00	\$141,960.30	\$171,960.30

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, 1917; 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. T. HACKNEY
E. W. HOCH
CORA G. LEWIS