

UNIVERSITY OF MISSOURI COLLEGE OF AGRICULTURE  
AGRICULTURAL EXPERIMENT STATION  
BULLETIN 179

# What the Agricultural Experiment Station Is Doing for Missouri

For the year July 1, 1919, to June 30, 1920



Fillies on Growth of Draft Colts test, May 5, 1920.

COLUMBIA, MISSOURI  
JANUARY, 1921

UNIVERSITY OF MISSOURI

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COLLEGE OF AGRICULTURE

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Agricultural Experiment Station

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June, 1920

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L. D. HAIGH, Ph. D.  
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EMORY M. ROLLER

AGRICULTURAL ENGINEERING

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MACK M. JONES, B. S.

ANIMAL HUSBANDRY

E. A. TROWBRIDGE, B. S. A.  
L. A. WEAVER, B. S. in Agr.  
F. B. MUMFORD, M. S.  
RAY E. MILLER, B. S. in Agr.  
D. W. CHITTENDEN, B. S. in Agr.  
J. H. LONGWELL, B. S. in Agr.

BOTANY

W. J. ROBBINS, Ph. D.  
W. E. MANEVAL, Ph. D.

DAIRY HUSBANDRY

A. C. RAGSDALE, B. S. in Agr.  
A. C. DAHLBERG, M. S.  
W. W. SWETT, A. M.  
PERCY WERNER, JR., A. M.  
W. H. E. REED, B. S. in Agr.  
C. W. TURNER, B. S. in Agr.

ENTOMOLOGY

LEONARD HASEMAN, Ph. D.  
K. C. SULLIVAN, A. M.  
S. R. McLANE, B. S. in Agr.

FIELD CROPS

W. C. ETHERIDGE, Ph. D.  
C. A. HELM, A. M.  
E. M. McDONALD, B. S.  
L. J. STADLER, A. M.

RURAL LIFE

O. R. JOHNSON, A. M.  
R. M. GREEN, B. S. in Agr.  
S. D. GROMER, A. M.\*

FORESTRY

FREDERICK DUNLAP, F. E.

HORTICULTURE

V. R. GARDNER, M. S. A.  
H. D. HOOKER, Ph. D.  
J. T. ROSA, JR., M. S. H.  
F. C. BRADFORD, M. S.  
H. G. SWARTWOUT, B. S. in Agr.

POULTRY HUSBANDRY

H. L. KEMPSTER, B. S.  
G. W. HERVEY, B. S.

SOILS

M. F. MILLER, M. S. A.  
H. H. KRUSEKOPF, A. M.  
W. A. ALBRECHT, Ph. D.  
R. R. HUDELSON, A. M.  
F. L. DULEY, A. M.  
WM. DEYOUNG, B. S. in Agr.

VETERINARY SCIENCE

J. W. CONNAWAY, D. V. M., M. D.  
L. S. BACKUS, D. V. M.  
O. S. CRISLER, D. V. M.  
A. J. DURANT, A. M.  
H. C. NEWMAN, B. S. in Agr.

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O. W. WEAVER, B. S., Agricultural Editor  
GEORGE REEDER, Director Weather Bureau  
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J. F. BARHAM, Photographer

<sup>1</sup>In service of U. S. Department of Agriculture.

\*On leave of absence.



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

Sir:

I submit herewith a report of the progress of the investigational work conducted by the Agricultural Experiment Station of the College of Agriculture for the year ending June 30, 1920. This report is required by the Federal law and its purpose is to indicate briefly how the Agricultural Experiment Station has utilized the Federal and State funds appropriated for investigational purposes.

The report which I am submitting herewith covers only the work in progress or completed during the period covered by this report.

Very respectfully submitted,

F. B. MUMFORD,

*Director.*

# The Missouri Agricultural Experiment Station

F. B. MUMFORD, *Director*

The demands upon the Agricultural Experiment Station for definite information on many complicated problems affecting the agricultural industry have been greater than in any previous year of its history. The farmers of Missouri have come more and more to rely upon the investigations of the Agricultural Experiment Station to guide them in the solution of many of the difficulties which surround the operations of the agricultural producer.

The value of the service which the Agricultural Experiment Station is able to give is often determined by the promptness with which it can attack the problem. Serious diseases may suddenly break out for example in connection with the market garden industry or the watermelon industry. If the Station is able to respond promptly by sending a trained investigator to the region where the trouble occurs, it is often possible to prevent the spread of disastrous diseases. A number of such instances have occurred during the past year, and the Station has been able materially to assist in combatting such outbreaks.

The only limitations to the amount of service which the Station is able to render to the agriculture of Missouri is the amount of funds available for its work. In this respect Missouri has not received appropriations commensurate with the great importance of the agricultural industry or equal to the appropriations which have been made for agricultural research in other states of much less agricultural importance.

The Station has had no increase in its appropriation for the past six years; yet the demands upon the Station for investigational work have more than doubled. The result of this situation has been to curtail the number of projects under investigation. The excessively high prices, due to post-war conditions, which the Station has been compelled to pay for all of its equipment and supplies have increased the difficulty.

The importance of fundamental research was emphasized by the experiences of all nations in the conduct of the European war. The world has come to recognize the fact that through scientific research only may we look for permanent and rapid development. The great business organizations have long recognized the importance of such research and have provided generously for its maintenance.

The farmer is perhaps more dependent upon all branches of science than any other single producer. He cannot carry out such investigations for himself. The State has undertaken to provide this service for the agricultural industry, and it is exceedingly important that sums commensurate with the fundamental importance of the agricultural industry be made available for its development.

The work of the Agricultural Experiment Station is the basis of all successful teaching, extension and demonstration work. A college of agriculture with a weak experiment station must necessarily have a superficial and unreliable course of study and extension service.

The Federal appropriations to the Missouri Agricultural Experiment Station now amount to \$60,000 for the biennial period. The General Assembly of

the State of Missouri meeting in January, 1921, will be asked to appropriate an equal amount to the Missouri Experiment Station. If this amount is appropriated it will be possible for the Experiment Station to meet more completely the demands made upon it by farmers of the state.

The following pages contain a record of the essential activities of the Experiment Station for the year.

## CHANGES IN STATION STAFF

### NEW APPOINTMENTS

Camp, J. R., Assistant in Agricultural Chemistry  
Hopkins, E. F., Plant Pathologist  
Jones, Mack M., Assistant Professor of Agricultural Engineering  
Jordan, Howard V., Assistant in Soil Survey  
McLane, S. R., Assistant in Entomology  
Price, O. B., Assistant in Soils  
Reid, Wm. H. E., Assistant in Dairy Husbandry  
Turner, Chas. W., Assistant in Dairy Husbandry  
Letson, O. W., Assistant in Field Crops  
Hall, A. R., Assistant in Agricultural Chemistry  
Peters, F. N., Assistant in Agricultural Chemistry  
Roller, Emory M., Assistant in Agricultural Chemistry  
Friedmann, Theo. E., Assistant in Agricultural Chemistry  
Bradford, Frederick C., Assistant Professor of Horticulture  
Schenken, A. R., Assistant in Animal Husbandry

### RESIGNATIONS

Lehmann, E. W., Professor of Agricultural Engineering  
Dahlberg, A. C., Associate Professor of Dairying  
Hopper, Turner H., Instructor in Agricultural Chemistry  
McDonald, E. M., Assistant Professor of Farm Crops  
Hudelson, R. R., Associate Professor of Soils  
Mangles, C. E., Instructor in Agricultural Chemistry  
Shirky, Sam B., Instructor in Agricultural Chemistry  
Talbert, T. J., Associate Professor of Horticulture  
Combs, W. B., Assistant Professor of Dairy Husbandry  
Fohrman, M. F., Assistant in Dairy Husbandry  
Roller, Emory M., Assistant in Agricultural Chemistry

### PUBLICATIONS

The publications of the Agricultural Experiment Station consist of bulletins, research bulletins and circulars. The bulletin series consists largely of definite reports on specific investigations. Nine new bulletins and five reprints were issued during the year. Research bulletins are essentially scientific papers presenting technical information for the investigator or the person well advanced in agricultural knowledge. Two publications were added to this series. Circulars are popular reports of experiments, or a summarization of information relative to some phase of practical agriculture. Seven new circulars and one reprint were issued.

**Bulletins**

- |  |  |
|--|--|
| 75. Wintering Yearling Cattle (reprint)                    | 165. Cost of Producing Some Missouri Farm Crops                          |
| 136. Feeding Wheat to Fattening Swine (reprint)            | 166. Handling Farm Manure  |
| 138. Farm Bee-Keeping (reprint)                            | 167. Renting Land in Missouri  |
| 144. Self-feeders for Fattening Swine (reprint)            | 168. Inspection of Commercial Fertilizers: 1919                          |
| 155. Meat Scrap and Sour Milk for Egg Production (reprint) | 169. Profitable Tomato Fertilizers                                       |
| 164. Capacities of Silos and Weights of Silage             | 170. Insect Pests of Field Crops   |
|  | 171. Agricultural Lime   |
|  | 172. Work and Progress of the Agricultural Experiment Station, 1918-1919 |

**Research Bulletins**

- |   |                                       |
|---|---------------------------------------|
| 35. A Study of the Birth Weight of Calves | 36. The Normal Growth of Dairy Cattle |
|---|---------------------------------------|

**Circulars**

- |   |                                      |
|---|--------------------------------------|
| 75. The Farmer's Poultry House (reprint)          | 92. Bagworms Destructive in Missouri |
| 89. Estimating Silo Capacities and Silage Weights | 93. The Missouri Poultry House       |
| 90. Pruning the Apple                             | 94. The European Corn Borer          |
| 91. Feeding Baby Chicks                           | 95. Growing Late Potatoes            |

**BULLETINS**

Showing number of pages, numbers of editions and totals.

No.	Name	No. Pages	Edition Ordered	Total No. Pages
75.	Wintering Yearling Cattle (reprint).....	45	3,000	135,000
136.	Feeding Wheat to Fattening Swine (reprint)	35	5,000	175,000
138.	Farm Bee-Keeping (reprint) .....	40	5,000	200,000
144.	Self-feeders for Fattening Swine (reprint)....	22	5,000	110,000
155.	Meat Scrap and Sour Milk for Egg Production (reprint) .....	16	8,000	128,000
164.	Capacities of Silos and Weights of Silage....	24	12,000	288,000
165.	Cost of Producing Some Missouri Farm Crops .....	26	10,000	260,000
166.	Handling Farm Manure .....	29	10,000	290,000
167.	Renting Land in Missouri .....	52	15,000	780,000
168.	Inspection of Commercial Fertilizers: 1919	55	6,500	357,500
169.	Profitable Tomato Fertilizers .....	12	5,000	60,000
170.	Insect Pests of Field Crops .....	39	5,000	195,000
171.	Agricultural Lime .....	24	10,000	240,000
172.	Work and Progress of the Agricultural Experiment Station, 1918-1919 .....	48	5,000	240,000
		467	104,500	3,428,500

## RESEARCH BULLETINS

35. A Study of Birth Weight of Calves .....	11	2,500	27,500
36. The Normal Growth of Dairy Cattle .....	20	2,500	50,000
	31	5,000	77,500

## EXPERIMENT STATION CIRCULARS

No.	Name	No. Pages	Edition Ordered	Total No. Pages
75.	The Farmer's Poultry House (reprint) .....	12	10,000	120,000
86.	Soil Inoculation for Legumes (reprint) .....	15	5,000	75,000
89.	Estimating Silo Capacities and Silage Weights .....	4	10,000	40,000
90.	Pruning the Apple .....	20	15,000	300,000
91.	Feeding Baby Chicks .....	4	12,000	48,000
92.	Bagworms Destructive in Missouri .....	4	5,000	20,000
93.	The Missouri Poultry House .....	9	12,000	108,000
94.	The European Corn Borer .....	4	5,000	20,000
95.	Growing Late Potatoes .....	4	4,000	16,000
		76	78,000	747,000
GRAND TOTAL, Bulletins, Research Bulletins and Circulars .....		574	187,500	4,283,000

## SYNOPSIS OF NEW PUBLICATIONS ISSUED DURING THE YEAR

**Capacities of Silos and Weights of Silage**, C. H. Eckles, O. E. Reed and J. B. Fitch (Missouri Agr. Exp. Sta. Bul. 164 (1919), pp. 3-24, figs. 2).—This bulletin, based on a combination of data gathered by the agricultural experiment stations of Missouri and Kansas, is designed to furnish more reliable figures by which the capacities of a silo can be estimated. Rules are given for applying the data to determine the size of a silo necessary to hold a given amount of silage and to determine the weight of silage after it has been in the silo for some time. Consideration is also given to factors influencing the weight of settled silage; such as percentage of water in the corn, the proportion of grain to forage, depth of the silage and the diameter of the silo.

**Cost of Producing Some Missouri Farm Crops**, O. R. Johnson, R. M. Green (Missouri Agr. Exp. Sta. Bul. 165 (1919), pp. 3-26, figs. 10).—This is a third publication in the series based upon the cost of production studies begun in 1910. This bulletin gives a rather condensed statement of crop production costs as determined by data from 52 Missouri farms on which complete cost-account records have been kept since 1910. The figures presented are average costs for the years 1910 to 1917, inclusive. The crops reported on are corn, oats, wheat, rye, clover, timothy, alfalfa, soybeans, and cowpeas.

**Handling Farm Manure**, F. L. Duley (Missouri Agr. Exp. Sta. Bul. 166 (1919), pp. 3-29, figs. 13).—The value of manure in growing crops, and how

best to handle it to receive the greatest returns, is set forth in this bulletin. The composition of manure and how the composition is changed and value lost thru improper handling is discussed. The best methods for storing and later applying barnyard manure to cultivated land, are described.

**Renting Land in Missouri**, O. R. Johnson and R. M. Green (Missouri Agr. Exp. Sta. Bul. 167 (1920), pp. 3-52, figs. 6).—The three common systems of renting land in Missouri—share, share-cash, and cash—are described in this bulletin which discusses the value of each method to both parties to the lease. The importance of the rental problem to the welfare of the state is emphasized by significant data. Rent rates realized over a period of years for the four crops—corn, wheat, oats and hay—are tabulated. Typical forms covering the methods of leasing land mentioned in the bulletin are appended.

**Inspection of Commercial Fertilizers: 1919**, F. B. Mumford and L. D. Haigh (Missouri Agr. Exp. Sta. Bul. 168 (1920), pp. 3-55).—This publication is a report on the analysis of 426 official samples representing 187 brands of commercial fertilizers offered for sale in Missouri. The power of limestone and similar materials to neutralize soil acidity is expressed in percentage of calcium carbonate for 143 samples tested. The brands and guaranteed analysis of fertilizers registered for sale in Missouri in 1920 are listed.

**Profitable Tomato Fertilizers**, J. T. Rosa, Jr. (Missouri Agr. Exp. Sta. Bul. 169 (1920), pp. 3-12, figs. 2).—The effect of different commercial fertilizers and mixtures as well as of stable manure on the yield and time of maturity of the tomato crop as determined by cooperative experiments with ten tomato growers, is reported in this bulletin. One-year tests were made; one in Livingston County, two in St. Louis County, one in Green County, three in Newton County, and three in Howell County. As a result of these tests, it is suggested that a fertilizer analyzing 3 or 4 per cent nitrogen and 10 to 12 per cent phosphorus can be profitably used.

**Insect Pests of Field Crops**, L. Haseman (Missouri Agr. Exp. Sta. Bul. 170 (1920), pp. 3-39, figs. 37).—The most important pests of corn, wheat, legumes, grasses, cotton and of stored grains and seeds are discussed in this bulletin, which is a revision of Bulletin 134 by the same author. A description of the insect, its life history, a statement of the injury caused, and recommendations for its control, are stated.

**Agricultural Lime**, M. F. Miller and H. H. Krusekopf (Missouri Agr. Exp. Sta. Bul. 171 (1920), pp. 3-24, figs. 8).—A full discussion of ground limestone for agricultural purposes is provided in this bulletin, which is a revision of Bulletin 146 by the same authors. What soils need lime and why, what crops best respond to it, where limestone can be procured and at what cost, and how to grind and spread it, are dealt with. The limestones in various parts of Missouri which are suitable for agricultural purposes are described.

**Work and Progress of the Agricultural Experiment Station, 1918-1919**, F. B. Mumford (Missouri Agr. Exp. Sta. Bul. 172 (1920), pp. 3-48, figs. 9).—This bulletin is the annual report of the Director and covers briefly the

work of the Experiment Station, its publications, and a financial statement for the year ended June 30, 1919.

**A Study of the Birth Weight of Calves**, C. H. Eckles (Missouri Agr. Exp. Sta. Res. Bul. 35 (1919), pp. 3-11, figs. 1).—This bulletin deals with the marked variations in the size of dairy calves at birth, the extent and cause of such variations, and their significance from the standpoint of the future welfare of the animal. The new data presented represent those accumulated over a period of twelve years from the dairy herd owned by the University of Missouri. The breeds represented are Holsteins, Ayrshires, Jerseys of the American and Island types and dairy Shorthorns.

**The Normal Growth of Dairy Cattle**, C. H. Eckles (Missouri Agr. Exp. Sta. Res. Bul. 36 (1920), pp. 3-20, figs. 5).—The curve of normal growth from birth to maturity, as represented by weight and height at withers, is given for females of the Jersey, Holstein, Ayrshire and the dairy type of Shorthorn breeds, in this bulletin. The data upon which this curve is based were taken at monthly intervals from birth to maturity from animals in the University of Missouri herd. A compilation of data is also given showing the average height at withers and weight of mature Jersey, Holstein and Ayrshire cows.

**Estimating Silo Capacities and Silage Weights**, C. H. Eckles (Missouri Agr. Exp. Sta. Circular 89 (1919), pp. 4).—This circular presents new tables for estimating silage weight when filling is completed, and for estimating the weight of settled silage. Rules for applying the tables to specific problems are given. This information is essentially a reprint from Missouri Agr. Exp. Sta. Bul. 164.

**Pruning the Apple**, V. R. Gardner (Missouri Agr. Exp. Sta. Circular 90 (1920), pp. 20, figs. 11).—Pruning apple trees to increase production, improve grades, and lower production costs, is discussed in this circular from the standpoint of the young tree, the tree just coming into bearing, and the bearing tree. The training of fruit trees is touched upon.

**Feeding Baby Chicks**, H. L. Kempster (Missouri Agr. Exp. Sta. Circular 91 (1920), pp. 4).—The essentials of a chick ration are set forth in this condensed discussion of feeds for baby chicks. The necessity for vitamins in the diet is emphasized. A daily routine and feeding schedule for chicks from the time they are hatched to maturity, is suggested.

**Bagworms Destructive in Missouri**, L. Haseman (Missouri Agr. Exp. Sta. Circular 92 (1920), pp. 4, figs. 4).—This circular deals with the evergreen bagworm which is periodically destructive in the state. The life history of the pest is given, and control measures suggested.

**The Missouri Poultry House**, H. L. Kempster (Missouri Agr. Exp. Sta. Circular 93 (1920), pp. 9, figs. 8).—This circular is descriptive of the Missouri Poultry house which was designed by the Poultry Department of the College of Agriculture to meet the demand for a house of such size as to accommodate the average Missouri farm flock and also be adapted to Missouri conditions. Plans and specifications for building are provided, and the valuable features of the house described.

**The European Corn Borer**, L. Haseman (Missouri Agr. Exp. Sta. Circular 94 (1920), pp. 4, figs. 1).—A description of the European corn borer,

its life history and methods for control, as well as a brief statement of the Missouri quarantine against the pest, are provided in this circular.

**Growing Late Potatoes,** J. T. Rosa, Jr. (Missouri Agr. Exp. Sta. Circular 95 (1920), pp. 4).—What varieties of Irish potatoes to select for late planting, how to plant and cultivate them, both for table use and for seed purposes the following spring are discussed in this circular. Harvesting and storing are also touched upon.

### CONTRIBUTIONS TO SCIENTIFIC JOURNALS AND PERIODICALS

C. R. Moulton—*Journal Biol. Chemistry* Aug. 1920. Biochemical changes in the flesh of beef animals during partial starvation.

L. S. Palmer and H. L. Kempster—September Issue of the *Journal Biological Chemistry*. Vol. 39 No. 2 Sept. 1919. "Relation of Plant Carotinoids to Growth, Fecundity, and Reproduction of Fowls." "The Physiological Relation Between Fecundity and the Natural Yellow Pigmentation of Certain Breeds of Fowls." "The Influence of Specific Feeds and Certain Pigments on the Color of the Eye, Yolk, and Body Fat of Fowls."

H. L. Kempster—*Journal, American Association of Instructors and Investigators in Poultry Husbandry*. "The Physiological Relation Between Fecundity and the Natural Yellow Pigmentation of Certain Breeds of Fowls."

F. B. Mumford—*Wallace's Farmer*, May 21, 1920. "Effect of Early Breeding of Swine."

J. T. Rosa, Jr.—*Prac. Annex Soc. Hort. Sci.* 16, 190, 197, December, 1919, "Nature of Hardening in Vegetable Plants."

J. T. Rosa, Jr.—*Prac. American Botanical Soc.* December 1919. "Effect of Hardening on the Chemical Composition of Tomato, Lettuce, and Cabbage Plant."

### DISTRIBUTION OF PUBLICATIONS

The mailing list for Experiment Station publications is divided into seven classifications with a total of 14,576 names. The classes are: Commercial fertilizers, dairy husbandry, animal husbandry, farm crops and soils, horticulture, poultry, and home economics. More than 102,000 copies of Station publications were distributed from the mailing room last year. Of this number, about two-thirds were sent to persons whose names appear on the classified mailing lists. The remainder were sent in answer to individual requests.

The demand for publications has been increasing annually. Slightly fewer were mailed out this year than last, yet the demand has not been reduced. Anticipating a more conservative mailing policy, a number of publications distributed toward the close of the year were not sent to the classified lists. Had these been mailed in keeping with the former policy, the year's total would have been greater. The increased demand has largely come through the increasing agricultural interest in high schools and a return to approximately normal attendance in the agricultural colleges throughout the United States. Also every increase in the boys' and girls'



club enrollment in the Agricultural Extension Service of the College is usually reflected to some degree in the distribution of Station publications.

It was a determination to meet the demands of those really needing the publications that caused the curtailment of distribution to the classified lists.

#### **A Mailing List**

The Missouri Station has had in force for some time, rules which seem a little more conservative and made for more economy in the distribution of publications than those in force at other experiment stations. A survey of all experiment stations in the United States to determine this point was made by the questionnaire method. This survey supported the advanced policy already in force by the Missouri Station and argued for an even more advanced step in conservation—that of mailing publications only on request. This policy is in force in three experiment station mailing rooms and others have the step under advisement.

It is not the intention of this Station to withhold publications from any one who desires them, but the increased cost of printing, which has reacted in a manner similar to a reduction in the appropriations for publications, makes strict economy necessary.

#### **PROGRESS OF INVESTIGATIONAL WORK**

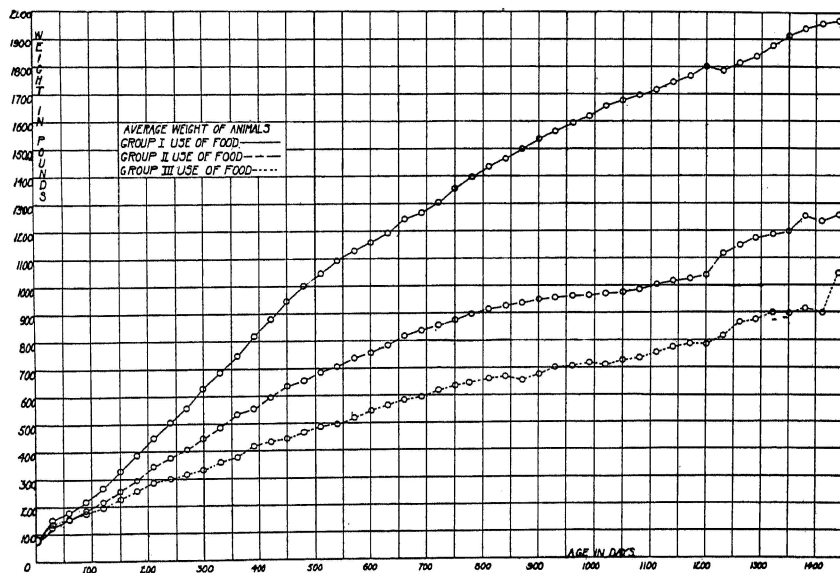
It has been customary for a number of years to make brief progress reports of investigations in the Experiment Station. Only the more important investigations are summarized in this report of active work. Such a report has value in indicating the character of investigations and the progress which is being made from year to year. There has been some disturbance of the Experiment Station activities due to the general unrest after the war. Such disturbance has not been serious and the work accomplished has, on the whole, been satisfactory.

It should be clearly understood that the summaries presented herewith are not complete records of all the work undertaken by the departments named. They do represent the major projects and are therefore, indicative of the achievements of the Station staff during the year.

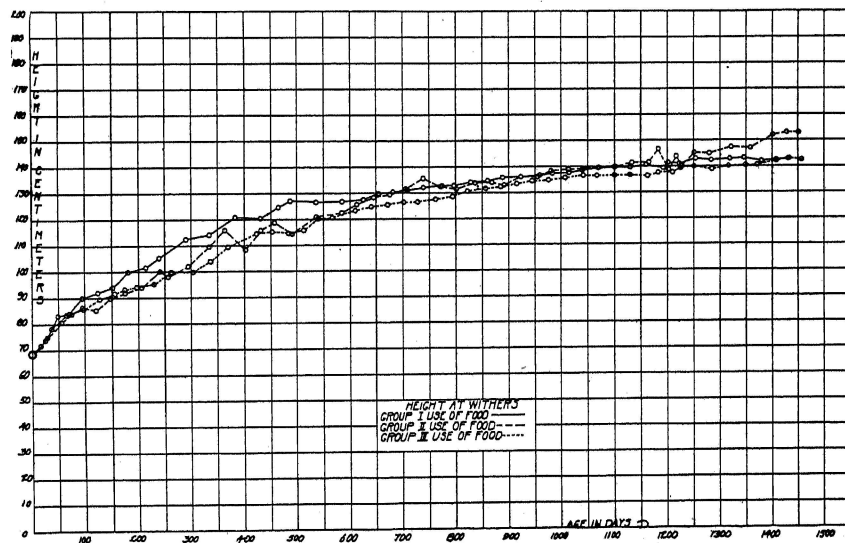
#### **AGRICULTURAL CHEMISTRY**

**Use of Feed Experiments** (C. R. Moulton, W. S. Ritchie, L. D. Haigh).—The data is being studied and interpreted for publication. The accompanying charts indicate the growth that may be expected of normal beef animals from birth to four years of age when fed (1) all they will eat, (2) a ration for maximum growth without much fattening and (3) a ration representing poor farm conditions. The first group gained rapidly and weighed on the average of about 2000 pounds at four years. The other groups weighed about 1000 to 1200 pounds respectively. This method of feeding made no difference in the height of the animals but decreased the length about 10 to 12 percent. The circumference of the chest at the region of the heart was decreased 20 to 25 per cent.

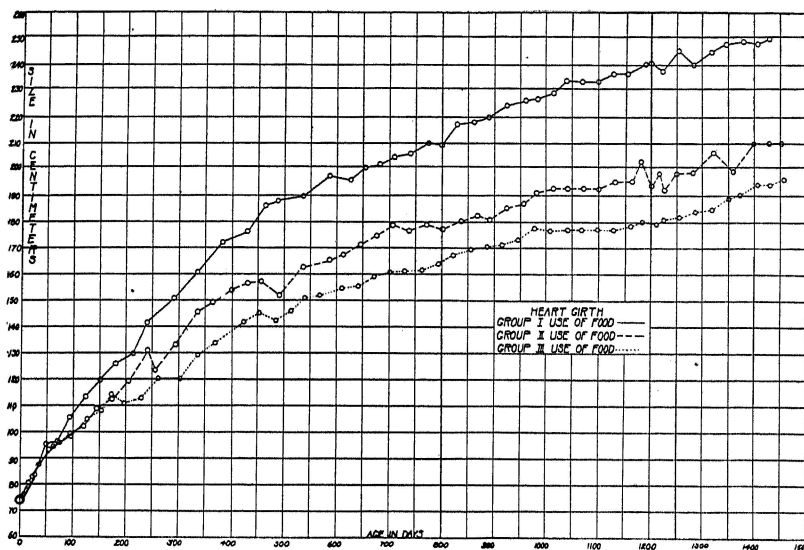
The charts presented should serve as a measure of the growth of a steer of the Hereford-Shorthorn type. They set a standard to which the performance of any steer can be compared.



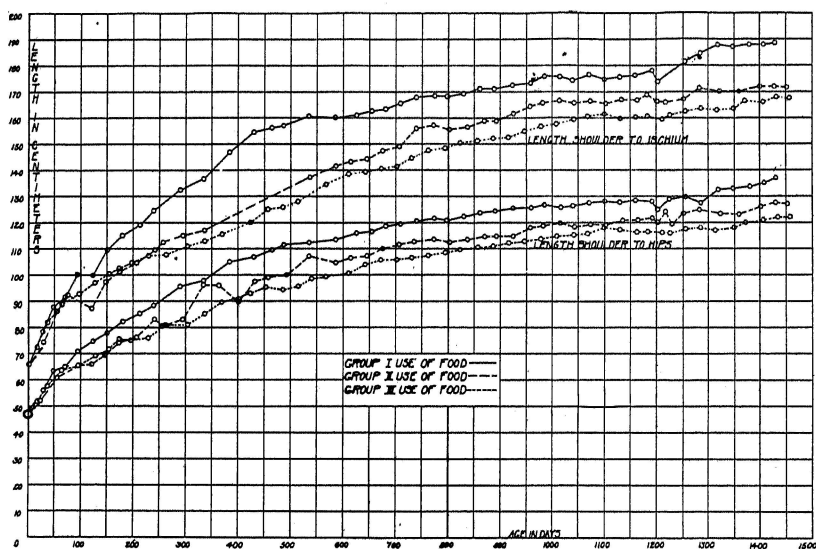
Weights of Steers as Influenced by Age of Animal and amount of Feed.



Heights of Steers as Influenced by Age of Animal and Amount of Feed.



Chest Girth of Steers as Influenced by Age of Animal and Amount of Feed.



Length of Steers as Influenced by Age of Animal and Amount of Feed.

## AGRICULTURAL ENGINEERING

**An Investigation of Sanitary Conditions on Farms and Experiments to Determine the Best Types of Sanitary Equipment** (Mack M. Jones, E. W. Lehmann).—The sanitary, social and economic survey of farms in Ashland Community, Howard County, Missouri, has been completed and the results have been filed for publication.

**Investigation to Determine the Draft of Various Farm Implements** (Mack M. Jones).—Draft tests have been made to determine the influence of speed upon the draft and power consumption of plows. The tests were made on the State Farm at Columbia, Missouri, in June, 1920, on a soil which is classified as a Putnam silt loam. The ground had been in corn the previous year. It was plowed in the fall of 1919, but during the winter the ground became compact, and in the following spring a heavy growth of weeds came up. The ground was prepared for the tests by double disking, followed by harrowing and rolling with a culti-packer. This put the ground into excellent plowing condition. All factors affecting the draft and power consumption of plows, except speed, were kept as nearly constant as possible. These tests were made on an Oliver (No. 273) two-bottom, 12-inch general purpose plow. A Moline tractor pulled the plow at various speeds, and an Iowa integrating dynamometer was used to measure the draft and the work done during each test, each individual test covering a distance of fifty feet. The time required to pull the plow the test distance was measured with a stop watch. From the work done and the time required to do it, the power developed was calculated. In order to make the tests more valuable, they were started at the same point on each round. Thus data were secured on strips of ground that lay parallel to each other.

The data secured were compiled and the results plotted in the form of curves with horsepower as ordinates against rate of travel in miles per hour as abscissae. From the curves the following table of averages was made, the draft being calculated from the value of horsepower.

Average Results of First Series of Tests

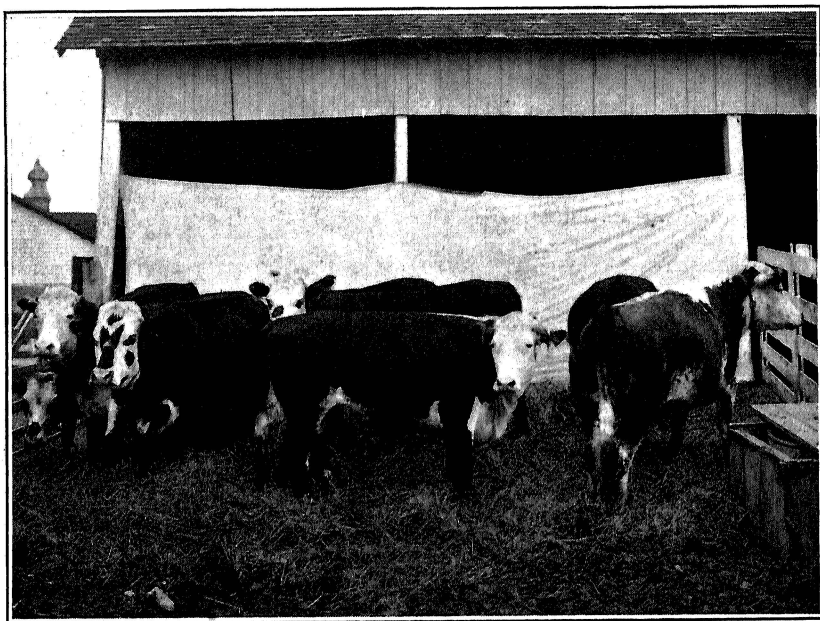
Speed per Hour, Miles	Draft Pounds	Horsepower
1.5	725	2.90
2.0	758	4.04
2.5	795	5.30
3.0	844	6.75
3.5	894	8.34
4.0	946	10.09
4.5	996	11.95

The results show that increasing the plowing speed increased the draft and the power consumption of the plow very materially. In these tests an increase of the plowing speed from two to three miles per hour (which increased the work done 50 per cent) increased the draft 11.3 per cent and increased the power consumption 67 per cent; and an increase of the plowing speed from two to four miles per hour (which increased the work done 100 per cent) increased the draft 24.8 per cent and increased the power consumption 149.5 per cent.

## ANIMAL HUSBANDRY

**A Study of the Effects of the Periods of Gestation and Lactation Upon the Growth and Composition of Swine (F. B. Mumford).**—A thesis has been written by J. H. Longwell entitled, "The Influence on the Period of Gestation and Lactation of Early Swine."

**Heavy and Light Grain Rations When Fed in Connection With Corn Silage and Clover Hay for Fattening Steers (E. A. Trowbridge).**—Forty head of steers were marketed at Chicago on May 17, 1920. The object of this experiment was to determine the effect of the increased use of corn silage and limitation or elimination of shelled corn in the ration for fattening two-year-old cattle for market. An added object of this year's



Lot V, fed a maximum amount of silage and alfalfa hay; and, in addition, linseed oil meal during the last sixty days of the feeding period.

test was to secure data concerning cattle which received, during the first half of their feeding period, only corn silage and alfalfa hay.

Each lot of cattle shows a loss; ranging from \$19.97 per steer for Lot 5 which was fed corn silage and alfalfa hay throughout the test and linseed oil cake (peasize) during the last sixty days, to \$34.12 per head for Lot 1 which was full fed for the entire period on shelled corn oil cake, corn silage and alfalfa hay. These results generally agree with results of previous work, showing an advantage on the present markets in favor of extensive use of corn silage and an elimination or reduction of shelled corn.

The following table shows the ration and loss per steer in each lot:

## Summary of Steer Feeding Trial—1920

Lot	I	II	III	IV	V
Number of steers .....	8	8	8	8	8
Average initial weight in pounds.....	923	919	907	917	906
Average final weight in pounds.....	1264.5	1205.9	1161.5	1174.2	1144.5
Average daily gain per steer, in pounds..	2.85	2.39	2.12	2.14	1.99
Average daily ration per steer, in pounds					
Shelled corn .....	16.10	*15.58	.....	*15.54	.....
Linseed oil cake .....	2.76	2.78	2.78	2.61	*2.61
Alfalfa hay .....	2.46	2.87	3.09	2.76	3.05
Corn silage .....	21.82	34.17	47.55	34.52	48.04
Cost of feed per steer .....	\$80.39	\$62.31	\$45.83	\$55.42	\$39.27
Necessary selling price in lots.....	\$15.23	\$14.43	\$13.44	\$14.21	\$13.06
Gain on hogs per steer, in pounds.....	62.00	14.88	.....	14.25	.....
Pork credit per steer (crediting gain on hogs at \$14.00 per cwt.) .....	\$ 8.68	\$ 2.08	.....	\$ 2.00	.....
Cost of gain per 100 lbs. on steers (credit- ing gain on hogs at \$14.00 cwt.).....	\$21.00	\$20.99	\$18.01	\$20.76	\$16.46
Necessary selling price in lots crediting pork produced .....	\$14.55	\$14.26	\$13.44	\$14.05	\$13.06
Selling price in Chicago .....	\$12.90	\$12.50	\$12.00	\$12.60	\$12.25
Shrinkage in shipment, pounds per head..	43.25	29.65	34.00	27.95	30.25
Dressing percentages .....	61.48	59.90	58.08	60.50	58.38
Net loss per steer (pork credited) .....	\$34.12	\$32.71	\$27.80	\$28.27	\$19.97

\*Lot II fed corn only last 60 days, average taken only for the time fed.

\*Lot IV fed corn and linseed oil cake only last 60 days, average taken only for time fed.

\*Lot V fed linseed oil cake only last 60 days, average taken only for time fed.

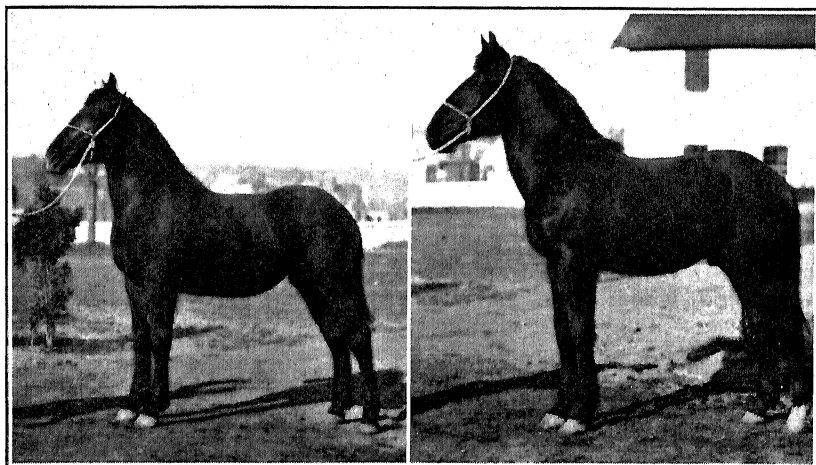
**Hogging Down Corn and Soybeans (L. A. Weaver).**—Five lots were hogged down and the additional ration fed as shown in the following table:

Plot	Crop	Additional Feed
1	Corn and Soybeans	* Tankage
2	Corn	Tankage
3	Corn and Soybeans	None
4	Corn	None
5	Corn and Soybeans	None

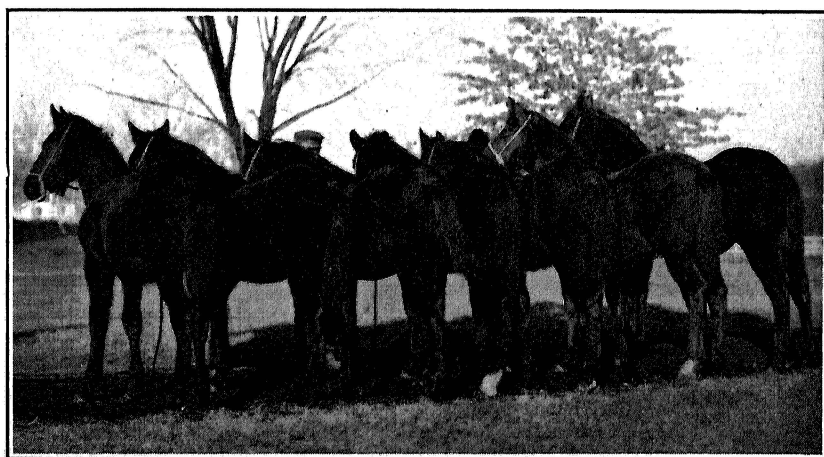
The soybeans in the plots 1 and 3 were planted in the rows at the same time the corn was planted. In the plot 5 the crop was planted by having two rows of corn and two rows of soybeans alternating. This year's results indicate: First, that either corn alone or corn and soybeans may be satisfactorily harvested by hogging down. Second, that the feeding of tankage in a self-feeder to hogs on corn materially increases the rate of gain, and in this case, also, the economy of gain. That is, the hogs not only gained more rapidly but the gain was cheaper. Third, that soybeans planted in the corn at last cultivation helped to balance the corn; for when

the crop is hogged down, the combination thereby increases both rate and economy of gain. Fourth, that when soybeans are used in this manner, they will not completely take the place of tankage. Fifth, that an acre of corn pastured off with hogs will produce more pork, if tankage is fed in addition, than will an acre of corn and soybeans hogged down without additional supplement. These results cannot be considered conclusive since they are only for one year.

**Growth and Development of Draft Colts** (E. A. Trowbridge, D. W. Chittenden).—The amount of feed required to grow a draft horse from



Growth of Draft Colts. On left: Meana spring 1920, filly making greatest gain through first period of test. On right; Chatonias spring 1920, colt making smallest gain through first period of test.



Foals on Growth of Draft Colts test, Dec. 15, 1919.

weaning time until old enough to work is one of the important factors in the production of horses. This experiment is concerned with the feed consumed by draft horses raised under approximately farm conditions and fed to secure liberal growth and condition. Seven purebred Percheron foals are being used in this test. The group consists of four fillies and three colts gelded in the spring of 1920. The foals were fed what grain they would eat while nursing their mothers. No group divisions were made since all the foals were to be treated in the same manner.

The first period of the experiment extended from September 26, 1919, to May 1, 1920. When the colts were turned on blue grass pasture, the second period was begun. The following is a summary of the results of the first period:

Average initial weight .....	506.5 lbs.
Average final weight .....	836.5 lbs.
Average total gain per colt per period .....	330.0 lbs.
Average daily gain per colt .....	1.51 lbs.
Average daily ration per colt grain .....	6.75 lbs.
2 parts crushed oats	
2 parts crushed corn	
1 part bran	
Hay, choice alfalfa .....	7.47 lbs.
Total feed per colt for the period	
Corn .....	10.56 bus.
Oats .....	18.5 bus.
Bran .....	295.8 lbs.
Alfalfa hay .....	1600 lbs.

**Corn Silage as a Part Ration for Horses of Various Ages** (E. A. Trowbridge, D. W. Chittenden).—Six mares were fed from January 15 to February 26, 1920, on a grain ration of two parts shelled oats, two parts shelled corn and one part wheat bran. Oats straw was fed as a roughage in the morning and corn silage as a roughage in the evening. These mares were not worked but were kept in the barn at night and allowed to exercise in a dry lot during the day.

A summary of the data secured follows:

Length of Trial .....	6 weeks
No. horses on trial .....	6
Average initial weight .....	1498 lbs.
Average final weight .....	1513 lbs.
Average gain for period .....	15 lbs.
Average daily ration of grain .....	9.49 lbs.
Average daily consumption of oats straw .....	8.08 lbs.
Average daily consumption of silage .....	15 lbs.

It will be observed that the ration was practically a maintenance ration, although the mares gained slightly. These mares were in good working condition throughout the trial.

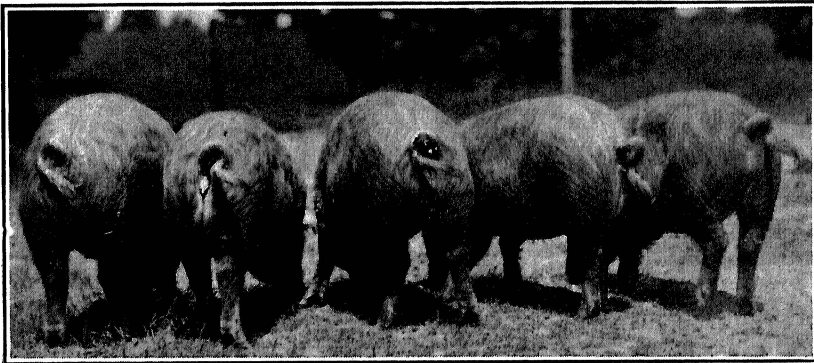
All of the horses on the test ate silage readily from the beginning. During the two previous years, some difficulty had been experienced in getting some of the horses to eat silage but such was not the case this year.

**Age as a Factor in Animal Breeding** (F. B. Mumford).—This project has now been in progress nearly ten years. Factor 90, from the second



litter of Factor 80, represents the ninth generation of the immature group and has farrowed two litters during the year, the first litter on June 25th, 1919, and the second litter February 6th, 1920. Factor 80 had no sow pigs in her first litter. During the year, forty pigs were farrowed and thirty-three were raised.

The five pigs in the accompanying photographs are from the fifth litter of Factor 70, representing the eighth generation of continued early breeding. This litter averaged 44 pounds at eight weeks of age, and reached 250 pounds in 290 days.

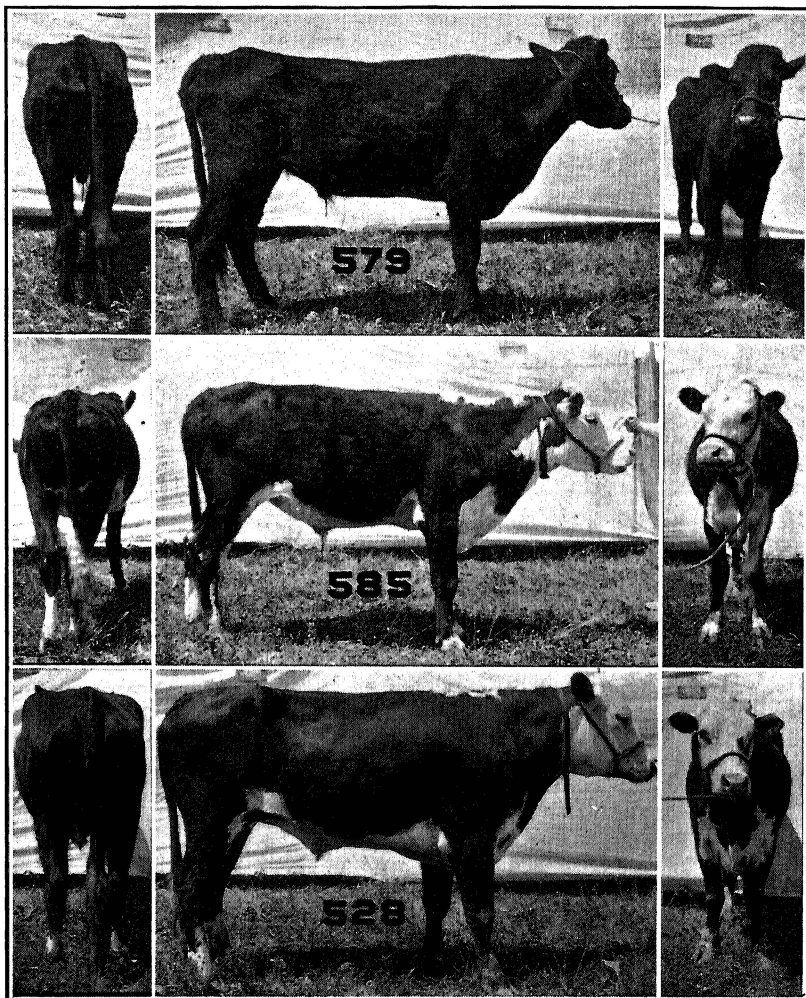


Fifth litter of Factor 70, in eighth generation of continued early breeding.

**Factors Influencing the Rate of Growth in Domestic Animals and the Permanency of the Effects of Arrested Development** (F. B. Mumford, D. W. Chittenden and J. H. Longwell).—There are ten steers under observation in this experiment. These steers are divided into three groups. Group I comprises the animals fed for "maximum growth," and the daily gains of each animal in this lot approximate 0.8 pound per day. This permits a fairly rapid development, but precludes a marked deposition of fat. The steers in group II receive a less liberal ration, and each makes daily gains

of about 0.5 pound. The steers in group III are given a decidedly limited ration, and the average daily gain is restricted to a little over 0.3 lb. per head.

These steers are six years old and represent each of the three nutritive planes. All are increasing in stature, but this rate of growth seems subject



Steer 579 is in Group II; steer 585 is in Group III, and steer 528 in Group I.

to the individuality of the animals. Numbers 528 (I) and 579 (II) are apparently growing at the maximum rate permitted by their respective planes of nutrition. Number 585 (III), however, is considerably shorter and more compact than the other two and has a relatively thicker covering.

The following table shows the development of typical steer of each group during past year.

All measurements are in centimeters

Number of steers and Number of group	Steer 528 Group I	Steer 579 Group II	Steer 585 Group III
Date of measurements .....	6/3/19-6/3/20	6/3/19-6/3/20	6/3/19-6/3/20
Height at withers.....	140.5-145.0	136.5-139.0	124.5-128.0
Height at point midway between top hip points .....	142.0-144.5	137.5-140.0	127.5-129.5
Depth of chest .....	76.0- 77.5	67.5- 69.0	59.5- 63.5
Width of chest .....	41.0- 43.5	33.0- 34.5	29.0- 36.0
Length of foreleg, elbow to ground .....	81.0- 82.0	82.0- 84.0	73.0- 77.0
Distance from withers to line between top hip points .....	101.0-106.0	106.0-110.0	89.0- 99.0
Width of hips .....	56.5- 60.5	47.5- 49.5	43.0- 47.5

## BOTANY

**A Study of Certain Fusarial Diseases of Plants** (E. F. Hopkins).—The two diseases corn root-rot and wheat scab have been studied principally although observations have also been made on two other fusarial diseases, tomato-wilt and cabbage yellow.

*Corn Root-Rot*: The experimental results indicate: (1) That corn seed from an apparently healthy ear may harbor fungous mycelium. (2) The mycelium is located near the tip of the grain in the darkened layer covering the scutellum. (3) Six different organisms, some of them fusaria, have been found commonly associated with these infected areas. (4) Some of these organisms are pathogenic being capable of invading the tissue of living, healthy corn roots under laboratory conditions.

*Wheat Scab*: The work on wheat scab during the past year includes: (1) A complete review and summary of the literature, on wheat scab has been made. (2) Data concerning the regional distribution and amount of damage caused by wheat scab has been summarized. In 1919, the average amount of scab as determined from a large number of counts in 40 counties was 4.0 per cent. The highest per cent, 25.6, was reported from Harrison County. The average amount this year was about 5.8 per cent. Wheat scab this season was more severe in Southeast Missouri than in any other section of the state. (3) Isolations from fungi from specimens of scabby wheat from various parts of Missouri showed that 75 per cent of the isolations were pure cultures from a fusarium of the *Giberella* type and of these over half formed perithecia of *Giberella saubinettii* in culture. In pot experiments with wheat seedlings, infection was obtained.

Preliminary experiments have been performed on the relation of the growth of wheat scab organism to hydrogen ion concentration with a view to the practical control of the disease.

**A Study of the Metabolism of Roots** (W. J. Robbins, W. E. Maneval).

—This investigation was designed to determine whether any other materials, in addition to the essential mineral salts and water obtained from the soil solution, oxygen obtained from the air and carbohydrate obtained from the plant top, are required for the growth and development of the root. A method has been developed for the growth of root tips or stem tips under sterile controlled conditions which will permit a direct attack on the problems indicated.

**DAIRY**

**Nutrition of Heifers—Raising Calves on Milk Substitutes** (A. C. Ragsdale, Chas. W. Turner).—*Putting Calves on a hay and grain ration at the age of 60 days.* The work done at this Station to determine if normal gains can be secured with calves if taken off skimmilk at 60 days of age, has been continued during the winter. The calves were weighed every ten days and measured every thirty days. These weights and measurements were compared with the normal weights and measurements for the breed as worked out at this Station.

The plan followed has been to get the calves to take a good ration of skimmilk with some hay and grain. For the first two weeks after birth, a small calf, such as a Jersey received from 8 to 10 pounds of milk daily. This should be fed in two or three feeds per day. When the calves were two weeks old, they were gradually changed from a ration of whole milk to a ration of skimmilk by substituting an equal amount of skimmilk for each portion of whole milk removed. The substitution was completed in a week or ten days. The calves were fed liberally on this plan until 60 days of age. At 60 days of age, the actual experiment began. The milk was decreased daily until at 65 days of age, they were receiving only grain and hay.

The rations fed were as follows: Lot I, soybean hay as a roughage and a grain mixture composed of corn chops, four parts; wheat bran, one part, and oil meal, one part by weight. Lot II, alfalfa hay as a roughage and a grain mixture similar to the first with the exception that one part soybean meal replaced the oil meal.

Lot I, fed soybean hay, made average daily gain of 1.05 pounds which is 71.24 per cent of normal gains for this age. They averaged 13.2 cm. gain in height which is 69.67 per cent of the normal gain in height. As the experiment progressed the animals fed soybean hay were easily distinguished by their vigorous appearance and smooth, sleek coats of hair. Lot II made average daily gains of 0.59 pounds which is only 39.47 per cent of normal gain in weight for this age. Their average gain in height was only 8.33 cm. during the period which is only 45.09 per cent of the normal gain. For some reason not yet determined the calves in Lot II did not eat alfalfa in as large quantity as previously even though the amount of grain was limited to five pounds a day. This seems to be the limiting factor in their growth rather than the fact that soybean meal replaced the oil meal in the grain mixture.

**Factors Affecting the Composition of Milk.**—*Factors Influencing the Per Cent and Quantity of Milk of Cows on Official Test* (A. C. Ragsdale,

W. W. Swett).—During the winter 1919-20, six cows were selected from the dairy herd. They were divided into two groups, each group containing one Jersey, one Holstein, and one Ayrshire. They were not fresh but were in the first half of their lactation period.

Group one showed a very decided increase of fat in milk when the ration was reduced one-half. The high point occurred either the second or third day after the reduction was made and almost immediately dropped back toward normal and remained considerable above normal the rest of the period. As soon as the cows of this group were put back on full feed, the test in each case went down very rapidly and remained considerably below normal during the entire ten day period. The daily average tests fluctuated considerably; but the result in every case was a rapid rise in test when feed was cut to half, followed by a rapid drop in test when full feed was again furnished. The amount of milk varied almost directly with the amount of feed given. Body temperatures were taken three times each day. The changes did not have any appreciable effect on these temperatures. Group II did not show any noticeable change when the amount of protein was reduced from 50 per cent excess to 50 per cent of requirements by a sudden change in the character of the ration. Neither was the test affected when the ration was again put back to the preliminary ration which furnished slightly above requirements in both protein and energy.

In order to check Group II and Group I, the cows were cut to a ration furnishing exactly one-half requirements in both protein and energy. The effect was not quite as extreme as with Group I but checked fairly well with it. The quantity of milk produced by cows in Group II showed a tendency to drop only slightly while the cows were on excessive protein, to drop appreciably and steadily while the protein was 50 per cent of requirements, to steadily increase as the full feed was reduced and to drop again decidedly when the entire ration was cut to half requirements in the last period. The body temperature was not affected by any of the manipulations of the tests.

**Protein Requirements for Growth** (W. W. Swett, A. C. Ragsdale).—Practically no difference in the results this year have been noticed between the Holstein and Jersey breeds. They seem to adjust themselves quite well to new experimental conditions and rations. All of the animals on experiment during the year have been on a mixed ration made up of common dairy feeds, except that starch was used in varying amounts to help balance the ration by furnishing energy. Two animals have been on a 35 per cent protein plane. One of these was a Holstein and one was a Jersey. In neither case, was normal growth secured. Apparently this is an excess of protein which cannot be used by the animals in promoting growth. The animals used during the year have been slightly above normal in size. The average figures reported indicate that on the average 101.4 per cent of normal in weight and 100.6 per cent of normal in skeleton measurements. Increases in the ration in some cases have been brought about by increasing the protein and in other cases by leaving the protein unchanged and giving an excess of energy ranging from 15 to 50 per cent above the requirements.

**Silage Investigation** (A. C. Ragsdale, C. W. Turner).—Studies on the

comparison of loss of nutrients in the silo and in the field have been continued during the past year.

The corn was cut in September, 1919, and at that time adjoining rows were used. A certain number of rows were cut and shocked in the field. To protect them from loss, they were screened in by and surrounded by a 12-inch plank buried in the ground to keep out the birds and rodents. The weather during the year was about average.

Silo No. 2 showed a loss of 3.06 per cent in weight. The loss in No. 1, 14.84 per cent was greater, due probably to the fact that the silage was spoiled down six to eight inches below the wire.

The ensilage in silo No. 3 composed of corn and soybeans grown together showed a loss in weight of 5.22 per cent. Silo No. 4 filled with stover from Leaming corn sustained a loss of only 1.83 per cent of its weight. The average per cent of loss of the four silos was 6.24.

**The Effect of Each Ingredient in the Manufacture of Ice Cream** (Wm. H. E. Reid).—This project necessitated the erecting of considerable new equipment. This equipment was constructed and set up and has proved very efficient. Ice cream freezers were constructed which would freeze four batches of ice cream at the same time, under the same conditions. Apparatus for determining the hardness of the ice cream when varied amounts of one or more ingredients, were used. A viscosity determinator was used in making the comparison of the heaviness and lightness of each mixture in the experiment, and for determining the standard melting period a melting vat with a galvanized iron water jacket on the outside. The following problems were completed:

1. *Uniformity of Maximum Overrun at Different Brine Temperatures.*—A series of freezings were made to show that the amount of sugar added to the mixture has a direct relation to the ultimate swell or overrun of the finished ice cream. Five different mixtures were used, the percentage of sugar varying from 8 to 16 per cent. In order that the relation of the temperature of the brine to the maximum swell might be made plain, two different brine temperatures were made.

The increase of sugar gave an increase of time required to freeze, which proved to be greater with the higher percentages than with a lower percentage of sugar. Increase of sugar content from 10 to 12 per cent changed freezing time from 15 to 16 minutes; while raising sugar content from 14 to 16 per cent resulted in an increase in time to freeze of from 18 to 23 minutes. There was an increase of 4.3 per cent in overrun of the mixture containing 12 per cent sugar over that of mixture containing but 8 per cent sugar. A loss of 4.3 per cent was noted in comparing mixtures containing 12 to 16 per cent sugar, due to the use of an excessive amount of sugar. Maximum swell obtained when 12 per cent of sugar was added to the mixture.

Freezing with the brine at 26 degrees F. gave practically parallel results with those obtained when freezing with the brine at a temperature of 23 degrees F. except that the higher brine temperature retarded the time of freezing. The temperature of the finished ice cream lowered as the percentage of sugar was increased, showing that additional sugar lowers the freezing point. The difference in temperature of brine did not affect the

relative curve of the maximum swell. Sugar was the principal factor influencing the swell of the mixture.

2. *The Effect of Increased Percentages of Sugar on the Hardness of Ice Cream.*—It was noted that there was a gradual increase in the depth of penetration with each additional 2 per cent of sugar. The depth of penetration when 16 per cent sugar was added to the mixture was nearly double to that secured when 8 per cent of sugar was used. The greatest resistance was offered when 8 per cent sugar was added to the mixture, the least when 16 per cent was added. The addition of syrup to the mixture gave a resistance equal to the resistance offered when 10 per cent of sugar was added.

3. *Determination of the Time Required for Creams With Different Percentages of Sugar to Melt Under Summer Conditions.*—A constant melting temperature was maintained. Tempering each brick eliminated any error that would enter in case the bricks were not of uniform temperature. Percentage loss in the case of the brick containing 16 per cent sugar was 12 per cent greater than that in the 8 per cent sample. One outstanding result is the direct correlation in the melting of the brick with 8 per cent sugar plus 4 per cent syrup and the brick with 12 per cent sugar only. Concluded that a brick of ice cream retaining greatest weight following the standard melting period of four hours had the highest melting resistance and proved best adapted for commercial use. A sugar content increased above 10 per cent weakened the body of the ice cream. Ice cream containing 10 per cent sugar had the best holding-up qualities. One brick of each was secured at the end of the first and seventh days, during which time the bricks were held at a constant temperature. Settling out of sugar increased with each additional increment of sugar.

*Notes:* There was a direct relation between the percentage of sugar added to a mixture and the hardness of the finished ice cream. The addition of syrup to the mixture gave the ice cream a greater resisting power. The quantity of sugar used in a mixture determined the length of time the ice cream would hold up when exposed to summer temperatures. Ten per cent of sugar gave an ice cream that offered the maximum resistance to a standard summer temperature. Syrup has a resisting power equal to that of sugar. When 14 per cent and 16 per cent was added to the mixture, the resisting power was greatly reduced, offering the least resisting power of all batches. Each additional per cent of sugar added to the mixture lessened its factor of resistance. If ice cream is to be held for several days, the addition of syrup will retard the settling out of fat and sugar. Syrup should not be used in quantities larger than 4 per cent because of its giving to the ice cream a syrupy and bitter flavor.

**The Effect of Each of the Normal Constituents of Butter Upon Its Keeping Qualities** (A. C. Dahlberg, Percy Werner).—The purpose of this experiment is to locate in which constituents the off-flavors in butter develop, and if possible to determine the factors in butter to lessen the production of these off-flavors. A high quality butter was prepared, primarily of butter fat and water. The keeping quality of the fat could thus be obtained and each normal ingredient of butter could then be introduced at

one time, and its effect noted. Four samples of cream were treated as follows:

1. Normal cream not treated in any way.
2. One part cream diluted with 10 parts water and separated at a temperature of 40 degrees F. A fat test on the skimmilk part showed an excessive fat loss and the temperature had to be raised to avoid this. The separated cream was again diluted one-tenth and separated at 100 degrees F. The separated cream was again diluted one-tenth and separated a fourth time at 100 degrees F. The skimmilk now appeared almost as clear as water and the cream looked like an oil emulsion.
3. Treated like No. 2 except that it was diluted and separated only twice each time at 100 degrees F.
4. Treated like No. 3 but diluted one part cream to 15 parts water, and the cream screw of the separator was turned in enough to give the desired richness of cream. The object of this greater dilution was to get a more thorough washing out of the solids not fat. The results show that the unaltered butter had the best keeping quality and batch No. 2 had the poorest. These results are due to the increased air content of the butter. Butter from batch No. 3 and 4 was somewhat mottled.

## ENTOMOLOGY

**An Investigation of the Hessian Fly Resistant Qualities of Different Varieties of Wheat** (L. Haseman, S. R. McLane).—The following varieties were grown in drill width plots in the fields here at Columbia to check up further on the results secured last year in the insectory.

Ziegler's Choice	Turkey
Kanred	Poole
Fultz	

The percentage of fall fly infestation was determined in November and the yield has just recently been determined, as follows:

Variety	Fall Infestation	Acreage Yield
Ziegler's Choice	0.	22 bu.
Kanred	2.6 %	28 bu.
Turkey	1.5 %	20 bu.
Poole	1.8 %	24 bu.
Fultz	0.05 %	23 bu.

The infestations at Columbia were light this past year which accounts for the low infestation records. In earlier experiments Kanred and Turkey have shown high susceptibility, Poole and Fultz average susceptibility and Ziegler's choice slight susceptibility.

Past results show clearly that the different strains of wheat vary greatly as regards susceptibility to fly attack. During the year we have been trying to determine what chemical, physical or physiological factors possessed by the wheat plant influence susceptibility. A study is being made including the anatomy and glandular secretions of the fly larva and the cellular response of the wheat plant to the work of the larva. The resistant



strains receive an abundant supply of fly eggs but later few or no flies mature from these eggs while six inches away on a susceptible strain the fly matures abundantly. It seems entirely likely that some common factor will be found to be responsible for this and that varietal resistance may be utilized in field in fly control.

The following table shows clearly the relative susceptibility of a number of common strains as determined from a large series of plantings in the insectory a year ago.

Variety	Per cent plants with eggs	No. eggs to 100 plants	Per cent infestation	No. flax seeds to 100 plants
Illinois Chief .....	39	78	5	6
Ziegler's Choice .....	37	.....	7	14
Mediterranean .....	37	79	10	18
Beechwood Hybrid ....	28	48	14	22
Michigan Wonder .....	48	102	14	23
Fulcaster .....	50	120	14	23
Dietz .....	53	255	18	48
Fultz .....	47	166	20	32
Michigan Amber .....	41	176	23	42
Currell .....	.....	.....	27	47
Turkey .....	45	151	28	46
Dawson Golden Chaff ..	.....	.....	30	44
Nigger .....	.....	.....	30	56
Kharkov .....	.....	.....	33	56
Early Ripe .....	.....	.....	47	94
Fultz-Mediterranean ..	.....	.....	49	135
Miracle .....	.....	.....	50	93

**An Investigation to Determine the Life History, Development and Habits of the Corn Ear Worm and Practical Methods of Controlling Its Ravages** (L. Haseman, K. C. Sullivan, S. R. McLane).—Ten varieties of field corn, one variety of pop corn and two varieties of sweet corn were each treated with the solution of lead arsenate (1 pound dry arsenate to 50 gallons of water). Other plants of these varieties were dusted with equal parts of dry arsenate of lead and hydrated lime. Others were left untreated as a check. These treatments did not give any special results.

**The Annual Life Cycle of the Hessian Fly in Missouri and Its Control** (L. Haseman, K. C. Sullivan, S. R. McLane).—Outlying plots have been maintained at Maryville on the grounds of the State Teachers' College; at Kirksville on the ground of the State Teachers' College; at Springfield by Mr. Bennett, at Lebanon by Mr. Johnson; at Webster Groves by Mr. Christ Toft and at Altenburg by Mr. Jacobs. With the exception of the plots at Kirksville, valuable data have been secured this year from each of the outlying fields and from the plots at Columbia. From six to eight seedlings at intervals of a week were made.

In November from each plot 25 linear yards of wheat plants were collected and examined to determine fall infestation. In every case, plots seeded on or after the fly-free date showed no effective fall fly infestation:

Owing to the early ripening and cutting of the plots at Centerview, Altenburg and Charleston no samples were secured to determine the yield as affected by the date of seeding last summer.

*Maryville Plots:*—The plot No. 2 seeded two weeks before the fly free date gave the maximum yield tho it was but slightly larger than that from plot No. 4 seeded on the fly free date.

*Carrollton Plots:*—The maximum yield came from plot No. 3 seeded one week before the fly free date and from plot No. 6 seeded two weeks after the fly free date. Plot No. 1 seeded three weeks before the fly free date gave the minimum yield.

*Columbia Plots:*—Plot No. 3 seeded one week before the fly free date gave the maximum yield being considerably more than that from both earlier and later seedings.

*Springfield Plots:*—The maximum yield came from plot No. 6 seeded two weeks after the fly free date. It was considerably more than the yield from plots No. 3 and No. 5 the next heavier yielding plots, seeded respectively one week before and one week after the fly free date.

*Lebanon Plots:*—The yields from these plots were small beginning with plot No. 1 and gradually decreasing in amounts until plot no 6 seeded two weeks after the fly free date.

The results of this year's work largely substantiate earlier results.

**A Study of the Life Cycle of the Codling Moth and the Best Time and Method of Applying Insecticides for Controlling It** (L. Haseman, S. R. McLane).—Chemical tests for amounts of arsenate of lead placed in calyx cups by using different nozzles and pressures were made. The pressures were of 100, 150 and 200 pounds. A spray gun, a Bordeaux nozzle and a Disc nozzle were used. After applying the spray, young apples were collected and prepared for determining first which treatment places most poison in the outer calyx cup and which most in the inner calyx cup. The following table gives the results of these trials:

Nozzle	Pressure	Number of Cups	Outer Cup Poison, %	Inner Cup Poison, %
Gun .....	250 lbs.	450	24.610	1.128
Bordeaux .....	250 lbs.	400	16.184	1.353
Disc .....	250 lbs.	410	20.852	1.006
Gun .....	150 lbs.	450	15.066	1.627
Bordeaux .....	150 lbs.	450	20.635	1.013
Disc .....	150 lbs.	450	9.756	1.249
Gun .....	100 lbs.	250	12.645	0.510
Bordeaux .....	100 lbs.	250	8.635	1.433
Disc .....	100 lbs.	250	7.800	2.660

From these results it is apparent, as our earlier results also show, that very high pressure and a coarse nozzle is not necessary for placing the poison down in the inner calyx cup. A pressure of from 75 to 150 pounds and a reasonably fine mist nozzle like the Disc will place as much or more

poison in the inner calyx cup than a higher pressure and a coarser nozzle. This does not agree with much of the earlier writings and theories regarding spraying but repeated careful experiments both in Missouri and New York including chemical tests of the contents of cups of sprayed blossoms convince us that this is true.

*Life History of Codling Moth.*—In connection with the life history work it has been found that in a cool cellar the overwintering apple worms may be prevented from maturing until July first following: the moth coming out with the normal July or second brood of moths.

**An Investigation to Determine What Insects Are Injurious to Nursery Stock in This State, Their Life Histories, Distribution, Injury and Methods of Control** (L. Haseman, K. C. Sullivan, S. R. McLane).—*San Jose Scale.*—The spring and summer months of 1919 were very favorable for the development of San Jose scale. The Experimental Nursery at Columbia, Missouri, showed a decided increase in the number and the distribution of the pest. As a result of the favorable season for scale, eight nurseries were found infested in 1919.

*Other Insects.*—The wooly aphis ranks second to the San Jose scale as a destructive pest to nursery stock in Missouri. Fifteen nurseries were found infested with this insect.

The growth of apple trees in thirty nurseries was hindered considerably by the work of the apple leaf hopper. Apple tree and peach tree borers were found in four nurseries. Thirteen strawberry beds were slightly damaged by the strawberry leaf roller. The strawberry crown borer was doing extensive injury to five old strawberry beds. Eight nurseries were found slightly damaged by the tarnished plant bug. Bag worms were found in eleven nurseries.

Other insects found doing only a small amount of damage were: grape leaf folder, fall web worm, canker worm, Forbes scale, oystershell scale, grasshoppers, and catalpa sphinx moth.

*Thirteen Year Cicada.*—Inspectors this year expect to find a few nurseries which are located in wooden districts to be damaged to a more or less extent by the thirteen year cicada, the distribution of which was widespread throughout Missouri during the spring months of 1920.

*Foreign Inspection.*—Three nests of brown tail moth, one of the most destructive pests to trees and shrubs, were found in a shipment of nursery stock from France. These nests of caterpillars were carefully destroyed in order that there would be no chance for the insect to gain a foothold in Missouri.

Bag worms were found in three foreign shipments of stock.

Several specimens of *Epidiaspis piricola* were found in one shipment. Six cases of narcissus bulbs were infested with mites.

**Injurious Insect Pests of Melon and Related Crops** (L. Haseman).—Tests of insecticides were made only in controlling the striped cucumber beetle and the melon louse.

*Striped Cucumber Beetle.*—By keeping the young plants dusted with dry arsenate of lead from the time the plants come up until they began to vine this pest was effectively controlled. Likewise one tablespoon of dry arsenate of lead to one gallon of water or one pound to fifty gallons of

water used as a spray gave equally good results. By supplementing the use of arsenate of lead, with hand picking in this morning, when the beetles are less active, soon after the beetles first begin to attack the plants, much better results were obtained than where the insecticide alone was used.

*Melon Louse.*—The louse feeding by extracting sap from the plant is not affected by arsenical insecticides though a contract spray readily controls it. Nicotine sulphate has proved most effective. When used at the rate of one tablespoon to one gallon of water or one part to five hundred parts of water the pest is quickly controlled. Soap added to the solution makes it work more quickly, however, the local hard water makes the nicotine sulphate sufficiently volatile to kill both by contact and as fumes.

### FIELD CROPS

**A Study of the Adaptations of the Important Varieties of Corn for Missouri Conditions** (W. C. Etheridge, C. A. Helm).—The only important feature of the 1919 studies of the adaptatoin of varieties of corn was the comparison of the Southern prolific varieties with some of the leading "native" varieties, in Southwest Missouri. The results of last year and the two preceding years in the comparison of these varieties follow:

Variety	Yields in bushels of grain per acre			
	1917	1918	1919	Average
Prolific types				
Biggs Seven-ear .....	37.9	13.9	21.0	24.3
Cocke Prolific .....	31.3	.....	17.1	24.2*
Sanders Improved ....	26.1	16.0	.....	21.1*
Native types				
Commercial White ....	31.1	14.3	23.3	22.9
Reid Yellow Dent ....	31.6	12.2	23.3	22.4
St. Charles White ....	29.6	12.0	22.0	21.2

\*Partial average.

Of the prolific varieties tested Biggs Seven-ear is the only one to compare favorably, on the average, with the best of the native varieties. However, the results of several additional seasons are required to decide the status of this promising variety.

**A Study of Certain Spring, Summer and Fall Sown Crops for Forage** (W. C. Etheridge, C. A. Helm).—In 1919, trials of seasonal forages were carried on at Warrensburg. They gave the following results:

Spring Sown	Yields—tons of cured forage per acre
Oats and Canada Peas .....	3.27
Oats and Spring Vetch .....	3.01
Canada Peas and Spring Vetch .....	2.47
Summer Sown	
Sudan-grass and Soybeans .....	1.93
Sorghum and Soybeans .....	3.38
Corn and Soybeans .....	2.61

Investigations in forage productions will for most crops be concluded at the end of the present season.

**Wheat Breeding Investigations Including the Improvement of Commercial Varieties by the Pure Line Methods of Breeding and Hybridization and Subsequent Selection** (W. C. Etheridge, L. J. Stadler). Hybrids and pure-line selections made here are yearly compared with a large number of other hybrids, selections and commercial varieties. By yearly elimination of the less worthy kinds, the better strains are rapidly being narrowed to small group. Seed of a few superior strains are now being increased for a wider test in various parts of the State.

The comparative value of some of the selected strains is illustrated by the following yields of two strains of the variety "Mediterranean."

		Average yield per acre 1914-1919
Mediterranean 30 (Selection)	.....	31.7 bu.
Mediterranean 31 (Selection)	.....	32.7 bu.
Mediterranean (original stock)	.....	24.0 bu.

**A Study of the Adaptations of the Important Varieties and Selections of Soybeans to the Various Soil Types of the State** (W. C. Etheridge, C. A. Helm).—Thirty varieties and selected strains of soybeans were tested at Columbia in 1918. Some of the most promising of these were tested also at Maryville, Warrensburg, Kirksville and Cuba. The yields of the six leading varieties at Columbia were as follows:

Varieties	Bushels of seed per acre	Varieties	Tons of cured hay per acre
Tokio	23.3	Chiquita	3.3
Mikado	20.5	Columbia	3.0
Morse	20.5	Taha	3.0
Chiquita	20.4	Virginia	2.6
Shingto	20.1	Arlington	2.6
Sable	19.9	Morse	2.6

At the outlying fields the following acre yields were made:

Varieties	Maryville		Cuba		Warrensburg		Kirksville	
	Bu. of Seed	Tons of Hay	Bu. of Seed	Tons of Hay	Bu. of Seed	Tons of Hay	Bu. of Seed	Tons of Hay
Wilson	24.5	1.9	2.5	.2	19.8	2.4	22.0	1.3
Virginia	23.1	1.9	2.9	.3	15.8	1.8	17.0	1.4
Morse	27.7	1.7	2.3	.2	15.8	1.3	18.0	1.8
Medium Yellow	30.1	2.2	2.7	.4	12.9	2.0	15.0	1.2
Mikado	27.6	1.8	2.5	.2	10.5	1.3	26.0	1.4

**Cultural Experiments With Cotton** (W. C. Etheridge).—In 1919 the fertilizer treatment of cotton was renewed in connection with a cropping system of corn, cotton and legumes. The fertilizer was applied to cotton on land which in 1918 grew a crop of cowpeas (harvested for hay) and a

crop of fall sown rye (turned under in the spring). The following yields resulted:

Fertilizer Treatment per acre	Pounds of Lint per acre
300 lbs. Acid Phosphate .....	644.6
35 lbs. Potassium Chloride .....	
No fertilizer .....	589.1
300 lbs. Acid Phosphate .....	653.2
200 lbs. Acid Phosphate .....	578.3

**Cultural Experiments With Corn** (W. C. Etheridge).—The investigation of cultural methods for corn was continued in 1919 at the Maryville and Warrensburg fields. The season was favorable for corn and at each field the yields were above the average of the locality. The following data show the relation between the method of cultivation and the yield:

Treatment of the Crop	Yield in bushels of grain per acre	
	Maryville	Warrensburg
Four Normal Cultivations .....	47.2	21.4
Four Normal Cultivations and two later Cultivations .....	43.0	16.8
Four Deep Cultivations .....	47.1	23.6
No Normal Cultivation, but the surface was scraped clean thruout the grow- ing season .....	55.9	30.4

There are two important results here; low yields from late cultivation, high yields from surface scraping. The first may be explained by the reasonable assumption that late cultivations tore out many of the surface roots. The second is explained by the fact that the surface scraping kept the crop entirely free from all extraneous plant growth during the growing season.

**Comparison of Soybeans and Cowpeas for Hay and Seed Production** (C. A. Helm).—Comparisons of the soybean and cowpea crops for hay and seed in 1919, as in previous years show strongly the superiority of the soybean for both purposes. Yields of the leading varieties in each group here follow:

Hay	Yield per acre
Wilson Soybeans .....	2.23 tons
Morse Soybeans .....	2.11 tons
Whippoorwill Cowpeas .....	1.30 tons
Red Ripper Cowpeas .....	.99 tons
Seed	
Medium Yellow Soybeans .....	23.8 bu.
New Era Cowpeas .....	21.9 bu.

**A Study of the Adaptations of the Important Varieties of Wheat for Missouri Conditions** (W. C. Etheridge, C. A. Helm).—In 1919 tests of a few commercial varieties of wheat were conducted at Maryville, Warrensburg and Cuba. A comparison of spring wheat, hard winter wheat and

soft winter wheat, was made at Maryville; of hard winter and soft winter wheat at Warrensburg; and soft winter and spring wheat at Columbia. The following were the results:

Variety	Yield in bushels of grain per acre			
	Maryville	Warrensburg	Cuba	Columbia
<b>HARD WINTER</b>				
Kanred .....	24.0	10.4	-----	-----
<b>SOFT WINTER</b>				
Fulcaster .....	24.0	16.3	7.07	28.7
Michigan Wonder .....	21.5	-----	-----	-----
Fultz .....	-----	13.6	7.6	-----
Poole .....	-----	16.9	9.6	-----
Red Wave .....	-----	-----	7.2	-----
Rudy .....	-----	13.2	-----	-----
Mediterranean .....	-----	14.4	-----	-----
<b>SPRING</b>				
Scotch Fife .....	11.3	-----	-----	8.9
Marquis .....	23.8	-----	-----	9.6

From these data the following indications may be set forth:

(1) The superiority of the hard winter sort, Kanred, and the semi-hard sort, Fulcaster, over the soft wheat, Michigan Wonder, and the spring wheats, Scotch Fife and Marquis.

(2) The inferiority of Kanred at Warrensburg.

(3) The very marked inferiority of spring wheat at Columbia and Maryville.

Among the large number of varieties of soft winter wheat tested on a nursery scale for the past six years at Columbia, the following are the leaders in yield:

Variety	Average yield in bushels per acre 1914-1919 inclusive
Mediterranean 31 .....	32.7
Mediterranean 30 .....	31.7
Harvest Queen .....	31.6
Fulcaster 8-y .....	31.2
Average of all varieties .....	26.1

**A Study of the Adaptations of the Important Varieties of Cotton for the Southeast Missouri Lowlands (C. A. Helm).**—Eight important varieties of cotton were compared in the season of 1919. They included three distinct types—(1) late, big boll, (2) early, small boll and (3) long staple. Yields by these groups were as follows:

Big Boll	Pounds of Lint per acre
Cook Improved .....	625.3
Mebane Triumph .....	482.7
Cleveland .....	330.7
Rowden .....	272.7
Average .....	427.9

Small Boll	
Trice .....	501.1
Simpkin Prolific .....	475.0
King Improved .....	291.8
Average .....	422.6
Long Staple	
Weber 49 .....	158.2

The difference between the yields of the big boll and small boll groups is not significant. It will be noted that the four leading varieties among the eight tested, are divided equally between the two groups. The extremely early small boll King Improved undoubtedly lost a large part of its yield through a failure to pick the crop at the proper time. This variety though normally a good yielder will not strongly hold its seed-cotton in the fully open bolls. Consequently when last season a shortage of labor made necessary a delay in picking until all varieties had matured their entire crop. King Improved was at a serious disadvantage, for it had matured and lost a considerable part of its crop before the late varieties were ready.

Weber, 49, the single variety to represent the long staple group gave an extremely low yield.

**Factors Influencing the Development of the Maize Plant—Field Studies of the Plant** (W. C. Etheridge).—In 1919 the effect of an associated growth of soybeans upon the yield of corn was similar to the effect of the same cause 1917 and 1918. In each of these three years there have been two outstanding general results:

(1) A material growth of soybeans, by whatever method combined with corn, always caused a material reduction in the yield of corn.

(2) Soybeans planted late, any method and in any manner, in all cases failed to make a material growth and have no effect on the yield of corn.

**Cultural Experiments With Wheat** (W. C. Etheridge).—Cultural experiments with wheat have for the past two years been limited to the treatment of soybean stubble in preparation of a seedbed for wheat. To find the method of preparing the bean stubble, which would re-act most favorably upon the following crop of wheat has been the object of the experiments.

The following are the summarized results of 1918 and 1919, presenting average yields of three series of plots:

Treatment of the stubble	Yield in bushels of grain per acre		
	1918	1919	Average
Untreated .....	23.1	15.6	19.4
Harrowed .....	22.4	13.5	18.0
Single-Disked .....	21.9	13.9	17.9
Double-Disked .....	22.6	15.6	19.1
Single-Disked, harrowed .....	24.4	14.6	19.5
Double-Disked, harrowed .....	21.2	16.1	18.7
Double-Disked, rolled .....	26.2	14.7	20.5

The results do not show that any of the treatments were profitable. They were all shallow treatments—the only kinds which may usually be applied to bean stubble in preparation for wheat, since the normal season



of seeding wheat comes close upon the harvesting of the bean crop, and plowing the stubble would obviously make the soil too loose for a good seedbed. There is indeed a strong indication that bean stubble land which has been spring plowed and kept fairly clean during the season is without further treatment an excellent seedbed for wheat.

**A Study of the Cultural Requirements and Adaptations of Sudan Grass** (C. A. Helm).—At Columbia a crop of Sudan grass sown in rows three feet apart in early summer yielded 2.7 tons of cured hay per acre on August 15th, and 1.3 tons of cured hay on September 15th; the total yield of 4.0 tons for the season. A part of the crop, allowed to mature, yielded 14.5 bushels of seed to the acre on October 1st.

At Cuba the hay crop, sown on a point of very thin land, yielded only 0.27 tons to the acre; but the seed crop, sown on moist sodland, gave an acre yield of 16.0 bushels.

The crop at Warrensburg seeded in rows three feet apart made an acre yield of 2.44 tons of cured hay from a single cutting on October 3rd; but the crop seeded with the grain drill, in rows eight inches apart, made on the same date a yield of only 1.93 tons per acre.

**A Study of the Important Varieties of Oats for Missouri Conditions** (W. C. Etheridge).—Commercial varieties of oats were tested at Maryville, Warrensburg and Springfield. The season was generally good and the crop yielded well in each section. The acre yields of the leading varieties in each group, early and late, are given in the following table:

Variety	Maryville	Warrensburg	Springfield	Average
Texas Red .....	51.2 bu.	32.2 bu.	23.7 bu.	35.7 bu.
Kherson .....	42.7 bu.	46.3 bu.	32.7 bu.	40.6 bu.
Burt .....	40.3 bu.	33.9 bu.	21.0 bu.	31.7 bu.
Silvermine .....	38.4 bu.	31.5 bu.	17.7 bu.	29.2 bu.
White Shonen .....	33.1 bu.	30.1 bu.	25.3 bu.	29.5 bu.
American Banner .....	44.8 bu.	29.7 bu.	30.7 bu.	35.1 bu.

The important feature of these results is the comparatively high yields of the group of early varieties. These amount to an average of 36.0 bushels to the acre, while the yields of varieties in the late group average only 31.3 bushels. A similar superior yielding capacity of early varieties had consistently been shown in previous years.

Tested on a nursery scale at Columbia, the leading varieties and their yields were as follows:

Variety	Bushels of grain per acre
Irish Victor .....	69.6
Kherson Selection .....	67.2
Sixty-day .....	62.1
Fulghum .....	60.9

**A Comparison of the Most Important Grain Sorghums With Corn for Grain and Forage Production** (W. C. Etheridge).—In 1919, both at Warrensburg and Cuba, grain sorghum outyielded corn by a wide margin, as the following data will show:

Corn	Bushels of grain per acre	
	Warrensburg	Cuba
Blackhull Kaffir .....	31.0	.....
Sunrise Kaffir .....	28.5	17.6
Dawn Kaffir .....	22.0	21.3
Dwarf Milo .....	38.8	8.9
Average .....	30.1	15.9
Bloody Butcher .....	29.0	1.6
St. Charles White .....	23.7	1.9
Reid Yellow Dent .....	21.6	.....
Leaming Yellow .....	19.6	.....
Commercial White .....	26.9	.....
Boone County White .....	18.2	.....
Ninety-day Silvermine .....	.....	1.7
White Pearl .....	.....	0.7
Average .....	23.2	1.5

#### Cultural Experiments With Alfalfa (W. C. Etheridge, C. A. Helm).—

The most interesting developments in the cultural experiments with alfalfa and sweet clover are in (1) comparative yields of the two crops when both are under the same cultural treatment, (2) the effect of the small grain nurse crop upon the yield of alfalfa or sweet clover and (3) the relative effect of the legume upon the yield of the nurse crop, in both hay and grain.

Briefly, the noteworthy results of the 1919 season are the following:

(1) Under a broad range of cultural treatment of average Missouri upland, at Columbia, sweet clover invariably outyielded alfalfa by a wide margin. The difference in favor of sweet clover was greatest on untreated land and least on land well limed, fertilized, and manured.

(2) Sweet clover or alfalfa sown with a nurse crop gave much lower yields than when sown alone.

(3) Small grain nurse crops in which was sown sweet clover gave decidedly lower yields, in forage and in grain, than when alfalfa was sown with them. This was doubtless due to the heavier growth and greater competition of the sweet clover.

**A Study of the Adaptations of the Important Varieties and Selections of Cowpeas to the Various Soil Types of the State (W. C. Etheridge and C. A. Helm).—**Ten varieties of cowpeas were tested at Columbia for yields of seed, with the following results:

Variety	Bushels of seed per acre
New Era .....	21.8
Red Ripper .....	21.1
Groit .....	20.3
Black .....	19.8
Whippoorwill .....	18.9
Clay .....	15.2
Early Ramshorn .....	14.5
Cream .....	11.1
Iron .....	9.0
Brabham .....	9.0

## HOME ECONOMICS

**Utilization of Apple Surplus** (Louise Stanley, Opal Davis).—This project was designed to find out a product which was palatable, compact and easily transported. It was found that apple sauce either with or without spice but with no sugar could be dried into compact form which with the addition of water and sugar gave a most palatable product after three to four minutes boiling.

The product was dried by two methods, in an oven at low temperature and in a current of heated air. The methods were equally satisfactory and in neither case was there a dried apple flavor.

**The Effect of Blanching in the Canning of Some Typical Crops of Vegetables** (Miss Ethel Geldehaus).—A comparison was made of the rate of heating of quart cans of spinach when heated directly and when heated after blanching and the cold dip. Temperature readings were taken every five minutes and the curves plotted. The density of the pack was varied as well as the method of previous treatment. After blanching spinach by steam and the cold dip as recommended in the government directions, fifteen minutes longer is required for a quart jar filled with spinach, so treated to reach the boiling point than when the material is wilted in the top of a double boiler and packed directly in a quart jar. Increasing the amount of spinach in the can from 1000 gms. to 1500 gms. per quart jar, had no influence on the time required for the center of the jar to reach the temperature of 100 degrees C.

In view of the recent findings of the b. Botulinus in canned foods, it was decided to test the effect of the above conditions on this organism. Cans of spinach were treated as above. Inoculated with b. Botulinus and sterilized, the time to reach 100 degrees C. was noted and the jars held at this temperature for varying lengths of time. This material was sealed and held for examination since tests on the thermal death point of this organism are not conclusive until three months have elapsed.

**Standardization of Cooking Temperatures**—*Temperatures for cakes as effected by amount of baking powder used* (Louise Stanley, Nita Collier).—A standard recipe was used in all the cakes. Eight series were baked at the following temperatures:

175 Degrees C	195 Degrees C
180 Degrees C	205 Degrees C
185 Degrees C	215 Degrees C
190 Degrees C	225 Degrees C

Temperatures at which cakes were baked had no effect on the specific volume or texture when a medium amount of baking powder was used. The specific volume of cakes made with eight teaspoons of baking powder was greater than those made with one teaspoon but the increase was not in regular sequence.

The specific volume of cakes at all temperatures was slightly larger when one cake was baked at a time than when four cakes were baked. Probably explained by the fact that the temperature inside the cake was higher in a shorter length of time where one cake was baked than where four were baked.

There was no relation between the amount of baking powder used and the water loss in the cakes in baking, in 24 hours, in 48 hours, or in total water loss.

There was no relation between water loss and the temperature used in baking.

The time required for baking was decreased as the temperature for baking was increased.

The kind of sugar used had little effect on the specific volume of the cake, but it did have a marked effect on the texture. Cakes made with powdered or fine grained sugar were the best cakes. The specific volume was greater when the egg white was beaten separately. There was no difference in the specific volume when the egg white was added last and when it was added before the baking powder.

Cakes were made to see if the specific volume, when the fat was melted differed from the specific volume when fat and sugar were creamed together. The greater the amount of batter the greater the specific volume of cakes.

## HORTICULTURE

**Fruit Bud Development of Fruit Trees as Influenced by Treatment and Previous Crops** (F. C. Bradford).—A considerable amount of data has been tabulated concerning the relation of length of spur growth to bearing and the relation of leaf area to length of growth and to bearing. Material has already been collected for a microscopic study of buds and tissues.

**Breeding Apples for Late Blooming Habit** (F. C. Bradford).—A few of the trees grown from seed resulting from crosses made in 1913 blossomed this year. While conclusions cannot be drawn with safety until several seasons of blossoming have passed, it is apparent that the trees will have blossoming seasons ranging from medium to late.

A considerable amount of pollination was done this spring, but because of poor weather the results secured were rather unsatisfactory. However, there will be more or less seed to plant next spring. The crosses made were designed to bring out, if possible, the principles of inheritance of the late-blossoming character more especially than to make an attempt to secure definite gains of new varieties. To this end, varieties representing a rather wide range of blossoming seasons were crossed.

Phenological records covering thirteen years have been arranged, analyzed and tabulated and will ultimately be used in connection with reports on the crosses made.

**Cabbage Seed Selection for Disease Resistance** (J. T. Rosa, Jr.).—It has been found practically impossible under our conditions to secure seed from cabbage plants selected for disease resistance, in summer, due to decay the following year, when seed should be produced. Cabbage plants are now being grown on yellows-infected land in such a way that the disease resistant plants will mature in the fall, thus making it easy to carry them over to the following spring for seed production.

The cabbage yellows disease increased rapidly throughout the state. Counts made in commercial fields of cabbage in St. Louis County showed 20 to 75 per cent destruction of the crop.

**Orchard and Strawberry Nutrition** (V. R. Gardner and H. D. Hooker, Jr.).—A bulletin on the nutrition of apples has been filed for publication.

Samples of apple fruit spurs with leaves, flowers or fruit removed were collected at intervals during the year and their chemical composition studied in relation to their physiological condition.

Three types were investigated: spurs that blossomed and bore fruit; spurs that did not blossom but which developed fruit buds and sterile spurs that neither blossomed nor developed fruit buds. The first type is represented by samples from Wealthy, Ben Davis and Jonathan trees; the second by samples from Ben Davis, and Jonathan trees, the Jonathan being the same one from which samples of the first type were taken; the third by samples from Ben Davis and Nixonite trees. Determinations were made of the dry weight, ash, titratable acidity potassium, phosphorus, total polysaccharides, and hydrogen ion concentration. In general official analytical methods were used. The starch values were obtained by digestion, followed by hydrolysis of the digestive products. Some supplementary microchemical tests were made.

1. The seasonal changes in most of the constituents examined are distinct and characteristic of the condition of the spur-bearing, non-bearing, or sterile. In general, the bearing and sterile spurs show extreme values, while the non-bearing spurs assume a position intermediate between them.

2. The conditions characteristic of bearing and non-bearing spurs of the same trees, (Jonathan) are practically identical with the conditions of spurs from trees (Ben Davis) in bearing and in the off year respectively. Spurs from barren trees are characterized by a seasonal chemical picture distinctly different from the two types of spurs from productive trees.

3. For most constituents, the spurs pass through one period of maximum content and one of the minimum content during the course of a year. In the case of starch and titratable acidity, there are two maxima and two minima; the maxima of one coming at approximately the same time as the minima of the other. Carbohydrate consumption and acidity seem to be correlated.

4. High starch and low nitrogen content at the time of fruit bud differentiation appear to be essential for productivity. Fruit-bearing spurs that develop leaf buds have low starch and high nitrogen content, and sterile spurs have a low starch and low nitrogen content. The starch-nitrogen ratio is more indicative than the total carbo-hydrate nitrogen ratio.

5. During the late summer and fall, there is a steady increase in the phosphorous and nitrogen content of spurs with fruit buds. The absence of this feature in sterile spurs suggests a necessity of phosphorus and nitrogen storage preparatory to the marked increase in these elements that is peculiar to bearing spurs in the spring.

**Study of Factors Influencing the Rest Period of Horticultural Plants** (H. D. Hooker, Jr.).—The rest period studies have been continued along the same lines described in last year's report. Analyses of fruit buds that survived last winter's cold and of buds that were killed, have been made. In addition to the analysis previously made, ether extract has been determined. The analyses on peach and cherry buds show the surviving buds to have a low ether extract, but to have a relatively high nitrogen, phos-

phorus and potash content. Analysis of comparable samples from the peach including the node with the bud showed the surviving buds to have a low moisture, acidity, and nitrogen content, and a high starch content. The starch is stored in the leaf gap and hence does not figure in the analysis of buds alone.

**Investigations With Seed Potatoes** (J. T. Rosa, Jr.).—Favorable results were secured with the late potato crop planted July 1st. Potatoes produced in the fall were found to be of excellent eating and keeping quality. Three hundred and fifty potato seedlings are being grown in an effort to develop a still better variety.

Good results were secured by the use of fall home-grown potatoes for planting the following spring.

In the testing of several varieties from different Northern and Western



On left—Early Ohio potatoes grown from fall, home-grown seed. On right—same variety from Northern-grown seed.

potato growing sections, especially good results were secured from seed grown under dry farming conditions in Western Nebraska.

In seed storage tests, it was found that potatoes intended for spring planting can be kept over winter satisfactorily in cold storage at 32 to 40 degrees Fahrenheit, and in cool out-door cellars.

**Peach Breeding for Hardy Sorts** (V. R. Gardner).—Many of the first generation seedlings fruited for their first time this year. Records were made of tree and fruit characteristics and seeds were obtained for the production of a second generation of trees. The young seedling trees are now growing in the nursery row.

**Walnut Grafting Investigation** (V. R. Gardner).—A collection has been made of what appears to be the most promising varieties for Missouri con-

ditions and suitable records are being kept of their behavior. Marked differences are in evidence in the ability of the English varieties to withstand our winters.

**Transplanting Investigations With Vegetables** (J. T. Rosa, Jr.).—It has been found that hardness may be increased in cabbage and tomato plants by various treatments which check vegetative growth. Analyses are being made to determine the effect of the various hardening treatments on changes in the composition of the plants and the correlation of such changes with the resistance of the plants to cold. Leaves and stems of plants subjected to various treatments are being sectioned to study effects of hardening on the structure of the tissues.



Bliss Triumph Potatoes, June 1919; Northern on left vs fall, home-grown seed on right.

**Home Vegetable Gardening** (J. T. Rosa, Jr., R. S. Marsh).—A model farm garden and a model back yard garden are being conducted on the horticultural grounds.

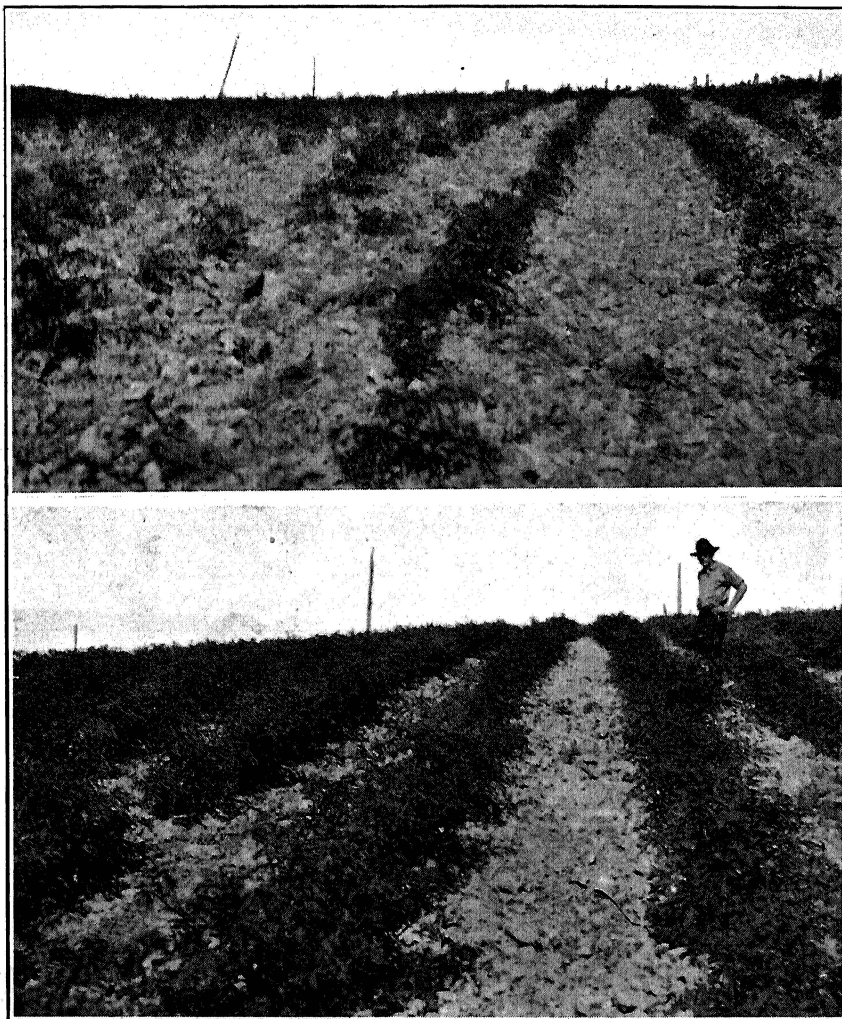
The farm garden, one-fifth acre in size, produced \$132.79 at the cost of \$42.00 including labor. The back yard garden, one-twenty-fifth acre in size, produced \$62.23 at the cost of \$18.45, including labor. Data were secured that indicate that certain vegetable crops are quite profitable under farm garden conditions, while others do not pay for cost of production.

**Cooperative Tomato Investigation** (J. T. Rosa, Jr.).—In ten series of cooperative tests in 1919, yields of tomatoes were increased on the average 159.2 per cent by 8 tons of stable manure; 152.9 per cent by 250 pounds of 4-8-5 fertilizer; 152 per cent by 250 pounds of 4-8-0 fertilizer and 106 per

cent by 250 pounds of acid phosphate. The most economical gain for the cannery tomato crop was produced by acid phosphate.

Another important result demonstrated in the fertilizer tests was the increased earliness of the crop when commercial fertilizer was used. Plots receiving complete fertilizer came into heavy bearing 3 to 4 weeks before the unfertilized plots, and plots receiving acid phosphate were 2 to 3 weeks earlier than the unfertilized plots.

A number of the large growers were assisted in saving their own tomato seed from selected plants. One grower saved 700 pounds of seed worth



Tomato Fertilizer test at Neosho, Mo.: Above, no fertilizer; below, 250 pounds of 4-8-0 fertilizer.



\$3.00 a pound at a cost of about \$60.00. A number of strains of these home-grown seed are being grown in comparison with regular seedsman's stock this year.

Cooperative tests of wilt resistant strains of tomatoes on wilt-infected land showed good results. Further selections are being made with a view of improving the quality of the wilt resistant strains.

Seed of wilt resistant strains have been distributed to 75 growers for testing.

**Investigation With Everbearing Strawberries** (H. G. Swartwout).—In a general way, it may be stated that the everbearing varieties of strawberries now on the market have not been found adapted to Missouri conditions.

## POULTRY

**Value of Sour Milk, Beef Scrap, Cotton Seed Meal, Gluten Meal and Oil Meal in Rations for Egg Production** (H. L. Kempster).—A scratch feed for all pens was supplemented with basal mash consisting of 2.2 pounds bran, 4.4 pounds shorts. To this basal mash was added meat scrap, and cotton seed meal or both in various amounts. In the check pens no protein concentrates were added. In one of these pens bone meal was added to the basal mash. In another pen, meat scrap was given in the ratio of 0.57 pounds of meat scrap to 6.6 pounds of basal mash or, in other words, the mash contained 8 per cent meat scrap. This amount is considerably less than is usually recommended. In the pens containing no animal protein concentrate, the average production was 306 eggs. The egg production in the other pens was in direct proportion to the amount of meat scrap used in the mash. In the pens, in which cotton seed meal was fed, the egg production was not as great as in the corresponding pens containing the same amount of meat scrap, but not containing the cotton seed meal. The pen fed a mash containing 8 per cent meat scrap produced more than twice as many eggs as did the pens fed no meat scrap.

**Age as a Factor in Poultry Breeding** (H. L. Kempster).—The relative hatchability of eggs from White Leghorn hens and pullets was observed. The hens' eggs were 4 per cent infertile and the pullets' eggs were 12 per cent infertile. On the average the hens showed an advantage of 4 per cent over the pullets in hatchability.

**Experiment in Chick Feeding—Studies of Various Supplementary Feeds on Growth.** (H. L. Kempster).—Eight lots of White Leghorn chicks, 31 in each lot, were fed chick feed and a mash consisting of bran, shorts, and cornmeal. This basal ration was supplemented with various feeds as is shown in the following summary:

Feeds	Hatching pounds weight	Weight pounds 2 weeks	Weight pounds 4 weeks	Weight pounds 6 weeks	Mortality %
Grain mash, whole milk....	.073	.141	.236	.35	10
Grain mash, skim milk....	.071	.136	.234	.33	19
Grain mash, whole eggs....	.072	.112	.218	.32	7
Grain mash, egg-whites, bone meal .....	.075	.10	.17	.23	32
Grain mash, skim milk, green food .....	.073	.148	.238	.35	16
Grain mash, tankage.....	.075	.086	.135	.23	23
Grain mash, tankage, green food .....	.071	.093	.103	.21	28
Grain mash, skim milk, egg yolks .....	.072	.162	.298	.422	3

The amount of the supplement was based on the consumption of milk so that each pen received approximately the same amount of protein. Evidently the milk, skim milk and egg yolks contain valuable essentials for promoting growth.

**Influence of the Time of Hatching on Future Production** (H. L. Kempster).—White Leghorn pullets hatched in February, March, April and May were observed. Contrary to the general opinion, early hatched birds layed well during the winter. This, however, was due to the high egg yield during November, after which a large proportion went into a partial molt, although a number kept laying the entire winter. It would also appear from these observations that if a person expects winter layers, Leghorns must be hatched not later than May.

**Winter Egg Production as an Indication of Year's Production** (H. L. Kempster).—White Leghorns were grouped in four classes as to production. From the data collected, it seems that the number of eggs a hen lays during the winter months, November 1 to February 28, is an excellent index to her total performance for the year.

**Time of Molt as an Indication of Past and Future Egg Production** (H. L. Kempster).—White Leghorn hens just through their first year's production were grouped into three classes; those which had completed the molt and had a new coat of plumage; those which were molting; and those which had not started to molt. The egg production of these birds was observed during the following year. The birds which molted early not only made poor egg records their first year but also their second year. Those which molted late made much better records each year.

**Relation of Plant Carotinoids to Growth** (H. L. Kempster).—White Leghorn chicks were hatched from carotinoid-free eggs from hens raised from hatching now two years old, on a carotinoid-free diet. These chicks have been fed a carotinoid-free diet. They are now 12 weeks old and are apparently normal except for the absence of yellow pigment. The growth has been excellent and the mortality extremely low. It can now be concluded that the natural yellow pigment of fowls which is derived from the xanthophyll of the food bears no relation to growth.

## RURAL LIFE

**Tractor and Other Farm Equipment Costs on the Farm** (O. R. Johnson, R. M. Green).—In farm cost accounting work the equipment charge for horse power equipment and the smaller tools is frequently prorated to different enterprises on the basis of the number of horse hours put in on the enterprise. Equipment charge is therefore expressed in terms of cost per horse hour. A summary of such costs for the last five years follows:

Year	Equipment Cost per horse hour	Cash outlay for repairs, replacements & additions in per cent of average inventory values
1914	2.3c	28.0 %
1915	2.8c	28.0 %
1916	2.9c	23.0 %
1917	2.9c	47.3 %
1918	3.7c	42.0 %

Five of the farms keeping complete cost accounts bought tractors last year.

**Cost of Producing Farm Products Under Farm Conditions** (O. R. Johnson, R. M. Green).—Sixteen complete sets of accounts were received from 14 counties. The work of setting up quantitative cost formulas from the large amount of data collected to date was begun. This work was undertaken in order to facilitate the giving out of recent cost information to farm bureaus. The Missouri Farm Bureau Federation is providing means for collecting up-to-date information on dollar costs. These data can be applied to the quantitative cost formulas to provide timely information as to current costs.

Using the "Wheat Formula," the cost of producing the 1919 wheat crop in Missouri was determined in July, 1919, as being \$25.27 an acre. The yield at that time was estimated at 13 bushels to the acre which gave a cost per bushel of \$1.94. The final yield reported for the year was 13.5 bushels. Using this yield, the cost per bushel would have been \$1.87. The latter figure checks exactly with a recent report of the U. S. Department of Agriculture made nine months later and after a careful field study of costs in three Missouri counties. Further tests of this kind are needed, of course, to establish the most dependable formulas, and to determine the allowances necessary to make under varying conditions.

Using the same formula and applying 1920 prices, the average cost per bushel of wheat in 1920 has been determined as \$2.26. This is on the basis of a 12¾ bushel yield indicated to date by State and United States crop reports.

Aside from the complete cost-account records, the financial accounts of 10 or 12 farms were summarized showing cash receipts and expenditures and inventory values.

Following is an extract from a report made to the Executive Secretary of the Missouri Farm Bureau Federation. It indicates in a brief way, the scope of work accomplished to date, on following acreage of main crops:

	Acreage		Acreage
Corn .....	5886	Clover .....	1287
Oats .....	1838	Timothy .....	1721
Wheat .....	2405	Alfalfa .....	544
Rye .....	327	Soybeans .....	465
		Cowpeas .....	430

And on main classes of livestock:

	No. Head		No. Head
Work Horses or Mules .....	750	Brood Sows .....	1550
Young Horses or Mules .....	300	Other Hogs .....	12500
Milk Cows .....	360	Sheep .....	1000
Other cattle .....	600	Poultry .....	17500

Showing result of adding later data to first two years' data.

Average total labor requirements of various crops:

Crop	Man labor in hours		Horse labor in hours	
	4 farms 1910-11	Data up to and including 1914	4 farms 1910-11	Data up to and including 1914
Corn .....	23.81	21.81	41.82	38.77
Oats .....	10.08	9.40	18.92	17.90
Wheat .....	10.48	15.49	18.38	27.17
Clover .....	8.62	7.73	9.43	7.62
Timothy .....	7.06	7.36	9.50	8.71
Alfalfa .....	26.59	18.50	45.50	32.01
Soybeans .....	21.80	21.08	36.10	34.47
Cowpeas .....	19.94	18.93	30.27	32.86
Rye .....	9.98	.....	20.38	.....
Rape .....	5.48	.....	14.87	.....

**The Agricultural and Market Value of Missouri Farm Lands** (O. R. Johnson, R. M. Green).—Work on this project was in the nature of trying out the following plan of obtaining the agricultural value of Missouri farm lands. Work was all on the basis of 1910 data.

Average acreage of corn, oats and wheat and each other crop per farm was obtained from the 1910 census report. Average yields as reported in the census and average prices for the period 1900-10 were used in arriving at gross returns from crop acres. Net returns except interest on investment was arrived at by taking cost of production except interest on land from gross receipts. Cost of production figures collected by the cost accounting work of this Department were used. The net receipts thus arrived at represent the rent the land pays after all other expenses are paid. Dividing this sum by six per cent gives the land value that will pay six per cent interest. This is designated agricultural or productive value. After allowing for pasture land, woodland and waste, this farm acre value is compared with the market values as reported in the census.

A partial report of the work done is as follows:

County	Crop-acres per farm	Total acres per farm	Agr. value of crop acre	Agr. value per acre of farm	Market value per acre of farm	Land value index
Atchison..	116.05	187.0	121.33	98.58	96.05	103.0
Holt.....	71.74	133.3	105.50	80.52	76.69	104.0
Nodaway..	68.47	139.8	106.16	79.62	80.02	99.5
Andrew....	52.00	107.0	103.16	77.37	83.22	93.0
Buchanan	46.68	92.1	137.16	102.87	106.70	96.5
Platte .....	60.26	116.8	133.83	102.13	77.47	132.0
Carroll ....	70.25	128.0	87.00	67.66	59.97	113.0
Livingston	51.97	128.0	98.50	68.95	57.02	120.5

**Land Tenure in Missouri** (O. R. Johnson).—There are three common systems of renting land: (a) For a share of all crops, (b) a share of the crop on the main crop-land, and cash for the rest of the farm; (c) a straight cash charge for the whole farm.

The share tenant has the least capital and the cash tenant most. The share tenant as a rule gets the more fertile land. He is also a better feeder of live stock, getting \$145 for each \$100 worth of feed fed compared to the \$126.00 for the cash tenant. The latter, however, was doing the bigger live stock business.

The share tenant pays 82 per cent more rent to the acre than does the cash tenant, and pays the landlord nearly twice the interest on investment that the cash tenant pays.

The share-cash running system serves merely as a middle ground between the other two systems.

**The Standard of Living on the Farm as a Factor in the Cost of Production** (O. R. Johnson, R. M. Green).—For 12 to 14 farms that have kept complete accounts continuously for several years, household expenses are tabulated as follows:

Year	Av. cash house- hold expense per farm	Per cent of 1914 cost	per cent of previous year's cost
1914	\$ 416	100	-----
1915	481	116	116
1916	505	121	105
1917	756	182	150
1918	849	204	112
1919	1082	260	128

**General Plan of Farm Organization and Operation in Different Sections** (O. R. Johnson, R. M. Green).—Men with less than \$5,000 capital should not attempt to own land in a moderate to high priced farming section. A better income will be realized by using all their capital as working capital.

In the group of farms with from \$5,000 to \$20,000 the main differences are in the investment and efficiency with live stock. The low income class kept out too little capital as operating capital and had too much invested

per acre for the yield they were getting; while they were poorer feeders of livestock and had greater losses from disease than did the more successful.

The problems confronting the men with from \$20,000 to \$40,000 capital do not differ greatly from those of Group II, except that the renting of additional land is not important. These farms are more strictly hog and beef cattle farms. Plenty of working capital and reforms in feeding practice are even more essential here than in Group II. Increase in wheat yields is worth trying for in all classes.

On farms with over \$40,000 capital, the first thing noticed is that those making low incomes are not farming their land. They live on an interest return of 3 to 4 per cent. Some of them rent out part of their land and live on the rent. The land they retain had better be rented and their working capital loaned out, as they do not retain enough to farm economically.

Another source of trouble is the failure to use silage in cattle feeding. Those making money used silage to cheapen their rations. Skill or luck in buying or selling is not a small factor in their success with cattle. With hogs, they need more pigs per sow, and the eradication of cholera would mean a big saving.

**Utilization of Labor on the Farm** (O. R. Johnson, R. M. Green).—Labor requirements by operations have been determined. The following report is for 1914:

*Corn Gathered from Standing Stalks, North Missouri Conditions.*

24.5 bu. North Mo. Corn	1914 Man hours	Horse hours
Cut stalks .....	1.24	2.38
Break .....	2.90	9.52
Disc, etc. ....	2.47	7.87
Plant .....	1.06	2.10
Harrow Corn .....	1.49	3.68
Cultivate .....	3.99	8.26
Cut Weeds .....	2.43	-----
Gather from Standing Stalks ....	4.91	8.55
Total .....	20.49	42.36

*Corn Gathered from Shock, North Missouri Conditions.*

	Man hours	Horse hours
Cut Stalks .....	1.24	2.38
Break .....	2.90	9.52
Disc and so forth .....	2.47	7.87
Plant .....	1.06	2.10
Harrow Corn .....	1.49	3.68
Cultivate .....	3.99	8.26
Cut Weeds .....	2.43	-----
Cut Corn .....	6.05	-----
Gather from shock .....	8.51	9.90
Total .....	30.14	43.71

*Corn Gathered from Standing Stalks, South Missouri Conditions.*

	Man hours	Horse hours
Break .....	4.95	12.92
Disc, etc. ....	2.52	8.55
Plant .....	1.11	2.10
Cultivate .....	7.00	12.20
Cut Weed .....	2.50	.....
Gather from Stalks .....	7.20	8.16
Total .....	25.28	43.93

**SOILS****Crop Rotation and Fertilizer Experiments (M. F. Miller, F. L. Duley).**

—The 1919 cropping year marked the 30th year of these experiments. It was a somewhat more favorable season than the average for general crops and on the whole the yields were good. There are two or three interesting comparisons from among the thirty-nine plots. A four year rotation which has been continued during this thirty year period consisting of corn, oats, wheat and clover gave a corn yield this season of 52.2 bushels while the same rotation with manure gave a yield of 60.1 bushels.

The plot which has been in continuous corn for thirty years without treatment yielded 19.6 bushels while a similar continuously cropped plot receiving barnyard manure yielded 39.1 bushels or approximately twice as much.

It can be said in general regarding the effect of crop rotation on corn that it has been more effective in maintaining the yield where no manure has been applied, than has continuous corn with manure. The same can be said of wheat, although this statement does not hold for oats and grass.

Another interesting result of the thirty years' experiments is that heavy applications of commercial fertilizer have been practically as effective in maintaining the yield of wheat under continuous cropping, and the yield of all crops in a six year rotation, as has the heavy use of stable manure.

**Experiments to Determine the Best Systems of Soil Management for the Most Important Soil Types in Missouri—*Soil Experiment Fields* (M. F. Miller, F. L. Duley, O. B. Price).**—The following fields have been in operation during the past year:

Field Name	County	Soil Type
Billings .....	Christian .....	Crawford silt loam
Cuba .....	Crawford .....	Lebanon silt loam
Chillicothe .....	Livingston .....	Wabash Clay
Eldorado Springs.....	Cedar .....	Bates silt loam
Kirksville .....	Adair .....	Lindley silt loam
Maryville .....	Nodaway .....	Marshall silt loam
Morley .....	Scott .....	Sarpy silt loam
Poplar Bluff.....	Butler .....	Waverly silt loam
Portage Des Sioux.....	St. Charles .....	Wabash Clay
St. James.....	Phelps .....	Gerald silt loam
Strafford .....	Greene .....	Lebanon silt loam
Union .....	Franklin .....	Union silt loam
Vandalia .....	Audrain .....	Putnam silt loam
Williow Springs.....	Howell .....	Clarksville silt loam
Windsor .....	Pettis .....	Oswego silt loam

Several farmers' meetings were held in connection with these fields during the year at which time the fields were visited, results were given and recommendations made regarding the soil management of the soil types in question.

Below is given a summary of results from these experiment fields from the time of their establishment until the close of the 1918 season. For convenience the results were applied to a corn, oats, wheat, clover rotation although the rotation varies somewhat on the different fields.

*Average annual value of crop increases due to treatments—14 years results:*

	Manure 8 tons 4 years	Limestone 1 ton	Bonemeal 300 lbs.	Acid Phos. 400 lbs.	Rock Phos. 1000 lbs	Potassium Chloride 50 lbs.	Legume
Corn .....	\$10.13	\$3.06	\$3.87	\$2.87	\$0.60	\$2.70	\$0.83
Oats .....	5.03	.78	4.52	1.56	.80	.67	.13
Wheat .....	10.10	2.26	10.08	11.22	3.96	2.98	.72
Clover .....	8.78	5.54	13.39	9.31	.53	1.00	1.30
Return per Rotation	32.04	10.08	31.86	24.96	4.83	7.35	1.06
Cost of Treatment..	10.00	4.00	6.40	5.40	7.00	5.00	2.00
Net Ret. per Rotation	22.04	6.08	25.46	19.56	—2.17	2.35	— .94
Per cent Increase on investment	220	152	397	362	—31	47	—47

It will be observed from the above table that the treatment known as the legume treatment has brought no financial returns. This can be explained by the statement that this treatment consists largely of growing cowpeas or soybeans in the corn which practice has been shown to be uneconomical from the standpoint of green manuring alone. It is not possible to pasture these legumes and secure any economic return in that way.

In the case of the potassium chloride application, it seems probable that this was somewhat high for the average soils in Missouri.



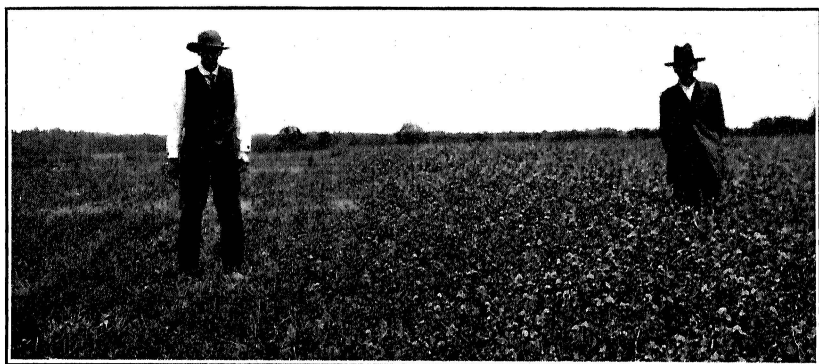
Wheat on left received 260 pounds per acre of acid phosphate and yielded twenty-seven bushels per acre. Wheat on right received no fertilizer and yielded fifteen bushels per acre. Wentzville Experiment Field.



The rock phosphate has always been applied in combination with manure. On certain fields a good response has been secured, particularly with wheat, but the small response from other crops has made this application uneconomical, as a state average.

Acid phosphate has not been used in so many cases as has bonemeal as a carrier of phosphorus. In the early experiments bonemeal, and rock phosphate were used extensively but the increased price of bonemeal has caused a change to acid phosphate on all the fields established within the last five years.

**The Determination and Mapping of Missouri Soil Types.—Soil Survey** (M. F. Miller, H. H. Krusekopf, Wm. De Young, Howard V. Jordan).—Maps of St. Louis and Polk Counties have been finished and field work begun in Lafayette and Cole counties. Including St. Louis and Cole counties, this makes a total of 51 counties now covered by detailed soil maps.



The effect of bone meal sown with wheat on the clover crop at the Willow Springs Experiment Field. The application of bone meal was required to secure a clover stand.

Work was also begun on a map covering the brown loess soils of Missouri. These soils are of very much interest because of their very wide crop adaptation for agricultural use and because of their special adaptation to fruit. The map will differentiate this brown loess into six distinct phases of types having varying agricultural and horticultural uses.

**Studies of Water Absorption, Runoff, Percolation, Evaporation, Capillary Water Movement, and Soil Erosion Under Field Conditions** (M. F. Miller, F. L. Duley).—This experiment includes a series of plots under different systems of cropping and cultivation to determine the effects of these treatments on the amount of erosion and surface run-off.

A summary of three years' results to May 1, 1920, is given in following table:

Treatment	Tons soil eroded per acre	Per cent of rainfall absorbed
1 Uncultivated, weed pulled .....	74.506	53.64
2 Plowed 4 in. deep in spring, summer fallowed .....	120.228	69.70
3 Plowed 8 in. deep in spring, summer fallowed .....	119.565	71.76
4 Sod .....	1.476	88.31
5 Wheat continuous .....	12.110	78.42
6 Rotation—Corn, wheat, clover .....	9.910	82.97
7 Corn, continuous .....	64.054	73.58

During the season 1919 the erosion from the land plowed 8 inches deep was made less than in 1918. This was due to the even distribution of rainfall. The loss of soil from plowed lands depends much more upon the



Fertilizer Experiment with Corn. Station Field, Plots 3 and 2. No treatment vs 2-10-2, 300 pounds per acre broadcast ahead of planter.

character of rainfall than it does upon the total amount. Sod land and rotated land are the most effective in preventing erosion.

**The Effect of Different Amounts and Different Methods of Applying Commercial Fertilizer on the Corn Crop** (M. F. Miller and F. L. Duley).—The season of 1919 was very favorable for the use of fertilizer on the corn crop. This was due to the even distribution of the rainfall which gave the fertilizer a good chance to act without having any tendency to burn the crop.

The increases due to fertilizer in 1919 were much better than for previous years of the experiment. This was doubtless due to the fact that the rainfall was more evenly distributed and at no time during the season did the corn suffer seriously from drought.

**The Determination of the Relative Values of Different Forms of Phosphorus Upon the Soils of Columbia** (M. F. Miller, F. L. Duley).—This project was continued according to plans and a crop of corn was harvested in the fall of 1919. Arranged in order of yield beginning with the highest, the different phosphates stood as follows: calcined phosphate, acid phosphate, basic slag, rock phosphate, bonemeal.

The average yields of corn from the different treatments are shown as follows:

Treatment	1919 Yield	Increase due to fertilizer over adjoining check plots
1. Checks (average) .....	23.4	.....
2. 2-10-2, 300 lbs. broadcast.....	.....	15.4 bu.*
4. 2-10-2, 150 lbs. broadcast.....	.....	9.0 bu.
6. 2-10-2, 250 lbs. broadcast 50 lbs. in row .....	.....	13.2 bu.
8. 2-10-2, 150 lbs. in row.....	.....	13.6 bu.
10. 2-10-2 75 lbs. in row.....	.....	8.9 bu.
12. Acid Phosphate, 100 lbs. in row .....	.....	5.9 bu.
14. 2-10-2, 150 lbs. at 3rd cultivation .....	.....	1.2 bu.
16. 2-10-2, 300 lbs. at 3rd cultivation .....	.....	2.5 bu.
18. 2-10-2, 150 lbs. at 2nd cultivation 75 lbs. in row .....	.....	1.8 bu.
20. 2-10-2, 150 lbs. at 3rd cultivation Acid Phosphate, 75 lbs. in row .....	.....	2.5 bu.
22. Acid Phosphate, 150 lbs. at 3rd cultivation .....	.....	1.3 bu.

\*Gain over two adjoining checks.

The yields this year were high, the untreated plots averaging 68.7 bushels per acre. The increase due to the phosphates were small and in most cases would hardly pay the cost of application.

**An Investigation Having to Do With the Development of the Various Parts of the Maize Plant as Influenced by Variation in Soil Moisture, Soil Composition and Texture, and in the Supply of Plant Food** (M. F. Miller, F. L. Duley).—The part of this experiment having to do with soil moisture was resumed after being discontinued for two years during the war. The results of this year's work check very favorably with those previously reported. Some further studies on the chemical composition of these plants as affected by the supply of water are being made. A report of this entire investigation is being prepared for publication.

**Nitrate Production in a Soil as Affected by the Crop and Cultivation** (Wm. A. Albrecht).—Results of three years of cropping give the following main facts:

1. The crop is of significant influence in removing the nitrates so that the accumulation of these is almost the reciprocal of the rate and season of crop growth.

2. Early spring tillage, particularly plowing, increases the nitrate content but surface tillage lessens rather than increases nitrate content in the upper seven inches of soil, mainly because it dries the larger part of this soil stratum. This emphasizes the need for shallow cultivation especially in soils whose surface layer is not very deep.

3. Of all treatments studied, the straw mulch produced the most significant effects in holding down nitrate production. During three years, this mulch plot never went higher than twenty-seven pounds of nitrogen though unmulched fallow soil rose to 204 pounds of nitrogen as nitrate per acre.

**Experiments to Determine the Value of Bat Guano as a Fertilizer** (Wm. A. Albrecht).—A survey of the state has located over seventy caves to

date with many containing small deposits of guano. Most of these are inaccessible and make developments of the deposit economically doubtful. The results of the work have been summarized and for using bat guano as a fertilizer, it is generally recommended (1) that fresh guano be reinforced by adding phosphorus. That taken from the older deposits is fairly rich in phosphorus but low in nitrogen and may require the addition of the latter. (2) Dry guano is too light to be spread through machinery, and if used alone should be spread before it has lost all its moisture. (3) Good bat guano is an excellent fertilizer and can be used alone, but for best results, it should serve in mixed fertilizers to make it a better balanced plant food.

**Studies on the Longevity of *B. Radicicola* in the Soil** (Wm. A. Albrecht).—*Pseudomonas radicicola*, the bacterium which produces the nodules on legume roots and keeps them fed on air nitrogen as well as that in the soil is not always present in the soil, but must be introduced by artificial inoculation. When once put into the soil, the question arises as to how long the bacteria will live there. The study of this question to the present time shows that legume bacteria live in a soil for a considerable time, even in a dry soil.

Two different soils on which soybeans and red clover had grown with plenty of nodules were stored under different conditions. Samples were left out of doors protected from contamination. Others were dried in the sunlight and some in the dark, and later stored so as to be free from chance contamination. At intervals of a half year, these soils are planted with their respective legumes whose seeds were sterilized, to see if there are enough bacteria in the soil to produce good root infection.

Tests have been run at intervals of six months for the past two years and will be continued for sometime. The results indicate clearly that even though soil may have been dried in the sun, there are enough viable bacteria to produce as good an infection as from the soil which was dried in the dark, or that left out-of-doors. In gathering an infected soil, with which to inoculate a few fields, it seems that there is no such great danger in exposing this inoculation material to the sun as has once been suggested. Drying in the sunlight and storing in the dry state for two years seem to have no serious injurious effect on the inoculating power of the soil as compared to a soil left in its natural condition out of doors. With this fact established, one can gather a well infected soil, in the season when nodules of the legumes are plentiful and store that soil in the dry state for use as inoculating material the next year.

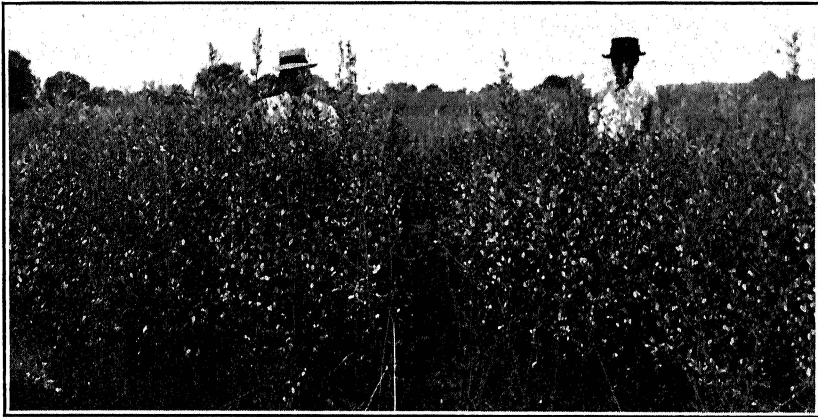
The following table giving the nodule production on plants grown in soils differently treated shows that the destructive action by sunlight is not serious:

Treatment	Nodules per plant	
	Soybean	Red clover
Dried in sun, stored two years .....	6	7
Dried in the dark, stored two years .....	4	10
No treatment, fresh field soil used for test	5	8

**Effect of Weathering and Storage Upon the Composition of Barnyard Manure** (M. F. Miller, F. L. Duley).—Three ton lots of manure were used

in this experiment. One lot was stored in a tight pan which represented about the conditions of a manure pit. Another similar lot was stored in a pan that was provided with a drainage hole. The leachings were caught and analyzed. The third lot of manure was piled in a conical pile on the ground.

The principal loss from the manure due to leaching, is on the potash rather than the other elements. Most of the nitrogen loss seems to disappear in a gaseous form into the air and only very small amounts are carried away in the leachings. Under the conditions of this experiment the conical pile on the ground seemed about equally effective with the closed pit in conserving the fertility in manure. This is probably due to the fact that for the most part, it was deeper and turned water fairly well; it does not, therefore, become alternately wet and dry so often, but it does lose heavily of its potash.



Plot on left had 8 tons lime applied in surface 8 inches and the yield was 2.48 tons of hay. Plot on right had the same amount of lime applied in subsoil and the yield was only 1.55 tons of hay per acre.

In another phase of this work liquid manure was absorbed by straw bedding, and exposed in thin layers during the winter months. The straw seemed very effective in holding the nitrogen from the manure.

**An Experiment for the Purpose of Determining the Proper Fineness of Grinding Limestone for Agricultural Purposes and the Rates and Methods of Its Application to an Acid Soil (M. F. Miller, F. L. Duley).**—The plots were in sweet clover. The unlimed land produced 1.319 tons per acre. The land having 8 tons of lime per acre, applied in the subsoil produced 1.728 tons per acre. The same amount of lime applied in the surface eight inches produced 2.432 tons; and where the lime was distributed through both soil and subsoil, the yield was 1.914 tons per acre. Where the lime was applied at different rates the yield of sweet clover increased with the application.

## MISCELLANEOUS

**Seed Testing Laboratory** (W. C. Etheridge, Miss Bertha Hite, Miss Helen Averitt, Miss Salome Comstock).—A total of 2,644 lots of seed were tested by the Seed Testing Laboratory during the year ending June 30, 1920. Of these lots, 2,117 were tested for Missouri farmers and seedsmen; 6 for the Missouri State Board of Agriculture, in connection with its seed inspection for the administration of the state seed law; and 55 for the Custom House. In addition 468 lots were tested for farmers and seedsmen of other states, as follows: Iowa 219, Nebraska 71, Kansas 56, Oklahoma 27, Colorado 24, Arkansas 22, Texas 20, South Dakota 19, Illinois 4, New York 2, Wyoming 2, Kentucky 1, Tennessee 1. On all of these lots of seed a total of 3,918 tests were made.

On account of the excellent condition of seed corn in the spring of 1920, very few samples reached the laboratory for a test of germination. In former years, when less favorable conditions have prevailed, the work in testing corn has been very heavy. The Laboratory is therefore ready to make a very large number of germination tests of seed corn in an emergency, although in normal times, it tests mainly small seeds, clovers and grasses.

Under the instruction of the Laboratory, officials of the Missouri Corn Growers' Association tested for germination in the spring of 1920, the growers' samples from 18,000 bushels of seed corn. Of this total lot of corn, 12,000 bushels were approved and sold under the official tag of the Association. During August and September, 1920, the Laboratory tested for the Association the growers' samples from a large quantity of seed wheat, of which about 15,000 bushels were finally approved for seed by the Association. It may therefore be said that the Laboratory is cooperating closely with all agencies whose purpose is to promote the production and use of better seed in Missouri.

**The Production and Distribution of Bacteria for Legumes** (Wm. A. Albrecht).—That the importance of thorough inoculation is becoming well recognized is shown by the numerous inquiries for culture of pure legume bacteria the station receives annually. During the last year, a total of 5,861 cultures were produced and distributed to approximately 900 different individuals. The varieties of legumes for which inoculation was ordered included the following number of cultures:

Soybeans .....	2,458
Alfalfa .....	2,244
Sweet Clover .....	601
Cowpeas .....	223
Red Clover .....	173
Peanut .....	81
Canada Pea .....	23
Hairy Vetch .....	18
Velvet Bean .....	17
Alsike Clover .....	15
Navy Bean .....	6
White Clover .....	2
<b>Total .....</b>	<b>5,861</b>

Some apprehension arose with regard to using the cultures on sweet clover seeded in the early spring when frosts are still common: Tests on freezing the cultures failed to show any serious harm to their viability by this treatment.

As a result of this distribution the farmers introducing new legumes are gaining better success according to their own reports. The large number of cultures sent out for soybeans, sweet clover and alfalfa show that these less common crops are being more widely cultivated and with thorough attention to their requirement for inoculation. Favorable reports are numerous and show that the need of legumes for proper bacteria is becoming more nearly common knowledge.

**Official Testing of Dairy Cows** (A. C. Ragsdale, Chas. W. Turner).—

During the year just completed, 667 cows were officially tested for 70 breeders of purebreds in 22 counties of the state. Supervisors made 359 visits to breeders and conducted 2,442 two-day tests and 133 seven-day tests. This is an increase of over 65 per cent of the number of cows officially tested, 118 per cent increase in the number of breeders making the official tests, 33 per cent increase in the number of two-day tests and 166 per cent increase in the number of seven or thirty-day tests.

The following table shows the progress of this work during the past five years:

	Fiscal Year Ending June 30				
	1916	1917	1918	1919	1920
No. cows tested .....	336	413	349	403	667
No. breeders represented ....	24	26	28	32	70
No. two-day tests .....	1744	2072	1473	1830	2442
No. seven-day tests .....	22	47	25	50	133

Beginning in September, 1919, a monthly summary of the progress of cows on test has been made. Included in this report are the records of all cows producing over three pounds of fat during the two days while being tested by official supervisors. It is interesting to note the rapid increase in the number of so-called "Honor Cows." Starting with twelve in September the number has gradually increased, reaching the peak in May when 82 cows secured honors. This information has gone into the hands of 300 Missouri breeders of purebred dairy cattle each month as well as to the farm publications of the state who have generously contributed space for the publication of this information.

**Fertilizer Control** (F. B. Mumford, L. G. Haigh).—During the fall of 1919 and the spring of 1920, forty-three counties were visited in Missouri by inspectors. One hundred and eight towns were visited and about twenty additional samples were analyzed for farmers, dealers and county agents. About one hundred and fifty samples for limestone for agricultural purposes were tested and the report of these findings were published. Results of the inspection indicate the conditions affecting the conformity of the composition of the fertilizer to its guarantees of 383 samples of fertilizer and nearly 150 samples of limestone for purity. It also lists the brands of fertilizer registered for sale in 1920 and the approximate sale of fertilizer in the state by counties for the years 1918-1919.

**Nursery Inspection** (Leonard Haseman, K. C. Sullivan, S. R. McLane):*Nursery Inspection*

Nursery inspected .....	93
Nurseries certified .....	80
Nurseries infested with San Jose scale.....	8
Total acreage of nursery stock inspected .....	1468.75
Number of counties in which nurseries were inspected .....	40
Number of men making inspection .....	4
Number of cases of foreign stock inspected.....	67
Number of foreign plants inspected .....	442,000
Number of counties in which these foreign shipments were inspected .....	6

*Papers Issued*

Inspection certificates issued .....	103
Dealers .....	23
Agents permits .....	121
Growers permits .....	157

**Manufacture and Distribution of Hog Cholera Serum** (Dr. O. S. Crisler, Superintendent University Serum Plant).—The Agricultural Experiment Station has been manufacturing and distributing serum to farmers and veterinarians for many years. In the beginning small quantities of anti-hog cholera serum were manufactured and distributed to farmers for the purpose of determining whether or not the anti-cholera serum was a practical treatment for the disease of hog cholera. So important was the work and so successful the original investigations, that in 1909 the Legislature appropriated \$10,000.00 for the production and distribution of anti-hog cholera serum. This was distributed free and the \$10,000.00 appropriated for the purpose was soon exhausted after which the Experiment Station furnished serum at cost of manufacture.

The General Assembly meeting in January 1911, made an appropriation of \$25,000.00 to supply serum to farmers. This appropriation was exhausted in the Spring of 1912 and from that time on the Station made a small charge covering cost of production for the serum distributed. The 47th General Assembly in 1913, made an appropriation of \$50,000.00 for the purchase of land and buildings with equipment for the efficient production of anti-cholera serum. With the \$50,000.00 there was purchased a farm of 87.72 acres two miles from Columbia at a cost of \$100.00 an acre, a modern laboratory including a refrigeration plant and virus laboratory with yards adjoining, a barn for the proper care of animals used in the manufacture of serum, a deep well and necessary fences and yards were constructed with the remainder of the appropriation.

At the present time, 1920, serum is produced at a cost of 1¼c per cubic centimeter and this is the price charged to farmers and veterinarians. The equipment of the laboratory has been improved from time to time, until at present the Experiment Station has one of the best equipped and most convenient laboratories for the production of anti-cholera serum in the country. All buildings and equipment are in good state of repair and the farm is being improved as rapidly as funds will permit.



The total amount of serum produced from 1909 to 1919, has been 28,592,973 c. c. The production by years is indicated in the following table:

Year	No. c. c.
1909 .....	527,701
1910 .....	1,032,248
1911 .....	2,743,099
1912 .....	4,104,311
1913 .....	6,993,702
1914 .....	4,060,960
1915 .....	3,562,799
1916 .....	1,557,250
1917 .....	254,375
1918 .....	1,569,001
1919 .....	2,187,527
	<hr/>
	28,592,973 c. c.

It is not the policy of the Experiment Station to push the sale of serum in a manner to seriously compete with the private manufacturers of anti-cholera serum, but to produce the highest grade of serum that it is possible to produce at a minimum price. This serum is at all times available for purchase by Missouri citizens. Undoubtedly this policy has resulted in keeping the price of serum down to a reasonable cost in the state. In seasons of great emergency it would be possible to greatly increase the production of serum. Thus the plant may be considered in the nature of a state insurance against serious outbreaks of hog cholera.

## FINANCIAL STATEMENT

Dr.		Hatch Fund	Adams Fund
To balance from appropriations for 1918-1919: Receipts from the Treasurer of the United States, as per appropriations for the fiscal year ended June 30, 1920, under acts of Congress approved March 2, 1887 (Hatch Fund) and March 16, 1906 (Adams Fund) .....			
		\$15,000.00	\$15,000.00
Cr.	abstract		
By salaries .....	1	9,107.63	6,292.38
Labor .....	2	1,498.09	1,990.40
Publications .....	3	000.00	omit
Postage and stationery .....	4	206.76	32.19
Freight and express .....	5	299.89	229.25
Heat, light, water, and power .....	6	79.59	117.14
Chemicals and laboratory supplies .....	7	195.70	498.50
Seeds, plants and sundry supplies .....	8	536.02	373.08
Fertilizers .....	9	000.00	28.00
Feeding stuffs .....	10	2,553.67	3,861.01
Library .....	11	000.00	6.00
Tools, machinery and appliances .....	12	33.13	2.25
Furniture and fixtures .....	13	83.03	000.00
Scientific apparatus and specimens .....	14	90.00	1,391.31
Live stock .....	15	85.15	4.50
Traveling expenses .....	16	103.56	78.79
Contingent expenses .....	17	000.00	000.00
Buildings and land .....	18	127.78	94.90
Balance .....		000.00	000.00
Total .....		\$15,000.00	\$15,000.00

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, 1920; that we have found the same well kept and classified as above; that the balance brought forward from the preceding year was \$ none on the Hatch Fund and \$ none on the Adams Fund; that the receipts for the year from the Treasurer of the United States were \$15,000.00, under the act of Congress of March 2, 1887, and \$15,000.00 under the act of Congress of March 16, 1906, and the corresponding disbursements \$15,000.00 and \$15,000.00; for all of which proper vouchers are on file and have been by us examined and found correct, leaving balances of \$ none and \$ none.

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

Signed:

EDWARD E. BROWN

Attest:

LESLIE COWAN

Custodian.

Auditors

Acting as Auditor for the  
Curators, University of Missouri.