

K A N S A S

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 .
K A N S A S S T A T E A G R I C U L T U R A L C O L L E G E .



DIRECTOR'S REPORT, 1915-1916.



MANHATTAN, KANSAS.

KANSAS STATE AGRICULTURAL EXPERIMENT STATION.

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* On leave of absence, 1915-16. † In coöperation with U. S. Dept. of Agriculture.

KANSAS AGRICULTURAL EXPERIMENT
STATION.

OFFICE OF THE DIRECTOR.
JUNE 30, 1916.

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, 1916. 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.

The efficient training of agricultural workers for the next half century demands deeper and more thoroughgoing methods of research in the agricultural experiment stations than have hitherto characterized their investigations. The state experiment station can no longer be looked upon as a purely local affair seeking to solve the production problems of its state alone; but it should serve as one unit in a national machine which is endeavoring to place agricultural production on as exact a basis as the elements of environment and marketing will permit. This can be accomplished only when station workers grasp the fundamental problems confronting them. Research that will produce basic facts upon which agricultural production may be based is the crying need of our nation. The day of giving advice based on a combination of interacting factors whose separate effects have not been studied should soon pass. The search for and recognition of each variable underlying successful production must be prosecuted with vigor.

In order that such an ideal may be met at the Kansas Agricultural Experiment Station, it is necessary that further funds and equipment become available to this institution. It is furthermore important that a sufficient staff be developed to give intimate and intelligent care to the projects already under prosecution. Under present conditions as good a method of extending the usefulness of the station as can be devised would be through the multiplication of fellowships for graduate students of agriculture in the college, who can become responsible for the prosecution of various projects under the direction of the heads of their departments. A small appropriation for this purpose would be of utmost value, since a few \$400 to \$500 fellowships would attract to this institution men of the proper character to pursue investigational work.

Were it possible to maintain the staff, the number of definite and practical discoveries the station is able to announce might be many times multiplied. Each year some few very definite achievements may be pointed out, achievements

highly creditable to the workers of the station, but not as numerous as they themselves would like because of lack of time and support for the developing of the problems which each worker finds facing him in his chosen field of study. Last year the station was able to announce the production of a sterile blackleg serum and new high-yielding wheat. This season the results of several pieces of work which promise to be far-reaching in their usefulness are available.

The animal husbandry department is closing an extensive investigation of the feeding value of the grain sorghums in comparison with corn. For five years, data on the different classes of animals have been assembled, involving three carloads of sheep, three hundred grade Hereford calves, and two hundred hogs. Kafir has been the principal sorghum used. As a result, it has been found that the grain sorghums can replace corn and give about 90 percent of its feeding value. The results also show that about 10 percent more time is required to bring the animals to a finish when feeding sorghums.

The important fermentative changes which occur in silage have been studied, and it has been shown that practically no change occurred in silage which was treated with antiseptics, but that typical acid production took place when pure cultures of bacteria were inoculated into a sterile silage. Plant enzymes seem to have little influence on the fermentative processes. It is possible, however, that improved technique in the study of enzymes and their action may demonstrate that they are of importance especially in the first stages of fermentation. The *Bacterium bulgaricum* group plays an important part in the production of acid in silage. Other groups found, which may influence the action, are yeasts, colon organisms, and miscellaneous types, but the part played by these has not been definitely proved.

The study of the relative drought resistance of corn and the sorghums shows that Blackhull kafir requires less water for the development of a unit of dry substance than any other plant studied. Dwarf milo requires only slightly more water than Blackhull kafir, and corn is the least economical of the three. Dwarf milo, however, is the most drought resistant of the plants named. A comparative study of the root systems and leaf areas of these crops showed that Dwarf milo and Blackhull kafir have fully as extensive a root system as has

Pride of Saline corn, for example, and in addition they have nearly twice as many secondary or feeding roots. The corn plant, though having no larger root system than the milo plant, has fully twice the leaf area; therefore, the intake area of the corn plant is no greater than that of the sorghums, while its area through which water is lost is double that of the sorghums. The daily transpiration from an entire plant of milo or kafir is much less than that from a corn plant, although per unit area of the leaf milo transpires much faster than corn. Probably the most important results are those showing the actual conditions that limit the growth of these plants. The percent of water in the leaves of corn decreases much more rapidly during a drying day than it does in the leaves of milo. In other words, the milo leaves keep fresh under conditions which cause the corn leaves to wilt. On such days the corn plant does not increase its dry weight a perceptible amount after 10 a. m., while the milo continues to manufacture food even in the hottest part of the day. Considerable other material and data have been obtained to continue this investigation further.

Ten years' work in wheat sowing to escape damage from the Hessian fly have shown that the important steps in controlling the fly are: (1) early deep plowing of the stubble; (2) the proper preparation of the seed bed; (3) destruction of all volunteer wheat; (4) delay in the sowing of wheat until the fly-free date; and (5) community coöperation. When the Hessian fly is not present in damaging numbers, the maximum yield of wheat can be obtained in an average season by seeding a little earlier than the fly-free date; but if the fly is present in damaging numbers, the seeding should be delayed until as near the fly-free date as is practicable. The better the seed bed is prepared the safer it is to wait until the fly-free date to sow.

Demonstrations have shown that the Hessian fly may be carried in dangerous numbers from three to five miles by the wind. This has an important bearing on the control of the pest, and means that coöperation must be practiced over large areas. All stubble fields and volunteer wheat fields must be plowed under early in the fall, because they are the greatest sources of infestation.

PERSONNEL.

Upon the resignation of C. E. Millar, instructor in soils, M. C. Sewell, formerly superintendent of the Garden City substation, was appointed to fill this position. George S. Knapp was chosen to fill the vacancy at Garden City. The position of the field superintendent of substations was abolished, and G. E. Thompson, who formerly held this position, was transferred to the extension division as specialist in soils and crops.

The superintendency of the Dodge City substation was resigned by F. J. Turner, and M. W. Kirkpatrick was chosen to fill the position. Charles R. Weeks was appointed superintendent of the Fort Hays Branch Station upon the resignation of G. K. Helder.

The vacancy caused by the resignation of Mrs. Elizabeth Harling, seed analyst in the botany department, was filled by Robert Schmidt. D. E. Lewis, associate professor of horticulture, resigned to engage in commercial undertakings, and F. S. Merrill of the horticultural department was given the orchard work. O. E. Strodman completed the work in hog-cholera eradication in Marshall county in August.

Theodore Macklin took up the work in agricultural economics after the position was vacated by E. D. Baker. F. E. Mixa, assistant in poultry husbandry, also resigned during the year, and his position was filled by F. E. Mussehl.

PUBLICATIONS ISSUED.

Nine bulletins, one director's report, and four circulars were published and distributed during the fiscal year, July 1, 1915, to June 30, 1916. They were as follows:

<i>Bulletin</i> No.	<i>Title.</i>	<i>Edition.</i>	<i>Pages.</i>	<i>Total Pages.</i>
207	Soil Survey of Cherokee County, Kansas.....	2,000	46	92,000
208	Soil Survey of Reno County Kansas.....	2,000	48	96,000
209	The Use of Dynamite in the Improvement of Heavy Clay Soils	5,000	34	170,000
210	Smuts of Grain and Forage Crops in Kansas... .	30,000	38	1,140,000
211	Soil Survey of Jewell County, Kansas.....	2,000	36	72,000
212	Sudan Grass for Kansas.....	35,000	35	1,225,000
TECHNICAL BULLETINS.				
1	The Milling and Baking Quality and Chemical Composition of Wheat Flour as Influenced by Methods of Storing, Heat Moisture, Germination, ..	2,500	83	207,500
2	Some Important Fermentations in Silage.....	3,000	32	96,000
INSPECTION BULLETINS.				
1	Kansas State Livestock Registry Report No. 5..	8,000	239	<u>1,912,000</u>
Totals		89,500	591	5,010,300
Director's Report, 1913.....		2,500	80	200,000

Director's Report, 1915-1916.

CIRCULARS.			
<i>Bulletin.</i>	<i>Title.</i>	<i>Edition.</i>	<i>Pages.</i>
<i>No.</i>			
53	Filling Silos	30,000	8
54	The Prairie-Dog Situation	5,000	4
55	Trees for Kansas	25,000	19
INSPECTION CIRCULAR.			
1	Analyses of Inspection Samples of Fertilizers....	3,500	7
Totals		63,500	38

SUMMARIES OF BULLETINS.

207. *Soil Survey of Cherokee County, Kansas.* (L. E. Call, R. I. Throckmorton, C. O. Swanson, *et al.*) A brief discussion of each of the twenty-three soil types found in the county, including the formation and characteristics of each type, is given. The results of the chemical analysis of each type indicate the relative abundance of plant-food elements. Several pages are devoted to the soil problems of the county, including rotations, methods of growing leguminous crops, value of organic matter and methods of increasing it in the soil, and the value of commercial fertilizers on the different soils. A soil survey map is included.

208. *Soil Survey of Reno County, Kansas.* (L. E. Call, R. I. Throckmorton, C. O. Swanson, *et al.*) The soil formation of Reno county is briefly discussed, and a description of the results of the chemical analyses of the thirty-nine types found within the area is also given. The analyses show the relative abundance of the different plant-food elements. A brief discussion of the soil problems includes the maintenance of the supply of organic matter, use of straw and manure, prevention of erosion, utilization of sandy land, and the kind of trees to grow on the sand hills of the county. A soil survey map is included.

209. *The Use of Dynamite in the Improvement of Heavy Clay Soils.* (L. E. Call and R. I. Throckmorton.) Results of experiments in dynamiting heavy clay soils are given. A study was made of the effect of dynamite on the crop-producing power of the soil, the bacterial content, the moisture content, the physical condition, and the leaching of alkali salts of soil. A study was also made of the value of dynamite in planting fruit trees.

210. *Smuts of Grain and Forage Crops in Kansas.* (L. E. Melchers.) The most serious smut diseases attacking cereal and forage crops in Kansas are described and illustrated in this bulletin; among them, the kernel smut of Sudan grass. Estimates of damage caused by these plant diseases for 1914 show an aggregate loss amounting to \$7,943,159. A portion of the bulletin is devoted to the cause of smuts and their life habits. The various methods for smut prevention are also carefully explained in detail. Some new features in equipment which may be used for seed treatment are described. The necessity for seed plots is urged, because this offers a means for procuring seed free from smut infection and affords the possibility of obtaining a better strain of seed.

211. *Soil Survey of Jewell County, Kansas.* (L. E. Call, R. I. Throckmorton, C. O. Swanson, *et al.*) This is a brief report, including the formation and characteristics of each of the twenty-four soil types found in the county. A chemical analysis of each type indicates the relative

abundance of the plant-food elements. A discussion is also given on the methods of maintaining the supply of organic matter, the use of straw, the prevention of erosion, types of drainage, and the value of commercial fertilizer. A soil survey map is included.

212. *Sudan Grass in Kansas.* (G. E. Thompson.) Soil adaptation, climatic requirements, and methods of seeding Sudan grass are discussed. Results are also given of experiments in feeding Sudan grass to milk cows, beef cattle, and horses.

Technical Bulletin No. 1. *The Milling and Baking Quality and Chemical Composition of Wheat Flour as Influenced by Methods of Storing, Heat Moisture, Germination.* (L. A. Fitz.) Investigational work shows that milling and baking qualities of new wheat improve as the wheat ages. Best results are obtained when the wheat sweats and ages in the stack. New wheat threshed from the shock may be tempered with heat and moisture before milling in order to improve its milling and baking qualities and approximate the results obtained when the wheat sweats in the stack. Germination, if carried too far, is injurious to both the milling and the baking qualities, but the presence in the mill mixture of a small percent of kernels not badly germinated has little or no deleterious effect.

Technical Bulletin No. 2. *Some Important Fermentations in Silage.* (O. W. Hunter and L. D. Bushnell.) More than three hundred samples of silage were analyzed at various stages of the fermentation. The silage used was that prepared in the laboratory and from several silos belonging to the dairy department. The results showed that the production of silage is the result of fermentation processes, which are due almost entirely to the activities of four prominent groups of microorganisms: the acid, colon, yeast, and miscellaneous. Acid production, which results from the most important fermentation in normal and good silage thus far noted, is due to organisms which will classify as belonging to the Bulgarian group. It is suggested that the greater part of acetic acid production is also the result of the Bulgarian and colon fermentation.

Inspection Bulletin No. 1. *Kansas State Livestock Registry Report No. 5.* (C. W. McCampbell.) The major part of this report gives the work of the Kansas Livestock Registry Board for the year 1915, and shows that 5,735 stallions were licensed to stand for public service in Kansas that year. Three thousand two hundred twenty-four of these stallions were purebred and 2,511 were grades and scrubs. This is an increase of 625, or 20 percent, in the number of purebreds, and a decrease of 1,255, or 33 percent, in the number of grades and scrubs during the past five years. The report also contains a number of valuable discussions on subjects relating to profitable horse production.

SUMMARIES OF CIRCULARS.

53. *Filling Silos.* (J. B. Fitch.) Methods of cutting and handling silage crops common to Kansas and the best time for doing this are suggested. The size of silage cutter required, power needed to run the cutter, and help needed at silo filling time are also discussed. Suggestions are also made and precautions given in regard to filling the silo,

tramping and adding water to the silage, and caring for the silo when full.

54. *The Prairie-dog Situation.* (R. K. Nabours.) For combating prairie dogs the use of poison is recommended. The Experiment Station has undertaken the preparation and sale of a poison for this purpose. A description of the method of preparation and use of the poison is given. A statement of the law relating to the giving out of the poison through township trustees is included.

55. *Trees in Kansas.* (C. A. Scott.) A list of trees suitable for planting in the three different sections of the state is given. The annual amount of precipitation was taken as a basis for dividing the state into the following sections: the eastern, that portion in which the annual rainfall is 35 inches or more; the central, which has at least 25 inches and less than 35 inches; and the western, with less than 25 inches. A discussion of growing nursery stock and the need of procuring fresh and vigorous trees for planting is also included. The preparation of the ground for planting, time and method of planting, and the cultivation and protection necessary to obtain successful results are set forth in detail. A tabulation is given showing results of the plantings of the years 1912, 1913 and 1914.

Inspection Circular No. 1. *Analyses of Inspection Samples of Fertilizers* (J. T. Willard and R. C. Wiley.) The results of analyses of 88 inspection samples of fertilizers taken during the spring months of 1915 are tabulated. The results indicated a general conformity to the law.

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. These papers have been presented at meetings of the respective scientific associations, or have appeared in the leading scientific periodicals. A partial list of these papers is given herewith:

"The Hessian Fly Train." Geo. A. Dean, *Journal of Economic Entomology*, vol. 9, pp. 139-141.

"Poison Bran Mash Effective in Destroying Sow Bugs." Geo. A. Dean, *Journal of Economic Entomology*, vol. 9, p. 245.

"Life History and Habits of Two New Nematodes Parasitic on Insects." J. H. Merrill and A. L. Ford, *Journal of Agricultural Research*, vol. 6, pp. 115-127.

"A Preliminary Report on the Life Economy of *Solenopsis molesta* Say." J. W. McCulloch and Wm. P. Hayes, *Journal of Economic Entomology*, vol. 9, pp. 23-38.

"Spermatogenesis in *Paratettix*." Mary T. Harman, *Biological Bulletin*, vol. 29, pp. 262-276.

"Effect of Rate and Date of Sowing on Yield of Winter Wheat" W. M. Jardine, *Journal of the American Society of Agronomy*, vol. 8, pp. 163-166.

"How Can We Increase the Yield of Wheat." W. M. Jardine, *Report of the Kansas State Board of Agriculture for the Quarter ending March, 1916*, vol. 35, pp. 80-86.

"The Grouping and Terminology of Plant Diseases." L. E. Melchers, *Phytopathology*, vol. 5, pp. 297-302.

"The Water Requirements of Corn and the Sorghums." E. C. Miller, *Journal of Agricultural Research*, vol. 6, pp. 473-484.

"The Root Systems of Agricultural Plants." E. C. Miller, *Journal of the American Society of Agronomy*, vol. 8, pp. 129-154.

"Comparative Study of the Root Systems and Leaf Areas of Corn and the Sorghums." E. C. Miller, *Journal of Agricultural Research*, vol. 6, pp. 311-332.

"Seeding Winter Grains in Furrows to Prevent Winter Killing." S. C. Salmon, *Journal of the American Society of Agronomy*, vol. 8, pp. 176-188.

"A Sex-Limited Color in Ayrshire Cattle." E. N. Wentworth, *Journal of Agricultural Research*, vol. 6, pp. 141-147.

"Inheritance of Fertility in Swine." E. N. Wentworth and C. E. Aubel, *Journal of Agricultural Research*, vol. 5, pp. 1145-1160.

"Sex in Livestock Breeding." E. N. Wentworth, *Journal of Heredity*, vol. 7, pp. 29-32.

"Rudimentary Mammæ in Swine a Sex-Limited Character." E. N. Wentworth, *Science, N. S.*, vol. 43, p. 648.

"Importance of the *Bacterium bulgaricus* Group in Ensilage." O. W. Hunter and L. D. Bushnell, *Science, N. S.*, vol. 43, pp. 318-320.

"Greater Accuracy in Clinical Diagnosis." R. R. Dykstra, *American Journal of Veterinary Medicine*, vol. 11, pp. 193-195.

"A Case Report: The Gelatin Treatment of Petechial Fever." R. R. Dykstra, *Journal of the American Veterinary Medical Association, N. S.*, vol. 1, pp. 320-321.

"A Study of Certain Conditions Which Affect the Activity of Proteolytic Enzymes in Wheat Flour." C. O. Swanson and E. L. Tague, *Journal of the American Chemical Society*, vol. 38, pp. 1098-1109.

"A Study of the Life History of the Maize Bill Bug." Wm. P. Hayes, *Journal of Economic Entomology*, vol. 9, pp. 120-128.

Experimental Work.

It is impossible to report the various lines of research work in detail. A brief summary indicating the progress which has been made in the more important lines of investigation is presented herewith, grouped according to the funds from which these projects receive their principal support.

HATCH FUND.

Soil Fertility. The soil fertility investigations with various cropping systems and the application of commercial fertilizers and barnyard manure have been continued as planned

originally. The season of 1915 was excellent for the production of corn and alfalfa, but was too wet for wheat. The five-year average results show that the application of 2.5 tons of manure increased the yield of wheat, where grown continuously, 35.2 percent, and the average yield of alfalfa, grown continuously, 80.2 percent. The application of 5 tons of manure annually increased the average yield of alfalfa 118.1 percent, while 2.5 tons of manure used with 380 pounds of raw rock phosphate increased the average yield 97.4 percent. Complete commercial fertilizer and potassium sulphate have not given sufficient increase to pay for the fertilizer when used on any crop. Manure on alfalfa produced higher yields than commercial fertilizer, but the difference was not so great where alfalfa was grown in rotation as where it was grown continuously.

The different cropping systems are producing some marked variations in the yields of both wheat and corn. During the season of 1915, corn after corn preceded by alfalfa yielded 70.3 bushels per acre; corn after wheat preceded by corn, 63.9 bushels; corn after wheat preceded by cowpeas, 66.2 bushels; and corn grown continuously, 52.7 bushels. The yield of wheat after corn was 19.5 bushels per acre; after cowpeas, 15.27; and after wheat continuously, 12.75.

Seed-bed Preparation for Wheat. The highest yields of wheat were obtained from the earliest methods of preparation, as in previous years. A close correlation was found to exist between the nitrate content of the soil at the time of seeding and the yield of wheat obtained. There was little correlation between the amount of moisture in the surface six feet and the yield, but the amount of nitrates produced seems to be in direct proportion to the amount of moisture in the surface soil. In order to study some of the physical and biological changes in the soil, a number of small plots under controlled conditions were started. The treatment of these plots varied in moisture content, degree of aëration, and methods of working. The variations in nitrate nitrogen accumulation in soil following various methods of seed-bed preparation were not found to lie in any potential differences in bacterial flora of the respective plots, nor in variations in the activity of the nitroifying organisms, but they appear to be in the activity of those organisms bringing about cleavage, hydrolysis, or oxidation of native proteins-thus they are physical.

Crop Experiments. The work in the development of varieties of cereals adapted to Kansas conditions and a study of their cultural requirements has been continued. The selection of hard winter wheat known as P-762 outyielded the standard Turkey and Kharkof varieties by 2.69 bushels and 3.86 bushels per acre, respectively, in a five-year average. A strain of Red Texas oats has been developed which for the five-year period has produced 3.5 bushels more per acre than the best variety previously grown.

The preparation of corn ground in different ways for oats has failed to show much difference in yield. Medium early seeding for oats, and sowing 2.5 bushels per acre, were found to be the best for this grain. Tests with wheat show that the best date of seeding for this section of the state is October 1, and the best rate of seeding 6 pecks per acre. In a cultivation test with corn, plots which were cultivated but in which the weeds were removed by hand gave practically as good yields as plots which were cultivated three times in the ordinary way.

A study has been made of Kentucky blue grass gathered from different sources. A marked variation in the manner of growth, the quantity of forage produced and the resistance to disease has been noted. One selection, No. 148, promises to yield two or three times as much forage as ordinary strains of Kentucky blue grass.

The head characters in Standard Blackhulled White kafir as related to yield were studied in detail. The unfavorable growing conditions prevented any definite conclusions, but valuable data were recorded. In the station's forage-crop breeding and improvement investigations the work of preceding years has been closely paralleled. The wet season prevented a successful stand of almost all of the forage crops until the middle of June. All plots grew slowly and sorghums required thirty days longer to mature than in average season.

In the silage yield tests, sweet sorghum was the highest producer, with a record of 23.6 tons of silage and 21.4 bushels of seed; kafir second, with a yield of 16.6 tons of silage and 54.4 bushels of grain; commercial white corn third, with a yield of 15.4 tons of silage and 74.28 bushels of grain. Two plots of Sudan grass, grown for hay, planted May 15, averaged 3.64 tons per acre of dry hay, and three plots planted June 16 averaged 2.8 tons per acre.

Poultry Disease. The work with roup has been continued as reported last year, with two objects in view: (1) to determine the relation between roup of the diphtheritic and eye types and the cutaneous or so-called "sorehead"; and (2) to discover a method by which the disease can be regularly reproduced. During this year both of these objects have been realized in part, but more experimental data are needed to substantiate the conclusions. The ocular form has been repeatedly produced from both the cutaneous and the diphtheritic; indicating, as in previous years, that they are different manifestations of the same infection. However, the diphtheritic form has not been produced from the ocular, nor has the cutaneous (pox) been produced from the diphtheritic.

Hessian Fly Investigations. Considerable additional data were obtained on the life history of the fly. There were five broods in the field this season. The data thus far obtained show that the flies may continue to emerge from a given clump of wheat for a period of at least two years. Only five species of parasites were obtained from flaxseed pupæ, one of which is new, but considerable data on the life economy of these parasites have been collected. A study of the distribution of the fly showed it to be present in eighty-three counties of the state. The western limit was found to be Norton and Clark counties. The areas of heaviest infestation were in Harper, Sumner, Cowley, Sedgwick and Harvey counties, but serious injury occurred in nearly every county in the eastern half of the state. A method of procedure has been developed which, if practiced coöperatively in the community, will control the fly.

Corn-ear Worm Investigations. The results of this year bear out those of previous years in that corn planted May 1 suffers least from corn-ear worm injury. Excellent results were obtained by dusting with arsenate of lead, and it was found that the percentage of injury decreased consistently with the increase in the number of applications. In one experiment sulphur was found to be superior to lime or flour as a carrier for the arsenate of lead, and there was some indication that it served as a fungicide. Twenty-six varieties of corn were grown, and complete data were kept on tasseling, silking, date of maturity, and per cent of ears injured. Hildreth and Pride of Saline had the lowest per cent of ears injured.

Fruit Insect Investigations. That arsenate of lead can not control the apple-leaf skeletonizer after the webs are formed, but that they may be reached by nicotine sulphate, is indicated by spraying experiments. Fall plowing is recommended. A nematode was found to infest the *Saperda tridentata* so heavily that all captured from shade trees on the campus for experimental purposes died. However, the life history and economy of this new nematode (*Diplogaster labiatus*) have been worked out and results published. Observations on orchards in Doniphan and Atchison counties showed that where *Aphis* were abundant and not controlled, the apple blight (*Baccillus amylovorus*) later appeared, but orchards receiving treatment for *Aphis* were practically blight free. A powdered substitute for liquid lime-sulphur was tried in some of the fruit-growing districts of northeastern Kansas, but proved to be impracticable. Blotch is present in all Kansas fruit-growing districts, and as it can be controlled only by using Bordeaux mixture, the experiment of using dust sprays has been dropped.

Grasshopper Investigations. The cool season of 1915 was extremely favorable for the propagation of the grasshopper fungus disease. Consequently many grasshoppers were killed in this way, and they did not do the damage indicated earlier in the season. Considerable data were obtained relative to this natural method of control. A complete life-history study was made of the nematode infesting the egg capsule of the grasshopper; considerable investigation made upon the mites found in the trachea of certain species; and some work was started on the ground beetles and blister beetles found attacking the eggs. Poisoned bran mash was used successfully against cutworms, army worms, crickets and sow bugs during the past year.

ADAMS FUND.

The Physiological Effect Upon Work Horses of Alfalfa Hay Cut at Different Stages of Growth. The work has been continued as reported in previous years. It was found that the leaves of alfalfa contain from two to two and one-half times as much protein as the stems and that the stems contain more than two and one-half times as much crude fiber as the leaves. It was demonstrated, also, that the loss of leaves is from 3 to 12 percent less when alfalfa is cut in the one-tenth bloom

than in any later stage of its growth; the loss increases with maturity. The chemical analyses show that the percentage amounts of ash and protein decrease regularly as the plant matures, and the percentage of crude fiber and nitrogen-free extract increases. The total amount of nutrients produced per acre depends upon the yield. In 1914 the greatest amount of all nutrients was obtained in alfalfa cut in the bud stage, while in 1915 the full-bloom stage surpassed the others in this respect. The additional amount of protein contained in the alfalfa cured in the sun over that cured in the shade was enough to more than offset the influence of the loss of leaves.

Three digestion experiments have been conducted, but the results have not been computed. The roots of the alfalfa cut at different stages were studied in December. There was a decided decrease in the size of roots where alfalfa had been cut in the bud stage. At the last cutting the plots cut in the bud stage were 80 percent foxtail and crab-grass seedlings. There were a few patches of grass in the one-tenth bloom plots, but there were no weeds or grass in the remaining plots. The largest yield in tons per acre was obtained from the plots cut in full bloom. The other plots ranked as follows: one-tenth bloom, bud, and seed stage.

Alfalfa Breeding Experiments. Investigational work has been continued with sixty-four different imported varieties and strains of alfalfa in an effort to get a drouth-resistant plant as well as one that is a high producer. From these varieties thirty-two individual plants showing desirable characteristics, such as erect stems, heavy foliage, evident resistance to leaf burn, and seeding ability, were selected with a view to obtaining pure lines from which to breed. The hybrids are all being self-fertilized and the seed thus obtained will be grown next year. The year after next the best seed will be sent to the western branch stations for trial.

Sex Type as Related to Functional Development and Performance. The work of this project has been continued as planned. Records of milk production for cows that dropped calves after September 1, 1915, are being kept. All cows have been bred to the bull at the head of the college herd.

Corn Mold Investigations. This work has been temporarily suspended because of the lack of material.

Chinch-bug Egg Parasite Investigations. Approximately 2000 chinch-bug egg parasites were reared during the summer, and owing to the cool, wet season the length of the life cycle was much longer, ranging from nineteen to more than fifty days. Daily collections of eggs were made in one field during the entire summer to determine the progress of infestation. The average percentage of parasitism for the year was 12.9 percent. A similar study was made at Winfield. Data collected thus far indicate that this parasite hibernates as an adult.

Climate and Injurious Insect Investigations. That it is possible to have as many as five broods of the fly in a single season under climatic conditions such as often exist in Kansas has been demonstrated by the use of the air-conditioner. Field studies have demonstrated that there are more than two broods of the Hessian fly in some seasons. One discovery of economic importance is that the larva of the Hessian fly can move upward on a perpendicular leaf two-thirds as fast as it can come down and that it can secrete a fluid to make this possible, if there is no moisture on the leaf. The season of 1915 being exceptionally cool and wet made it possible to obtain data on the effect of these conditions on the life economy of a number of insects. The life cycle of the chinch-bug egg parasite was prolonged and only seven generations instead of nine were produced, while the season favored the Hessian fly and five broods were produced.

Breeding Investigations. Progress has been made in further breeding out forms of Orthoptera. The distinctness of the patterns and general nature of the material have made it possible to distinguish two classes of characters. The principles that have been worked out in connection with Orthoptera also apply in the inheritance of the combs of fowls, colors of the albumen of peas and other plants, and may have universal application. If acceptable, this idea may require widespread revision of texts and literature on Mendelian inheritance. One "cross-over" or "coupling" of characters in Orthoptera has also occurred in material kept in the controlled breeding chambers, but it will require further experimentation to determine whether this was only a coincidence. The work so far accomplished indicates great usefulness for the temperature

and moisture control apparatus installed by the entomology department last year.

Parasitological Investigations. Research studies on the life histories of chicken tapeworms are being continued. Progress has been made in the rearing under controlled conditions of suspected intermediate hosts of the fowl cestodes. Recent work on the transmission of the nematode to fowls by the latter eating dung earthworms indicates that it is a case of association rather than one of parasitism in the earthworm.

STATE FUND.

Farm Management Investigations and Surveys. An investigation was begun during this fiscal year to study farm management problems and the business of farming. Labor income records for the year 1914 were obtained on 313 farms in Allen, Cowley, Jewell, and Pottawatomie counties. The percentage distribution of farms by tenure closely approximates the distribution as given by the federal census for 1910. Stock share leases are uncommon; those found are usually among members of the same family. The methods of renting followed do not permit the keeping of much livestock on rented farms, and many owners tend too much to grain farming. Consequently many farms are in need of more and better-paying livestock. Data so far collected indicate that the distribution of labor to give the most efficient and profitable use is one of the big problems confronting the Kansas farmer.

Inheritance Investigation in Swine. The close of the first year's work in swine inheritance indicates tentatively that the short dish face of the Berkshire is transmitted as a dominant sex-linked characteristic. Statistical studies demonstrated (1) that the number of pigs per litter is not correlated with any of the characteristics of form which are commonly supposed to influence it; (2) that selection of dams and sires on the basis of the size of litter in which they are farrowed has no effect on the immediate progeny nor on the second generation; and (3) that the method of fertility inheritance is extremely obscure. In order to study the latter point, a wild boar coming from a strain which is relatively pure for the production of four pigs per litter was mated with Tamworths from a strain high in production of pigs per litter. The results in swine will be checked by means of laboratory animals, such as rats and rabbits.

Silage for Beef Cattle Investigations. Some interesting results were obtained in the fourth feeding trial to determine the value of silage in the production of yearling beef. Cattle fed on a ration of ground corn, cottonseed meal, with alfalfa and silage as roughage, showed more finish and bloom, and dressed out a higher percent but at a higher cost per unit of gain, than those fed other rations. The cattle fed corn-and-cob meal made slower but cheaper gains than the ground-corn lots, and also dressed out well. Kafir meal put on excellent but slower gains at a lower cost than the foregoing. Although these cattle did not sell at as high a price, they made a good profit. This shows that where corn can not be obtained at reasonable prices, as is often the case in western Kansas, kafir makes a good substitute. Kafir heads seemed to be too bulky for fattening animals, although the gains put on were the cheapest of all. Cattle fed no silage at all made the greatest gains and seemed to utilize their feed to good advantage. These cattle were thickly and evenly fleshed and showed almost as much bloom as the first two lots. It is the intention to carry this experiment further to substantiate these results before they are taken to be conclusive.

Grazing Experiment. A new experiment was begun in 1915 to determine methods of improving native pasture land in Kansas by a system of grazing management. This is being conducted on the pasture land of D. D. Casement, nine miles north of Manhattan. Some of the grass plots were protected from grazing until seed maturity of the predominant forage species, while others were not protected. The protected area was then grazed heavily to use all the available forage as rapidly as possible, and at the same time work the seeds into the ground by trampling. Protection resulted in a decided increase in germination of seeds of the predominant grasses and an increased number of seed stalks produced. A study to determine the effect of burning native pasture land was begun.

A mixture of tame forage species seeded in 1915 resulted in no seedlings of tame grass being established in 1915. Sweet clover was seeded once every month on the protected area from June, 1915, until January, 1916. This seed did not germinate until after March, 1916, but then the seedlings were found to be growing well. Sweet clover seeded in April, 1916, gave an average of two seedlings per plot on the unprotected

and eleven per plot on the protected area. Results to date indicate that mowing on level areas is practical and that it is efficient in getting rid of the weeds.

Silage Investigations. The general conclusion from all experiments is that the primary condition for making silage from alfalfa is the rigid exclusion of the air and the addition of some kind of easily fermented carbohydrate. Wilted alfalfa is more likely to make good silage than that not wilted, and the addition of water to the wilted alfalfa is a slight advantage. Meal from germinated corn is more effective in producing good silage than meal from corn not germinated. Tightness in packing contributes to success only so far as it makes exclusion of air more certain. It is possible to make good silage from alfalfa alone, but the conditions are such that it is difficult to realize them in practice. When some substance containing easily fermentable carbohydrate is added, such as molasses, corn chop, cane butts or rye, good silage can be made from alfalfa. This is not very practical, however. Bacteriological analysis has shown that poor silage results from improper physical factors, such as temperature, moisture, and anaerobic conditions.

Heifer Development Experiments. The purpose of this experiment is to determine the best method of feeding and developing dairy heifers. Twenty-four calves were divided into three lots. All calves received milk until six months of age, and in addition the first lot received alfalfa hay alone, the second lot alfalfa hay and silage, and the third lot silage and grain. After weaning, these rations were continued. Records are kept of the amount of feed consumed by each animal, and every calf is weighed and measured each month.

Physiological Investigations of Drouth-resistant Plants. In the work done previous to the season of 1915 a large number of hybrids between the various strains of supposedly drouth-resistant corn and the Kansas and Minnesota corn varieties were produced. In the season of 1915, 476 different hybrid subfamilies were planted, and 23 pedigree strains from the drouth-resistant and Kansas stocks were used as mother plants of the crosses. Seven lots of seed, amounting to 3 pounds each, derived from hybrid 58, supposed to be the best drouth-resistant hybrid, were sent to each of the five sub-stations and to two other points. In pot experiments carried

on at Garden City substation in 1914 and 1915 it was shown that hybrid 58 has lower water requirements for each year than Chinese corn, Pride of Saline or Sherrods, standing next to Dwarf milo in economy of water. In 1911 it produced a pound of dry matter on less water than Northwestern Dent or Iowa Silvermine. Hybrid 58 also withstood the drouth of 1913 without injury on plots where all the other corn was ruined by drouth. A study is also being made to determine the characteristics possessed by the sorghums that enable them better to withstand severe climatic conditions than the corn plant.

Milling Investigations. The milling, baking and analytical work on samples of wheat from the 1914 crop have been completed. It has been exceedingly difficult to establish from the data at hand any relation between chemical composition of the wheat and baking value of the flour except in the four leading wheats in variety tests. A large number of baking tests were made to determine the effect of egg albumen as an ingredient in baking powder, but the results showed that this substance had no measurable effect in the amounts used. That the new so-called wheat-purifying process for which the International Sterilizing Company claims to have patents and is selling to Kansas millers does not obtain beneficial results was proved by investigation. Millers in Kansas were so informed.

In connection with these milling investigations the chemistry department has been doing work to discover the factors that determine the gluten quality in wheat flour. Investigations have shown that the baking qualities of flour are markedly influenced by protein decomposition products, and that a large amount of nitrogen in amino form is an indication of poor baking qualities.

Flour Investigations. The object of this investigation was to make a bacteriological analysis of samples of flour collected from different parts of the state to get data on the organism causing "rope" in bread. Fifty-one samples of flour were examined, and 40 percent of them contained "ropy" bread organisms. The data to date indicate that since "ropy" bread organisms were found in the samples of the better grades of flour in much higher proportions than the corresponding losses from "rope" indicate, that the ultimate source of the trouble is to be sought in bakery practice rather than the flour used.

Rust-resistant Strains of Wheat. A marked freedom from rust attack was shown by varieties P 1068 and P 1066. Varieties immediately adjoining (ten inches away) showed an infection from 40 to 85 percent. Variety P 762 showed only 10 percent rust and also looked promising, but P 706 showed from 40 to 65 percent rust. In all cases the seed was badly shrivelled. Leaf rust on wheat this year was severe enough to reduce the yield in some cases, although this is contrary to the general belief. The life history and habits of the corn-smut fungus are being more thoroughly worked out, and tests for control measures are being made. Indications are that certain fungicides applied to the corn plant may reduce the percentage of corn smut. A date-of-planting test is furnishing data on percentages of infection, and a variety test is showing that some varieties of corn are more susceptible to corn smut than others. Forty-six varieties of sorghums are being tested as to their susceptibility to kernel smut. By various mechanical injuries an attempt is being made to break down the immunity of milo and the resistance of feterita, and to discover whether their resistance to sorghum smut is due to anatomical or biochemical factors.

Kafir Ant and Cutworm Investigations. That the billbug can be controlled by a rotation of crops whereby corn does not follow corn was the conclusion of an experiment in which the life history of this pest was worked out in full. A large amount of information was also gathered with regard to the effect of external and physical conditions on the life of various insects and the agricultural methods practiced with reference to insect injury. Owing to the small size of the kafir ant, the experimental work has progressed rather slowly, but a large amount of data was obtained on the life history and habits of this pest.

Termite Investigations. In the termite investigations, data were obtained on the following points: (1) proportion of casts in local colonies; (2) distribution in and about Manhattan; (3) food habits; (4) habits in colonies; (5) method of molting; (6) time and method of emergence; and (7) habits following the flight. The life history and economy of the nematode (*Diplogaster ærivoræ*) found attacking the termites were studied and the results published.

Investigations on Staple-crop Insects. In the study of insects injurious to the roots of staple crop plants, data were collected on many points in the life history of the white grubs present in this state, and the work was put on a substantial basis. Similar data were obtained on the wireworms, *Eleodes opaca*, and *Eleodes tricostata*. Considerable work has also been done toward developing methods of rearing underground insects. Some of the methods devised are successful and will warrant description in some publication.

Experimental Tree Planting. Investigations carried through the past two seasons prove conclusively that the damping off of coniferous seedlings can be controlled by steam sterilization of seed-bed soil. That pecans can be grown successfully on overflow lands throughout the southeastern fourth of the state, and that the industry may become one of considerable importance in the future, was concluded from an experiment in pecan growing. The problem to be solved is that of developing a hardy pecan of superior size and quality. Considerable work had also been done in growing maple trees in certain sections of southeastern Kansas. The yield of sap was remarkably good, and maple syrup production can be made an item of considerable importance on many farms. Manuscripts on pecan growing in Kansas and the native trees of the state have been prepared.

Fruit-bud Formation. A study of the factors influencing the formation and development of fruit buds, in order to work out a system of orchard management adapted to the greatest production of fruit, has been carried on under two heads—soil treatment and training of plants. Under soil management the work has included a study of soil types, comparison of crops, frequency and depth of cultivation, sod, recultivation, and the effect of interplanting apples with other fruits. A new branch of the work was inaugurated to obtain definite knowledge of the effect of pruning in the various seasons. The results will be checked against trees of the same varieties that have never been pruned since setting.

Small Fruits and Garden Crops. Vegetable trial-garden experiments were started to study the effect upon the yield of pruning, staking and spraying of tomato vines. Varietal tests are also under way to find out which are best adapted to Kansas conditions. Many complaints have been received from

many sections of the state dealing with the disease and insect problems that are so pertinent in this state. As a result, work was begun to eradicate these pests if possible. Tomatoes grown in the greenhouse were sprayed with several different fungicides in an effort to control blossom-end rot. Spraying in the field, however, was confined to Bordeaux mixture. Different methods of planting vegetables are being tried with special attention to the control of insects and diseases. Twenty different genera of vegetables and many varieties of each have been tested for hardiness and yield. A series of tests have also been made with lettuce, radishes, peas and beans to determine the practicability of growing these crops during the hot months of summer.

Potato Investigations. Four coöperative experiments in the testing of commercial fertilizers for potato growing are being carried on with growers in the Kaw Valley. Scarcity of potash has hampered the work with fertilizers. Variety tests have been increased to include coöperative work with the Department of Agriculture. Promising seedling varieties are being compared with standard varieties grown under the same conditions. The use of straw mulch has been undertaken and the work on soil management, crop rotations, seed treatment and spraying has been continued as in the past. Coöperative tests of cold storage of home-grown seed are being planned with growers in the Shawnee county district.

Improvement and Conservation of Farm Poultry. Some interesting results in the improvement of farm poultry products were obtained in the effort to grade up mongrel flocks by using standard-bred males from high-producing strains. The laying records of the first generation of offspring showed a marked improvement, as compared with the records of their mongrel mothers. In the case where the pure-bred Single Comb Leghorn was crossed on the mongrel females, the gain was more than 100 percent; with the purebred White Orpington, 47 percent; and with the Barred Plymouth Rock male, 32 percent. The mongrel check pen also showed an increased production of more than 11 percent, which was probably due to good care.

Injurious Mammal Investigations. The work of the eradication of rodents has been continued. Two circulars, one on the "Pocket Gopher" and another on the "Prairie-dog Situa-

tion in Kansas," have been published. A treatise on "The Pocket Gopher's Relation to Alfalfa in Kansas" is being published by the secretary of the State Board of Agriculture as a part of his report. It is expected that this work with rodents will now enter a new and enlarged usefulness because efficient and additional help has been obtained in the work.

Blackleg Investigations. The use of blackleg anti-infectious serum and pellets was found to be the only certain and safe means of controlling blackleg outbreaks. Almost 20,000 doses of this blackleg extract were given in the past year, and it can be used successfully by farmers and stockmen who use the regular blackleg vaccine. This germ-free filtered blackleg extract has been 100 percent efficient in protecting against blackleg. It differs from the present vaccine in that the protective properties are not in proportion to its virulence. Considerable progress has been made in lessening the cost of production of this commodity.

Investigation of Outbreaks of Animal Diseases. One outbreak of cornstalk diseases was investigated and some rather encouraging information was obtained which will prove helpful. Arrangements are being made to coöperate with some breeders of the state in the controlling of contagious abortion. A number of shipments of cattle from Kansas City were found to be affected with hemorrhagic septicemia, but local cattle were seldom affected.

The Marketing of Kansas Butter. The results of the first year's work have shown that cows in Kansas are generally kept as a side line. This makes it evident that a relatively small amount of butterfat is produced in Kansas per square mile. Under these conditions the cream-station system as a means of profitably concentrating butterfat for manufacture seems to be an economic necessity. The conclusion thus far is that the low prices paid farmers for butterfat are the result of this expensive method of handling the product. This investigation is being continued and the results will be published when the work is concluded.

Coöperation in Kansas. Investigation of farmers coöperative organizations, begun this year, has shown that many of these associations are instigated without reference to the principles which determine their subsequent success or failure,

Consequently, a needless number of failures and their accompanying losses result. The data procured are being prepared for publication.

OTHER WORK.

The control and demonstration work carried on by the Experiment Station staff, in addition to the regular investigational work, is outlined below:

Control Work.

Pure-seed Control. Samples of the various agricultural seeds to the number of 1,028 were received at the seed laboratory for purity and germination tests. This is a slight decrease in number from last year's tests, but is partially explained by the fact that a nominal tax of 25 cents per test has been levied upon all tests made for dealers. This was found necessary in order to stop the indiscriminate sending of old and worthless seeds in large quantities at seasons of the year when the seed laboratory was rushed with work for farmers who wished to sow their crops. The seed received during the year was only fair in quality. Alfalfa and clover seeds were not as clean as they should be. Seeds of the sorghums were generally of poor viability, having been frosted before they were mature. Red oats for seeding purposes, most of which were shipped in from Texas, were found to contain a considerable mixture of Johnson-grass seeds. Many samples of weed seeds have been received for identification, and numerous samples of weed seeds have been sent out upon request.

Fertilizer Control. Eighty-eight samples of fertilizers were analyzed during the year in connection with the enforcement of the fertilizer law. Inspection Circular No. 1 of the station reports the results of this work.

State Dairy Commissioner. The dairy outlook in Kansas was never brighter and more encouraging than at present. The number of milk cows has increased from 856,883 in 1914 to 1,077,067 in 1916, and their value has increased from \$52,269,863 to \$68,932,288 during the same period. This is a particularly good showing considering the fact that there was no fall and winter pasture available in the state. Reports available show that 34,412,520 pounds of creamery butter were manufactured from Kansas cream. This is an increase of 2,512,520 pounds over the average of the four preceding years.

Examinations for cream buyers were held in 42 cities throughout the state and 13 additional regular examinations were held in Manhattan. Final examinations for cream buyer's permits were given to 1,261 applicants, and temporary examinations were given to 600 applicants. During the year 112 dairies, 4 condensaries, 130 creameries, 52 ice cream factories and 1,701 cream stations were inspected in 1,238 towns. It was found necessary to close 87 stations and 2 creameries. Three prosecutions were instigated and won by the state and two operator's permits were permanently canceled because of persistent violations.

Fourteen days were expended in institute work and eight meetings of the Kansas Creamerymen's Improvement Association were attended and addressed upon request. In addition to this, two trips to Washington, D. C., were made in the interests of dairying. Seven cities received suggestive milk ordinances, and one city has adopted them. Circular letters containing general information were sent out on six different occasions and 4,660 letters were written in answer to inquiries. In addition to this a circular on "Cream Production and Grading in Kansas" was published and distributed.

Livestock Feed and Remedy Control. Under the livestock remedy law and the feeding-stuffs law, inspectors visited 795 towns, in which 2,999 firms manufacturing or offering for sale either livestock remedies or feeds were inspected. A total of 3,162 samples were collected and analyzed. There were 462 violations of the feeding-stuffs law and 1,573 violations of the livestock remedy law reported by inspectors. One conviction was obtained under the livestock remedy law.

State Livestock Registry Board. The work accomplished by this board is incorporated in Inspection Bulletin No. 1.

Coöperative Experiments and Seed Distribution:

Investigations on the different soil types of the state, in order to obtain information regarding the fertility and tillage requirements of the various soil types and crop adaptations, have been continued. In 1916 the agronomy department cooperated with farmers in 85 counties in conducting the following experiments: 179 variety tests of corn; 15 ear-to-row tests of corn; 89 variety tests of grain and forage sorghums; 43 forage and silage tests; 57 variety tests of wheat; 6 date-of-seeding tests of wheat; 50 fertilizer tests with wheat, oats,

corn and alfalfa; fertility and rotation projects on eight out-lying experimental farms; 70 tests with sweet clover and *Lespedeza*; and 89 tests in which improved varieties of crops were grown for the production of seed for increased planting. In addition to this, 95,000 bushels of seed grain of the various crops have been listed and sent to inquirers for seed for planting.

Demonstrations.

Dairy. The institution continues to maintain its herd of dairy cows, representing the four principal breeds. They are used for the same purposes as previously reported. The average production during the past year for thirty-six cows, several of which are heifers with their first calves, is 397 pounds of butterfat. One two-year-old Holstein has produced 15,170 pounds of milk and 534 pounds of butterfat; a Jersey, 14,600 pounds of milk and 650 pounds of butterfat; a Guernsey, 9,990 pounds of milk and 522 pounds of butterfat; and an Ayrshire, 15,250 pounds of milk and 559 pounds of butterfat. The creamery is still maintained as a medium for marketing the products of the dairy herd. The cream is also used for giving instruction and conducting investigational work along commercial lines. The Dickinson County Cow-testing Association, now in its fourth year, is proving to be more efficient than ever. The department has continued its work in conducting advance registry tests of pure-bred dairy stock in the state. This is an indication of the growth and demand for better dairy cattle. The members of this department have also assisted the farmers in buying fifteen carloads of dairy cattle during the past year.

Entomology. The station entomologist has continued his work as a member of the State Entomological Commission. The funds (\$2,500) available for his use during the fiscal year were expended in the control of San Jose scale, inspection of foreign nursery stock, and the inspection of apiaries for foul brood and other diseases. The department has continued to give much attention to the fruit-growing interests in several of the northeastern counties. Many orchardists were furnished with directions for spraying, and the work in several orchards was conducted under the direct supervision of the department. This work has not only aroused much interest, but has succeeded in getting a large number of orchardists to spray, prune

and cultivate their orchards properly. Greatly increased financial returns have been attained by those who have adopted modern methods in handling their orchards. The history of Mr. Groh's orchard, at Wathena, is typical of what has been accomplished by adopting modern methods. In 1912 Mr. Groh considered that his orchard had passed its days of usefulness, and was about to remove it, when he was persuaded to change his method of handling the 550 trees that remained. The results of adopting new methods were as follows: In 1912 he received \$1,670 for his apples; in 1913 they brought him \$3,386.11; in 1914 his orchard produced 4,686 bushels; in 1915 he netted \$3,565.50; and in 1916, in spite of the adverse conditions, he netted \$2,634.50. His trees have borne five consecutive large crops of apples, and are to-day in better condition than they were in 1912.

Horticulture. The demonstration work of this department has enlarged this year as in previous years. The coöperation with growers in the production of Irish potatoes, sweet potatoes and melons has served to emphasize the advantages of rotation and the use of fertilizers, as recommended by this department. Practical assistance has been furnished for the control of insects and disease. Investigation of problems concerning the storage of truck crops was instigated in response to inquiries sent by truck growers, who must either sell on the glutted market or provide storage until the demand is more insistent. The storage of apples in common climatic storage thus far has emphasized the fact that the control of ventilation and humidity is the important storage problem. An increased amount of attention is being given to the improvement of landscape conditions in the state, and a considerable amount of energy is being expended in investigating the possibility of improving private grounds in both city and country, public parks, cemeteries, and the surroundings of schools and colleges.

Veterinary. During the year 2,048,865 cc. of anti-hog-cholera serum were sent out from the station laboratories. About 7,000 hogs were vaccinated, with a loss in well herds of less than one percent. Coöperative work with the federal government in hog-cholera control in Nemaha, Leavenworth, Pottawatomie, Doniphan and Dickinson counties grew rapidly during the year, and effective results were obtained. The number

of farms visited was less, in proportion to the size of the territory in which work was being done, than usual. This was because the outbreaks of cholera were fewer and farms generally were kept in a more sanitary condition as a result of effective work done previously in combating this disease.

The work in the eradication of blackleg was unusually effective. Deaths of calves treated amounted to only a fraction of one percent. During the year 426,160 cc. of blackleg serum and 114,820 doses of blackleg vaccine were sent out over the state. Station Circular 59, "A Preliminary Report on Two New Methods of Preventing Blackleg by Means of an Anti-Blackleg Serum and an Agressin," is being published. A more complete and detailed statement of the manufacture of this blackleg serum and the germ-free fluid vaccine is appended to this report.

MISCELLANEOUS MEANS OF DISSEMINATING AGRICULTURAL INFORMATION.

More than 45,000 copies of station bulletins and circulars were mailed during the year in response to miscellaneous requests received. In addition to this, 21,000 persons on the regular mailing lists received publications from the station. More than 70,000 letters were written by members of the station staff, giving advice and information on every conceivable phase of agriculture in reply to inquiries received. Between 700 and 800 days of the time of the staff members were occupied in field work in compliance with requests for speakers at various 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.

Branch Stations of the Kansas Agricultural Experiment Station.

The five branch stations discussed in the last report have continued in operation. No radical changes in the plan of their work have been made during the year. The Department of Agriculture has continued to coöperate in conducting investigations in dry-land agriculture at the Fort Hays, Garden City and Colby stations, irrigation investigations at Garden City, and cereal and forage-crop investigations at Fort Hays.

FORT HAYS BRANCH EXPERIMENT STATION.

The investigations carried on in commercial farming, dry-land agriculture, cereal crops, forage crops, the forest nursery work, demonstration dairy farming, public park and forestry work, livestock breeding and feeding, and tenant farm management, have been continued as previously reported.

Cereal-crop Investigations. Though the 1915 season was one of heavy rainfall, a poor crop of wheat was harvested. The rains prior to harvest were untimely for wheat. The sorghums made good crops, but growth and development were slow on account of cool, wet weather, and many varieties were injured by frosts early in October. Corn produced well this season in western Kansas. Spring grains, like winter wheat, made low yields and were of poor quality.

Experiments with different varieties and strains of winter wheat were conducted on small duplicate plots. Because winter wheat is the most important crop in western Kansas, varieties of this cereal that are adapted to the Great Plains area have been developed. Further improvement is being sought by developing improved strains from these adapted varieties. Other experiments with wheat include sowing on grain-sorghum stubble to test the effect of gathering winter snows, rate and date of sowing, and spring cultivation tests. The results, as indicated by yields, show that early seedings should be made at low rates and later seedings at higher rates. The rates of seeding tested were from one-half to four pecks per acre. Of the grain sorghums, Dwarf milo produced the highest yield, 59.8 bushels. This test included Dwarf and standard milos, kaoliangs, feterita, broom corn, durras, and kafirs.

Forage-crop Investigations. In experiments to determine the best date for sowing different forage crops it was found that the optimum time for planting kafir and feterita from which both fodder and grain are desired is June 1, while saccharine varieties such as Freed, Minnesota Amber, and Red Amber produced best when planted June 15 if the production of fodder was the chief object. May 5 and May 15 seedings did well, but were less than a foot high on June 25 and were never much ahead of the June 1 planting in growth and maturity. July plantings were entirely satisfactory as to yield and quality of forage, but were too late for grain.

The results of the rate-of-planting tests indicate that the thickest rates were best for both feterita and Red Amber in 1915. This rate was four inches apart in the rows. The thin feterita suckered most and ripened too unevenly, and the thin Red Amber was rather coarse. Both 1914 and 1915 yields showed a decided advantage in favor of close-drilled Red Amber as compared with cultivated rows, when hay alone is desired. Feterita planted in alternate rows yielded only two-thirds as much fodder and grain per acre as was produced from four-inch spacing in regular rows.

Of the fifty-two varieties of sorghums planted, Red Amber was preferred to the other saccharine varieties because it combines high yield, good quality and early maturity. In general, the other early sweet sorghums lack leafiness and the high-yielding ones are coarse and late. Among the general-purpose varieties, Dwarf Yellow milo was the best in this test. Ordinarily this variety is only of medium or inferior rank at Hays, because it is most readily destroyed by insect pests, does not escape drouth so well as the early varieties like Freed and feterita, and its forage is inferior to that of the kafirs.

Sudan grass made the best hay when cut in the full-head stage, and the best time for planting it was found to be between May 10 and 15. Plantings of Tunis grass have proved this to be an unsatisfactory crop. Legumes were entire failures in Sudan mixtures both in 1914 and 1915. German millet has proved itself to be superior to other millets the past three years, but Sudan grass has excelled it in yield and quality.

Miscellaneous Experiments. Investigations on the general station fields since 1903 and on the dry-land project indicate

that only rarely can a good stand of upland alfalfa be obtained, and the yields have usually consisted of one light cutting or none at all. Alfalfa on the bottom land is an unquestioned success in western Kansas. A test was begun in 1913 with alfalfa planted in rows different distances apart. No definite conclusions have been reached because the seasons of 1914 and 1915 were unusually favorable, and there was so little difference in the average yields among the 6-, 12-, 24-, 30-, and 36-inch rows that they were insignificant. Six- or 12-inch drills have been preferable because they need less cultivation, are easier to mow, and the hay is free from dust. No seed yields have been obtained. Annual legumes have not proved to be profitable crops at Hays either for hay or seed. Tepary beans offer the most promise for an annual legume.

Dry-land Project. The highest yields of small grains were again produced on disked corn ground. These tests included barley, oats, and spring and winter wheat. Kafir and milo produced best with fall or early spring plowing. The relation of moisture to yield of winter wheat in western Kansas was reported upon in 1915 by Messrs. Call and Hallstead in Bulletin No. 206 of the Kansas Agricultural Experiment Station, in cooperation with the Bureau of Plant Industry, Department of Agriculture.

Dairy. Progress in the dairy this year consisted of making improvements in the sanitary conditions about the dairy barns and the installation of labor-saving devices.

Cattle. Investigations in live-stock feeding methods for western Kansas have been continued for the fourth year. During this time no group of animals has been fed at a loss. To turn into cash the by-products of grain farming that would otherwise have no value is the purpose of the feeding experiments. In order to determine the relative values of several kinds of roughage, 100 head of three-year-old heifers were divided into five lots and fed for 120 days during the past winter. Maintenance through the winter in good condition was desired more than gain. The feed combinations, the average gain per head for the lots, and the average cost of feed per head, are contained in the following table:

	Lot 1.	Lot 2.	Lot 3.	Lot 4.	Lot 5.
	Feterita silage and alfalfa.	Kafir silage and alfalfa.	Kafir stover and alfalfa.	Kafir stover and alfalfa on range lot.	Sudan stover and kafir silage.
Average gain in pounds per head	71.3	104.8	63.5	3.5	31.5
Average cost of feed per head	\$7.54	\$7.32	\$6.26	\$5.35	\$5.64

It will be seen that kafir silage and alfalfa produced the greatest gain, while kafir stover and alfalfa combination fed on the range lot made a comparatively poor showing. Although the feterita silage and alfalfa were fed at a somewhat higher cost than kafir silage and alfalfa, the average gain was 33.5 pounds less. The kafir silage was better preserved and more palatable than the feterita. The average daily gain per head of the heifers fed kafir silage and alfalfa was .87 of a pound, while the average daily cost for feed was 6.1 cents. The average daily ration consisted of 16.4 pounds of kafir silage in good condition, 13.8 pounds of alfalfa hay in fair condition, and 1.1 pounds of wheat straw. The feed values as estimated per ton are: silage, \$2.50; kafir stover, \$1.50; Sudan stover, \$4; alfalfa, \$6; wheat straw, 50 cents.

In another test of 120 days' duration forty Hereford heifers were fed silage, alfalfa, and straw; while another forty were given the same feed with the addition of 4.54 pounds of corn-and-cob meal and 1 pound of linseed meal a day. One-half of the heifers in each lot will be bred as yearlings and the other half will be bred as two-year-olds. The object is to determine the effect of the feeding and the time of breeding upon the development of the heifers and the calves they produce. The average daily gains in weight for the 120-day period were 1.88 pounds for the lot fed corn-and-cob meal and linseed meal, and .92 pounds for the other lot. The average costs per head for feed were \$11.43 and \$4.73, respectively. The average daily rations in pounds per head in the lot where meal was added was as follows: Alfalfa hay, 7.96; silage, 8.72; wheat straw, 56; corn-and-cob meal, 4.54; and linseed meal, 1. The rations in the second lot were: Alfalfa hay, 9.12; silage, 9.50; and wheat straw, .55 pounds. The cost of corn-and-cob meal was listed at 93 cents and that of linseed meal at \$1.81 per hundred.

An experiment was carried on for 130 days in order to de-

termine the cost of keeping mule colts. The total cost of maintaining thirty-one mule colts, including both feed and labor, averaged \$8.16 per head, and the average gain in weight was 109 pounds. The colts for this investigation were purchased at weaning time.

State Forest Nursery. In the spring of 1915 a total of 345 tree orders, which called for 60,000 trees, were filled. The following table shows the species of trees sold and which were most in demand :

KIND OF TREE.	Number of orders.	Number seedling and cutting plants sold.	Number of trees sold, 2 and 3 years old.
Red cedar.....	14	10,450	57
Chinese arbor vitae.....	127	113	1,930
Tamarix.....	38	2,172	75
White elm.....	53		5,755
Honey locust (smooth).....	65	420	2,281
Honey locust (thorny).....	46	6,485	1,950
Hackberry.....	32		852
Norway poplar.....	104		1,230
Osage orange.....	30	15,569	106
Catalpa.....	17	2,225	508
Wild olive.....	45		457
R. Mulberry.....	22		454
Green ash.....	30		644
Redbud.....	26		332
Kentucky coffee tree.....	10		57
China berry.....	4		27
Black walnut.....	3		36

GARDEN CITY BRANCH EXPERIMENT STATION.

Climatic Conditions. The growing season of 1915 was a favorable one at the Garden City Station. Small grains which had never proved to be profitable crops since the establishment of the station, in 1909, gave fair returns in 1915.

Dry-land Crop Investigations. In the experiments with winter wheat, that planted on ground which was summer tilled produced the highest yield, 21.3 bushels per acre. Land subsoiled every three years yielded no better than land not so treated. Winter wheat planted on disked corn ground produced 16.8 bushels per acre, while that on disked potato ground produced 14.8 bushels. The highest yields of spring wheat, 16.1 and 17.4 bushels per acre, were obtained upon disked corn ground and summer-tilled plots, respectively. The best yield of oats, 56.7 bushels per acre, and also that of barley, 45.3 bushels, were obtained on summer-tilled plots. Fall plowing produced 28.8 bushels of oats per acre, while spring plowing produced 37.2 bushels; and the yields of barley for these methods were 24.2 and 31.4 bushels per acre, respectively. The

highest yields of Dwarf milo, 41.9 bushels of grain and 3,900 pounds of stover per acre, were obtained on plots listed in the fall; and the next best yields, 38.2 bushels of grain and 3,300 pounds of stover, were obtained from fall plowing. Yields from spring-plowed plots were much less than those from either of the other two methods. In a test of eighteen sorghum varieties, Dwarf Yellow milo produced the most grain, 48 bushels per acre. Red Amber produced 37 bushels of seed, and Western Orange sorghum 36 bushels. The heaviest yields of forage were obtained from Sumac sorghum, which yielded 17,200 pounds per acre, and Orange sorghum, which yielded 15,800 pounds. In the case of kafir, fall plowing produced 4.3 bushels more grain per acre and 1,309 pounds more of stover than did the fall listed plots. Summer-tilled land produced 46.6 bushels of corn per acre and 4,000 pounds of stover; spring listing, 35.6 bushels of grain and 2,500 pounds of stover; spring-plowed land, 33.1 bushels of grain and 2,730 pounds of stover; subsoiled land, 30.5 bushels of grain and 2,970 pounds of stover; and fall-plowed land produced only 28.4 bushels of grain and 1,761 pounds of stover. In a test of fourteen varieties of corn, Freed's White Dent produced the highest yield, 47 bushels per acre. With the small-grain varieties, Kharkof and Turkey Red were the best varieties of winter wheat. These yielded approximately 16.5 bushels upon continuously cropped ground. Of spring wheats the highest yields were made with Marquis and Kubanka durum. These produced 11 and 10.6 bushels, respectively. Oats yields were 24.4 bushels for Kherson and 20.2 bushels for Red Texas. With the barleys, the Common Six Row and Common California have proved to be the best.

Irrigation Investigations. The most profitable yields of cereal crops were obtained with two irrigations—one in the winter, applying 6 inches to wet the subsoil, and the second irrigation of 4 to 6 inches applied as the wheat forms in the boot. With forage crops, a winter irrigation and two summer irrigations seemed preferable, but a total of 12 inches of water produced the most profitable yields. Alfalfa required an irrigation for each cutting.

The table which follows presents data showing the costs and profits of irrigation where water has to be pumped 130 feet. The crops given were the only ones irrigated on a field

scale. The cost of production given is the actual cost at the station for labor and irrigation water. Horse labor is not included. Labor is calculated upon the basis of the wages paid to each man and the time spent upon a given field. Irrigation water is calculated on the basis of the number of acre feet used on a field, at the rate of \$3.13 per acre foot.

The following prices were assumed in computing the value of crops: alfalfa hay, \$7 per ton; wheat, 89 cents per bushel; oats, 40 cents per bushel; oats straw, \$2 per ton; Sudan seed, 10 cents per pound; Sudan straw, \$2 per ton; Sudan hay (first cutting), \$3.50 per ton; and Sudan hay (second cutting), \$7 per ton.

IRRIGATION COSTS AND VALUE OF CROPS PRODUCED, 1915.

Crop.	Acreage	Acre feet.	Cost.			Yields, per acre.		Value crop.	Profit.
			Water.	Labor.	Total.	Grain, bu.	Stover, tons.		
Alfalfa	15	1.42	\$4.33	\$5 32	\$12 70		3 22	\$22 54	\$9 84
Winter wheat	8	1 03	3 25	9 17	12 42	28 37		25 25	12 83
Oats	5 5	1.28	4.00	12 25	16 25	66 30	1 47	29 46	13 21
Sudan	6	0 24	0 78	10.33	11 11	1,361 ^a	1 39	16 38	5 27
Sudan	7 8	0.99	3 10	19 9 1	14 01		4 4	18 79	4 78

^aPounds.

Cost of Pumping. Seventy-five acre feet of water were pumped into the irrigation well during the year. The cost of pumping per acre foot (when based on the actual fuel, oil and repairs used) was as follows:

Fuel	\$1.95
Oil29
Engine repairs22
Pump repairs67
Total	\$3.13

This is a reduction of \$2.43 per acre foot since last year.

COLBY BRANCH EXPERIMENT STATION.

A dairy herd of six high-grade Ayrshire cows and a pure-bred Ayrshire bull was purchased for the Colby Station in the fall of 1915. The herd is necessary in order to utilize the roughage and grain produced at the station and at the same time to demonstrate the advisability of keeping a small dairy herd on each farm in western Kansas.

The studies in moisture conservation, prevention of wind erosion, and rotations adapted to the soil and climatic conditions of northwestern Kansas, have been continued in cooperation with the Department of Agriculture. Of the sixteen varieties of corn tested, Freed's White Dent, Pride of Saline, Ford County White and Bloody Butcher were the highest-yielding varieties, ranging from 42.6 bushels to 39.7 bushels, in the order named. The corn matured and was cut on October 20. The first killing frost occurred on October 4.

Kanred, the wheat bred at the Manhattan Experiment Station, yielded slightly better than the local Turkey wheat. The yields were 34.25 and 33.66 bushels, respectively. The small difference in the yields may have been due to the fact that the annual precipitation was 31.8 inches as compared to the normal, 17.09 inches. The spring wheats yielded well this season, Bearded Fife producing 30 bushels and Black Macaroni 31.4 bushels per acre.

Seventeen varieties of sorghums were tested for grain and forage production. Owing to heavy rains at planting time, which caused the soil surface to crust, full stands were not obtained. Almost all of the varieties were cut before the first killing frost, and Red Amber was the only one which matured good seed. Freed Sorgo, Western Orange and Sudan grass matured seed of inferior quality.

During the year more than seven hundred visitors were received at the station, and 2,500 persons attended the farmers' institute held on October 18 and 19. Coöperation is maintained with the Colby high-school superintendent, in order that the students in agricultural classes may become familiar with the methods of soil handling, cropping, and the yields obtained with these various treatments.

TRIBUNE BRANCH EXPERIMENT STATION.

The experiments at the Tribune Station have for their object the adaptation of early-maturing varieties of crops and their seed-bed preparation. The crops under cultivation are the grain and forage sorghums, wheat, potatoes, millet, beans, sweet clover, cane, and Sudan grass. In connection with variety tests of these crops, there have been conducted rate, date, and spacing tests. Some selection and breeding have been carried on with the best-producing varieties.

The total rainfall during the year was 33.34 inches, which was twice the normal amount; consequently all crops yielded well regardless of varieties and cultural treatment. Sixty varieties of sorghums were grown during the 1915 season, but owing to the early frosts only the very early-maturing varieties produced grain. These varieties were Freed's White cane, Red Amber, Black Amber, Dakota Amber, and Minnesota Amber. These produced from 15 to 20 bushels per acre. Pink kafir, the Amber and Orange sorghums and Schrock kafir produced the heaviest tonnage of forage, ranging from 8 down to 5.8 tons per acre. In methods of seed-bed preparation for sorghums, all results were in favor of early preparation. Fallow is not considered advantageous for sorghum crops. On fallow the maturity of sorghum crops is retarded. In broadcast planting of sorghums for forage, best results were obtained by double-rowing with the corn planter, making the rows 21 or 22 inches apart. Sudan grass being exclusively a hay crop, it is recommended that this sorghum be planted as early as possible and cut twice during the season when the crop is well along in bloom. A finer hay and heavier tonnage will be produced by this method.

Summer fallow for wheat has proved the only method to insure a crop except the partial fallow system of wheat or double-spaced corn stubble. For a summer-tilled system, a listed fallow is superior to the plowed fallow. In 1915, Turkey wheat grown in a rotation of sorghum, fallow, wheat, produced 22.2 bushels per acre. Other tests of alternate fallow only produced yields of 10 and 5 bushels on listed and plowed fallows.

Corn varieties are tested out each year after winter wheat in a four-year rotation of sorghums, fallow, wheat, corn. This crop can not be classed with the drouth-resistant crops, but favorable yields are frequent enough to warrant giving it a place in diversified farming. Following are the varieties, among the twenty-nine tested, which produced best and their yields:

	Bushels per acre.
Nebraska Calico	64.4
Cassel's White Dent.....	62.2
Moore's Calico	63.0
Freed's White Dent.....	61.9
Towner White Dent.....	61.2

In average years, corn on a fallow seed bed has produced 31 bushels per acre, and corn after wheat 20.4 bushels. Experi-

ments in the double spacing of corn—that is, planting the rows 84 inches apart instead of 42 inches—have given larger yields than single spacing in average years. This season, however, the single-spaced corn yielded so well that the three-year average yields for both methods are the same, 27.2 bushels per acre.

Both the Mexican and the Tepary bean have yielded about 8 bushels per acre for three seasons. They offer promise of being profitable crops. The most promising varieties of potatoes for this section are New York Rurals, Pearl, Green Mountain, Triumph, and Irish Cobbler. These varieties yielded from 73 to 115 bushels per acre this season.

DODGE CITY BRANCH EXPERIMENT STATION.

During the 1915 season the station was conducted only as a demonstration farm, except for variety tests of corn and sorghum and work on bindweed eradication. All other experimental work carried on in former years was discontinued.

The season was exceptionally favorable for corn and the forage crops. The dry fall of 1914 prevented the sowing of wheat, consequently none was produced on the station. The ground which was prepared for wheat was seeded to oats in the spring of 1915 and a good crop was produced. The rainfall throughout the season was twice the normal amount. The prevailing cool weather prevented the maturing of the sorghums at the usual dates. However, good crops of Pink kafir, feterita, and Red Amber sorghums were produced. The Red Amber sorghum grown for silage was especially good.

The grain grown on the station was pure and yields for the season were as follows: seven acres of oats produced 400 bushels; five acres of Pink Amber, 150 bushels; and fifteen acres of feterita, 325 bushels. Of the eighteen varieties of sorghums tested, Western Orange and Red Amber are the best forage varieties for this section. Pink kafir is a good grain crop in average seasons and Yellow milo produces well where chinch bugs do not infest it. Of the varieties of corn tested, the western varieties yielded 51 bushels per acre and the eastern varieties yielded only 35 bushels per acre.

Sudan grass grown for seed in cultivated rows 44 inches apart, seeded at the rate of six pounds per acre, yielded 400 pounds per acre. Two acres of Sudan grass, seeded May 1 at the rate of 22 pounds per acre, furnished continuous pasture

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from June until November for twenty head of hogs and four calves. The Sudan grass was more satisfactory than the sweet sorghum which had been used in the same pasture previous years. Another field of Sudan grass, planted at the rate of 22 pounds, produced 6,500 pounds of field-cured hay per acre. After being cut it was pastured for the remainder of the season.

In a study of the eradication of bindweed, eight different rates of applications of salt have been made upon a bindweed infested area. The rates varied from three tons to twenty tons per acre. The work indicates that ten tons of salt to the acre are sufficient to kill the weeds provided the small spots where weeds grow up are resalted.

Dairy. The dairy herd was increased nine head during the year, and the increase in value of the herd was \$340. The cash income from milk and cream sales was \$219.95 from ten milk cows.

Hogs. The nine head of hogs on hand January 1, 1915, were increased to 27 head by December 1, 1915, in addition to 21 head of stock hogs and two fat hogs, which were sold. Besides the cash income of \$159.50 from sales of hogs, the increase in value of the herd was \$170. The hogs were fed separated milk in addition to the small amount of grain produced upon the station, and were pastured on Sudan grass and oats.

Buildings. A pit silo 12 by 20 feet, with a 3½-foot collar 6 inches thick, was built at a cost of \$108.22. Of this amount \$50 was expended in the construction of the collar, which is the portion above the ground.

Financial Report.

The Kansas Agricultural Experiment Station, in account with Federal and State Appropriations, 1915-1916.

	Federal Appropriations.	State Appropriations.	Totals.
Manhattan station	\$30,000.00	\$40,000.00	\$70,002.86
Branch stations		44,088.63	44,088.63
Cooperative experiments		7,500.00	7,500.00
Branch station, farm products			23,337.85
			\$144,929.39
Salaries	\$18,393.67	\$21,823.91	\$40,222.58
Labor	5,138.29	33,461.55	38,599.84
Publications	21.16	532.91	554.07
Postage and stationery	62.82	1,108.82	1,171.64
Freight and express	91.69	1,169.75	1,252.44
Heat, light, water, power	142.30	1,002.59	1,144.89
Chemicals and laboratory supplies	1,043.94	965.20	2,019.14
Seeds, plants, sundry supplies	886.47	6,077.23	6,973.70
Fertilizers		124.41	124.41
Feeding-stuffs	2,151.14	5,096.34	7,247.48
Library	5.40	334.79	340.19
Tools, machinery, appliances	159.04	3,135.29	3,294.33
Furniture and fixtures		770.28	770.28
Scientific apparatus and specimens	905.38	731.66	1,637.04
Livestock	120.91	17,666.95	17,787.86
Traveling expenses	232.81	2,850.13	3,082.94
Buildings and land	585.18	2,903.16	3,488.34
Contingent expenses	49.50	680.22	730.02
Balance		14,498.20	14,498.20
Totals	\$30,000.00	\$114,929.39	\$144,929.39

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, 1916; 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.

Methods of Controlling Blackleg Developed by the Kansas State Agricultural College.

By L. W. Goss.

The veterinary department of the Kansas State Agricultural College began a series of experiments in 1912 to increase the efficiency of the blackleg vaccine which the College had been making. The department was led to undertake these investigations because of the losses which were occurring from blackleg following the use of the old spore vaccines, administered in powder or pill form. The work was under the direction of Dr. F. S. Schoenleber, with Dr. O. M. Franklin and Dr. T. P. Haslam in charge.

The first phase of the investigations involved an extensive and critical test of the strength and composition of the spore-containing vaccines produced by the leading laboratories of the United States and Europe. This work extended over a period of two years and a summary of the results was published in *The Journal of Infectious Diseases*.¹ It was found that spore vaccines were at best more or less unreliable because of the narrowness of the range of virulence between a good and a poor vaccine; that is, between a vaccine that will immunize and one that will kill. It was found, also, that the degree of susceptibility of calves varied greatly, which decreased the efficiency of the spore vaccines. As a result of this work the department succeeded in increasing the efficiency of its vaccine to a small degree. This investigation shows the weakness of spore vaccines, while the work done by Kitt, Leclainche and Vallee, Grassberger and Schattenfroh, Foth, and others gave encouragement for the production of an immune serum, which had been tried in an experimental way. As a result of further investigations, covering an additional period of three years, a serum has been produced from the horse which will stop immediately the losses in a herd in which calves are dying from blackleg. Also, a germ-free fluid vaccine or aggressin has been produced from calves, which when used upon healthy calves will produce a more durable immunity against blackleg.

1. Vol. 19, No. 3, September, 1916, pp. 408-415.

BLACKLEG SERUM.

In the preparation of blackleg serum, pure cultures of *B. chauvæi* are grown upon a liver bouillon brain infusion. The culture medium is inoculated from a test tube of stock culture, then grown for twenty-four hours, and passed through gauze. This material is injected intravenously into the jugular vein of a horse in increasing doses, beginning with 50 cc., followed at intervals of seven to ten days with 150, 250, 400 and 400 cc. doses. Nine days after the fifth injection about 20 cc. of blood is drawn from the jugular vein. This is allowed to clot. Fifty-five hundredths cc. of the clear serum is injected subcutaneously into each of three guinea pigs. About fifteen hours after this the guinea pigs are injected subcutaneously with 125 mg. of dried, finely ground muscle from a blackleg lesion of a calf. If none of the three guinea pigs dies within the three following days, the horse is bled upon the third day. The blood is drawn from the jugular vein into sterile 2½-inch glass tubes, 20 inches high. Weights are placed upon the clot within from two to three hours after bleeding. The following day the clear serum is poured off, and after the addition of one-half percent of phenol it is filtered through an infusional earth filter. The filtrate is then bottled and tested for sterility. Upon the second day serum is again poured from the tube.

Each horse is bled 1,200 cc. to each 100 pounds of weight. Ten days after bleeding the horse is again injected with 400 cc. of culture and again tested in nine days. Should the blood fail to be potent, as is true in about 20 percent of the cases, the horse is again injected with 400 cc. of culture on the third day following the test. Some horses will produce a potent serum following one injection after bleeding, while others require two or three injections. The injections are sometimes followed by local and general disturbances, resulting in some cases in the death of the horse.

The following table shows the time and amount of injection of cultures in one case:

TABLE I.

March 8	50 cc. cultures of <i>B. chauvæi</i> .
March 16	150 cc. cultures of <i>B. chauvæi</i> .
March 24	250 cc. cultures of <i>B. chauvæi</i> .
March 31	400 cc. cultures of <i>B. chauvæi</i> .
April 7	400 cc. cultures of <i>B. chauvæi</i> .

April 16, 20 cc. of blood was drawn. Fifty-five hundredths cc. of the serum was injected into each of three 12-ounce guinea pigs. Fifteen hours later they were injected with 125 mg. of dry muscle virus, 2 mg. of which would kill a guinea pig not protected with serum. All three of the guinea pigs survived the test. April 19, 13,400 cc. of blood was drawn from this horse.

In the production of serum from three to eight horses are bled at the same time. The serum from all horses bled at one time is mixed prior to filtration.

The following table shows the protective properties of blackleg serum upon calves:

TABLE II.

Number of calf.	Date of injection of serum.	Dose (serum).	Date of infection of virus.	Dose (virus).	Results.
712	2-16-'15	20	2-20-'15	450	No symptoms.
19	2-16-'15	22	2-20-'15	250	No symptoms.
25	2-16-'15	20	2-20-'15	450	No symptoms.
43	2-16-'15	15	2-20-'15	250	No symptoms.
331	2-16-'15	15	2-20-'15	1000	No symptoms.

The foregoing table shows that 15 to 20 cc. protected the five calves against infection from the 250 to 1,000 mg. doses of virus. This amount of virus will kill most calves which have not been protected previously. The test shows that a serum which will protect guinea pigs in doses of .55 cc. against 125 mg. of muscle virus will protect calves in doses of 15 to 20 cc. of serum against 250 to 1,000 mg. of virus.

The material is an anti-blackleg serum, and therefore will produce only a passive immunity. In order to produce active immunity the serum must be followed in three days with a virus. From experiments and field observation it is deemed unwise to administer virus in doses exceeding 4 to 8 mg., as the susceptibility of calves varies greatly.

The virus is made up in pellet form. The pellets weigh from 4 to 5 mg. each. They are made by selecting the darkest meat from a blackleg lesion of a calf. This is ground and passed through an 80-mesh sieve. It is then made into pellets with a pill machine, after which the pellets are attenuated at 60° C. for one hour to kill all nonspore-forming organisms which might be present.

As shown by Table II, blackleg serum produces within five

days an immunity in calves which will protect them against large doses of virus. Observations in the field show that in nearly every case serum will stop death from blackleg within twenty-four hours after it is administered. On that account serum treatment is valuable for use upon infected herds. Blackleg serum has curative properties when administered in large doses. An injection of 150 cc. of serum will cure blackleg if the calf is treated in the early stages of the disease. Recoveries have taken place in about 50 percent of the cases treated.

The serum and pellet vaccine produced by the College has been used upon about 60,000 animals in the past eighteen months. During this time information has been received of the death of twelve animals upon six farms. These deaths occurred in the earlier tests. These instances of loss might suggest that pellets used after serum are not of sufficient strength to give immunity that will protect all animals. However, the percentage of loss is small, and the immunity is remarkably good when compared with the immunity produced by use of other biologics.

GERM-FREE FLUID VACCINE.

Germ-free fluid vaccine, a tissue aggressin, is made by the inoculation of calves with muscle virus in doses of one gram, or by the use of 20 to 30 cc. of pure cultures of *B. chauvæi*. After the death of the calf the affected tissue is removed, ground, frozen, thawed, and drained, then filtered through infusorial earth filters. The filtrate is bottled after the addition of one-half percent of phenol or one percent of chloroform, and is then tested for potency and sterility. Three guinea pigs are each given 10 cc. of the vaccine, subcutaneously. They are kept under observation for four days to determine whether the material contains pathogenic organisms or toxin. Should any one of the guinea pigs die the material is condemned, although it may have passed the sterility test required by the Bureau of Animal Industry of the Department of Agriculture.

One of the most difficult problems in the production of these vaccines is the obtaining of filters which will remove the various microorganisms with which the material becomes contaminated prior to filtration. The material is also difficult to filter because of the high content of albumins.

Table III shows the protective properties of germ-free fluid vaccine given in 8 cc. doses.

TABLE III.

Number of calf.	Weight.	Date of vaccination.	Dose aggressin.	Date test dose.	Size test dose.	Result.
	<i>lbs.</i>		<i>cc.</i>		<i>mg.</i>	
325	300	7-3-'15	8	7-27-'15	1	No symptoms.
307	300	7-3-'15	8	7-27-'15	1	No symptoms.
311	325	Not vaccinated	7-27-'15	1	Died blackleg (7-29-'15).

It is seen that the vaccine protected calves against a dose of virus which killed a nonvaccinated calf.

The station has sold over 50,000 doses of germ-free fluid vaccine. Field reports indicate that it produces within three days an immunity of high degree and long duration. A standard potency test has not been adopted. The field use of 50,000 doses indicates that it has been highly potent. At present tests are being made which may show, when completed, the average degree of potency to be expected.

There are several problems in connection with the production of these vaccines which require additional study. Further investigations are under way at the present time.

CONCLUSIONS.

Blackleg Serum.

1. Blackleg serum is curative in the early stages of the disease.
2. It will check outbreaks within twelve to twenty-four hours.
3. The use of virus pellets on the third day following the injection of serum produces an active immunity.

Germ-free Fluid Vaccine.

1. It is toxic.
2. It will not cure blackleg.
3. It produces immunity within four to five days after injection.
4. The immunity is of much longer duration than that produced by the powder or pill form of vaccine. The length of immunity conferred by the germ-free fluid vaccine has not yet been determined.

Use of Serum, Serum and Pellets, and Germ-free Fluid Vaccine.

1. Serum should be used upon animals with symptoms of blackleg.
2. Serum and pellets should be used upon herds in which losses are occurring at the time of vaccination.
3. Germ-free fluid vaccine should be used as an annual vaccination upon calves at weaning time or earlier, should conditions indicate necessity.

