

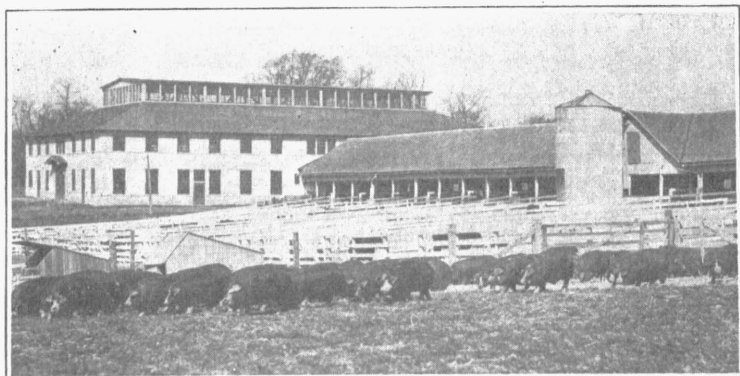
UNIVERSITY OF MISSOURI COLLEGE OF AGRICULTURE
AGRICULTURAL EXPERIMENT STATION
BULLETIN 163

WORK AND PROGRESS

OF THE

Agricultural Experiment Station

For the Year July 1, 1917, to June 30, 1918



Carload of purebred Poland China hogs fed by the Missouri Agricultural Experiment Station. Average weight at beginning of feeding period, 117.8 pounds. Average weight after 98 days feeding, 297.7 pounds. Average daily gain, 1.83 pounds. Feed per pound of gain, 4.75 pounds. Experimental cattle feeding sheds with lots and the live stock judging pavilion in the background.

COLUMBIA, MISSOURI
MAY, 1919

UNIVERSITY OF MISSOURI

COLLEGE OF AGRICULTURE

Agricultural Experiment Station

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STATION STAFF

- J. W. Connaway**, D.V.S., M.D., Veterinary Science
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C. H. Eckles, M.S., D.Sc., Dairy Husbandry
W. C. Etheridge, Ph.D., Farm Crops
W. H. Lawrence, M.S., Horticulture
M. F. Miller, M.S.A., Soils
M. N. Beeler, B.J., B.S.A., Publications
G. M. Reed, Ph.D., Botany
E. A. Trowbridge, B.S.A., Animal Husbandry
P. F. Trowbridge, Ph.D., Agricultural Chemistry
J. C. Whitten, Ph.D., Horticulture
H. O. Allison, M.S., Animal Husbandry
Leonard Haseman, Ph.D., Entomology
O. R. Johnson, A.M., Farm Management
H. L. Kempster, B.S.A., Poultry Husbandry
E. W. Lehman, B.S. in A.E., Farm Mechanics
L. S. Backus, D.V.M., Veterinary Science
O. S. Crisler, D.V.M., Veterinary Science
R. M. Green, B.S.A., Farm Management
Howard Hackedorn, B.S.A., Animal Husbandry
L. D. Haigh, Ph.D., Agricultural Chemistry
C. A. Helm, A.M., Farm Crops
R. R. Hudelson, A.M., Soils
E. H. Hughes, A.M., Assistant to Director
H. F. Major, B.S.A., Landscape Gardening
E. M. McDonald, B.S., Farm Crops
C. R. Moulton, Ph.D., Agricultural Chemistry
L. S. Palmer, Ph.D., Dairy Chemistry
E. C. Pegg, M.F., Forestry
L. G. Rinkle, M.S.A., Dairy Husbandry
L. A. Weaver, B.S.A., Animal Husbandry
W. A. Albrecht, M.S., Assistant, Soils
E. L. Dakan, B.S.A., Assistant, Poultry
F. L. Duley, A.M., Assistant, Soils
A. J. Durant, A.M., Assistant, Veterinary Science
M. H. Fohrman, B.S.A., Assistant, Dairy Husbandry
- G. W. Hervey**, B.S., Assistant, Poultry Husbandry
T. H. Hopper, A.B., Assistant Agricultural Chemistry
H. H. Krusekopf, A.M., Assistant Soil Survey
H. F. Libbey, B.S.A., Assistant, Veterinary Science
C. E. Mangels, M.S., Assistant, Agricultural Chemistry
S. R. Miles, B.S., Assistant, Animal Husbandry
L. W. Morley, Assistant, Dairy Husbandry
H. G. Newman, B.S.A., Assistant, Veterinary Science
I. F. Nuckols, B.S.A., Assistant, Animal Husbandry
V. T. Payne, A.B., Assistant, Agricultural Chemistry
W. S. Ritchie, B.S.A., Assistant, Agricultural Chemistry
J. T. Rosa, Jr., M.S.H., Assistant, Horticulture
John B. Smith, A.M., Assistant, Farm Crops
L. J. Stadler, B.S.A., Assistant, Farm Crops
K. C. Sullivan, A.M., Assistant, Entomology
W. W. Swett, A.M., Assistant, Dairy Husbandry
Percy Werner, Jr., A.M., Assistant, Dairy Husbandry
C. C. Wiggins, A.M., Assistant, Horticulture
George Reeder, Director Weather Bureau
Rachel E. Holmes, A.B., Seed Testing Laboratory
J. G. Babb, M.A., Secretary
R. B. Price, B.S., Treasurer
Edith Briggs, Stenographer
J. F. Barham, Photographer
Turner H. Brink, Herdsman, Animal Husbandry
C. A. Easterly, Herdsman, Dairy Husbandry

*As of 1917-18.

To His Excellency,
HONORABLE FREDERICK D. GARDNER,
Governor of Missouri.

Sir:

In accordance with the provisions of the Federal Hatch Act establishing agricultural experiment stations and approved March 2, 1887, I am submitting herewith a report of the activities and progress of the Agricultural Experiment Station of the College of Agriculture of the University of Missouri for the year ending June 30, 1918.

This Act provides that, "It shall be the duty of each of said stations annually, on or before the first day of February, to make to the Governor of the State or Territory in which it is located a full and detailed report of its operations, including a statement of receipts and expenditures, a copy of which report shall be sent to each of said Stations, to the said Commissioner (now Secretary of Agriculture) and to the Secretary of the Treasury of the United States." This report attempts to give in condensed form a brief statement concerning each important project which has been in progress during the year, coming under the administrative direction of this Division. Several new projects have been begun and a few important projects have been completed. Prior to June 30, 1918, at least ten men on the Station staff were granted leaves of absence and others resigned to enter military service.

Respectfully submitted,

F. B. MUMFORD,
Director.

The Missouri Agricultural Experiment Station

F. B. MUMFORD

The Agricultural Experiment Station, in common with all other scientific and educational institutions, has been influenced in its policy and work by the war emergency. The Director of the Missouri Agricultural Experiment Station was appointed Chairman of the Missouri Council of Defense on April 24, 1917. In October, 1917, his responsibilities were further increased by accepting the appointment of Federal Food Administrator for Missouri. The activities incident to the administration of these two war organizations made it necessary to so organize the affairs of the Experiment Station that the major portion of the time of the Director could be devoted to the above named war enterprises. During this period Mr. M. F. Miller, Professor of Soils, has served as Assistant to Dean and Director. The excellent progress of the Station during the trying period of the war is in large measure due to the wisdom, energy and fine enthusiasm of Professor Miller.

The fundamental value of the work of the Experiment Station has been demonstrated in connection with the many increased production campaigns that have been organized in this State. It was found possible immediately to suggest to farmers the most certain methods for increased production and in every case the recommendations were based upon careful investigations conducted thru a series of years by this Station. In a number of Departments, special emergency investigations were made with the view to solving problems arising from the changed conditions incident to national and international necessity.

A considerable number of men on the Experiment Station staff were engaged directly in the military service. It may be said that every man in the Experiment Station rendered a real national service either in connection with food production, conservation or preservation.

ADDITIONS TO EQUIPMENT

The equipment of the Experiment Station has been strengthened somewhat during the year by the addition of the following:

(4)

Three farm lighting systems for testing purposes and one dynamometer to be used in connection with the work of the Agricultural Engineering Department.

The Department of Entomology has put out a small nursery at Columbia in order that they may better study some of the more common pests of nursery stock.

Apparatus for determining the temperature, fertilizer, moisture and exposure to anaesthetics have been installed by the Department of Horticulture to aid in their investigational work.

Minor additions to the equipment of other departments have been added during the year.

CHANGES IN THE STATION STAFF

NEW APPOINTMENTS

- L. L. Alexander, A.M., Assistant in Farm Crops
- O. S. Crisler, D.V.M., Superintendent of Serum Production
- E. L. Dakan, B.S., Assistant in Poultry Husbandry
- Wm. DeYoung, B.S., Assistant in Soil Survey
- R. W. Elliott, B.S., Assistant in Agricultural Chemistry
- M. H. Fohrman, B.S. in Agri., Assistant in Dairy Husbandry
- T. H. Hopper, A.B., Assistant in Agricultural Chemistry
- J. A. Machlis, B.S. in Agri., Assistant in Soil Survey
- S. R. Miles, B.S., Assistant in Animal Husbandry
- L. W. Morley, B.S., Assistant in Dairy Husbandry
- I. F. Nuchols, B.S., Assistant in Animal Husbandry
- V. T. Payne, A.B., Assistant in Agricultural Chemistry
- Phil Ronzone, B.S., Assistant in Agricultural Chemistry
- J. T. Rosa, Jr., M.S.H., Assistant in Horticulture
- Sam B. Shirkey, B.S. in Agri., Assistant in Agricultural Chemistry
- L. J. Stadler, A.M., Assistant in Farm Crops
- K. C. Sullivan, B.S. in Agri., Deputy Nursery Inspector
- Clifton R. Thomson, B.S., Assistant in Animal Husbandry
- B. C. Zimmerman, A.M., Research Assistant in Animal Husbandry

RESIGNATIONS

- P. M. Brandt, A.M., Assistant to Dean and Director
- Willis B. Combs, B.S. in Agri., Assistant in Dairy Husbandry
- A. H. Hollinger, A.M., Deputy Inspector of Nurseries
- Helen Johann, A.M., Research Assistant in Botany
- E. W. Knobel, A.M., Assistant in Soil Survey

J. A. Machlis, B.S. in Agri., Assistant in Soil Survey
 S. R. Miles, B.S., Assistant in Animal Husbandry
 L. W. Morley, B.S. in Agri., Assistant in Dairy Husbandry
 I. F. Nuckols, B.S. in Agri., Assistant in Animal Husbandry
 V. T. Payne, A.B., Assistant in Agricultural Chemistry
 Clifton R. Thompson, B.S., Assistant in Animal Husbandry
 L. W. Wing, B.S., Assistant in Dairy Husbandry
 J. C. Whitten, Ph.D., Horticulturist

ON LEAVE OF ABSENCE FOR MILITARY SERVICE

A. J. Durant, A.M., Assistant in Veterinary Science
 G. W. Hervey, B.S., Assistant in Poultry Husbandry
 J. H. Hopper, A.B., Assistant in Agricultural Chemistry
 R. R. Hudelson, A.M., Assistant Professor of Soils
 O. R. Johnson, A.M., Professor of Farm Management
 C. E. Mangels, A.M., Assistant in Agricultural Chemistry
 E. M. McDonald, B.S., Assistant Professor of Farm Crops
 J. B. Smith, A.M., Assistant in Farm Crops
 L. J. Stadler, A.M., Assistant in Farm Crops
 Percy Werner, Jr., B.S. in Agri., Assistant in Dairy Husbandry

ON LEAVE OF ABSENCE

C. R. Moulton, Ph.D., Professor of Agricultural Chemistry
 H. H. Hackedorn, B.S. in Agri., Assistant Professor of Animal Husbandry

DISTRIBUTION OF PUBLICATIONS

Bulletins and circulars published by the Agricultural Experiment Station form one of the natural channels thru which the findings of the Station are given to farmers. These publications are distributed free of charge. Persons who desire to receive the publications as they are issued may have their names placed on the free mailing list. The mailing list now contains 13,909 names. About two-thirds of the bulletins and circulars published are sent to the persons whose names are kept on the regular mailing list. The remainder are sent in response to individual requests from farmers of Missouri and other states.

Names will be added to the mailing list upon application to the Director, Agricultural Experiment Station, Columbia, Missouri. Publications of the Agricultural Extension Service are distributed in the same manner as those of the Experiment Station.

The demand for publications of the Agricultural Experiment Station and of the Agricultural Extension Service has been increasing from year to year. The demand during the last year has been greater than ever before. In this demand is reflected a desire on the part of farmers to use the findings of the Experiment Station in their efforts to increase production. Wartime necessity has, therefore, induced farmers to use their Station and Extension Service.

While the mailing list has been increased by 940 names, this number does not account for the increased distribution of publications. It has been found during the year that ordinary editions of new publications are not sufficient to supply the permanent mailing lists and the daily requests as long as these same editions did a year or two ago. There has been an increased demand also for the older publications, and it has become necessary to reprint many of these. Stocks of publications on hand, the editions for which were calculated to supply the demand for the probable period of usefulness of the publications, have been so depleted by this large demand that new editions will have to be printed at an early date. Requests for bulletins received from farmers indicate that information on livestock, poultry, control of insect pests and diseases, fruit growing, fertilizers, and general farm crops, is especially in demand.

PUBLICATIONS

The Experiment Station published during the year 3 new circulars, 10 reprints of circulars, 8 new bulletins, 2 bulletin reprints, and 1 research bulletin. In addition to these, 53 issues of the Farm News Service were sent to the daily and weekly papers of Missouri, and 53 issues of the Agricultural Copy Service were sent to farm papers of Missouri and the United States. These two news services are designed to supply timely farm news to the newspapers and farm papers. They are used widely, and thru them the College of Agriculture reaches more than a million persons each week. In spite of the great demand for newspaper space, in spite of the space which newspapers themselves have used in reporting the great events of the last year, in spite of the vast quantity of copy which newspapers have been receiving from various sources, there has been an increased use of these farm news services which the College has been sending out.

The Agricultural Extension Service published 31 circulars, 1 project announcement, and cooperated with the Experiment Station in financing the issues of the news services.

NEW CIRCULARS

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|-------------------------------|----------------------------|
| 83. The Home Vegetable Garden | 85. The Farmers' Beef Club |
| 84. How to Keep Farm Accounts | |

REPRINTS OF CIRCULARS

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|---|--|
| 41. Directions for Testing Milk on the Farm | 65. Advantages from Use of Pure Bred Ram |
| 44. Feeding for Milk Production | 71. Putting Shock Corn in the Silo |
| 47. Raising Calves on Skim Milk | 74. The Yellow Color in Cream |
| 63. Inspection Service, Control of Insects Pests and Plant Diseases | 75. The Farmers' Poultry House |
| | 78. Control of Soil Washing |
| | 80. Missouri Poultry House |

NEW BULLETINS

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| 148. Soil Experiments on Ozark Upland | 151. How the Experiment Station Works |
| 149. Preparation of Corn for Fattening Steers | 152. Cost of Horse Labor on the Farm |
| 150. Corn Silage With and Without Shelled Corn in Rations for Fattening Steers | 153. The Soils of Missouri |
| | 154. Fertilizer Inspection |
| | 155. Meat Scrap and Sour Milk for Egg Production |

BULLETIN REPRINTS

- | | |
|---|--------------------------------|
| 115. Rations for Fattening Western Yearling Sheep | 120. Rations for Breeding Ewes |
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NEW RESEARCH BULLETINS

28. Effect of Limited Food on Growth of Beef Animals

NEW EXTENSION CIRCULARS

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|--------------------------------------|--|
| 23. Drying Fruits and Vegetables | 41. Principles of Sewing |
| 24. Crops for Overflowed Lands | 42. Hog Butchering and Pork Curing |
| 25. War Breads | 43. Profitable Dairy Herds Thru Cow Testing |
| 26. The Story of a Backyard Flock | 44. How to Select and Store Household Linens |
| 27. Work of a Farmers' Exchange | 45. How to Cook Soybeans and Cowpeas |
| 28. Fertilizers for Wheat | 46. How to Save Fats |
| 29. Growing Wheat in Missouri | 47. How to Save Sugar |
| 30. Farm Cheesemaking | 48. How to Test Seed Corn |
| 31. Farming on a War Basis | 49. Water Systems for Farm Homes |
| 32. Silos and Silage | 50. Cottage Cheese Making |
| 33. Community Livestock Breeding | 51. Selection and Management of the Dairy Bull |
| 34. Tile Drainage | 52. Canning by the One-Period Cold Pack Method |
| 35. Pickles and Relishes | |
| 36. Sweet Clover | |
| 37. Hogging Down Corn | |
| 38. Farm Buildings for Missouri | |
| 39. Farm Lighting Systems | |
| 40. The Emergency Agricultural Agent | |

NEW PROJECT ANNOUNCEMENTS

11. Extension Schools in Agriculture

SYNOPSIS OF THE YEAR'S EXPERIMENT STATION PUBLICATIONS

A brief summary of the Agricultural Experiment Station publications which have been issued during the year is given in the following paragraphs. This summary attempts to record in briefest form the important contents of each publication. Copies of these publications, as long as the supply lasts, may be obtained by writing to the Director, Agricultural Experiment Station, Columbia, Missouri.

The Home Vegetable Garden, J. C. Whitten (Missouri Experiment Station Circular 83 (1918) pp. 22).—This circular deals with the kind of soil best adapted to garden purposes, the preparation of the soil, the arrangement and cultivation of the garden. It also contains information on fertilizers, hotbeds and cold frames, and culture of garden crops.

How to Keep Farm Accounts, R. M. Green and D. C. Wood (Missouri Experiment Station Circular 84 (1918) pp. 28, figs. 11).—This circular shows that farm accounts are necessary (a) as a basis for planning business operations, (b) to determine costs of production, (c) to secure the most advantageous loan, and (d) to make a correct income tax report. It gives details of how the farmer may keep accounts of stock, crops, real estate, labor, equipment, general farm, trading, bills I owe, and bills owed me. The system of accounting outlined in the circular does not meet all the requirements of technical cost accounting. It omits some of the more tedious details. Its main purpose is to enable the farmer to find his net income and with the aid of labor records and feed records to determine, in the case of a few of his most important enterprises, whether the net income from those enterprises covers the cost of labor at a fair rate, interest on investment, equipment charge, and the value of feed fed.

The Farmers' Beef Club, P. F. Trowbridge (Missouri Experiment Station Circular 85 (1918) pp. 32, figs. 37).—This circular explains how a farmers' beef club is operated, and how the beef is slaughtered under farm conditions. It tells how the club cuts are made, how the wholesale cuts are made, and how to preserve the beef in warm weather. Illustrations show how and where the cutting is done.

Soil Experiments on the Ozark Upland, M. F. Miller and F. L. Duley (Missouri Experiment Station Bulletin 148 (1917) pp. 28, figs. 7).—This bulletin reports the results of experiments in soil management begun in 1910, near St. James, Mo., on Gerald silt loam in the non-timbered parts of the Ozark region and forms one of a series of such studies on various soil types thruout the state. The plan of the experiment embraces a four-year rotation of corn, soybeans, wheat, and clover grown alone and under different soil treatments, including the use of legumes, barnyard manure, lime, rock phosphate, bone meal, and potash. Tabulated data are presented and discussed, showing the results obtained with each crop separately, and the cost of production and the monetary returns from the different soil treatments.

Barnyard manure showed the highest net return for any one fertilizing material—\$7.07 per acre annually, or \$3.54 per ton for an 8-ton application once in four years. Eight tons of barnyard manure and 1,000 pounds of rock phosphate, applied to clover stubble and plowed under, showed the highest annual net return for any combination of treatments, \$4.49 per acre. Bone meal netted \$2.43 annually, rock phosphate \$0.72, and potash \$1.88 per acre. Lime applied at the rate of 2 tons per acre at the beginning of a 6-year period was profitable, but the legume treatments alone have not been profitable.

Recommendations for soil management, based on the results obtained in these experiments, are outlined in detail. The main features are a system of livestock farming in which little grain is sold and all the manure carefully returned to the land, the manure to be supplemented with ground limestone raw rock phosphate, bone meal, acid phosphate, or a highly phosphatic mixed fertilizer, and a small amount of potash (when prices are normal) applied in the course of a systematic crop rotation.

Preparation of Corn for Fattening Two-Year-Old Steers, H. O. Allison (Missouri Station Bulletin 149 (1917) pp. 35, figs. 11).—The investigations reported in this bulletin were made to determine the most effective form in which corn can be fed to two-year-old steers. The trials were made with 90 head of two-year-old steers. Thirty head of cattle in 5 lots of 6 each were used each season thruout a period of three years.

To rations made up of a nitrogenous concentrate, corn silage, and legume hay, there was added for Lot 1 broken ear corn, Lot 2 shelled corn, Lot 3 crushed corn and cob, Lot 4 corn-and-cob meal, and Lot 5 ground corn. The nitrogenous concentrate consisted of cottonseed meal or cake and the legume hay, alfalfa for the first and third periods and clover for the second. As nearly as possible the proportion of corn to the nitrogenous concentrates was kept at 6 pounds of the former (shelled basis) to 1 pound of the latter. Pigs weighing from 100 to 125 pounds followed the cattle to utilize the feed which would otherwise have been wasted. There were 4 pigs in Lots 1 and 2, 3 in Lot 3, and 2 in Lots 4 and 5.

Lot 5 (ground corn) brought the highest price per pound, while Lot 4 (corn-and-cob meal) stood second, and Lot 2 (shelled corn) third. The higher price, however, was not enough to offset the reduced gain in weight per unit of feed and the expense of preparing the corn.

Corn Silage With and Without Shelled Corn in Rations for Fattening Steers, H. O. Allison (Missouri Experiment Station Bulletin 150 (1917) pp. 24, figs. 7).—Some of the results obtained from two years' experiments in fattening steers by the use of corn silage as a maximum, and shelled corn and protein concentrates as a minimum, ration are reported in this bulletin. The first trial, made from December, 1915, to May, 1916, covered 133 days; the second from December, 1916, to May, 1917, covered 130 days. The feeders were of good grade bought on the Kansas City market, and after fattening were sold on the Chicago market. The lots in the first trial consisted of 6 steers each, those in the second trial of 8 each. The results were based on the following prices: First trial, feeders \$7.64 per 100 pounds, corn 70 cents per bushel, corn silage \$4.50 per ton, cottonseed meal and linseed oil meal \$37 per ton, and alfalfa hay \$14 per ton; second trial, feeders \$.45 per 100 pounds, corn \$1.50 per bushel, corn silage \$8.50 per ton, cottonseed meal and linseed oil meal \$45 per ton, and alfalfa hay \$15 per ton.

The records for Lots 3 and 4 (without shelled corn) indicate the possibility of fattening from three to four steers per acre with corn fed as silage. While the average daily gain was not so large as when shelled corn was added to this ration, it was satisfactory. The value of protein concentrates was shown by the record for Lot 4, which produced gains at the lowest cost. Lot 3, with cottonseed meal in the ration, stood second. The linseed meal ration, as compared with the cottonseed meal rations, showed a greater net profit per steer, and the gain made by hogs following the cattle was also greater. The results indicate that the difference in the market price of the cattle was not sufficient to justify the feeding of shelled corn in the first trial, but in the second it was justified with corn at \$1 per bushel and silage at \$6 per ton, but not with \$1.50 corn and \$8.50 silage.

The results of the two trials indicate that it is ordinarily advisable to add a high protein concentrate to a ration of shelled corn, corn silage, and alfalfa hay for fattening cattle.

How the Station Works, F. B. Mumford (Missouri Experiment Station Bulletin 151 (1917) pp. 68, figs. 12).—This bulletin is the annual report of the Director and covers briefly the work of the Station, the publications

of the Station and the Extension Service, and a financial statement of the Station for the year ended June 30, 1917.

Seventeen new appointments were made to the Station Staff during the year and fifteen resignations were accepted. A list of publications including new bulletins and circulars, research bulletins, and press bulletins is given. Four Station projects were completed, fifteen new ones were added, and ninety-four begun prior to July 1, 1916, were continued during the year.

At the end of the year the soils of forty-four Missouri counties had been surveyed in detail. Callaway, Barry and St. Francois counties were completed during the year, and the survey of Texas county was about half completed. Fertilizer control, nursery inspection, cow testing work, anti-hog-cholera serum manufacture and distribution, and work of the seed testing laboratory are summarized.

A brief report of the soil and crop experiment fields is given. Experiments have been conducted on more than half the soil types of the state. Fifteen soil fields were in operation thruout the year. One field was discontinued in the fall of 1916, and no new fields were added. Three crop experiment fields were conducted thruout the year and one field was discontinued during the year.

Cost of Horse Labor on the Farm, O. R. Johnson and R. M. Green (Missouri Experiment Station Bulletin 152 (1918) pp. 32, figs. 8).—This bulletin contains the results of records kept on the cost of horse labor on representative farms in Missouri. In 1912, records were kept on 6 farms; in 1913, on 9 farms; in 1914, on 20 farms; and in 1915, on 24 farms. The diary used contained three classes of records pertaining directly to the farm business—labor records, financial records, and feed records, besides a record of farm products used, and other miscellaneous information.

It was found that, exclusive of depreciation, the average cost of keep per head of 75 farm work horses during 1912-13 was \$92.33; of 113 head for 1914, \$95.58; and of 132 head for 1915, \$86.63, or an average for the whole period of \$91.22. The average rate of appreciation on work horses from 1 to 5 years old is 16.56 per cent per year; while the depreciation on those from 5 to 12 years old is 7.17 per cent per year. The actual depreciation on the work horse herd as a whole is materially lessened, if not eliminated, by keeping a good proportion of young work stock that is appreciating in value.

The cost of feeding, as a rule, made up 72 per cent of the total cost of keeping a farm work horse. Farms on which the feed cost per head ran lowest (average \$45.69 per head) fed an average of 10.3 bushels of oats per head of work stock, while farms on which the feed cost per head ran highest (average \$93.25 per head) fed an average of 41.6 bushels of oats per head of work stock. Of the 20 farms with the lowest feed cost per head, only six fed oats, bushel for bushel or in large proportion, with corn; while of the 18 farms with the highest feed cost per head, eleven followed this practice. Farms which used corn for grain and no oats had an average feed cost of \$58.79 per head and received approximately the same amount of work from their horses as farms which fed oats almost pound for pound with corn at a feed cost per head of \$71.56.

The average amount of labor per horse of 1912-13, 1914 and 1915 was 1165 hours, 1164 hours, and 1127 hours respectively. The heaviest working of horses with the most liberal feeding or the lightest working with approximately a maintenance ration did not in general prove as economical from the viewpoint of horse labor cost as medium work on a moderate ration. From the viewpoint of economy, experience seems to warrant keeping sufficient work stock on a general farm in this region so that each horse will not have more than an average of 1400 to 1500 hours of work, but it will not warrant a large enough supply to make the average amount of labor per horse less than 800 hours. Records on the farms in this study indicate that mules do more work on a given cost than either geldings or mares, and likewise geldings do more work than mares.

Indications (July, 1917) are that the ratio between the price of corn and the price of oats that has existed the last several years will be changed so that feeding oats to work stock in considerable quantities will be an economical practice temporarily.

The Soils of Missouri, M. F. Miller and H. H. Krusekopf (Missouri Experiment Station Bulletin 153 (1918) pp. 132, figs. 59).—This bulletin contains information on the origin, distribution, character and crop adaptations of the various soil areas of the state, as determined by field and laboratory studies and by field experiments. Descriptions of the twenty-eight main types of soils are given in detail. Statistical data on Missouri farms are given graphically in maps and diagrams. A color soil map, illustrating the location of twenty-seven main types of soil, is appended.

Inspection of Commercial Fertilizers, 1917, P. F. Trowbridge (Missouri Experiment Station Bulletin 154 (1918) pp. 44, fig. 1).—This bulletin contains the actual and guaranteed analyses and valuations of 596 samples of fertilizers, representing 181 different brands. These samples were collected from 227 localities in 58 counties in Missouri during 1917. Twenty-three manufacturers registered a total of 427 brands of fertilizers for sale in Missouri as compared with 27 manufacturers and 473 brands for 1916. Of the 427 brands registered for sale, inspectors found samples of only 181 brands.

As to the relative valuation of 1917 of 475 samples analyzed, 116 showed a valuation below the manufacturer's guarantee. This is 24.4 per cent of the samples analyzed, as compared with 15 per cent for samples analyzed in 1916; 35.5 per cent for the samples analyzed for 1915; and 38.4 per cent for the samples for 1914. The total samples analyzed for 1917 showed an average valuation of \$1.58 per ton above the manufacturer's guarantee. For 1916 this average increased valuation was \$1.83 per ton; for 1915 it was \$0.53 per ton, and 1914, \$0.57 per ton. The average valuation was below the guarantee for one manufacturer in 1917, for one manufacturer in 1916, for three manufacturers in 1915, and for six manufacturers in 1914.

Meat Scrap and Sour Milk for Egg Production, H. L. Kempster and G. W. Hervey (Missouri Experiment Station Bulletin 155 (1918) pp. 16, figs. 4).—Results of tests to determine the relative efficiency of animal proteins thru experiments with meat scrap and sour milk, and vegetable proteins, represented by oil meal, gluten meal and cottonseed meal, in rations for egg production are given in this bulletin. A series of tests which were reported in Circular 79 extended from November 1, 1914 to October 31, 1915. The second test which was reported in Circular 82 extended from November 1, 1915 to October 31, 1916. A comparison is made between results obtained at the Missouri Station and those obtained at several other stations by feeding protein supplements of vegetable origin. These experiments indicate that protein supplements of animal origin are more efficient in egg production than protein supplements of vegetable origin. Another series of experiments was conducted from November 1, 1916 to October 31, 1917 in which meat scrap, cottonseed meal and gluten meal alone and in combinations supplied the basal protein.

Effect of Limited Food Supply on the Growth of the Young Beef Animal, P. F. Trowbridge, C. R. Moulton, and L. D. Haigh (Missouri Experiment Station Research Bulletin 28 (1918) pp. 129, figs. 26).—Three groups of steers were fed to determine the effect of limited food supply on the growth of young beef animals. The supermaintenance group which was fed to gain one-half pound per day included Steers 593 and 599. The maintenance group, which included Steers 597 and 595, was fed to produce no change in the weight of the animal. The submaintenance group included Steers 591 and 592 and was fed to lose one-half pound per day. One steer, 594, was slaughtered as a check animal. The same ration was supplied to all animals. The only variation was in quantity. Four-tenths as much alfalfa hay as grain was fed. The grain consisted of eight parts corn chop and one part linseed meal.

Steers 597, 591 and 593 were slaughtered after six months; 592 was slaughtered after eleven months; 595 was slaughtered after twelve months; and 599 was discarded after sixteen months. The following conclusions were drawn:

All animals grew in height and length, with scarcely a perceptible retarding of growth at first. Later the submaintenance animals appeared to stop growing.

When a fat yearling steer is held at body weight maintenance for one year, his maintenance cost in nutrients per thousand pounds of animal is only slightly less the first six months than the second six months. During the first period the impetus to growth causes the addition of flesh and skeleton. Fat must be consumed to maintain constant weight, thus supplementing the ration. During the second period the impetus to grow is less, there is more active tissue to maintain than there is less available fat, hence the increased demand for food to maintain body weight. During the first 188 days Steer 595 cost in nutrients 8.06 pounds per day per thousand pounds; during the second period, 8.20 pounds.

During the first 188 days for the two steers (591 and 592) on submaintenance one pound loss in weight effected a saving of 1.9 pounds of nutrients for 591 and 2.8 pounds for 592. During the second period of 139 days one pound loss in weight effected a saving of 4.5 pounds of organic nutrients. For the total period of 327 days, 3.7 pounds of organic nutrients were saved by each pound of weight lost.

During the first period of 188 days one pound gain in Steers 593 and 599 cost 2.6 and 3.6 pounds of organic nutrients respectively above the cost of maintenance. For the second period the cost was 2.0 pounds and the average for 362 days was 3.0 pounds. In the growing animal the cost of gain above the calculated maintenance requirement appears to decrease during the second year of the animal's life.

ARTICLES BY MEMBERS OF THE STAFF FOR TECHNICAL PUBLICATIONS

AGRICULTURAL CHEMISTRY

"The heone bases of some flesh proteins," by W. E. Thrum and P. F. Trowbridge. *Journal of Biological Chemistry*.

"The bromination of the hydrolysates of some beef flesh proteins," by W. E. Thrum and P. F. Trowbridge. *Journal of Biological Chemistry*.

DAIRY HUSBANDRY

"The Influence of the Stage of Gestation on the Composition and Properties of Milk," by L. S. Palmer and C. H. Eckles. *Journal of Dairy Science* I, pp. 185-198, 1917.

"The Composition and Market Qualities of Butter When Corn Silage is Fed with Cottonseed Meal," by L. S. Palmer and D. S. Crockett. *Journal of Dairy Science* I, pp. 235-245, 1917.

"Influence of the Age of the Cow on the Composition and Properties of Milk and Milk Fat," by C. H. Eckles and L. S. Palmer. *Journal of Agricultural Research* XI, pp. 645-658, 1917.

"Milk as a Galactagogue," by L. S. Palmer and C. H. Eckles. Submitted to and accepted by the *New York Medical Journal*, April 26, 1918.

"The Relation of *Oidium Lactis* and *Penicillium* to the Keeping Qualities of Butter," W. B. Combs and C. H. Eckles. *Journal of Dairy Science*, I, pp. 347-355, 1917.

"A plan for Controlling the Milk Supply of the Small Town," Percy Werner, Jr. *Journal of Dairy Science* I, pp. 284-289, 1917.

ENTOMOLOGY

"This Missouri Nursery Inspection Service," by L. Haseman. *Journal of Economic Entomology*, Vol. II, No. 1, Feb., 1918.

"Bee keeping at the University of Missouri," by L. Haseman. *American Bee Journal*, Vol. LXVIII, No. 6, June, 1918.

"Taxonomic Value of Antennal Segments of Certain Coccids," by A. H. Hollinger. *Annals of the Entomological Society of America*, Vol. 10, No. 3, Sept. 1917.

HOME ECONOMICS

"Recent Advances in our knowledge of Digestion and Absorption," by Louise Stanley. *American Journal Home Economics* 9 (1917) 65.

"Recent Contributions to our Knowledge of Food Preparation," by Louise Stanley. *American Journal Home Economics*. 9 (1917) 537.

SOILS

"Changes in the Nitrogen Content of Stored Soils," by W. A. Albrecht. *Journal American Society of Agronomy*, Vol. 10, No. 2, pp. 83-88, Feb., 1918.

PROGRESS OF INVESTIGATIONAL WORK AT COLUMBIA

EXPERIMENT STATION PROJECTS

All of the investigational work in the Agricultural Experiment Station is organized by departments. The investigational work within the department is organized by projects. Before an experiment can be undertaken by any department a complete plan of the investigation including a statement of the reasons for such investigation is filed with the Director. This plan includes a statement of the probable cost, time required for its completion, and person or persons who are to conduct the investigation. If the investigation is approved it becomes an authorized project of the Agricultural Experiment Station.

At the end of the fiscal year covered by this report each Experiment Station project was given a permanent number. By means of this system of numbering the records of the different projects in the Director's office can be kept much more easily, and the relationship of the various minor phases of certain projects to the major project can be better shown. The number assigned to each project appears in the left-hand margin in the following list. Hereafter, when a new project is approved, it will be assigned a number, which will identify it thruout its existence.

The investigational projects now in progress in the Agricultural Experiment Station are listed below. The name of a project gives little information as to the real character and extent of the investi-

gation. Among the projects listed, many are of the greatest fundamental significance. A few would more properly be classed as minor projects.

PROJECTS BEGUN PRIOR TO JULY 1, 1918, AND STILL IN PROGRESS

1. An Investigation of Sanitary Conditions on Farms and Experiments to Determine Best Types of Sanitary Equipment.
2. Investigations to Determine the Draft of Different Farm Implements and the Cost of Different Operations with Them.
3. Fertilizer Control.
4. Age as a Factor in Animal Breeding.
5. Factors Influencing the Normal Rate of Growth in Domestic Animals and the Permanency of the Effects of Arrested Development. (Animal Husbandry and Agricultural Chemistry.)
6. A study of the Effect of the Periods of Gestation and Lactation Upon the Growth and Composition of Swine.
7. Use of Nitrogenous Concentrates and Heavy and Light Rations of Silage for Fattening two-year-old Steers.
8. Rations for Pigs at Weaning Time.
9. Forage Crops for Pork Production.
10. Corn Silage as a Part Ration for Horses of Various Ages.
11. A study of the Residual Effects of Forage Crops for Swine.
12. Maintenance of Brood Sows.
13. Fall Forage for Fattening Lambs.
15. An Investigation of Forest Tree Diseases.
16. A Systematic and Physiological Study of Rusts.
17. Grain-Smut Investigation and Control.
18. Micro-Organisms in Silage.
19. An Investigation of Watermelon Diseases Found in Southeast Missouri.
- 20a. Factors Influencing the Normal Composition of Milk—The Cause of the Counteracting Influence of Corn Silage When Fed with Cottonseed Meal.
- 20b. Factors Influencing the Normal Composition of Milk—The Influence of the Condition of Parturition on the Composition of Milk and Butter Fat.
- 21a. Influence of the Nutrition of Heifers and the Age of Breeding Upon Their Subsequent Development—Normal Growth.
- 21b. Influence of the Nutrition of Heifers and the Age of Breeding Upon Their Subsequent Development—Protein Requirements for Growth.
23. Silage Investigations.
24. A Study of the Factors Causing Fishy Flavor in Butter.
25. Cheese Making Under Missouri Conditions.
26. Official Testing of Dairy Cows.
27. A Study of the Heat Coagulable and Water Soluble Proteins of Cow's Milk.
28. Nursery Inspection.
29. Injurious Insect Pests of Melon and Related Crops.
30. An Investigation to Determine the Life History, Development and Habits of the Corn Ear Worm and Practical Methods of Controlling It.
31. An Investigation of Methods for Controlling the Chinch Bug.
32. An Investigation to Determine the Cause of the Periodical Recurrence of Insect Pests as Scourges.
33. An Investigation of the Hessian Fly Resistant Qualities of Wheat.
34. An Investigation to Determine What Insects Are Injurious to Nursery Stock in the State. Their Life Histories, Distribution, Injury and Methods of Control.

35. An Investigation to Determine How Sapsucking Insects Injure Plants.
36. The Annual Cycle of the Hessian Fly in Missouri and Its Control.
37. A Study of the Life Cycle of the Codling Moth and the Best Time and Method of Applying Insecticides For Controlling It.
38. A Study of the Adaptation of the Important Types, Varieties and Regional Strains of Alfalfa to Missouri Conditions.
39. Corn Breeding Investigations to Determine to What Extent the Yield of a Commercial Variety of Corn May be Increased by the Selection of High Yielding Strains by the Ear to Row Method.
40. A Study of the Cultural Requirements and Adaptations of Sudan Grass.
41. A Study of Certain Spring, Summer and Fall Sown Crops for Forage.
42. Sweet Clover Investigations Including Varietal Studies, the Variation of Cumarin Content and Cultural Experiments.
43. A Study of the Adaptation of the Important Varieties and Selections of Soybeans to the Various Soil Types of the State.
44. Cultural Experiments with Soybeans Including Time of Seeding, Method of Seeding and Rate of Seeding.
45. Cultural Experiments with Cowpeas Including the Method of Seeding, Time of Seeding and Rate of Seeding.
46. A Study of the Adaptations of the Important Varieties and Selections of Cowpeas to the Various Soil Types of the State.
47. Comparison of Soybeans and Cowpeas for Hay and Seed Production.
48. A Comparison of the Most Important Grain Sorghums with corn for Grain and Forage Production.
49. Investigation with Spanish Peanuts to Determine the Value of Peanuts as a Crop in the Southeast Missouri Lowlands.
50. A Study of the Adaptation of the Important Varieties of Cotton to the Southeast Missouri Lowlands.
51. Cultural Experiments with Cotton, Including Fertilizer Tests.
52. Cultural Experiments with Alfalfa to Determine the Adaptation and the Best Methods of Obtaining a Stand of Alfalfa on the Various Soil Types of the State.
53. A Study of the Adaptations of the Important Varieties of Spring Barley to Missouri Conditions.
54. Investigations with Winter Barley including Variety Tests and Methods of Improvement.
55. A Study of the Adaptations of the Important Varieties of Corn to Missouri Conditions.
56. Cultural Experiments with Corn, Including the Rate of Planting, Methods of Preparing Sod Land and Stubble Land, Depth of Plowing and Subsoiling, Methods of Cultivation and Planting.
57. Influence of Environment Upon the Development of the Wheat Plant.
58. A Study of the Inheritance of Quantitative Characters in the Wheat Plant.
59. Cultural Experiments with Wheat Including Methods of Preparing the Seedbed and the Rate of Seeding.
60. A Study of the Adaptations of the Important Varieties of Wheat to Missouri Conditions.
61. A Study of the Important Varieties of Oats for Missouri Conditions.
62. Investigation with Winter Oats Including Variety Tests and Improvement.
63. Wheat Breeding Investigations Including the Improvement of Commercial Varieties by the Pure Line Method of Breeding the Hybridization and Subsequent Selection.
64. Cultural Experiments with Oats Including Methods of Preparing the Seedbed and the Rate of Seeding.
65. Experiments with Sorghum, Sudan Grass and Spanish Peanuts for Forage.
- 66a. Farm Management Survey.
- 66b. Farm Management Survey—The Cost of Family Living on the Farm.

- 66c. Farm Management Survey—Systems of Renting Land and Rent Rates.
67. Farm Cost Accounting.
68. The Distribution of Farm Labor.
70. Deadening White Oak Pole Wood.
71. A Working Plan for a Portion of the Experiment Station Woodlot.
72. A Study of the Methods of Prolonging the Service of Wood Fence Posts.
73. An Investigation of the Method of Culture and Varieties of Basket Willows for Missouri.
74. The Effect of Blanching in the Canning of Some Typical Crops of Vegetables.
75. A Study of the Factors Influencing the Rest Period of Horticultural Plants.
76. The Nutrition of Fruits with Special Reference to their Hardiness and Resistance to Disease.
77. Bud Selection for Increasing Yields—Apples.
78. Peach Breeding for Hardy Sorts.
79. Asparagus Selection.
80. Self Fertility and Self Sterility of Fruits.
81. Examination of Buds in Winter for Forecasting Probable Bloom.
82. Treatment of Apple Canker Diseases.
84. Fruit Bud Development of Fruit Trees as Influenced by Treatment and Previous Crops.
85. Apple Breeding for Late Blooming Habit.
86. Orchard Tillage—Sod, Clean Cultivation, Mulch, Combined Cultivation and Cover Crops.
87. Drying and Evaporating Fruits and Vegetables.
88. Investigation in Mendelian Inheritance.
89. The Value of Sour Skim Milk and Beef Scrap, Cottonseed Meal, Gluten Meal and Oil Meal in Rations for Egg Production.
90. The Value of Sour Skim Milk and Beef Scrap in Rations for Growing Chicks, and the Cost of Growing Chicks.
91. Age as a Factor in Poultry Breeding.
92. Crop Rotation and Fertilizer Experiments.
93. Studies of Water Absorption, Run Off, Percolation, Evaporation, Capillary Water Movement and Soil Erosion Under Field Conditions.
94. An Investigation Having to do with the Development of the Various Parts of the Maize Plant and Influenced by Variation in Soil Moisture, Soil Composition and Texture and the Supply of Plant Food. (Soils and Farm Crops.)
95. The Rate of Accumulation of Nitrogen and Carbon in Soils under Different Systems of Green Manuring and Rotation.
96. Determination of the Relative Values of Different Forms of Phosphorous upon the soil at Columbia.
97. An Investigation of the Effect of the Various Systems of Cropping and Manuring upon the Soil and Subsoil.
98. An Experiment for Determining the Proper Fineness of Grinding Limestone for Agricultural Purposes and the Rates and Methods of its Application to an Acid Soil.
99. Experiments to Determine the Best Systems of Soil Management for the Most Important Soil Types in Missouri. (Soil Experiment Fields.)
100. An Experiment to Determine the Interrelations of Corn and Cowpeas as a Nitrogen Metabolism, Soil Moisture, Conservation and Yield.
101. Studies on the Longevity of *B. Radicicola* in the Soil.
102. Nitrate Production in the Soil as Affected by the Crop and Cultivation.
104. The Effect of Cowpea Land Handled in Various Ways on the Growth of Wheat following.
105. The Determination and Mapping of Missouri Soils. (Soil Survey.)

107. The Effect of Different Amounts and Different Methods of Applying Commercial Fertilizer to the Corn Crop.
108. An Experimental Study of Hog Cholera and Factors Concerned in Immunity Against the Disease.
109. Contagious Abortion Investigations. (Veterinary Science and Dairy Husbandry.)
110. Hog Cholera Serum Manufacture and Distribution.

PROJECTS COMPLETED

- Factors Influencing the Normal Composition of Milk—Influence of Feeding Cottonseed Meal and Byproducts.
 Winter Rations for Dairy Heifers.
 Corn and Cob Meal, Linseed Meal and Oat Straw as a Wintering Ration for Farm Work Horses.
 Relation of Better Preparation of Feeding Stuffs and Different Methods of Feeding upon the Rate and Economy of Gain put on by Fattening Swine.
 The Effect of Storage Condition on the Vitality of the Forest Tree Seeds. Fall vs. Spring Planting of Trees.
 Studies on the Nitrogen Content of Soils as Affected by Storage.

PROJECTS DISCONTINUED

- Factors Influencing the Normal Composition of Milk—The Influence of Feed Reduction and Other Factors in causing High Fat Tests with Officially Tested High Producing Cows.
 A Fundamental Study of the Physiological Relation of the Powdery Mildeews to their Hosts.
 Problems of Management Causing a Reduction of Acreage for 1918 and the Extent of such Reduction if any.
 The Effect of the Addition of Organic Matter to Soils Upon the Development of Soil Acidity.

DEPARTMENT REPORTS IN THE PROGRESS OF INVESTIGATIONS

An annual record of the progress of investigations in connection with the various authorized projects of the Agricultural Experiment Station is desirable. It not only has great historical value, but also presents a view of the various activities of the entire Agricultural Experiment Station organization. It is a definite attempt to place on record the important progress of the research activities of the Station. It is believed that by reading the following account of the progress of investigation during the year, one may gain an intelligent notion of the important problems which are receiving the attention of the Station staff. It must be remembered that the reports included here do not give a complete record of all the progress that has been made or all the work that has been done during the year. Much progress is frequently made on many investigations of such an indefinite nature as to be recorded with difficulty.

The reports of progress are compiled from the reports made by the chairmen of departments to the Director. The relation of the

individual members of the station staff to the various projects is indicated in the text.

AGRICULTURAL CHEMISTRY

Factors influencing the normal rate of growth of domestic animals and the permanency of the effects of arrested development (P. F. Trowbridge, L. D. Haigh, W. S. Ritchie, T. H. Hopper).—This project is conducted in cooperation with the Department of Animal Husbandry. Three groups of steers are being fed. The steers in Group 1 received food for a maximum growth without fattening. Those in Group 2 are being fed to gain at the rate of fifteen pounds a month. Those in Group 3 are being fed to gain at the rate of ten pounds a month.

One animal of each group was on full feed during the year. Group 1 fed out at 1423 pounds, Group 2 at 1221 pounds. Animals from both groups were apparently in the same condition, making choice carcasses.

Steer 520, Group 1, required 4.152 kilos of digestible nutrients for each pound of live weight. Steer 587, Group 2, required 3.751 kilos of digestible nutrients for each pound of live weight.

The Group 3 steer, No. 583, at time of slaughter of the other two weighed only 931 pounds, and was judged to lack 60 to 90 days of being finished. At that time each pound of live weight required 4.113 kilos of digestible nutrients. This steer did not gain well, going off feed at attempts to crowd. He did not reach a condition approximating the other two until March, 1918. He weighed 1240 pounds when slaughtered and had used 4.644 kilos of digestible nutrients for each pound of gain.

Administration (P. F. Trowbridge, L. D. Haigh, L. S. Palmer, C. R. Moulton, W. S. Ritchie, T. H. Hopper, R. W. Elliott).—The Department of Agricultural Chemistry does the routine chemical work of the Station, consisting of analyses of soils, fertilizers and food stuffs. The analytical work required by various departments is conducted by this department. In addition a large amount of routine analysis in connection with fertilizer control and with the work of the department itself is carried on.

AGRICULTURAL ENGINEERING

An investigation of sanitary conditions on farms and experiments to determine the best types of sanitary equipment (E. W. Lehmann).—This investigation has been started near Fayette in

Howard County in a community which is very much interested in modern improvements and agricultural advancement. The work has been carried on in cooperation with C. C. Taylor of the Department of Sociology of the University.

A social, economic and sanitary survey is being made. Data have been collected on about forty farms to date. The feature of the work which has not been completed is the collecting of samples of water for sanitary analysis.

From the information collected, it is found that: (1) Few farmers have adequate means for taking care of household wastes, and altho this community is really above the average, not one home has a complete sanitary equipment; (2) practically no modern water supply systems are installed; (3) houses and out buildings are not properly screened and are neglected; (4) most of the farmers can afford a modern water system and sewerage disposal plant; (5) they lack information relative to simple, inexpensive systems; and (6) the convenience most wanted by the housewife for the farm home is a running water supply.

Few other modern conveniences, such as lighting systems and heating systems, are in use. The fact that the mortality records of the total registration area of the United States show that the death rate from typhoid in rural districts varies from 15 to 35 per 100,000, while the death rate in our encampments is only 1 per 100,000 indicates that this phase of rural life is sadly neglected.

Since the capacity for work or the efficiency of the individual depends on his health, the farmer would do well to have conditions in the home such as would be conducive to good health.

As further work on this project, tests have been started on a few electric light plants to determine the cost of operation and efficiency. This work is not yet complete.

ANIMAL HUSBANDRY

Age as a factor in animal breeding (F. B. Mumford, B. C. Zimmerman). Factor 80, representing the eighth generation of the immature group farrowed her first litter October 23, 1917, at the age of ten months. During the year 77 pigs were farrowed and 59 were raised.

The pen of barrows in the accompanying photograph were selected from the third litter of factor 60 and represent the seventh generation of continued early breeding. This litter averaged 39 pounds per head at eight weeks of age and attained 250 pounds in

200 days. The litter had the run of bluegrass pasture and consumed 3.91 pounds of grain per pound gain.



Barrows under six months, at International Live Stock Exposition, 1917. Seventh generation from continuous early breeding.

The influence of different systems of management upon the cost of producing pork (L. A. Weaver).—The animals used on this project were purebred pigs farrowed in late spring 1917 by sows of similar breeding and were sired by boars which were litter brothers. Seventy-three head of these pigs (Lot 1) were full fed a ration of shelled corn 9 parts, shorts 2 parts, tankage 1 part, for 161 days, or from weaning time, June 16, 1917, until they were ready for market, November 24, 1917. This lot was on pasture from June 16 until October 13. The average initial weight of the pigs in this lot was 34 pounds and the average final weight was 202.58. The average daily grain ration was 4.15 per head. The pigs gained on the average 1.05 pounds daily. It required 3.95 pounds of concentrated feed to produce 1 pound gain in live weight.

Approximately the same number of pigs made up Lot 2 of this project. They were on pasture until the end of the grazing season and were fed the same concentrated feed as were the hogs in Lot 1. The amount of concentrated feed given this lot while they were on pasture, however, was only one-half that eaten by the full-fed lot. In other words, the pigs in this lot were grown rather than fattened until the end of the grazing season, at which time they were put in a

dry lot and full fed until they were of approximately the same weight as the hogs in Lot 1, when they were marketed. This required 208 days, 155 days of which time they were on pasture.

The average initial weight of the pigs in Lot 2 was 34.3 pounds and the average final weight was 204.8 pounds. The average amount of concentrate eaten per pig daily was 3.36 pounds, while the average daily gain was 0.82 pounds. For this lot 4.09 pounds of grain were required to produce 1 pound gain in live weight.

These data indicate that with pigs of spring farrow there is a little difference in the amount of grain required to bring a hog to a marketable weight whether he is full fed from weaning to market or whether he is grown until a weight of 100 to 125 pounds has been reached and he is then full fed until the desired weight has been attained.

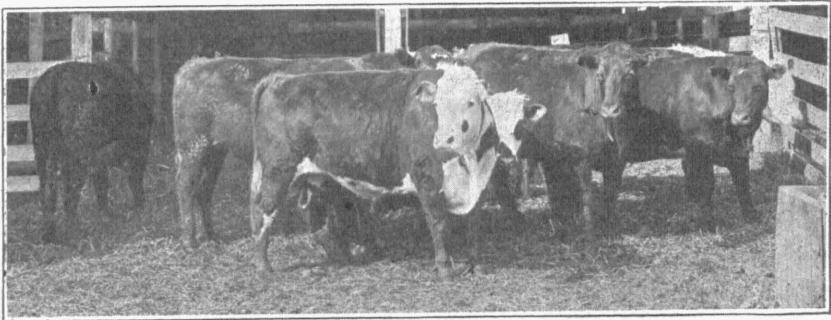
In this trial, 37 days more of time were required to make a 34-pound pig weigh 200 pounds when grown thru the summer and then fattened than when he was full fed for the entire feeding period.

Factors influencing the rate of growth in domestic animals and the permanency of the effects of arrested development (F. B. Mumford, B. C. Zimmerman).—Fourteen animals were on experiment during the year ending June 30, 1918. In accordance with the original plan of the experiment, Group 1 was fed so as to make a normal growth, while group 2 was fed to gain 0.5 pounds a day, and Group 3 to gain 1/3 of a pound a day. Steer 583, a Group 3 steer, was slaughtered March 25, 1918, at a weight of 1240 pounds. At the time of slaughter, this steer was three years and nine months old and had been full fed for approximately 20 months. Steer 580, which had been fed to gain 10 pounds a month previous to May, 1917, has been full fed since that time and now weighs 1060 pounds. Steer 528 has been fed to make a normal growth and now weighs 1180 pounds. Steer 597 in Group 2 has been allowed to gain 15 pounds a month and now weighs 842 pounds. Steers 585 and 586 belonging to Group 3 have been fed to gain 10 pounds a month and now weigh 584 and 590 pounds, respectively.

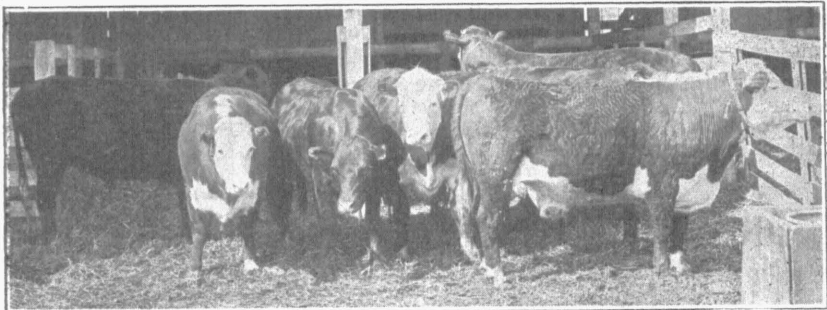
The calves mentioned in last year's report were given a period of preliminary feeding and placed on experiment August 1, 1917.

Heavy and light grain rations when fed in connection with corn silage and clover hay for fattening steers (H. O. Allison).—Forty-two head of two-year-old steers were fed for one hundred days beginning December 18, 1917, and ending March 27, 1918. They were divided into five lots of eight head each. The following rations were fed:

- Lot 1. Shelled corn (full feed)
Linseed oil meal (1 lb. to 6 lbs. of corn)
Corn silage
Clover hay
- Lot 2. Shelled corn (one-half feed)
Linseed oil meal (same quantity as fed to Lot 1)
Corn silage
Clover hay
- Lot 3. Shelled corn (full feed the last 70 days)
Linseed oil meal (same quantity as fed to Lots 1 and 2)
Corn silage
Clover hay
- Lot 4. Linseed oil meal (same as Lot 3)
Corn silage
Clover hay
- Lot 5. Linseed oil meal (average about 5 lbs. per head daily)
Corn silage
Clover hay



Experimental steers marketed April, 1918. Lot 4—Fed corn silage, linseed oil meal and clover hay.



Experimental steers marketed April, 1918. Lot 1—Fed shelled corn, linseed oil meal, corn silage and clover hay.

The results show that the largest average daily gain was made by cattle in Lot 1 which received full feed of corn thruout the feeding period. Their gain was 3.05 pounds per head daily. The average daily gain in Lot 2, which received half a ration of corn,

was 2.37 pounds and in Lot 3 which received corn in addition to the other feeds for the last forty days only, the gain was 2.45 pounds. Lot 4 which received the same amount of linseed oil cake as was fed to the first three lots, averaged 2.36 pounds per head daily, and Lot 5 averaged 2.29 pounds.

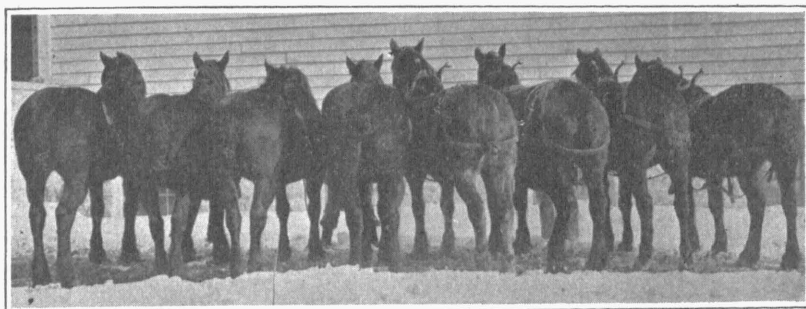
The gain upon the hogs in the various lots was largest where full feed of shelled corn was fed to the cattle, the amount of gain being 50.5 pounds per steer for the feeding period in this lot. In Lot 2 the hogs gained 30.21 pounds per steer, and in lot three the hogs gained 19.05 pounds. An attempt was made to keep the hogs in Lots 4 and 5, but as no feed was available they declined in weight and were removed after the first 60 days.

This is the third of a series of tests conducted at the University of Missouri in which two-year-old calves have been fed corn silage and nitrogenous concentrate and a legume hay. In each of these tests the cattle fed this ration have yielded a greater profit to the feeder than where shelled corn was fed in addition.

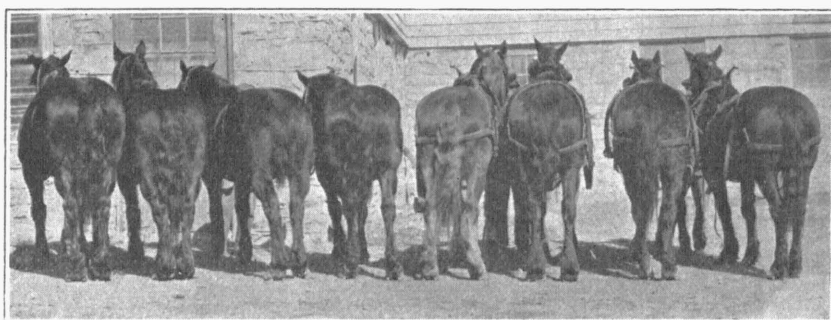
Corn and cob meal, linseed meal, and oat straw as a wintering ration for farm work horses (E. A. Trowbridge).—Since timothy hay and prairie hay have been considered standard as horse and mule feeds and since the cost of winter maintenance of these classes of animals is an important item on the average farm, this test was conducted with the idea of building a ration for horses doing ordinary winter farm work, with oat straw as a basis.

This experiment began on January 11, 1918, and the period during which oat straw was fed closed February 22, 1918, making a total of six weeks. The following data show average weight per horse at the beginning and at the close, the gain or loss in weight during the period, average daily feed consumed, and the average daily labor performed per horse.

Average initial weight.....	1439 lbs.
Average final weight.....	1415 lbs.
Average loss for period.....	24 lbs.
Average daily feed—	
Corn and cob meal.....	14.77 lbs.
Linseed oil meal.....	1.672 lbs.
Oat straw.....	14.34 lbs.
Average daily labor.....	5.553 hours



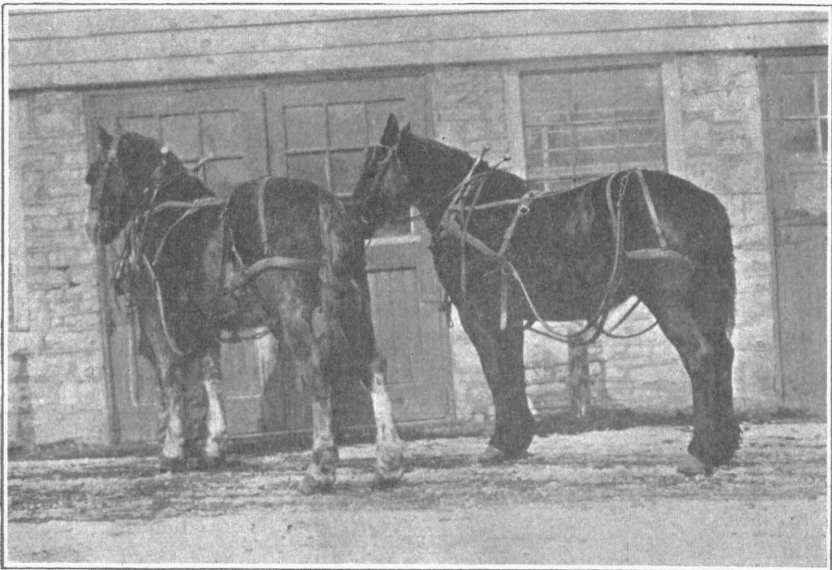
Corn and cob meal, linseed meal, and oat straw as a wintering ration for farm work horses. Purebred Percheron mares used in the test. Photo taken at beginning, January 11, 1918.



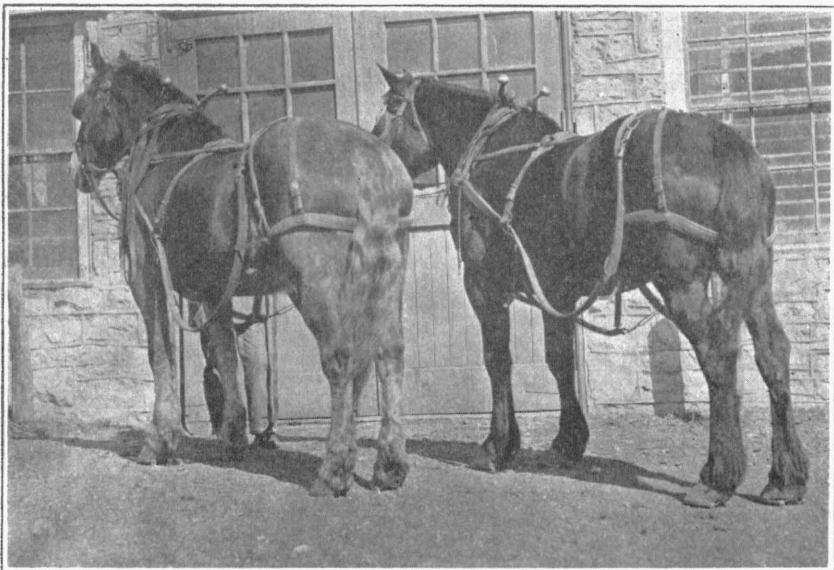
Same group of mares photographed at close of the winter feeding experiment, March 15, 1918.

At the close of this test mixed clover and timothy hay was substituted for the straw for the three weeks' period beginning February 22, 1918 and ending March 15, 1918. The daily feed for these horses consisted of corn and cob meal, linseed oil meal and mixed clover and timothy hay, for purposes of comparison. Data for this subsequent period similar to that presented above for the period during which the horses received oat straw, are presented:

Average weight at beginning.....	1415 pounds
Average weight at close.....	1404 pounds
Average loss per horse for period.....	11 pounds
Average daily feed—	
Corn and cob meal.....	15.42 pounds
Linseed oil meal.....	1.928 pounds
Clover and timothy hay.....	16.71 pounds
Average daily labor.....	6.916 hours



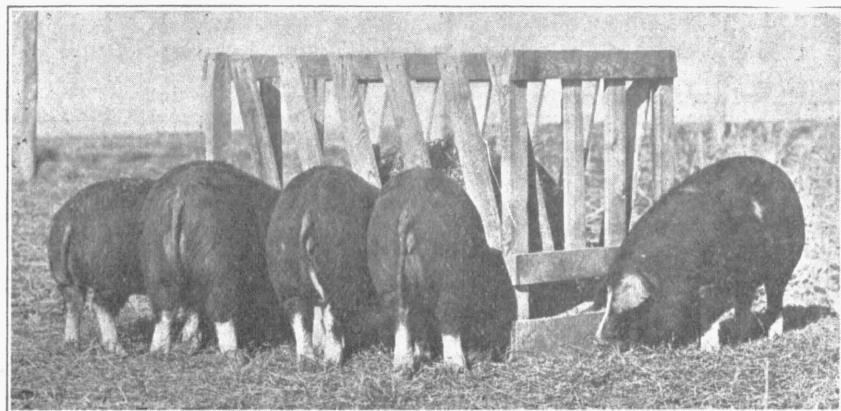
Corn and cob meal, linseed meal, and oat straw as a wintering ration for farm work horses. Team of purebred Percheron mares used in the test. Photo taken at beginning of the experiment, January 11, 1918.



Same team of mares photographed at close of the winter feeding experiment, March 15, 1918.

It will be observed that during the six weeks that these horses ate oat straw they showed an average loss in weight of 24 pounds. However, at the close of the experiment they were in satisfactory condition to begin the spring work.

It seems quite clear from this test that a ration of oat straw, corn and cob meal and linseed oil meal can be used very satisfactorily as a wintering ration for farm work horses.



Very little clover or alfalfa was wasted. The hays were fed in a homemade rack.



Plots where maintenance experiment was conducted, showing the methods of housing.

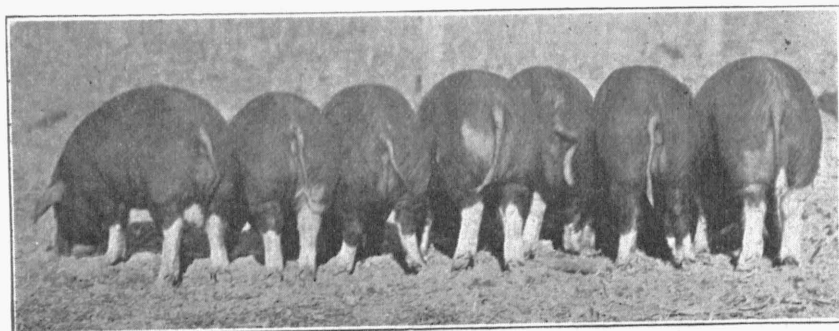
Maintenance of brood sows (L. A. Weaver).—This project was begun in December, 1916, with forty-two head of purebred Poland China gilts farrowed in late March and April of the previous spring. These gilts had been liberally fed on forage during the summer and fall. They were divided into six lots of seven hogs each, and all lots were handled in exactly the same manner except that a

different ration was fed. All lots were fed so that they were kept in good growing and breeding condition.

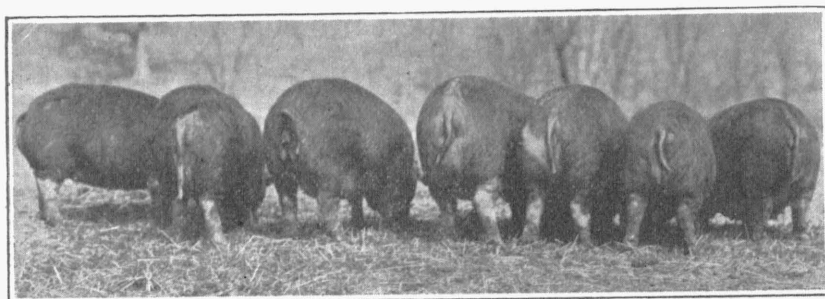
An effort was made to keep all lots at uniform weight. The average weight of the gilts in each lot at the beginning of the trial (December 17, 1916) was from 186.7 pounds to 188.2 pounds. The average weight of the gilts April 1, 1917, just before they began farrowing was 265.8 pounds to 270.5 pounds, showing a gain of approximately three-fourths of a pound per head daily during the winter period.

The average daily ration for the different lots was:

Lot 1. Corn 3.59 pounds	Lot 4. Corn 3.98 pounds
Tankage 0.35 pounds	Linseed oil meal 0.80 pounds
Alfalfa hay 2.14 pounds	Lot 5. Corn 3.42 pounds
Lot 2. Corn 3.87 pounds	Shorts 0.85 pounds
Tankage 0.38 pounds	Tankage 0.42 pounds
Clover hay 1.94 pounds	Lot 6. Corn 2.61 pounds
Lot 3. Corn 4.46 pounds	Shorts 1.30 pounds
Tankage 0.44 pounds	Bran 0.33 pounds
	Tankage 0.33 pounds



Brood sows comprising Lot II photographed at the beginning of the maintenance experiment, December 17, 1916. Average weight, 187.1 pounds. Average daily ration: Corn, 3.87 pounds; tankage, 0.38 pounds; and clover hay, 1.94 pounds.



Brood sows comprising Lot II photographed just before farrowing, April 1, 1917. Average weight, 265.8 pounds. Gain, 0.74 pounds per head daily. Cost of wintering, \$12.93, with corn at \$1.25 a bushel, tankage \$90 a ton, and clover hay \$20 a ton. Crediting the sow with the gain in pork at 16 cents a pound, the cost of wintering each sow in this lot was 33 cents.

Accurate data were kept on the number of pigs farrowed, the condition and weight of the pigs at birth and the number and weight of pigs raised by the sows in each lot.

The gilts in Lot 6 farrowed the largest number of pigs, an average of 7.85 per sow. The average birth weight, 2.48 pounds, in Lot 6 was the smallest of any lot.

The pigs farrowed by sows in Lot 4 had the largest average birth weight; namely, 2.79 pounds.

Lot 2 had the largest percentage of strong pigs while Lot 6 had the smallest percentage.

Lot 4 had the smallest percentage of weak and dead pigs, 12.19%, as compared with 41.86% for Lot 1.

During 1917 and 1918 it became necessary to discontinue Lot 5 and to remove one sow from each of the lots, leaving thirty head on the experiment. The rations were also slightly changed, as follows:

	WINTER PERIOD	SUMMER PERIOD
Lot 1.	Corn 10 parts, alfalfa hay, Tankage 1 part	Corn 10 parts, alfalfa forage, Tankage 1 part
Lot 2.	Corn 10 parts, rye forage, Tankage 1 part	Corn 10 parts rye forage, Tankage 1 part, rape forage
Lot 3.	Corn 10 parts, bluegrass, Tankage 1 part	Corn 10 parts, bluegrass, Tankage 1 part
Lot 4.	Corn 5 parts, bluegrass, Linseed oil meal 1 part	Corn 5 parts, bluegrass, Linseed oil meal 1 part
Lot 6.	Corn 8 parts, bluegrass, Shorts 4 parts Bran 1 part Tankage 1 part	Corn 8 parts, bluegrass, Shorts 4 parts Bran 1 part Tankage 1 part

The average amounts of feed consumed per sow during the winter (1917-1918) did not vary much from that eaten by them the previous winter when they were gilts.

The sows in all the lots farrowed more pigs their second litter than they did the previous spring. Those in Lot 6 again farrowed the largest number of pigs. The largest birth weight per pig was 2.78 pounds for those in Lot 1. The smallest average birth weight was 2.09 pounds for the pigs farrowed by sows in Lot 4. Lot 3 had 78.9 per cent of strong pigs, which was the largest percentage of any lot, while the percentage for Lot 4, 47.5 per cent, was the smallest. Lot 3 had the smallest percentage of weak and dead pigs, 5.26 per cent, compared with 24 per cent for Lot 6.

Relation of better preparation of feed stuffs and different methods of feeding upon the rate and economy of gain put on by fattening swine (L. A. Weaver).—This trial began December 21, 1917, and closed March 29, 1918, making the feeding

period 98 days. The seventy-two purebred Poland China shoats farrowed in April and May, 1917, were divided into five lots. Rations and manner of feed were as follows:

LOT A	
Shelled corn	9 pounds
Shorts	2 pounds
Tankage	1 pound

Shelled corn was fed dry morning and evening. The shorts and tankage were mixed with water just before feeding and given in the evening as a slop. The hogs received one-half of their entire ration as shelled corn in the morning, one-fourth as shelled corn and one-fourth as shorts and tankage in the evening.

Lot B.—Ration and method of feeding for this lot was identical with Lot A except that the corn was ground.

LOT C	
Ground Corn	9 pounds
Shorts	2 pounds
Tankage	1 pound

The shorts and tankage were mixed for feed and given as a slop twice daily.

Lot D.—Same ration and manner of feeding as Lot C. In addition the hogs in this lot had access to a self-feeder containing the same ration as that which they received as a slop; that is, corn 9 parts, shorts 2 parts, tankage 1 part.

Lot E.—Ground corn, shorts and tankage each in a separate self-feeder.

The average initial weight of the hogs in each lot was 116.9 pounds to 119.1 pounds.

The average final weights varied from 286.2 pounds in Lot A to 312.2 pounds in Lot D. The self-feeder hogs (Lot E) required as little grain (4.63 pounds) to produce one pound of gain as did the hogs in any of the lots, the proportion in which they chose their feed being:

Corn	16.25 parts
Shorts	1.58 parts
Tankage	1 part

The small amount of tankage used in this ration resulted in producing the cheapest gain. This lot gained an average of 1.83 pounds per head daily. The hogs getting ground corn (Lot B) ate the same amount of feed per head daily as those which received shelled corn (Lot A), but gained more rapidly, with the result that less feed was

required to produce one pound of gain. Lot C which received their ration twice daily as a slop ate more feed and gained more rapidly than Lots A and B.

The lot which made the largest gain was the one (Lot D) getting the ration mixed and fed as a slop twice daily, and in addition had access to a self-feeder containing the same ration. They were noticeably fatter than the others. The gain which they put on, however, was the most expensive of any since it required more feed to produce one pound of gain (5.01 $\frac{1}{2}$ pounds) as compared with 4.63 pounds, the most economical lot in the experiment.

BOTANY

A fundamental study of the physiological relation of the powdery mildews to their hosts (George M. Reed, C. A. Philpott).—The experimental work with the powdery mildews was a continuation of the work done in previous years. Additional varieties of oats have been tested with reference to their susceptibility to the mildew found on oats. Similar experiments have been conducted with varieties of barley in their relation to the barley mildew. Practically all varieties of oats and barley have proved to be quite susceptible to the respective mildews.

Further experiments have been carried on to determine the relation of the infection of the host to various external conditions, such as light, water supply, mineral nutrients, etc. The results have confirmed those previously obtained. Many aspects of the work on powdery mildews have been completed and the results are ready to prepare for publication.

An investigation of forest tree diseases (George M. Reed).—Several additional forms of wood-destroying fungi have been added to the collection. The collection is fairly complete and representative of the forms found in this vicinity. Some progress has been made in culturing wood-destroying fungi and observing their effects upon the wood.

The special work in connection with the Department of Forestry, on the fungi responsible for the decay of fence posts, has been continued. Additional forms have been collected. At present about forty different fungi have been obtained from the fence posts under observation.

A systematic and physiological study of rusts (George M. Reed, C. A. Philpott).—The experimental work during the past year has been largely with the crown rust of oats. Additional varieties of

oats have been tested with reference to their susceptibility. Very few varieties under greenhouse conditions are resistant to the crown rust. Relatively few observations have been made under field conditions, because the season has been very unfavorable for the development of the crown rust in the open.

The collection of rusts of this vicinity has been materially extended. New forms have been discovered during the past year. Approximately ninety forms have been found up to the present time.

Grain smut investigations and control (George M. Reed, C. A. Philpott, Jesse A. Cline).—The work in connection with smut investigations may be grouped as follows:

1. *Sorghum smut*.—About forty-five varieties of sorghums have been tested with reference to their susceptibility to the kernel smut, *Sphacelotheca sorghi*. The seed of these varieties were all inoculated by dusting the spores from the same host.

As found in previous years, the Milos as a group remain free from smut; feterita shows only a slight infection. The highest percentages of infection were obtained with the Kafirs, pink kafir giving 76.8 per cent infection and black-hull kafir 68.7 per cent. The Sorgos also gave fairly high percentages of infection. The broom corns proved to be fairly susceptible, the percentage of infection varying from 21.7 per cent to 31.2 per cent on the different varieties.

2. *Covered smut or bunt of wheat*.—The main work with this smut was with reference to varietal susceptibility of several varieties of wheat commonly grown in Missouri. The seed of these varieties was inoculated by dusting with the spores of *Tilletia foetens* and then planted. About thirty varieties were used. Practically all of the varieties proved to be highly susceptible, the percentage of infection varying from five to eighty per cent.

3. *Oat smut*.—Several varieties of oats were again tested to determine their susceptibility to the loose smut, *Ustilago avenae*, and the covered smut, *Ustilago levis*, of oats. Marked differences were observed with reference to the susceptibility of the different varieties. Practically one hundred per cent infection was obtained with *Avena nuda* and some of its varieties; *Avena brevis* remained free. The percentage of infection in the more common varieties varied from less than five to more than thirty.

An attempt was also made to determine the influence of the data of planting upon infection, one set of seed being planted about three weeks earlier than a second set. No striking differences were observed in the amounts of smut in the same variety of oats in the two different plantings.

A large number of tests were made to determine the influence of various seed treatments on the germination of oat seed. Six different samples of oats were used in these tests and various modifications of the copper sulphate and formaldehyde treatments were made. The principal work was to determine the influence of the length of time of exposure of the seed to the chemical on the germination of the seed. In general it was found that a rather wide range of time of application of the formaldehyde was permissible in seed treatment without materially lessening the seed germination. Most of the treatments were very effective in preventing smut.

Special tests were made with some of the newer modifications of the formaldehyde method, such as spraying with concentrated solution. The results in general confirm the work of others in the prevention of smut.

An investigation of watermelon diseases found in southeast Missouri (W. E. Maneval, Helen Johann).—During the previous year several apparently distinct strains of *Fusaria* were isolated from wilted watermelons. They were found in greenhouse experiments to cause wilt. In the summer of 1917, six of these strains were used to inoculate a field plot in which watermelons were grown, and in some cases a considerable percentage of wilt was obtained. From wilted plants more than twenty isolations of *Fusaria* were made.

These isolations have been compared with the fungi originally used to inoculate the field plot. While some of them are doubtless not disease producing, others agree closely with the originals. They have been studied on a number of different media with reference to maximum, optimum and minimum temperatures for growth, pigment production, etc.

A study has also been begun of the relation of a very few forms to various chemicals, especially their ability to obtain carbon and nitrogen for growth from various sources.

A series of pot experiments in the spring of 1918 added more evidence that there are several strains of *Fusaria* that cause watermelon wilt, also that the disease is probably favored by certain types of soil.

DAIRY HUSBANDRY

Factors influencing the composition of milk (C. H. Eckles, L. S. Palmer, W. W. Swett).—Only one phase of this investigation has been in progress during the past year. Work on the other phases has either been completed or suspended.

The influence of condition at parturition on composition of milk and butter-fat.—The experimental work during the year was confined to work with one animal, this being the third year she had been used in this test. She calved this year in much better flesh, her body weight being about 250 pounds above that of the two previous years. The abnormal composition of the milk fat observed shortly after parturition in the previous experiments when this cow calved was not observed during the past year.

According to the plan of the experiment a protein allowance of approximately 1.5 pounds a day, which was calculated to be just sufficient for maintenance and milk production, was continued for the first two months following parturition. This was accompanied by a protein percentage in the milk of about 3.1 and a fat percentage averaging about 3.5 for the period. These levels were slightly higher than those obtained during the two previous years on a minimum protein plane. When the protein consumption was raised to 2 pounds and then to 2.5 pounds per day, the protein in the milk increased to 3.5, and the fat to a value of above 4 per cent, this finally reaching a value of 5 per cent or better. These results corroborated those secured during 1916-17 and again indicate a relation between the protein plane of nutrition and the percentage of protein and fat in the milk. When the protein plane was subsequently reduced to 1.6 pounds per day it was not accompanied by a decline either in the protein or fat percentage of the milk. This may have been due, however, to the fact that intake of protein did not represent as low a level in the protein plane of nutrition as the 1.5 pounds of protein intake at the beginning of the experiment.

The cow will calve the coming year in practically the same condition as in August, 1917, and it is planned to begin the lactation period on a high plane of protein intake, instead of on a low plane as in the previous years. It is planned to reduce this later to a level corresponding to that with which she began her lactation periods in the three previous years.

The data should show conclusively, at least as far as the cow is concerned, the relation between protein plane of nutrition and the percentage of protein and fat in the milk, and also the influence of the state of nutrition at parturition upon the composition of the milk fat.

Influence of nutrition of heifers and the age of breeding upon their subsequent development (C. H. Eckles, W. W. Swett).—This investigation is concerned with normal growth and with protein requirements for growth.

Normal growth.—The collection of data on this project has continued during the past fiscal year and it is expected that the data will be completed during the coming fiscal year. Complete records of growth as represented by height and weight are now available for a considerable number of animals from birth to maturity. No new facts have been developed during the year but each year shows more clearly the importance of these data. Our curves of normal growth are now made the basis of comparison for all our other experimental work with growing animals. Without such a normal curve as a basis for comparison it would be necessary to have check groups for each experiment and to have this group include a sufficient number of animals to give a fair average.

Protein requirements for growth.—Work was continued during the year according to the original plan. Ten animals have been used. Three planes of protein nutrition have been used, one a low plane in which the animal received 8 per cent of its energy in the form of protein, one a medium plane with 15 per cent and one a high plane with 25 per cent. In calculating these protein planes an allowance is made for both protein and net energy for the maintenance of the animals, using Armsby's tables. The normal gain in weight for an animal of this age is found from the normal growth data taken by this Department. The allowance of energy to produce this growth is secured from the data taken on a considerable number of animals in previous experiments. This figure for energy for growth is added to that required for maintenance in order to secure the total energy the animal is to receive. The amount of protein to be fed is calculated on this basis.

The data show that both Jerseys and Holsteins fall far below normal growth on the 8 per cent protein plane. On the 15 per cent plane the Holstein nearly reached the normal but the Jersey were considerably below. On the 25 per cent plane the Holstein made more than normal growth and the two Jerseys made approximately normal growth. As in the past the effects of unfavorable conditions show much more strongly upon the increase in weight than upon the skeletal growth. No explanation is offered of the marked difference in results between the Jerseys and the Holsteins. The data so far indicate that a 20 per cent plane of protein, or about 75 per cent of that prescribed by the Wolf-Lehman standard, is ample for normal growth in heifers.

Raising calves on milk substitutes.—The work during the year has been of a preliminary nature. The problem has been studied

from the standpoint of the recent advances in the knowledge of nutrition, and rations worked out which promise to furnish the necessary quality of proteins and growth accessories. The use of skim milk powder as a substitute for milk has been tried with good results. Skim milk powder is too expensive for general use but may be used with advantage by those who are selling whole milk at a high price and at the same time wish to raise their calves.

In this study of the problem of raising the calf with the minimum amount of milk the tests were begun with thrifty calves from three to four months old to determine what rations are necessary in order to make a satisfactory growth for animals of this age. Data on this point are not yet complete. Later younger animals will be used until it is possible to determine the minimum amount of milk that may be used and reasonably good results expected. All comparisons of gains in weight and height are made with the normal growth figures.

Winter rations for dairy heifers (C. H. Eckles, W. W. Swett).

—The work on this experiment was completed during the fiscal year. The wintering trial carried out during the winter of 1917-18 included eighteen animals and covered one hundred fifty days. The special object this year was to determine more fully how nearly normal growth may be reached on a ration of roughage alone. The rations received by the three groups were:

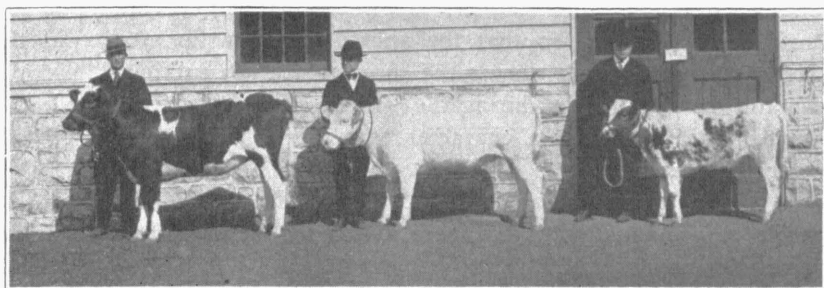
- Group 1. Alfalfa and silage ad libitum, with corn sufficient to make normal growth.
- Group 2. Alfalfa limited to 6 pounds daily and silage ad libitum, grain to be fed if necessary to secure normal growth.
- Group 3. Alfalfa and silage, both ad libitum.

Gains in weight equal to or in excess of the normal were made by Groups 2 and 3 on roughage alone. These data show that with silage and a good grade of alfalfa fed ad libitum entirely satisfactory winter gains may be expected from heifers more than eight or ten months old.

During the winter of 1916-17 three groups of heifers were wintered on rations differing widely in nutrients furnished and gains made with the special object in view of noting the gains made by the three groups during the pasturing season when all were subjected to the same conditions.

The group receiving the heavy grain ration made an average daily gain of 1.63 pounds during the winter and only 0.15 pounds during the summer. The group receiving the medium ration during

the winter made a gain of 1.10 pounds, or about 0.4 pounds above normal. The group that received the poor winter ration and gained 0.35 pounds daily during the winter gained 0.88 pounds daily during the summer. While this group made the best gains of the three during the summer, the gains were not sufficient to overcome the loss as compared to the normal which resulted from the poor winter ra-



Dairy heifers representative of three groups used in the wintering experiments. The heifer on the left receiving a medium ration gained 1.2 pounds daily in winter and 0.55 pounds daily on pasture. The middle one wintering on a liberal grain ration gained 1.67 pounds daily in winter but weighed less October 1 than she did when put on pasture May 1. The one on the right, as the result of a poor ration, gained only 0.21 pounds daily during the winter but on pasture gained 0.61 pounds daily, the greatest of the three.

tions. These data show it is not economical to feed growing dairy heifers grain to the extent that gains considerably above the normal are made during the winter, as such winter gains are always followed by poor gains the following summer. Animals wintered on rations so poor that very small gains are made during the winter are so low in vitality that they do not make enough gain on grass to make up for the poorer gains made during the winter. The results of the investigation for the past year are summed up as follows:

1. Heifers should be raised mostly on roughness.
2. Grain feeding should continue for some time after skim milk feeding is discontinued, since the common practice of stopping the feeding of grain and of skim milk at the same time requires too great an increase in the consumption of roughness. As a result, growth is slow.
3. From the age of probably ten months the animal should be fed on roughness almost exclusively until within possibly three months of calving when it is desirable to feed some grain.
4. Such a plan of feeding will result in many cases in the heifers being slightly under the normal size during the growing period

and this should be counteracted by delaying the time of breeding to some extent.

5. Animals fed a ration which results in a heavy gain during the winter make small gains the following summer on pasture. Those making normal gains during the winter make about normal gains on pasture, those making gains below normal during the winter gain in excess during the summer. However, if winter conditions are sufficiently extreme so that the animals are low in vitality in the spring the gains made during the summer are not sufficient to make up for the small gains during the winter. The best results follow a winter ration of such a character that the animal makes a growth near the normal.

Silage investigations (C. H. Eckles, M. F. Fohrman).—The work of previous years has been continued during the past fiscal year with results as follows:

Alfalfa exposed to heavy rains after being partly cured for hay was found to make excellent silage. Good silage was also made from cowpeas and soybeans by following the plans reported previously of allowing the green material to partly dry in the field before putting it in the silo. Tests have now been made of preserving alfalfa, soybeans, cowpeas, field peas and oats in the silo. All make a good quality of silage if the dry-matter content is near forty per cent.

If these legumes are put into the silo in the very succulent condition in which they are usually cut for hay, the resulting silage is of very inferior quality and almost worthless but when the dry matter is higher excellent silage is made, the percentage of loss is not high, and it is eaten readily by cattle. Wheat and rye have been tested for silage with fair results. Both keep well but the rye is not very palatable and its use is questionable. Data were taken to determine the comparative losses in the ear and in the forage, when corn is put into the silo. A preliminary test was made of filling an experimental silo with corn from which the ears had been removed and of preserving soft corn in the silo. Results on these tests are not yet available.

A test was made in cooperation with the Department of Farm Crops of three varieties of special silo corn in comparison with Leaming.

The following figures give the yields and proportions of ear and forage:

Variety	In Fresh Weight			Yield lbs. Air-dry matter	
	Yield per acre, lbs.	Percentage Ears	Percentage Forage	Per Ear	Per Acre Forage
Eureka	27,358	23.3	76.7	2996	5813
Cocke's prolific.	26,684	25.5	74.5	2592	5626
Biggs Seven Ear	24,393	27.2	72.8	3258	6280
Leaming	19,811	35.6	64.4	3710	3244

The heating of silage after removal from the silo for feeding was found to be due primarily to the growth of certain yeasts. Molds appear to be a minor factor developing after the yeasts have made a considerable development.

A study of factors causing fishy flavor in milk (L. G. Rinkle).—Experiments have been continued in a limited way during the year according to the plans submitted. Eleven additional experimental churnings have been made reproducing combinations of factors suspected of bearing a relation to the fishy flavor. So far the results have all been negative and conditions reported by others as responsible for the trouble have not produced the fishy flavor when tried under controlled laboratory conditions. Some tests were also made of inoculating fresh butter and fresh cream with fishy butter but results were entirely negative.

For the coming year it is proposed to repeat some of these experiments, storing the butter at typical cold storage temperatures, five degrees below zero. In the experiments so far conducted the storage temperatures have been considerably higher than ordinary cold storage and it is thought this may be a factor in the negative results secured.

Cheese making under Missouri conditions (L. W. Morley).—This experiment has been in progress since 1916, formerly under the direction of Mr. L. G. Rinkle. Sufficient work has been completed to justify the publication of a circular for popular distribution (Extension Circular 30) based in part upon the experimental results obtained. A second phase of the work was to find some method of controlling temperatures during ripening without the use of ice or expensive curing rooms. Tests have been made of curing cheese packed air tight in cans and placed in well or spring water to control the temperature. Entirely satisfactory results were obtained re-

garding the quality of the cheese cured under these conditions, but so far no practical plan has been found to pack cheese in cans in such a manner that all air will be excluded around the cheese within the can and to keep out air. The exclusion of the air is necessary in order to prevent the growth of mold. The most promising plan now under trial is curing the cheese in an atmosphere of carbon dioxide. Tests so far made show the ripening process in an entirely normal manner under this condition and the growth of mold is entirely repressed. This plan also offers a possible solution of the problem of curing cheese satisfactorily in pound packages.

The chemistry of churning (L. S. Palmer).—This experiment was begun in July, 1917, so that only one year's results are available. The studies carried out during the year indicate that the ease of churning is under the control of the buttermaker to a limited extent only. Beyond that there are certain changes in the normal composition of milk which tend to decrease the ease of churning, and which the buttermaker may not be in position to control. For example, an increase in the protein concentration of milk and a decrease in the relative size of the fat globules, such as normally occurs with advance in the stage of lactation, were found to tend to make churning more difficult. It was also found, however, that extremely difficult churning is probably related to much more fundamental changes in the composition of milk, which may or may not be accompanied by a material rise in the protein and a decline in the relative size of the fat globules.

In the course of the work certain interesting properties of cream were observed to be associated with extreme difficulty of churning. One of these properties, excessive whipping, promises to throw considerable light upon the question of what are the real factors which cause the extremely difficult churning sometimes encountered.

The problem has now reached the point where it appears that the explanation of the relative ease of churning is to be sought in the investigation of one or both of two hypotheses, namely; (1) changes in the relative amount of a hitherto *unknown* colloidal constituent of milk, whose properties, or the changes in whose properties in the normal preparation of cream for churning, interfere with the normal physico-chemical process of churning, or (2) changes in the properties of known colloidal constituents of milk brought about during the normal preparation of cream for churning by some method or methods of handling the cream the significance of which is not yet clearly understood; such changes interfering with the normal physico-chemical process of churning.

The work carried out during the year has confirmed the belief that the explanation of both normal and difficult churning is to be sought in a study of the properties of the colloidal constituents of milk, the changes which occur in the properties of these constituents during the ripening of cream, the effects of the inorganic constituents of milk and of acids, especially lactic acid, on these changes, and in study of the bearing which these changes have upon the formation of butter from cream.

By staining cream with Sudan 111 (a fat stain) and Fuchsin (a protein stain) dissolved in acetone and then churning the cream, some preliminary work carried out during the year in which microscopic observations of the cream and butter were made, have given strong support to Fischer's idea that the formation of butter is the change of fat-in-colloid-hydrate emulsion (cream) into a colloid-hydrate-in-fat emulsion (butter). More work along this line is planned.

ENTOMOLOGY

Injurious insect pests of melon and related crops (L. Haseman, J. I. Keith).—During the fiscal year, no carefully planned spraying or dusting experiments have been made. On a small scale the striped cucumber beetle has been controlled by hand picking and by using arsenate of lead.

Observations, records, and photographs were made on the squash bug and pumpkin bug last fall on the new orchard farm at Turner. This pest was unusually abundant and destructive to these crops late last summer and fall.

The melon louse has also been under observation and nicotine sulphate has been tested further as a remedy, with the same unflinching results.

An investigation to determine the cause of the periodical recurrence of insect pests as scourges (L. Haseman).—

Hessian fly.—During the year the Hessian fly practically disappeared from Missouri and observations and records have been made on what forces were most active in eliminating the pest. The winter of 1916-17 eliminated the pest in part in some sections of Missouri, but the early spring of 1917, with its cold rains, seems to have been the principal factor at work. The Hessian fly eggs in the fall of 1916 showed an unusually high record of infertility or high-larval mortality before reaching the base of the leaf sheath. The fly has succumbed apparently to weather conditions and not to parasites or other natural agencies.

Grasshoppers.—During the past two years grasshoppers have been on the increase. The past winter and the dry spring and summer thus far have been decidedly in their favor and we now have one of the severest general outbreaks we have had in years. The effect of farm practices to eliminate breeding places with heavy cropping will no doubt prove to be a factor in their elimination.

Chinch bugs.—Normally, chinch bugs appear every ten to fifteen years but between 1910 and 1913 the pest was present in large numbers. This year and last year they are sweeping forward again from Oklahoma across Missouri. Just what the conditions are which bring this record wave forward are not yet clear. The past relatively dry winter, however, is probably one important factor.

An investigation to determine what insects are injurious to nursery stock in the state, their life history, distribution, injury and method of control (L. Haseman, K. C. Sullivan).—As in previous years this project is being carried out in connection with the Nursery Inspection project. During the year greater stress was placed upon the eradication of the San Jose scale than upon that of any other pest, and very noticeable results have been obtained. In 1915-16 twenty-four nurseries were found infested with San Jose scale. This number was reduced to twenty-two in 1916-17, and to fifteen in 1917-18. Cooperative work in fumigating with hydrocyanic acid gas, dipping with miscible oil, and spraying with miscible oil and lime-sulphur for controlling San Jose scale is being successfully conducted in a number of Missouri nurseries.

The woolly apple aphid is becoming rather numerous and is doing considerable damage to nursery stock, especially in the southern half of the state.

Other nursery pests that are of economic importance and which are being studied with special reference to their control are: Forbes scale, oyster shell scale, scurvy scale, maple scale, rosy apple aphid, apple leaf hopper, the leaf folders and crumplers. Apple leaf skeletonizer, bag worm, peach tree and apple tree borers, leaf miner caterpillar, strawberry leaf roller and tarnished plant bug.

During the past season a small nursery has been established at Columbia which will make possible a more detailed study of the insects attacking nursery stock.

The annual cycle of the Hessian fly in Missouri and its control (L. Haseman, A. H. Hollinger, K. C. Sullivan, J. I. Keath).—During the year experimental plots at Charleston, Altenberg, Fredericktown, Ste. Genevieve, Lebanon, Springfield (2 cooperators),

Centerview, Maryville and Carrollton have been operated. The Hessian fly disappeared almost completely from the state a year ago this spring and except for one locality, Charleston, no Hessian flies appeared on the plants last fall. Judging from last fall's record and from field conditions little or no fly may be expected in the present crop of flax stubble. However, the records of yields are being collected from plots seeded on various dates. Records will be kept on out-lying plots, even tho the fly is eliminated, perhaps for several years.

Owing to the climatic conditions last fall and to the fact that no injury was done by the fly, the earliest seedings in a number of the experimental fields proved much better than the later seedings.

The experimental plots at Columbia will give valuable information when the stubble counts and threshing records are completed. Here, as in the out-lying plots, no fly of consequence appeared.

An investigation of the malarial mosquito plague in Missouri (L. Haseman, K. C. Sullivan, J. T. Rosa, Jr.).—During the week of February 10-17, 1918, a preliminary survey of conditions in Mississippi, Dunklin, New Madrid and Pemiscot counties was made. County agents, public school officials and business men held meetings in Mississippi and Dunklin counties and an effort was made to determine the need for this work, the probable results which could be accomplished, and the extent of cooperation on the part of local officials and others.

The original plan of making a comprehensive mosquito survey of all of southeast Missouri this year was abandoned and substitute plans were made to confine the effort to Mississippi County where some local work was already being done and where a laboratory was available.

The real survey work was begun on June 10, 1918. The material collected will be identified during the summer and fall with the assistance of the federal mosquito specialists. Hundreds of separate collections were made from every recognized mosquito-breeding resort in the county and from many localities reported to be mosquito-free. Malarial mosquitoes or their larvae were collected at practically every place visited.

FARM CROPS

A study of certain spring, summer and fall sown crops for forage (W. C. Etheridge, C. A. Helm, J. B. Smith).—Among spring

sown forages at Columbia, a mixture of oats and Canada field peas led with a yield of 3.1 tons of cured forage per acre. This was similar to a yield of 3.2 tons of cured forage by fall sown rye. Vetches whether seeded alone or in combination with a variety of small grain were failures on account of winter killing.

Among the summer sown forages, amber sorghum, white kafir, and a mixture of white kafir and soybeans were the leaders, with respective yields of 6.25, 4.58, and 4.35 tons of cured forage per acre.

At Warrensburg a mixture of oats and Canada field peas gave the best returns among spring sown forages, while a mixture of soybeans and sweet sorghum were the best among forages sown in the summer.

Sweet clover investigations (W. C. Etheridge, C. A. Helm, J. B. Smith).—No sweet clover seedings were made on the Station farm in the spring of 1917. Plots were seeded in the fall of 1917 with a view to determine the best time and manner of cutting, together with best methods of handling the crop for production of both hay and seed.

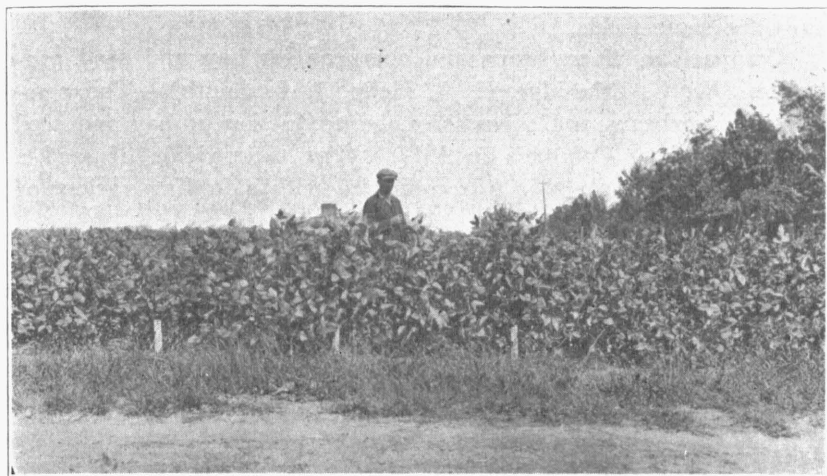
A total of 10 cooperative tests were located with farmers, mostly in south Missouri. Of the ten tests eight were spring sown and two were sown in the fall. In every case failures were reported where oats was used as a nurse crop. On the better soils where no nurse crop was used, fair stands were secured. On the extremely poor lands sweet clover has not proved successful under any method of culture.

A study of the adaptation of the important varieties and selections of soybeans to the various soil types in Missouri (W. C. Etheridge, C. A. Helm, J. B. Smith).—Eighty-four varieties and selected strains of soybeans were tested in 1917 for yields of seed and hay. The yields of the best eight follow:

Bushels of seed per acre		Tons of hay per acre	
Virginia	20.8	Chiquita	4.5
Taha	20.7	Tarheel	4.0
Okute	20.1	Missouri No. 2	3.8
Chesnut	19.0	Edward	3.7
Early Brown	19.0	Haberlandt	3.4
Wisconsin Black	18.7	Taha	3.4
Manchu	18.7	Austin	3.3
Morse	18.3	Buster Brown	3.2

At Maryville, Peking, Wilson and Virginia were the leading seed varieties among twelve tested. Their respective yields were 19.4, 18.9 and 17.5 bushels per acre.

At Warrensburg, Mongol, Morse and Mikado were the leading seed varieties among six tested. The yields per acre were 17.9, 17.0 and 14.3 bushels respectively.



Variety test of soybeans on the Experiment Station farm. This crop finds its natural home in Missouri soils.

A study of the cultural requirements and adaptations of Sudan grass (C. A. Helm, J. B. Smith).—Investigation of Sudan grass was limited to Columbia and Warrensburg fields. At Warrensburg the crop planted in rows three feet apart gave a yield in cured forage of 2.6 tons per acre. The yield was approximately only half that secured from sweet sorghum. The stand of Sudan grass was very poor, which partly explains the comparatively low yield.

At Columbia Sudan grass yielded 1.56 tons of cured forage per acre when seeded following a cropping of rye and 4.2 tons per acre when seeded in a mixture with soybeans June 15.

Cultural experiments with soybeans (W. C. Etheridge, C. A. Helm).—In cultural experiments with soybeans conducted on the Russell farm in 1917 better yields in seed and hay resulted from seedings May 15 to June 15 than from earlier to later dates.

Practically no difference in yield of seed and hay resulted from seeding in rows 16 inches and 42 inches apart. Drilling the Jet variety in rows 8 inches apart gave the same yields when seeded at 90 pounds and 120 pounds per acre. Seeding at lower rates than these gave reduced yields.

At Maryville seeding at 25 pounds per acre in rows 3 feet apart gave slightly larger yields than lower rates of seeding. At Warrensburg seeding at 30 pounds yielded 13.7 bushels per acre, while seeding at 20 pounds gave a yield of 12.8 bushels per acre, or practically the same yields.

Comparison of soybeans and cowpeas for hay and seed production (W. C. Etheridge, C. A. Helm, J. B. Smith).—The comparison of soybeans and cowpeas in the production of hay and seed was continued at Columbia in 1917. For their yields of seed a leading variety of cowpeas was compared with a leading variety of soybeans. The results follow:

New Era Cowpeas	15.1 bu. per acre
Medium Yellow Soybeans	12.2 bu. per acre

Three leading varieties of cowpeas and of soybeans were compared for their yields of hay, with the following results:

COWPEAS		SOYBEANS	
Wippoorwill.....	4.5 tons per acre	Wilson.....	3.5 tons per acre
Clay.....	2.8 tons per acre	Barchet.....	2.5 tons per acre
New Era.....	2.9 tons per acre	Arlington.....	3.2 tons per acre
Average.....	3.4 tons per acre	Average.....	3.1 tons per acre

A comparison of the most important grain sorghums with corn for the production of grain (W. C. Etheridge, J. B. Smith).—In 1917, six of the most popular and important varieties of grain sorghum were tested at Warrensburg on Boone silt loam upland of less than average fertility, to determine their relative yields and to compare their productivity with that of the leading varieties of corn. The following data show the best yields per acre of the two kinds of grain:

Highest yielding varieties of grain sorghum		Highest yielding varieties of corn	
Shallu	81.3 bu.	Commercial White.....	69.3 bu.
White Kaffir	63.0 bu.	St. Charles White.....	58.3 bu.
Standard Milo	43.7 bu.	Leaming Yellow.....	47.3 bu.

These results which indicate the high productivity of the best varieties of grain sorghum, were obtained in a season remarkably favorable for the production of corn.

A study of the adaptations of the important varieties of cotton for the southeast Missouri lowlands (W. C. Etheridge, J. B. Smith).—A successful comparison of varieties of cotton was carried thru in 1917. The outstanding result was the marked superiority of early varieties over late varieties which, on account of early

frost failed to mature well. The following data show the best performance of each class of varieties:

Best two early varieties	Best two late varieties
Kings Improved, 380 lbs. lint per acre.	Mebane Triumph, 260 lbs. lint per acre.
Simpkins Prolific, 330 lbs. lint per acre.	Rowden, 213 lbs. lint per acre.

A study of adaptations of the important varieties of corn for Missouri conditions (W. C. Etheridge, E. M. McDonald, J. B. Smith).—Insofar as immediate practical benefits were concerned, the tests of varieties of corn, which have been conducted by the Station since 1905, reached a satisfactory conclusion upon the publication of Bulletin 143. It was found that Boone County White, Commercial White, St. Charles White, Reid's Yellow Dent, Leaming Yellow and St. Charles Yellow, were the leading varieties of corn for Missouri. The general sectional adaptation of these varieties was also determined. The most outstanding features of the general findings were (1) the marked superiority of St. Charles White over other varieties for the southeast lowlands, (2) the high standing of Reid's Yellow Dent on the rolling prairies of Central Missouri, and (3) the failure of Leaming Yellow to lead in any section of the state, altho in general it ranked among the best six varieties.

Tests of these leading varieties will be continued indefinitely at Maryville, Kirksville, Warensburg and Kennett, to accumulate a longer record of their comparative yields at the principal climatic points—north, central and south Missouri; to serve as a standard by which new varieties introduced into these sections may be judged; and to serve as subject material for educational demonstrations at the normal schools—Maryville, Kirksville and Warrensburg.

In 1917, two of the leading varieties of southern prolific corn was included in the test at Kennett for comparison with the six native varieties just mentioned, that previous investigations had concluded were best for the state. The outstanding result of the whole year's work with corn was the performance of the best native varieties:

Prolific varieties	Best two native varieties
Bigg's Seven Ear.....38 bu. per acre	Reid's Yellow Dent...32 bu. per acre
Cock's Prolific33 bu. per acre	St. Charles White....30 bu. per acre

On the basis of these results, an attempt is being made to produce a strain of prolific corn more perfectly adapted to south Missouri than when brought directly from the South. Seed of Bigg's Seven Ear was placed with a number of farmers in the southern

part of the state, and field selection for the adaptation of the variety will be made in the fall.

A test for their comparative yields of ensilage was begun with a number of varieties last year at Columbia. The test was successful and will be repeated for five or six years. At this time, however, insufficient data have accumulated to form the basis for a report.

A study of the adaptation of the important varieties of wheat for Missouri conditions (W. C. Etheridge, E. M. McDonald, J. B. Smith).—In 1918 variety tests of wheat were continued at Columbia, Warrensburg and Maryville. At Maryville the stand was so irregular from unequal degrees of winter killing on the various plots as to be unworthy of comparison. The tests at Columbia and Warrensburg, however, were successful, and the following data show the performance of the leading varieties at each location:

Best six varieties at Warrensburg	Best six varieties at Columbia
Turkey 27.9 bu. per A.	Harvest Queen 30.6 bu. per A.
Jones Red Wave..... 25.3 bu. per A.	Beechwood Hybrid ... 29.7 bu. per A.
Michigan Wonder ... 24.0 bu. per A.	Defiance 26.5 bu. per A.
Rudy 23.5 bu. per A.	Reliable 26.1 bu. per A.
Harvest Queen 23.5 bu. per A.	Fulcaster 26.1 bu. per A.
Fulcaster 23.5 bu. per A.	Poole 23.8 bu. per A.

At Columbia the highest yielding variety produced 12.6 bushels more per acre than the lowest yielding variety, while at Warrensburg the difference between the highest and the lowest yielding varieties was 11.6 bushels. This is a fair illustration of the value of varietal adaptation.

A study of the important varieties of oats for Missouri conditions (W. C. Etheridge, E. M. McDonald, J. B. Smith).—In 1917 the variety tests of oats were continued at Columbia, Warrensburg and Maryville. At Warrensburg, on account of changes in the general plan of the whole group of field experiments, land was available for only two varieties—Burt and Kherson. There was practically no difference in the yields of these varieties, each yielding within a fraction of 20.5 bushels per acre. The following yields were by the leading varieties at Columbia and Maryville:

At Columbia	At Maryville
Swedish Select..... 41.6 bu. per A.	Great Dakota..... 68.7 bu. per A.
Fulghum 41.1 bu. per A.	Red Rust Proof..... 69.0 bu. per A.
Iowa 105..... 42.2 bu. per A.	Burt 66.6 bu. per A.
Red Algerian..... 42.0 bu. per A.	Silvermine 65.3 bu. per A.

Investigations with winter oats (W. C. Etheridge, E. M. McDonald, J. B. Smith).—In the unusually severe winter of 1916-17, all

varieties and selected strains of winter oats were killed. In the fall of 1917, a number of varieties secured from the Office of Cereal Investigations, U. S. Department of Agriculture, which were considered extremely hardy, were planted at Kennett and at Columbia. But at Kennett the varieties were completely winter killed while at Columbia only a few plants survived. These were the results from a season when, on account of the long duration of the snow covering, the degree of winter killing among other cereals was unusually low. From this experience, and that of past years, it is not reasonable to believe that a strain of winter oats hardy enough to be useful in Missouri can be developed within an anticipated period.

Wheat breeding investigations (W. C. Etheridge, E. M. McDonald, L. J. Stadler).—The project for the improvement of winter wheat in Missouri continued thru 1917 and is still in progress. New pure-line selections and hybrids made at this Experiment Station are yearly included in the comparison of a large number of selections, hybrids, and commercial varieties. When the value of new strains have been proved on the Station field they will be distributed among cooperators at typical points in the state and subjected to a more thoro test to determine their general value and sectional adaptation. Small stocks of the improved strain will then be given to farmers.

Some of the selected strains are much superior to the parent stock; some are inferior; and some are practically identical in performance with the parents. The following are typical examples of the three cases:

	Average yield per acre 1914-15-16-17
Fulcaster (original)	37.1
Fulcaster (selection 8-Y)	42.0
Early Ripe (original)	33.6
Early Ripe (selection 26)	27.8
Poole (original)	34.3
Poole (selection 3)	35.0

In general this project is making excellent progress and within a reasonable period it may be expected to become the means of supplying yearly to the farmers of the state improved strains of wheat thru which the State yield may be increased. The time has not come, however, when such a substantial benefit may be pointed out.

A study of the adaptations of the important varieties of spring barley for Missouri conditions.—In 1916 spring barley was successful at Maryville and Warrensburg, where the respective average yields were 22.7 and 21.5 bushels per acre. But in the same

season the barley crop failed at Columbia, yielding only 8.6 bushels per acre. In the remarkably favorable season of 1917, however, the crop at Columbia produced good yields, these ranging from 19.0 bushels per acre by the poorest variety to 30 bushels per acre by the best variety. The present crop on the Station field is thrifty. Accumulating results are indicating that spring barley is a fairly safe crop for north Missouri; an uncertain crop for central Missouri, succeeding here only in the most favorable seasons; and generally a failure in south Missouri.

Cultural experiments with corn, including the rate of planting, methods of preparing sod land and stubble land, depth of plowing and subsoiling, methods of cultivation, and planting (J. B. Smith).—This investigation of cultural methods for corn was continued in 1917 at Maryville and Warrensburg. On account of the unusually favorable season which produced a thrifty growth under all conditions of culture, some of the various cultural methods did not cause such marked differences in yield as have resulted in previous years. The most marked instances of the effect of culture were the following:

At Warrensburg	
Corn, surface planted, normal cultivation.....	59 bu. per acre
Corn, list planted, normal cultivation	70 bu. per acre
Corn, surface planted, late cultivation.....	73 bu. per acre
At Maryville	
Corn, surface planted, normal cultivation.....	75 bu. per acre
Corn, list planted, normal cultivation.....	84.2 bu. per acre

FARM MANAGEMENT

Main cost of producing farm products under farm conditions (R. M. Green).—A study of milk production costs near St. Louis, St. Joseph and Kansas City, during the past year indicate that dairy farmers who were retailing their milk made some profit. Farmers who were selling wholesale, in general, failed to receive a price that covered cost of production. The feed cost of a gallon of milk was lowest on farms where silage was used extensively in the ration.

The standard of living on the farm as a factor in cost of production (R. M. Green).—Certain factors in living conditions in one of the richest and one of the counties below average, on owned and on tenant farms were studied. This brief study shows that the basis of rural improvement is economic. The farmer's problem has been one of financing a large and costly plant, and to provide cash for the education and comfort of his family. He has been able to

do this on his operating profits, only in sections richly endowed by nature.

Land tenure in Missouri.—Records have been secured on 848 tenant farms as to the system of land rental, rate, value of land, yields and other related data. These data have been tabulated and show conclusively that where the price of land is about equal to the agricultural value of the land, a tenant can secure the use of capital at a much cheaper rate by renting the best farms.

Cheap lands with tenants adapted to living on such lands, return a larger percentage on investment to landlords. This type of farming is often especially attractive to the absentee landlord.

FORESTRY

A study of the methods of prolonging the service of wood fence posts (E. C. Pegg).—This experiment was begun in November, 1913, with posts treated in various ways to determine the best means of preserving them. The third examination of these posts was made during the past year. In addition to those which had failed previously, 72 more failed during this year. These represent twenty species of wood and six treatments. The control series of thirteen species have all failed; the series set in gravel show total failures in the case of nine species; twelve species in the charred series have failed; six species of the series painted with creosote have failed while twelve of the species painted with carbolineum have rotted. One basswood post which was given the open tank treatment with creosote for one hour has decayed.

Practically all posts in the two series treated by the open tank method are still sound while relatively few posts in any other series fail to show some rot.

Investigations of the method of culture and varieties of basket willows for Missouri (E. C. Pegg).—This investigation has been continued during the past year according to previous plans. Several varieties of willows are under test. According to results during the last year no regularity of yield has been shown in relation to different methods or spacing. The problem of sprouting has been worked out thru the use of vats or tanks. Very few rods were lost during the past year.

HOME ECONOMICS

The effect of blanching in the canning of some typical crops of vegetables (Miss Louise Stanley, Miss June Findley, Miss Lois

Lhamon).—Several jars each of greens, peas and carrots have been canned, and the keeping quality and color noted. Part of the vegetables were canned before sterilization and part after sterilization. The same cooking times were used in each case. Factors other than blanching were kept constant. No differences were noted on those blanched as compared with the unblanched. The chemical analysis of the resulting product has been started but has not gone far enough for definite conclusions to be drawn.

HORTICULTURE

Study of the factors influencing the rest period of horticultural plants (W. H. Lawrence).—During the year seeds and buds, together with portions of the plant carrying them, have been exposed to various physical and chemical influences for the purpose of collecting data useful in planning horticultural practices effective in influencing the rest periods of plants or the parts of plants employed in propagation. The following statement shows the nature of the tests:

1. Chemical and physical changes preceding, accompanying and following the breaking of the rest period in seeds, roots, and stems both normal and specialized.
2. Regulating and intensifying the rest period of the flower buds of the apple.
3. Influencing the date of flower bud development in the peach by use of insecticides, fungicides, fumigation, etherization and treatment with rest breaking agents other than ether.
4. Economical methods of training and treating the grape vine with special reference to uniform development of the rest period in all the buds occurring on individual plants.
5. Influencing the date of blooming, fruiting and seed production in cucurbits thru fumigation and the use of ether and other rest-period breaking agents with special reference to the rest period exhibited by seeds.
6. Study of carbon-dioxide and oxygen in relation to the rest period.

The results thus far do not make possible definite conclusions.

Asparagus selection (J. C. Whitten, J. T. Rosa, Jr.).—During the spring of 1918 experimental plots have been put out in permanent form, one plot containing rich, succulent plants selected from the largest parents and the other seedlings of miscellaneous plants of the same variety taken at random. Within two years these beds should

be old enough to begin to yield products for the market and records of their comparative yields will be of value.

It is planned also to study the individual plants in the plot of selected parents with a view to further breeding and selection from plants that may show still further superiority. During the past year the further development of the plants still show emphatically finer character of the selected plants as compared with the poor and variable character of the unselected seedlings.

Drying and evaporating fruits and vegetables (W. H. Lawrence).—Work with sweet potatoes, spinach and beets gave positive proof that a constant current of air and a temperature just high enough to induce a good rate of evaporation results in a product of good quality. The results indicate that care must be exercised in the selection of the materials in the right stage and of uniform sectioning when thick and fleshy. Furthermore the structure of parts sectioned determines the manner in which the sectioning must be done.

Investigations with seed potatoes (J. T. Rosa, Jr.).—During the spring of 1918, plantings have been made to test the yield from northern grown as compared with home grown stock of commercial varieties. The plants are in excellent condition and it is expected that yields will be secured this season so that storage experiments outlined may be carried on.

With a view to planting new varieties which might be better adapted to southern conditions we have in the past been attempting to induce seed formation on various varieties of potatoes. Heretofore we have been unsuccessful in securing seeds. During 1917 several hundred plants of the Peachblow variety, which is grown in the higher elevations in North Carolina, were grown on our experimental plots. These plants show great variation, not two plants showing similar varietal character.

Tubers were planted in the spring of 1918 from each of the more promising of these new varieties. It is hoped from this stock that we may secure varieties better adapted to Missouri conditions than our commercial varieties which have been originated in the northern states.

Apple breeding for late blooming habit (J. C. Whitten).—The Department has this year been able to add an additional phase to this breeding work thru crosses between some of our leading commercial varieties and a large-fruited wild crab apple tree which blossoms later than any cultivated variety of apple which has been found.

General characteristics of this tree and its fruit indicate that it is an accidental hybrid between the native wild crab and some cultivated variety of apple, perhaps the Bellflower.

In the spring of 1918 crosses have been effected between some of our leading commercial varieties such as Jonathan, Delicious and other varieties that blossom early and this supposed hybrid between the wild crab and common apple. It will be of great interest to observe the behavior of these crosses as our wild crab apple has qualities of strength of tree, hardiness, late blooming habit and long-keeping fruit, characters in which it excels any of the strains of common apple introduced from Europe.

Peach breeding for hardy sorts (J. C. Whitten).—The fruit buds of the peach were killed in this state during the winter of 1917 and 1918. The trees in all the breeding plots have been pruned back to overcome the effects of winter injuries. They are in good shape to continue the breeding work the first year in which breeding conditions allow production of a crop.

Examination of buds in winter for forecasting probable bloom (J. C. Whitten).—A sure method of predicting the probable bloom is by forcing the bud into bloom any time after midwinter in a vase of water in a sunny window of the house. A representative twig such as bear fruit spurs may be cut from average trees thruout the block composing each variety of apple. By repeated winter tests it is found that the proportion of blossom buds put out by forcing in this manner corresponds very closely to the percentage of buds which bloom on the trees the following spring.

It is possible for one who acquires sufficient skill and experience to determine very accurately the proportion of fruit buds by cutting into the center of a representative bud with a sharp knife.

Treatment of apple canker diseases (J. C. Whitten).—Treatment for this disease consists in pruning out of limbs that are dead or practically destroyed by canker. The limbs should be cut close and the wound painted with common paint containing corrosive sublimate as a disinfectant.

Where canker occurs in patches on the limbs or on the side of a tree the wound should be scraped clean and painted with disinfected paint.

Eighty percent of canker infections may be avoided by reducing the number of bare unnecessary wounds during pruning and cultivation.

Bud selection for increasing yields—apples (J. C. Whitten).—In previous reports no differences have been observed either in the yield or quality of the fruit on Ben Davis apple trees propagated from a high yielding parent tree, as compared with those propagated from a low yielding parent which produced also an inferior quality of fruit. In 1917 the comparative yield of these bud selected trees was as follows:

Trees of high yielding parentage produced eleven and three-eighths bushels per tree. Trees of low yielding parentage produced six and seven-twelfths bushels per tree. These records show almost exactly the reverse of those reported for 1916.

This is explainable for the reason that individual Ben Davis trees tend to bear in alternate years. The trees of poor parentage which made the high yield in 1916 produced a low yield in 1917 and vice versa. There was no measurable difference in the size or quality of the fruit produced on these trees of different parentage.

Summing up the results for the entire period of years since the trees came into bearing there is no significant difference between the total yield of the trees of high yielding parents and low yielding parents.

Self fertility and self sterility of fruits (J. C. Whitten, C. C. Wiggans).—Observations of peaches covering a period of years indicate that practically all leading varieties of peaches grown in this state are apparently self fertile in an average season. Only two varieties out of 160 tested have shown to be in any measure self sterile. These two varieties are not among the leading varieties and are not generally grown in the state.

In apples, Paynes Keeper is, in most years, almost entirely self sterile. The Jonathan also shows more or less tendency towards self sterility. These two varieties should be planted in blocks alternating with such varieties as Delicious, Gano, York and Grimes, which are known to be good pollen producers and which are probably every year fully self fertile.

It is apparent from several seasons' observations that if a self sterile variety of eight rows has a good pollen bearing variety in blocks on either side of it each pollen bearing block will furnish sufficient pollen to fully fertilize the four adjacent self sterile rows.

Fall vs. spring planting of trees (J. C. Whitten).—The results of extensive tests covering approximately a decade are now being prepared in bulletin form for publication. While nearly all varieties of hardy fruits prove to succeed better when planted in late fall than

when planted in the spring, fall planting is recommended where possible except in such cases as the Ingram apple which is exceptional in that it has done better when planted in the spring.

Results at this Experiment station are conclusive in that early fall planting of hardy fruit trees gives better results than spring planting. Also that late fall planting just before the ground freezes is superior to early fall planting, a fact not hitherto recognized.

Orchard heating in years when spring frosts occur (C. C. Wiggans).—The need of orchard heating has been reduced thru the formulation of the following factors which oppose frost injury and which were worked out by this Experiment Station:

(a) The more concentrated the sap in fruit trees or other plants, the lower their freezing point and consequently the more frost they will endure without injury.

Fruit trees may be made to store larger quantities of plant-food reserves by maintaining a healthy leaf surface until late in the fall, to elaborate plant-food reserves for as long a period as possible after length growth of the branches ceases in summer. This may be varied by spraying, which maintains healthy foliage, proper pruning the previous winter to maintain the right degree of vigor in parts that remain; summer pruning where necessary to check abnormal length growth and proper soil handling in the bearing orchard to avoid having the trees begin a partial rest period during dry, hot weather of July or August, and then putting out a late summer growth or spring-like awakening of new growth when autumn rains come on.

(b) The later fruit trees go into their rest period in the fall, the later will they wake up from this rest period in spring and this prolonged dormancy opposes injury from spring frosts.

It is exceedingly undesirable to allow trees to suffer from July or August drouth so as to begin a partial rest period at this time, then upon occurrence of autumn rains to awaken from this partial rest and make a tender spring-like growth during the autumn. If trees pass a portion of their real rest period in late summer and then awaken and make autumn length growth they will pass a correspondingly shorter rest period during the following winter. The buds will tend to wake up more or less during sunny days of late winter and become tender so they cannot so well endure spring frosts.

Sometimes fruit trees begin their rest period in July or August and if unsprayed and improperly managed their leaves will partly shed without any autumn awakening of growth, provided the

autumn is dry. In such cases the trees have a very brief winter rest and become very susceptible to frost injury thru late winter and early spring.

The same factors—proper spraying, proper pruning and proper soil management, that favor concentration of sap thru storage of plant-food reserves also favor delaying the beginning of the rest period to very late autumn and enable the trees to maintain this rest period until it is safe for them to awaken growth in spring.

During the spring of 1918 somewhat heavy frosts occurred during all but two nights thruout the blossoming period of apples. This was not sufficient to prevent the setting of a good crop of fruit on the Experiment Station grounds and in well managed orchards generally thruout the state. There was, however, a moderately heavy bloom on neglected orchards.

We are not yet ready to conclude that general care of the trees may avoid injury from the very severe frosts which occasionally occur in this state. Orchard heating may perhaps be necessary for protection when unusually severe frosts occur. It is perfectly apparent, however, that good management of fruit trees is avoiding injury by such spring cold and frosts as are likely to occur frequently in the state.

Orchard tillage—sod, clean cultivation, mulch, combined cultivation and cover crops (J. C. Whitten, C. C. Wiggins).—In the spring of 1918 the number of blossoms was much larger on the sod plots containing alfalfa, clover or timothy than on the plots given clean tillage or tillage followed by late summer and autumn cover crops. Fruit spur development is much more marked on the sod plots, altho short branches (potential fruit spurs) are forming on the tillage plots.

The vigor of wood growth is most marked on the plot given clean cultivation in corn until July and then put in cowpeas as a cover crop. In the other plots the relative vigor of growth follows in the order named: cultivation and corn, clover, timothy and alfalfa.

The size of the individual leaf, and the area of leaves on the average fruit spur, is greatest in the cultivation in cowpeas plot and decreases in case of the other plots as follows: clean cultivation in corn, timothy, clover and alfalfa.

The trees of all varieties drop their leaves and leaf out in the different plots in the following order as to earliness: clover, timothy, cultivation in corn, alfalfa, cultivation and cowpeas. The treatment

which causes the trees to drop their leaves earlier in the fall also causes the leaves to appear earliest in spring. This is of interest in connection with rest period and hardiness studies being carried out as a separate project. The trees in clover shed their leaves earlier in the fall and leaf out earlier in the spring. Those given clean cultivation in early season followed by cowpeas as a cover crop hold their leaves latest in the fall and leaf out latest in spring. This fact is of much interest for Missouri growers, as we find it is desirable that trees hold their leaves late in autumn in order to retain their rest period until as late as possible in spring. Early spring awakening during late spring frosts is one of the limiting factors for a safe setting of the fruit crop in this state.

Tree mortality has been greatest in the timothy plot and decreases in the other plots as follows: alfalfa, clover, cultivation in corn and cultivation and cowpeas.

While the foregoing results are significant, it is perhaps too early to draw final conclusions from this experiment alone as to what may prove to be the best system of orchard soil management over a long period of years or thruout the life history of the orchard.

Spraying fruits for insects and fungous diseases (W.W. Lawrence).—Investigations during the year were conducted to determine:

1. The relative value of various combination sprays for use in controlling insect pests and fungous diseases attacking the foliage and fruit of the apple, and
2. The relative influence of various materials used in combinations upon the chemical composition of the combination.

Results strongly indicate that among the arsenicals used to destroy insects that chew and swallow their food the ortho, neutral or triplumbic form of arsenate of lead produces the least injury to fruit and foliage and gives satisfactory results from the control point of view. Lime and sulphur gave the most desirable results for early spraying, while bordeaux gave better results, for late spraying.

The nutrition of fruits with special reference to their hardiness (J. C. Whitten, C. C. Wiggans).—In January, 1918, as in the preceding winter, the fruit buds of the peach were killed thruout the state. For that reason no data were available upon the effects of the various fertilizers upon the peach crop produced.

As in previous seasons, however, it is noted that the nitrogen fed trees are in much more vigorous condition than are the trees which received no nitrogen. They are making more new growth and are much more quickly recovering from severe injury to the wood last winter than are the trees that received no nitrogen.

No visible effects are observable where potash or phosphorous has been applied to peaches in past years, either singly or in combination.

Young bearing apple trees in the Brandsville plot made larger growth (as determined by trunk diameter increase and general observations of the branch system) where nitrogen was applied.

Negative results were obtained where phosphorous or potash were applied, singly or in combination.

A record of the crop of 1917 shows no significant difference in the yield between check plots and plots where the various fertilizers were applied.

In the plot of old mature bearing apple trees at Amoret, no differences were obtained in the quantity of the crop in 1918 and there is no measurable difference in the growth of the trees on check plots, nitrogen plots or plots where mineral fertilizers were applied. The soil at Amoret is of medium fertility but richer than the thin soil at Brandsville.

On the other plot of young trees recently planted at Lebanon no differences in growth were secured on the various fertilizer and check plots. The soil is thin, not much richer than that at Brandsville; but exceedingly good care and cultivation of the orchard was given by the owner, which may account for no greater growth, even on the nitrogen plots.

The above experiments on the use of fertilizers on fruit trees in the orchard tend to confirm the past season's results and seem to justify the following conclusions to date: On the various Missouri soils under test there is no apparent advantage in adding mineral fertilizers even up to the time that the orchard reaches mature bearing age. It is not yet possible to predict whether these fertilizers may prove profitable in prolonging the life or bearing vigor of the tree after it otherwise would have begun to reach a decline.

In every instance except at Lebanon during 1917, young peach trees and apple trees have made much stronger growth and suffered less mortality and have reached bearing age and strength sooner where nitrogen was applied.

Blight, however, has during the past three years, been very much more severe on the trees rendered more succulent by the addition of nitrogen. It is doubtful as to whether the application of nitrogenous fertilizers is justified on young trees in the case of blight susceptible varieties of apples. The more succulent trees suffer enough more from blight to offset the greater growth produced by the nitro-

gen. On young peach trees the use of nitrogen is justified on account of less mortality of the trees in the orchard, stronger, more vigorous growth, better recovery after winter injury and in some years it has increased the fruit crop fully 50 per cent.

The foregoing observations in commercial orchards are rendered more conclusive by the behavior of dwarf apple trees grown in tubs on the Horticultural grounds. One set of these trees is growing in Missouri River sand, the other set being grown in loess soil taken eight feet below the surface so as to include none of the surface humus. These trees reached their first bearing year in 1917.

The application of phosphorous and potash applied singly or in combination has not visibly affected the growth or behavior of the trees, even in these soils very low in plant food. Nitrogen applied singly or in combination has resulted in almost double the growth that has been secured on check trees or trees to which mineral fertilizers alone were applied.

The nitrogen-fed trees produced a fair fruit crop in 1917, while no fruit buds whatever set on trees receiving any other treatment or no treatment.

Counts made in the spring of 1918 showed that nitrogen is a very important limiting factor in blossom formation upon the tree. The blossoms were numerous in the spring of 1918 on the nitrogen-fed trees, but were entirely absent on these receiving mineral salts, altho a few of the check trees had an occasional bloom.

The nitrogen-fed trees are establishing a splendid stand of fruit spurs, while no such fruit spur development is beginning on check trees or those fed mineral salts.

These tests indicate that no liberal amount of mineral salts is required for proper development of young apple trees, but indicate emphatically that available nitrogen is very essential in developing the strength, vigor and size of the trees and in hastening their development to fruiting capacity.

Fruit bud development of fruit trees as influenced by treatment and previous crops (C. C. Wiggans).—Continued observations during 1917-18 upon the behavior of individual fruit spurs of the apple show that fruit spurs of Jonathan, Winesap, Gano, Rome and York tend to bloom in alternate years. This confirms observations made upon the individual fruit spurs in past seasons. The evidence now seems conclusive that in all our leading commercial varieties of apples observed a given fruit spur is not usually able to mature fruit and at the same time develop a fruiting bud for the

following year. On Gano, Rome and York only an occasional fruit spur produces blossoms two years in succession. Jonathan, Grimes and Winesap may produce blooms on the same spur two years in succession somewhat more frequently, tho this occurrence is somewhat rare even in these varieties.

The explanation why Gano, Rome and York tend to produce alternate crops is that on the year when they bear at all, practically all their individual fruit spurs produce fruit, leaving very few non-fruiting spurs to blossom the following year. The explanation for the more regular annual bearing of Jonathan and Winesap lies in the fact that only a portion of their fruit spurs set fruit on a given year and the remainder carrying no fruit are able to mature fruit buds for the following year.

The foregoing facts in the life history of the development of the individual fruit spurs and fruit buds have not heretofore been definitely known to horticulturists. The knowledge now established is very important as a fundamental fact upon which to base intelligent operations in pruning, thinning the fruit and other phases of management of the tree.

It has also been made possible now to determine the age or duration of fruiting of the individual fruit spur on these leading commercial varieties. Observations since the experiment began show that an individual fruit spur has a fruiting life history ranging from two to eight years. Few spurs, however, begin to bear before they are three years old and but few retain their bearing form beyond six years of age. From three to six years of age is the most efficient fruiting period of the individual spur. Spurs older than this are usually either shaded out and fail or, if requisite light and other conditions are favorable to their continued growth, they develop into longer branches, upon which a new crop of fruit spurs develop.

A study of the above varieties of trees growing on different types of soil from the heavy clay loam and subsoil on the Horticultural grounds at Columbia to the deep loess soil on the grounds at Turner Station, shows that there is apparently no relation between the character of the soil on which the tree grows and the alternation of the individual spurs. The fact that more regular crops are secured on a favorable fruit soil is due to the fact that favorable conditions enable the trees to produce annual succession of fruit spurs.

Removing the blossoms from a tree by accident or design may result in a change in the fruitful year. To some extent removal of the blossoms or fruit (thinning) of an individual fruit spur or branch may result in changing its fruitful year.

Sap from bearing spurs has slightly higher concentration (lower freezing point) during a considerable portion of the year than sap from non-bearing spurs. Sugar and starch are present in slightly greater amounts in the bearing spur than in the non-bearing one.

If the blossoms or fruit are removed from a bearing spur, apparently this available sugar is directed toward the development of a fruit bud for the following year.

Trees pruned to a low head and just now reaching fruiting age are developing fruit spurs in far larger number than are high-headed trees of the same age. The low-headed trees have a far larger trunk diameter, and limbs are larger toward the base and they have in every way a stockier, stronger form than the high-headed trees. Incidentally, the high-headed trees are suffering from sunscald (drying out of the cells and growing layer on the sunny side of the tree, due to the alternate sunny days and freezing nights), which occurs during the last half of winter. It is apparent that the shorter the distance between the main root and the fruit spur, the better will be the fruit spur development and the easier it is to renew a succession of fruit spurs by pruning. Apparently long stems and branches not only dry out in the sun in late winter, but they bend and twist and restrict proper flow of sap. In short stemmed trees there is no such restriction to the ready passage of sap.

POULTRY

Sex-linked inheritance in poultry (George Lefevre).—(a) The inheritance of spangling in poultry. The results of this experiment are now practically ready for publication. A large number of photographs illustrating the main facts have been taken and will appear in the published results.

(b) The inheritance of hen-feathering in the male fowl. The experiments, which were undertaken to determine the mode of inheritance of hen-feathering in the male, have been continued during the year, and additional matings have been made to test the genetic constitution of the different types of males obtained from the crosses. This series of experiments has been greatly interfered with by the loss of birds from roup during the past two seasons making necessary a repetition of a number of the crosses that had previously been made.

Value of sour milk, beef scrap, cottonseed meal, gluten meal and oil meal in rations for egg production (H. L. Kempster,

George Hervey, E. L. Dakan).—During 1917-18 the use of gluten meal was discontinued and various combinations of meat scrap with and without cottonseed meal were used. From the data collected during the year it is seen that the use of a small amount of meat scrap even as small as three or four per cent of the entire ration greatly increases the efficiency of the ration. There is no evidence that cottonseed meal adds to the efficiency of the ration.

SOILS

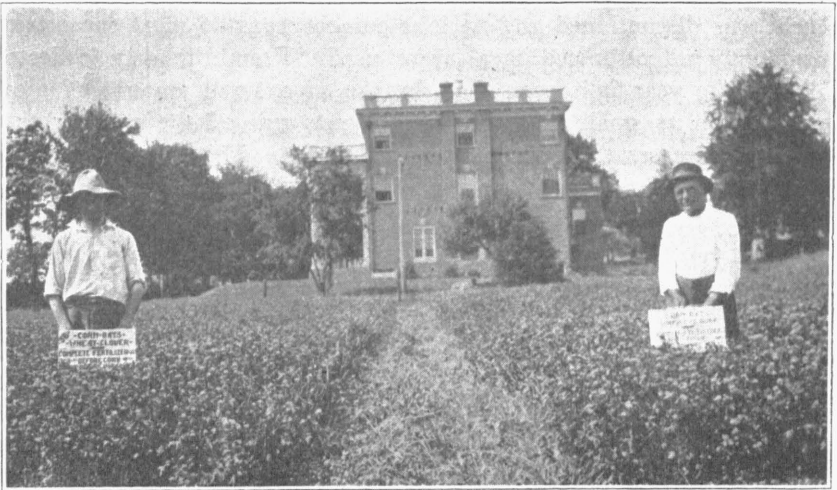
Crop rotation and fertilizer experiments (M. F. Miller, F. L. Duley).—The summarized data from these experiments have been given in several previous reports. This year they will be confined purely to the yields of wheat on various treated plots since it happened during the last fiscal year that a large number of the plots were in wheat. The following table shows some significant effects of rotation and manuring on the yield of wheat after twenty-eight years of cropping.

YIELDS OF WHEAT ON ROTATION EXPERIMENT FIELD, 1917

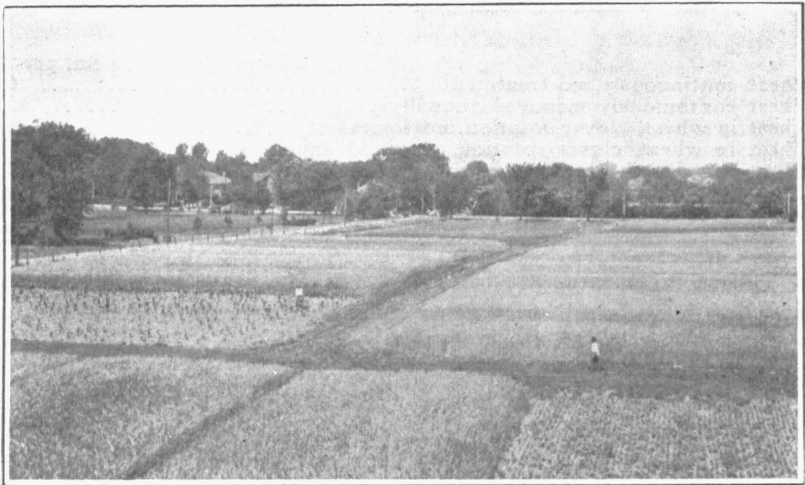
28th Crop

	Bu. per A.
Wheat continuously, no treatment	0.2
Wheat continuously manured annually	10.9
Wheat in wheat, clover rotation, no treatment	20.7
Wheat in wheat, clover rotation, manured annually	27.4
Wheat in corn, wheat, clover rotation, no treatment	13.5
Wheat in corn, wheat, clover rotation, manured annually	31.0
Wheat in corn, oats, wheat, clover rotation, no treatment	30.0
Wheat in corn, oats, wheat, clover rotation, manured annually	39.4

These differences are certainly very significant in indicating the effect of various soil treatments thru long periods. The untreated plot was particularly low in yield this last year, evidently due to seasonal conditions which affected this plot more than the others.



Red clover grown in the corn, oats, wheat, clover rotation. Plot on left, lime and 3-10-4 fertilizer applied, yield 4550 pounds. Plot on right, 3-10-4 fertilizer applied, yield 3920 pounds.



Rotation field, looking west from the top of the veterinary building.

Some significant figures which have never been given before in regard to the effect of rotation as it influences the return from manure and fertilizer are as follows:

AVERAGE YIELD FOR 25 YEARS

Continuous wheat, no treatment	9.5
Continuous wheat, manured	17.4
Continuous wheat, heavily fertilized	17.9
Wheat in rotation, no treatment	20.7
Wheat in rotation, manured	25.9
Wheat in rotation, heavily fertilized	29.1

The revised plan of treatment for certain plots, which went into effect at the beginning of the second twenty-five-year period has begun to show some marked results, but the treatments have not been given a sufficient length of time to warrant a report on them.

Studies of water absorption, percolation, evaporation, capillary water movement and soil erosion under field conditions (M. F. Miller, F. L. Duley).—This experiment includes a series of plots subjected to different systems of cropping and cultivation to determine the effects of these treatments on the water entering the soil and the material removed from the soil by erosion. The plots are six feet wide and $90\frac{3}{4}$ feet long, or about $\frac{1}{80}$ of an acre. The slope is about three per cent. The plan of treatment is as follows:

- Plot 1. Cultivated (land kept free of weeds).
- Plot 2. Plowed four inches deep and cultivated shallow after rains.
- Plot 3. Plowed eight inches deep, cultivated shallow after rains.
- Plot 4. Sod continuously.
- Plot 5. Rotation of corn, wheat, clover.
- Plot 6. Corn continuously.

Each plot is enclosed by a curbing which carries the water directly down the slope. At the lower end of each plot is a deep concrete tank in which the run-off water and eroded material is collected. Measurements of this water and sediment are made after each rain.

This test has not proceeded far enough to furnish very consistent data but some of the more striking points can be mentioned. For instance, the amount of water running off the land during the summer of 1917 from the uncultivated plot was 51.4 per cent of the total rainfall, or about twice the amount which ran off the cultivated plot and more than four times the amount leaving when the plots were kept in grass.

The erosion from the bare plot where the weeds were kept down was only slightly greater than that from the cultivated land in spite of the fact that the run-off was greater. The amount of run-off from the bare plot was nearly thirty times as much as that from the plot kept in sod. The other plots which are not quite so extreme in treatment, such as those in corn and those in small grain, have

amounts of run-off which are intermediate between these. It will take several seasons to secure accurate data as to the exact effect of these various systems of cropping upon the run-off and erosion.

The plan of experiment also includes a study of the movement of moisture in the upper four feet of soil and the evaporation from this column. This is made by collecting drainage coming thru lysimeters four feet deep which enclose large blocks of soil in place. The leachings from these lysimeters are to be analyzed from time to time to determine the amount of plant food being removed by leaching. Careful records of the rainfall, temperature, humidity, wind velocity and the evaporation of water from a water free surface are being kept.

It is believed that this experiment will give accurate information regarding the losses to land thru erosion and the effect of different systems of soil management upon penetration and erosion.

The rate of accumulation and cost of nitrogen and carbon in soils under different systems of green manuring and cropping (M. F. Miller, F. L. Duley).—This experiment is designed to study the effect of certain crops and systems of cropping upon the nitrogen and carbon content of the soil. The soil was analyzed at the beginning of the work and will be analyzed at intervals of about three years. The comparative analyses are to be used as a basis for comparing the effect of the various treatments. One series of these plots occupies the crest of the ridge where there has been very little erosion of the surface soil. The other series is farther down the slope and has lost much of the top soil thru surface washing. These facts may be seen from the analyses given below.

Analyses were made for the total nitrogen content of the surface 7 inches of soil and the subsoil 8 to 12 inches. The nitrogen in the top soil varied from 0.116 per cent to 0.158 per cent in the better series of plots 1 to 16. The subsoil from these same plots varied from 0.0745 per cent to 0.105 per cent nitrogen. The plots 17 to 24 on the more sloping land showed 0.101 to 0.116 per cent nitrogen in the top soil and 0.062 to 0.079 per cent in the subsoil.

It is hoped that the final results on these plots will show the exact value of nitrogen and organic matter from the turning under of a clover crop, from taking off a clover crop, from leaving land in sod, from the turning under of cowpeas and rye and from the growing of alfalfa.

The work has been proceeding very satisfactorily during the past year, good crops having been produced and all work having been done according to schedule.

Determination of the relative value of different forms of phosphorus upon the soil at Columbia (M. F. Miller, F. L. Duley).—The results of the comparative trials of phosphates during the past year when the plots have been in wheat show some rather interesting differences. The following table shows the average increase in bushels of wheat per acre from equal money values of the various phosphates used in the experiment:

	Increase bu. per acre
Rock phosphate	2.3
Acid phosphate	3.0
Bonemeal	7.5
Basic slag	3.8
Calcined phosphate	5.5

The results indicate that while rock phosphate is the lowest in actual returns per acre some of the other phosphates have brought very significant increases. The calcined phosphate is a new one which is just being tried out. It is made by heating rock phosphate under certain conditions, and promises a good deal for future fertilization if it can be put on the market at an economical figure.

The effect of different amounts and different methods of applying commercial fertilizer to the corn crop (M. F. Miller, F. L. Duley).—The results of this experiment during the past year have been somewhat interfered with because of the dry season as was the case the preceding year. As an average of two years' trial it may be said that when the weather is dry the application of fertilizers in the row has brought materially less return than the application of fertilizer with the fertilizer drill in advance of the corn planter. The early effects of the row fertilization are more marked than the early effects of the fertilizer applied over the whole surface, but corn so fertilized does not seem to be able to stand the drought so well during July and August because of the larger leaf development. Fertilizer applied as a side application along the row at the second or third cultivation has brought fairly good increases as an average of these two years.

Nitrate production in soil as affected by the crop and cultivation (William A. Albrecht).—Since the beginning of this project nitrate determinations have been regularly made on the surface soils of ten plots under different systems of cropping and cultivation.

- Plot 1. Unplowed, scraped to remove weeds, corn.
- Plot 2. Plowed, scraped to remove weeds, corn.
- Plot 3. Plowed, mulched with straw, no crop.
- Plot 4. Plowed, scraped to remove weeds, no crop.
- Plot 5. Unplowed, weeds pulled by hand, no crop.

- Plot 6. Plowed four inches deep, cultivated, no crop.
- Plot 7. Plowed eight inches deep, cultivated, grass.
- Plot 8. Plowed eight inches deep—rotation.
- Plot 9. Plowed eight inches deep—rotation.
- Plot 10. Plowed eight inches deep, cultivated.

The results of the first year indicate the following:

1. The most significant influence of the crops is that of removing the nitrates. A reduction of nitrates takes place when the crop makes its rapid growth. For corn, nitrates accumulated until late in June but decreased very decidedly thereafter. For the grasses, including oats and timothy sod, no significant accumulation ever occurred, altho there was slight increase after the crops were harvested.

2. Cultivation failed to have any significant favorable effect. The greatest accumulation was obtained in the plot which was plowed in the spring and scraped to remove the weeds. The next highest accumulation resulted where the soil was left entirely undisturbed save that the weeds were pulled by hand. No appreciable difference was given by plowing four inches deep as compared to plowing eight inches deep. Plots left uncultivated were higher in nitrates than those cultivated regularly during the year.

3. The straw mulch had a decidedly depressing effect on nitrate accumulation. No significant accumulations occurred. Apparently the high moisture was responsible, since the curve of moisture percentage bears a negative correlation to that of nitrate accumulation.

Studies on the nitrogen content of soils as affected by storage (W. A. Albrecht).—Since the last report this project has been completed and a report of it is published in the *Journal of the American Society of Agronomy* (Volume 10, No. 2, pp. 83-88, February, 1918). The results showed that changes in nitrogen of stored soil may take place thru contamination by absorption of ammonia if stored in a room near ammonia fumes. Under conditions prohibiting such contamination, no detectable change in the various forms of nitrogen was found. This indicates that bacterial action was of no significance while the soils were in storage, but that precautions must be taken in storing soils to prevent their absorbing much nitrogen if stored near laboratories containing ammonia.

Experiments to determine the best systems of soil management for the most important soil types in Missouri (M. F. Miller, F. L. Duley, B. W. Tillman).—The following fields have been in operation during the past fiscal year:

FIELD NAME	SOIL TYPE	COUNTY
Maryville	Marshall silt loam	Nodaway
Chillicothe	Wabash clay	Livingston
Hurdland	Grundy silt loam	Knox
Kirksville (b)	Lindley loam	Adair
Vandalia	Putnam silt loam	Audrain
Wentzville (a)	Putnam silt loam	St. Charles
Portage des Sioux	Wabash clay	St. Charles
Windsor	Oswego silt loam	Pettis
Billings	Crawford silt loam	Christian
Strafford	Lebanon gravelly loam	Greene
Willow Springs	Clarksville gravelly loam	Phelps
Union	Union silt loam	Franklin
Morley	Sarpy sandy loam	Scott
Poplar Bluff	Waverly silt loam	Butler

- a Closed during year.
- b Established during year.

Some of the more striking results of these experiments may be summarized as follows:



St. James experiment field, wheat, 1918. Plot on right received manure and yielded 23.08 bushels per acre. Plot on left received manure and phosphate and produced 33.33 bushels per acre.

As an average of all trials a ton of barnyard manure has given a crop increase value at \$4.20, at present crop values, and \$2.50 at pre-war values. On certain fields much more striking returns have been secured for manure. For instance, on the St. James field during the past year an application of eight tons of manure applied before corn gave an increased value in the 1917 soybean crop which followed the corn crop of \$35 per acre. The corn crop the preceding



Effect of fertilizer on Ozark land.



Wentzville experiment field, wheat, 1917. Yields: Plot on left, acid phosphate, 27.16 bushels; plot on right, no treatment, 15.37 bushels.

year had been increased 25.2 bushels per acre by this application. Figuring corn at one dollar a bushel this would give a return on these two crops from the manure of \$60.20 or \$7.52 per ton.

As an average of all experiments to date the application of 300 pounds steamed bone meal has brought a return in four years of ap-

proximately \$20 an acre at present crop values. Similarly, an application of 400 pounds of acid phosphate has brought a return of almost exactly the same amount. This means that considering the present prices of bone meal and acid phosphate, one dollar invested in either of these fertilizers has brought \$4 return in the increased crops.

It should be mentioned in this connection that raw rock phosphate which has been applied on a number of these experiment fields during a period of from six to ten years has just about paid for its cost when all figures are averaged.

The use of ground limestone has brought particularly good returns on the northeast Missouri experiment fields and on the upland experiment fields south of the river. As an average of these fields the return from a ton of ground limestone at present crop values has been approximately \$8. Figuring the cost of ground limestone applied the land at \$3 a ton, which is a fair price at this time, the return per dollar invested has been \$2.65.

During the past year special attention has been given to the furthering of the use of limestone on the soil types occupied by these soil experiment fields and some progress has been made in putting out demonstrations with farmers.

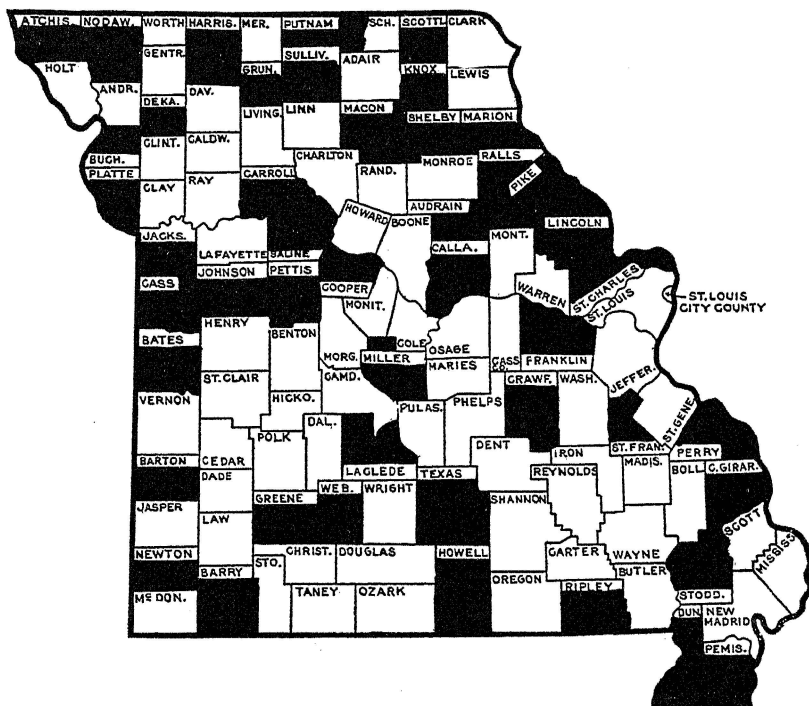
Soybeans are coming to be of more and more importance in these experiments. The effect of eight tons of barnyard manure applied the previous year at St. James has increased the yield 8.7 bushels per acre with a thousand pound increase in straw. The results are shown in the accompanying photographs.

Good results have been secured on the sandy soils of southeast Missouri from the plowing under of cowpeas as a green manure. In this particular region cowpeas are rather commonly grown after wheat and are usually harvested. The result is that the wheat yield is not maintained at the highest point. These results show that the turning under of occasional cowpea crops will be of remarkable advantage to the land. For instance, the 1917 yield showed that the turning under of cowpeas increased the yield of corn 24.2 bushels and wheat 6.7 bushels.

The determination and mapping of Missouri soil (M. F. Miller, H. H. Krusekopf, Wm. DeYoung).—The soil survey work in cooperation with the U. S. Department of Agriculture, has been conducted as in previous years, altho somewhat interfered with by the war. It has been impossible to maintain a full force of workers. The following counties have been completed during the year: Knox,

Lincoln and Texas. This brings the total number of counties surveyed to date up to forty-seven.

The map of the reconnaissance survey which was completed during the previous fiscal year has been issued together with the



Map locating the forty-seven Missouri counties in which soil surveys have been conducted.

accompanying report. This map and report summarizes a great deal of information in regard to the soils of Missouri. It should be of much value to Missouri farmers and those interested in Missouri land, as well as to soil specialists. Ten thousand copies have been published and an additional thousand copies of the map have been printed with the idea of placing these in the high schools and banks of the State.

VETERINARY SCIENCE

Contagious abortion investigations (J. W. Connaway, A. J. Durant, H. G. Newman).—Work on this project was continued during the year 1917-18. Valuable cooperation has been given by the Department of Dairy Husbandry, stock breeders, county agents and

veterinary practitioners. By means of the complement fixation test for contagious abortion, the presence, extent and progress of the disease has been studied in a number of suspected herds, and measures of prevention and eradication have been advised and experimented upon.

In the routine testing work during the year 63 herds of cattle were tested, comprising 856 animals. Total number of tests made, including retests, were 1981. The herds tested were distributed in 29 counties of the State. Of the 63 suspected herds investigated, samples from 45 herds gave a positive reaction to the complement fixation test. Thus 71.4 per cent of the suspected herds contained infected animals while 18 herds or 28.6 per cent of the suspected herds were found to be free from the disease.

Systematic Experiments.—The more systematic studies on contagious abortion in cooperation with the Department of Dairy Husbandry, were continued from the previous year on the Experiment Station dairy herd. In this experiment, which began three years previously, monthly blood tests were continued on all the animals in the herd, comprising more than one hundred animals. Each newborn calf as well as the dams and sires was tested.

The data obtained in these experiments, show that:

1. (a) Some of the mature breeding cows of the herd which had become infected with the contagious abortion disease retained the infection within the body continuously (i. e. without a probable reinfection) for a period of at least three years, as shown by the persistent monthly reactions of a group of experimental cows, and by other confirmatory facts in these experiments. In three cows of this experimental group the bacilli of abortion, which were infectious to guinea pigs, were present in the milk; showing that in these cases, an active focus of abortion infection was located in the udder. And indicating that a persistent focus of active infection is located in the udder, or in some other organ, of all the constant positive reactors.

- (b) That some of the mature breeding cows, after infection with contagious abortion disease, gave a variable reaction to the complement fixation test. That is, some positive reactors became negative, and remained so for a considerable period; and in some instances the data indicate that the negative reaction may be permanent. It thus appears that the abortion infection may die out and disappear in some breeding cows. In these cases the infection was probably localized in tissues which are not so favorable to the continued vitality of the *B. abortus*, as the udder appears to be. Another

variable reaction which was observed was the occurrence of an occasional positive reaction in breeding cows whose monthly reactions were in the main negative; and it was observed that in such an animal the positive reaction was more liable to occur at or near the calving period. The most rational interpretation of these cases is that a focus of dormant infection is localized in some portion of the body, and that this infection becomes active only when pregnancy is well advanced.

2. Other mature breeding cows, altho exposed to the same conditions in barns and on pastures, and served by the same bulls, as the groups of cows mentioned above, escaped infection, or at least showed no clinical nor serological indications of it during a three-years' period in which monthly tests for abortion were made.

In this experimental herd, dangerous infection apparently was not discharged in the feces and urine of the positive reactors during the greater part of the pregnancy period. But the conclusion should not be drawn that in all abortion infected herds, non-reactors may mingle continuously with immune reactors without danger of becoming infected; since in this experimental herd the dangers of spreading the infection to susceptible cows and heifers were lessened by the temporary isolation of the pregnant cows at time of calving, as well as by the prompt isolation of cows which showed premonitory symptoms of abortion. The thoro disinfection of the calving pens, and the "afterbirths" and discharges also lessened the dangers to susceptible cows. Moreover, the death of some of the older reacting cows, and the butchering of others which were not particularly valuable as milk producers still further lessened the opportunities to spread abortion infection to the susceptible non-reactors. The possibility too of a greatly diminished virulency in the strain of abortion infection in this herd may have lessened the dangers to the susceptible non-reactors. Too much stress, however, should not be laid upon the latter interpretation; since the only cow which aborted in this herd, during the year just closed, was a cow which had aborted twice previously, but had calved normally at the two regular intervening periods. The immunity or resistance which is apparently acquired by some cows, following an abortion, was not permanent in this cow. Her resistance against the infection was evidently greatly diminished, if the virulency of the infection which she is harboring, was not greatly increased.

3. Calves from every immune, positive reacting dam, in the herd under experiment showed a positive reaction at or near birth;

but this positive reaction gradually disappeared and they became non-reactors. The time in which this change took place varied from forty-two to two hundred days; the average time being one hundred and ten days.

Whether the positive reaction of a new born calf is due to preformed antibodies which have passed from the dam to the calf in utero, or to antibodies produced by the foetus itself, under the stimulation of abortion bacilli which have passed from the dam to the foetus, or whether these antibodies may come from both sources, are unsettled questions which are under investigation.

4. None of the heifers which were positive reactors at birth, and later became non-reactors with one exception, has had a return of the positive condition, either before or after the breeding period. And all which have been bred and have calved have produced at full term healthy non-reacting calves.

It is thus evident that a permanent systemic abortion infection is not often transmitted from the mother to the viable foetus. And the feasibility of rearing abortion free progeny from positive reacting dam is demonstrated.

5. The data also show that, with the one possible exception mentioned above, none of the positive reacting calves, after becoming non-reactors, acquired a permanent or even a transient systemic abortion infection thru the ingestion of raw milk from the abortion reacting cows of the herd; nor from the ingestion of other foods which may have been accidentally contaminated with the uterine discharges or other excreta from the abortion reactors. During the experimental period, however, the dangers of infecting the young heifers from these sources became less and less thru the gradual elimination of abortion reactors from the herd, and from better sanitary measures than are applied on stock farms where abortion disease persists in a more or less virulent form.

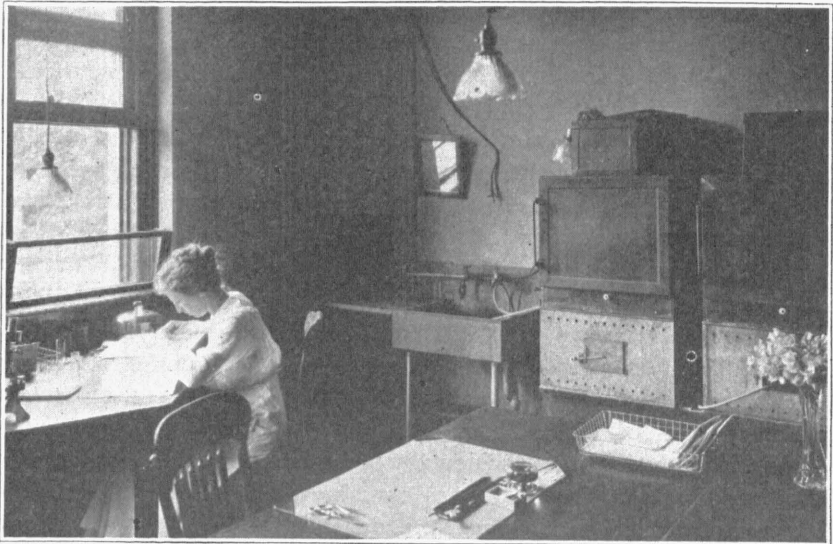
6. One heifer of the group which gave a positive reaction at birth, had a recurrence of the positive reaction after a six months' negative phase, and seven months before breeding. This heifer dropped a positive reacting calf eighteen days prematurely.

This heifer apparently retained for a time, in a dormant condition, abortion infection derived before birth from the mother. And this prenatal infection became active again before the breeding period; or on the other hand she acquired an apparently permanent systemic infection, before breeding, by ingesting milk or other foods infected with abortion virus.

7. None of the herd bulls, which were bred to positive reacting immune cows, developed a positive reaction to the complement fixation test; and presumably, did not become systematically infected.

MISCELLANEOUS WORK OF THE STATION

Seed testing laboratory (W. C. Etheridge, Rachel Holmes, Helen Averitt).—The work of the Missouri Branch Seed Laboratory conducted cooperatively by the Missouri Experiment Station and the Bureau of Plant Industry, has been in progress for a number of years.



Seed testing laboratory conducted cooperatively by the Missouri Agricultural Experiment Station and the Bureau of Plant Industry, U. S. D. A.

During this time the number of samples analyzed each year both for purity and for germination has greatly increased. During no year, however, has the increase over the preceding year been greater than that of the last fiscal year. Thus showing that the farmers of the State are taking much more interest in the matter of pure seeds. The following data bear on this point:

Number of samples received	4409
Number received from Missouri	3689 or 84%
Number of tests made for purity	928
Number of tests made for germination	4150
Number of examinations made	59
Number of identifications	103
Number of general tests of corn	895
Number of tests of ear corn	1287

The number of samples received for 1917-18 was 156 per cent greater than the number received in the preceding year.

Fertilizer control (F. B. Mumford, Director, P. F. Trowbridge, Chemist).—Manufacturers are selling more fertilizers in Missouri, but are making a less number of brands.

During 1917, 227 localities in 58 counties, were visited by the inspectors. Five hundred ninety-six samples, representing 181 different brands, were taken. Owing to unsettled conditions and the high price of sulphuric acid the manufacturers did not carry an excessive stock of acid phosphate. There was an increased demand for fertilizers for wheat. In attempting to meet this demand nearly every manufacturer sold out completely and some confusion resulted in making substitutions that would give as nearly as possible the fertilizer desired.

Official testing of dairy cows (M. H. Fohrman).—During the year just completed 349 cows were officially tested for 28 breeders in 15 counties of the state. Supervisors paid 157 visits to breeders and conducted a total of 1473 two-day tests and 25 seven-day tests. There was a decrease of approximately 20 per cent in the number of tests conducted in the state during the past year.

The following tabulation shows the progress of this work for the past three years:

	Fiscal year ending June 30		
	1916	1917	1918
No. cows tested	336	413	349
No Breeders represented	24	26	28
No. counties represented	12	11	15
No. 2-day tests	1,744	2,072	1,473
No. 7-day tests	22	47	25

Nursery inspection (L. Haseman, A. H. Hollinger, K. C. Sullivan).—Following is a statement of the work done by the Nursery Inspection Department:

Nurseries inspected	123
Nurseries certified	103
Nurseries found infested with San Jose scale	15
Total acreage of nursery stock inspected	2,035
No. of counties in which nurseries were inspected.....	48
No. of men making inspection	3
No. of cases of imported nursery stock inspected	44
No. of foreign plants inspected	125,849
No. of counties in which these shipments were inspected.....	7

CERTIFICATES AND PERMITS ISSUED

Inspection certificates issued	103
Dealers certificates	47
Agents permits issued	131
Growers permits issued to outside nurseries.....	169

FINANCIAL STATEMENT

The Missouri Agricultural Experiment Station in Account with the United States Appropriation—1917-18

	Dr.	Cr.
To receipts from Treasurer of the U. S. as per appropriation for the year ending June 30, 1918 under the acts of Congress approved March 2, 1887 and March 16, 1906	\$30,000.00	
By salaries		\$17,016.07
Labor		4,261.01
Publications		4.00
Postage and stationery		151.76
Freight and express		106.70
Heat, light, water and power		46.01
Chemical supplies		642.59
Seeds, plants and sundry supplies		599.60
Fertilizer		68.33
Feeding Stuffs		4,441.24
Library		4.50
Tools, machinery and appliances		468.33
Furniture and fixtures		342.15
Scientific apparatus and specimens		392.09
Live stock		536.11
Travel expenses		311.66
Contingent expenses		3.50
Buildings and land		604.35
	\$30,000.00	\$30,000.00

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

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

Attest:

J. G. BABB
Secretary

EDWARD E. BROWN,
Business Manager,
Acting as Auditor for the Board of Curators