

University of Minnesota

AGRICULTURAL EXPERIMENT STATION

THIRTY-THIRD ANNUAL REPORT

PART I



UNIVERSITY FARM, ST. PAUL
JULY 1925

LETTERS OF TRANSMITTAL

MINNEAPOLIS, MINN.,
JULY 1, 1925

*To His Excellency, Theodore Christianson,
Governor of Minnesota.*

SIR: I have the honor to transmit to you herewith the annual report of the Agricultural Experiment Station of the University of Minnesota for the fiscal year ending June 30, 1925.

Respectfully,
FRED B. SNYDER,
President of the Board of Regents

UNIVERSITY OF MINNESOTA, MINNEAPOLIS, MINN.,
JULY 1, 1925

*The Hon. Fred B. Snyder,
President of the Board of Regents, University of Minnesota.*

SIR: I have the honor to transmit herewith the report of the Director of the Agricultural Experiment Station of the University of Minnesota for the fiscal year ending June 30, 1925.

Respectfully,
LOTUS D. COFFMAN,
President of the University of Minnesota

UNIVERSITY FARM, ST. PAUL, MINN.
JULY 1, 1925

*Lotus D. Coffman,
President of the University of Minnesota.*

SIR: I have the honor to hand you herewith the annual report of the Agricultural Experiment Station for the fiscal year ending June 30, 1925.

Respectfully,
W. C. COFFEY, *Director*

THIRTY-THIRD ANNUAL REPORT OF THE AGRICULTURAL EXPERIMENT STATION

W. C. COFFEY, Director

REPORT OF THE DIRECTOR

The Purnell fund, made available by Congress through the Purnell Act, will ultimately provide each state agricultural experiment station now established with \$60,000 annually for research. This is the third subsidy which the Federal government has established for the support of experiment stations, and its purpose is to add to the funds already provided by the states and the nation for experiment station maintenance rather than to relieve the states of their financial or other obligations.

The Act is, unquestionably, a splendid expression of confidence in those engaged in agricultural research, for it was passed at a time when the financial depression in agriculture was so acute that great pressure was brought to bear on the federal government for remedial legislation. This expression of confidence, however, merely serves to emphasize the added responsibilities and obligations of experiment stations, because Congress supported the Act on the ground that experiment stations constitute "a fact-finding agency for agriculture."

Those placed in charge of the Purnell fund are expected to attack problems in agriculture by the research method, in order to uncover facts for intelligent future guidance along various lines. As anyone acquainted with agriculture or informed about agricultural research knows, however, the problems involved are vast and complex, and a large fund may easily be expended without making a material contribution to their solution. It goes without saying, therefore, that all funds entrusted to experiment stations for research should be spent as wisely as possible.

With the Purnell fund, particularly, an earnest effort should be made to avoid needless duplication in setting up projects. In other words, the states should co-operate in laying out programs of research within special fields. The need for research is so great and its cost so apparent that uncorrelated duplication of effort among experiment stations will be regarded with actual disfavor by the public.

Shortly after the Purnell Act was passed, a meeting of the officials of the Association of Land Grant Colleges was held in St. Louis, Mo., to find ways and means of setting up unified programs of research

under the Purnell fund. Committees were appointed to outline problems of regional and national significance. Through these committees much has already been accomplished in the direction of desirable co-operation.

Provision for fundamental scientific research was the objective uppermost in the minds of those responsible for drafting the original Purnell bill, and such research should be prosecuted under the fund provided, even tho it may be well understood that the investigations are to be directed toward the solution of problems having a very evident and practical bearing on agriculture. In the older fields of production, elementary work dealing with simple tests as ends in themselves or with purely empirical facts regardless of their scientific value and relationships should be discouraged. Work of that nature belongs to an earlier and more primitive age of experimentation. The new opportunity provided calls for investigations of a more significant kind.

Three fields of work, agricultural economics, home economics, and rural sociology, were repeatedly emphasized in the campaign for the Act. The experiment stations have done little in these fields. There may be more excuse for elementary work to uncover economic facts and social conditions, therefore, than for such work in fields that have long been subjects of research; but even in these newer fields the work should be planned with care, in order to make use of methods adequate to the various subjects and in accordance with the rules of scientific investigation, with a view to securing facts of wide significance and lasting value.

The Purnell fund should contribute to the advancement of sound agriculture in Minnesota. Undoubtedly it will. But if it contributes to the fullest degree, those who are to be responsible for setting up and carrying out the program will need steadily to enlarge their concept of research problems and methods.

Changes in Staff

Resignations

Agricultural Biochemistry.—E. L. McIlhenny, special analyst, resigned to enter commercial work.

Agronomy and Farm Management.—F. L. Higgins, graduate assistant resigned to assist in the barberry eradication campaign.

Dairy Husbandry.—Chester D. Dahle, assistant dairy husbandman, resigned to become associate professor of Dairy Husbandry at State College, Pa.

Entomology and Economic Zoology.—William E. Hoffman, assistant in entomology, resigned to accept a position in China; Harry H. Knight, assistant entomologist, resigned to take a similar position

at Ames, Iowa; Walter Carter, research assistant, resigned to enter the service of the United States Bureau of Entomology, in Washington; Orville C. McBride, assistant, resigned to accept a position with the United States Bureau of Entomology at Orlando, Fla.

Plant Pathology and Botany.—Henry C. Gilbert, assistant in plant pathology, resigned to enter private business; James L. Seal, assistant plant pathologist, resigned to accept a position at Miami, Fla.; Frank M. Eaton, assistant in plant pathology, resigned to accept a position with the United States Department of Agriculture on cotton investigation work in California.

Appointments

Agricultural Biochemistry.—Arnold H. Johnson, assistant agricultural biochemist, was appointed for the fiscal year 1924-25, to fill the position occupied by Dr. C. H. Bailey, who was away on leave for the year; F. R. Davison, Kurt W. Franke, and D. R. Briggs were appointed assistants; H. O. Triebold and Emily Grewe, fellows.

Agronomy and Farm Management.—Jesse H. Lefforge was appointed graduate assistant to fill the vacancy caused by the resignation of F. L. Higgins.

Dairy Husbandry.—W. B. Combs was appointed Dairy Husbandman to fill the vacancy caused by the resignation of J. R. Keithley; R. B. Becker was appointed assistant in dairy husbandry.

Entomology and Economic Zoology.—Erich Horlbog was appointed assistant entomologist to take the position left vacant by the resignation of Dr. H. H. Knight. Walter Carter was appointed assistant to fill the vacancy caused by the resignation of W. F. Hoffman; and George H. Sterrett was appointed assistant to fill the vacancy caused by the resignation of J. R. Eyer.

Plant Pathology and Botany.—Paul D. Peterson was appointed assistant plant pathologist to fill the vacancy caused by the resignation of J. L. Seal.

Soils.—Geoffrey B. Bodman was appointed assistant in soils.

Leave of Absence

Agricultural Biochemistry.—Dr. C. H. Bailey was granted leave of absence for the year.

Publications

The following publications have been issued since the last annual report.

Experiment Station Series

No. 213. Feed Requirements and Cost of Gains of Spring and Fall Pigs, by E. F. Ferrin and M. A. McCarty, Division of Animal Husbandry. 20 pages, edition of 10,000.

No. 214. Observations on the Clear-Winged Grasshopper (*Camnula pellucida* Scudder) by J. R. Parker, Division of Entomology and Economic Zoology. 44 pages, 5000.

No. 215. Raising the Dairy Calf when Whole Milk is Sold, by C. H. Eckles and T. W. Gullickson, Division of Dairy Husbandry. 32 pages, 10,000.

No. 216. Farm Drainage Methods, Survey and Design, by H. B. Roe, Division of Agricultural Engineering. 72 pages, 5000.

No. 217. Farm Drainage Methods, Construction, by H. B. Roe, Division of Agricultural Engineering. 44 pages, 5000.

No. 218. Feeding the Dairy Herd, by C. H. Eckles and O. G. Schaefer, Division of Dairy Husbandry. 48 pages, 15,000.

No. 219. Wheat By-Products for Growing Pigs, by E. F. Ferrin and M. A. McCarty, Division of Animal Husbandry. 10 pages, 10,000. Reprint—

No. 163. Investigations in Costs and Methods of Clearing Land, by M. J. Thompson, Superintendent, Northeast Experiment Station. 32 pages, 5000.

Annual Report Series

Thirty-second Annual Report of the Agricultural Experiment Station, 1923-24, Part I. 40 pages, 2500.

Thirty-second Annual Report, Part II. 40 pages, 5000.

Thirty-second Annual Report, Part III. 35 pages, 5000.

Report of Northwest Substation, Crookston, 1924, by C. G. Selvig, Superintendent. 78 pages, 3000.

Five-year Report of Southeast Substation, Waseca, 1920-24, by R. E. Hodgson, Superintendent. 36 pages, 1000.

Report of West Central Substation, Morris, 1924, by P. E. Miller, Superintendent. 44 pages, 2000.

Technical Series

No. 22. Root-Rots of Wheat, by A. W. Henry, Division of Plant Pathology and Botany. 82 pages, 2500.

No. 23. A Study of the Physiologic and Pathologic Changes Occurring in the Reproductive Organs of the Cow Following Parturition, by W. L. Boyd, Division of Veterinary Medicine. 48 pages, 3000.

No. 24. Observations of the Effect of *B. abortus* Bang on the Weight of the Spleen of the Guinea Pig, by C. P. Fitch and R. E. Lubbehusen, Division of Veterinary Medicine. 24 pages; 2500.

No. 25. Potato Breeding Methods, by F. A. Krantz, Division of Horticulture. 32 pages, 2500.

No. 26. Economic Aspects of Creamery Organization, by J. D. Black and E. S. Guthrie, Division of Agricultural Economics. 112 pages, 2000.

No. 27. Effectiveness of Calcium Cyanide in Poisoning the Pocket Gopher (*Geomys bursarius* Shaw), by F. L. Washburn and C. E. Mickel, Division of Entomology and Economic Zoology. 12 pages, 2500.

Agricultural Extension Service

Special Series

No. 89. Farm Management Principles for Southern Minnesota, by W. L. Cavert, Division of Agricultural Extension; and G. A. Pond, Division of Agronomy and Farm Management. 16 pages, 10,000.

No. 90. Sugar Beets in Minnesota, by F. W. McGinnis, Division of Agronomy and Farm Management. 12 pages, 6000.

No. 91. Raising the Dairy Calf When Whole Milk is Sold, by T. W. Gullickson, Division of Dairy Husbandry. 12 pages, 10,000.

No. 92. Judging Dairy Cattle, by W. E. Petersen, Division of Dairy Husbandry. 36 pages, 10,000.

No. 93. Cattle Feeding an Important Enterprise in the Farm Business, by L. F. Garey, Division of Agronomy and Farm Management. 16 pages, 10,000.

No. 94. Mineral Supplements for Farm Animals, by L. S. Palmer, Division of Agricultural Biochemistry. 8 pages, 10,000.

No. 95. Producing and Handling Milk on the Farm, by H. Macy, Division of Dairy Husbandry. 8 pages, 10,000.

No. 96. Field Beans for Minnesota, by A. C. Arny and F. H. Steinmetz, Division of Agronomy and Farm Management. 12 pages, 10,000.

Reprints—

No. 15. Textiles, by Marion Weller, Division of Home Economics. 20 pages, 10,000.

No. 60. Simple Steps in Land Clearing, by M. J. Thompson, Division of Agricultural Engineering. 16 pages, 5000.

No. 79. Modern Bush Fruit Growing, by F. P. Daniels, Division of Horticulture. 24 pages, 10,000.

No. 83. The Care and Feeding of Chicks, by A. C. Smith, Division of Poultry Husbandry. 12 pages, 10,000.

No. 86. The Minnesota Plan of Marketing Eggs, by E. C. Johnson, Division of Agricultural Economics. 16 pages, 6000.

No. 90. Sugar Beets in Minnesota, by F. W. McGinnis, Division of Agronomy and Farm Management. 12 pages, 5000.

Circular Series

No. 18. Storing Potatoes on the Farm. 4 pages, 20,000.

No. 19. Approved Varieties of Field Crops for Minnesota, by A. C. Arny, Division of Agronomy and Farm Management. 4 pages, 12,000.

No. 20. Feeding Poultry for Profit, by A. C. Smith, Division of Poultry Husbandry. 4 pages, 10,000.

No. 21. Care of the Milking Machine, by H. Macy, Division of Dairy Husbandry. 4 pages, 5000.

No. 22. Treating Seed Potatoes with Hot Formaldehyde, by R. C. Rose, Division of Agricultural Extension. 4 pages, 10,000.

Reprints—

No. 9. Home Orchard Spray Calendar, by A. G. Ruggles, Division of Entomology and Economic Zoology; and R. C. Rose, Division of Agricultural Extension. 4 pages, 10,000.

No. 13. How Should Grape Vines Be Pruned? by W. H. Alderman, Division of Horticulture. 4 pages, 10,000.

No. 14. Poisoning Pocket Gophers, by C. E. Mickel, Division of Entomology and Economic Zoology. 4 pages, 10,000.

Miscellaneous

Some Useful Birds and Others Found in Minnesota; Their Economic Relations to the Agriculturist, a reprint of Entomologist's Circular 43, by F. L. Washburn, Division of Entomology and Economic Zoology. 44 pages, 5000.

Boys' and Girls' Club Songs, reprinted in an edition of 15,000.

Extension Folders, Nos. 11-13—Sheep Management Pointers for Autumn, Sheep Management Pointers for Winter, and Treatments for Seed Grains.

Extension Service News, monthly, 1700.

Among Ourselves, monthly, for the editors of the state, 750.

New Letter, weekly, 1100.

Journal Series

No. 373. "The Effect of Drying upon the Acidity of Soil Samples," by C. O. Rost and E. A. Fieger. In *Science*, Vol. LX, No. 1552, p. 297 (September 1924).

Air-drying and oven-drying of soil samples was found generally to change the hydrogen-ion concentration. Some became more acid and some less so but the general tendency was to become more acid. The hydrogen-ion concentration of fresh, moist soils stored for three months in air-tight glass containers changed in the same manner. Only when the hydrogen-ion concentration determinations are made with soil samples freshly taken is a reliable indication of conditions existing in the field to be obtained.

No. 394. "Sunscald of Tomatoes," by R. B. Harvey. In *Minnesota Studies in Plant Science: Studies in the Biological Sciences*, No. 5, pp. 229-33 (November, 1924).

The conditions for sunscald in tomatoes were determined and measurements made by thermocouples to determine the lethal temperature. Sunscald was found to be decreased by shading, plentiful moisture, and slight breezes. It can be decreased by raising the fruits from the soil and by using varieties of tomatoes which are not dark green at the stem end.

No. 401. "Morphological and Physiological Studies on the Resistance of Wheat to *Puccinia graminis tritici* (Pers.) Erik. and Henn.," by C. R. Hursch. In *Journal of Agricultural Research*, Vol. XXVII, No. 6, pp. 381-411 (1924).

The resistance of certain wheat varieties to black stem rust may be due to physiologic or morphologic characters. In stems of some varieties with a large amount of sclerenchyma there is a mechanical limitation to the spread of rust, as the mycelium grows only in the chlorenchymatous collenchyma. The relative proportion of sclerenchyma to collenchyma may be altered by fertilizers. There is no correlation between resistance and the number of leaf hairs, the size and number of stomata, or certain physico-chemical properties of wheat sap, such as sugar content, hydrogen-ion concentration, total solids, and freezing point depression.

No. 404. "Determination of Nitrogen in Connection with the Wet Combustion Method for Carbon," by A. K. Anderson. In *Journal of Biological Chemistry*, Vol. LXI, No. 1 (August, 1924).

The material remaining after a wet combustion may be used for a determination of the nitrogen by distilling off the ammonia, but if the original material contained chlorine, the results are low. By inserting a U-tube containing silver sulfate solution between the oxidation flask and the CO₂-absorbent and aerating the mixture of material for analysis and concentrated sulfuric acid at a temperature just below boiling before adding the bichromate, the hydrochloric acid may be removed, the combustion then completed, and the residue made alkaline and distilled for the determination of nitrogen.

No. 405. "The Diseases of Wheat," by E. M. Freeman. In *The Northwestern Miller*, Vol. 135, No. 10, pp. 999-1000, 1016-20 (September, 1923).

Brief discussion of the relation of wheat diseases to climatic factors and to world production and world distribution of wheat. Diseases become relatively of increasing importance as intensification of culture increases. There is a general discussion of the chief groups of important diseases of wheat, (a) rust, (b) bunts and smuts, (c) foot- and root-rots, and their prevalence in the large wheat-growing areas of the world. The disease problems of the different areas of wheat growing in North America (e.g., spring wheat, winter wheat,

Palouse country) and of the chief wheat areas of Europe, South America, India, and Australia are briefly reviewed.

No. 408. "Biochemistry of Plant Diseases. Biochemistry of *Fusarium lini* Bolley," by A. K. Anderson. In *Minnesota Studies in Plant Science, Studies in the Biological Sciences*, No. 5, pp. 237-80 (1924).

The general object of this series of investigations is to arrive at a better understanding of the chemical reactions of both host and parasites, and the chemical relations between them. In this investigation a quantitative study of the carbon metabolism of *Fusarium lini* was made. *Fusarium lini*, the organism which causes flax wilt, is not sensitive to extremes of hydrogen- and hydroxyl-ion concentration of the medium on which it grows. It has grown on media with initial pH values of from 1.84 to 12.04. The range for good growth is wide, extending from pH 3.5 to 9.5. The optimum for growth appeared to be at about pH 5 in two cases, and pH 7 in a third case. In most cases there was a change in pH toward the acid side during growth. This change is especially noticeable on alkaline media, due more to carbon dioxide than to the production of other acids. Some of the decrease in alkalinity is due to the binding of alkali by the peptone of the medium. After an initial drop in pH there is a rise, which may be due to a utilization of organic acids produced in the early stages of growth. The change in reaction is such as to bring the final reaction within the range for good growth. There is a drop in pH in alkaline peptone medium on standing uninoculated and protected from the carbon dioxide of the air by soda-lime tubes. The dry matter produced on media with potassium nitrate, aspartic acid, urea, asparagin, and ammonium sulfate as the only sources of nitrogen decreases in the above order. On ammonium sulfate the pH of the medium decreases, evidently because of the quicker absorption of ammonium ions than of sulphate ions; while on potassium nitrate of the medium it increases, evidently because of the more rapid absorption of the nitrate ions. *Fusarium lini* grows well on all the following carbohydrates as an only source of carbon: glucose, levulose, galactose, mannose, xylose, sucrose, maltose, lactose, soluble starch, and inulin. Fermentation tubes are of no value in studying gas production by this organism because no growth occurs in the closed arm of the tube. The products of metabolism on glucose are mainly carbon dioxide and ethyl alcohol, with traces of succinic acid and glycerol. More than 90 per cent of the carbon in the glucose originally present can be accounted for in the unused glucose, carbon dioxide, ethyl alcohol, mycelium, and lead precipitate. The ratio of carbon dioxide to ethyl alcohol is nearly that of a typical yeast fermentation. However, the ratio is usually high, because alcohol is utilized by the fungus

as a source of carbon. The initial pH of solutions has no effect on the nature or proportion of the products formed. The only effect appears to be in the rate at which fermentation occurs. *Fusarium lini* grows more slowly in xylose than on glucose. Carbon dioxide and ethyl alcohol are the main products of metabolism. Eighty per cent of the original carbon can be recovered in the alcohol, carbon dioxide, mycelium, lead precipitate, and unused xylose. The proportion of carbon in alcohol to carbon in carbon dioxide on a xylose medium is nearly 1:1 as compared to 2:1 in the case of a glucose medium. *Fusarium lini* grows on ethyl alcohol as an only source of carbon, producing carbon dioxide as the main by-product. The ratio of carbon in carbon dioxide to carbon in mycelium on alcohol is 1:1, whereas on the sugars it is from 2 to 4:1. The alcohol medium became more strongly acid than any other medium, the final pH being 2.57. The fungus will grow on solutions of ethyl alcohol up to a concentration of 3.24 grams in 100 cubic centimeters. The highest concentration so far obtained is 4.33 per cent by volume of alcohol, and this was on a 10 per cent glucose medium. Succinic acid serves as a carbon source for this fungus and ethyl alcohol and carbon dioxide are the main products of metabolism. On glucose the percentage of carbon in the mycelium increases with the age of the mycelium from 40.62 per cent to 52.65 per cent. The percentage of nitrogen as a rule decreases slightly. On xylose, there is very little change in the composition of the mycelium due to age. On alcohol, the percentage of nitrogen in the mycelium is greater than when glucose or xylose is the sole source of carbon.

No. 411. "The Effect of Storage on the Peroxidase Activity of Whole Milk Powders," by C. D. Dahle and L. S. Palmer. In *Journal of Dairy Science*, Vol. VII, No. 2, pp. 141-46 (March, 1924).

Factors known to favor oxidation such as air, heat, and moisture, proved detrimental to peroxidase activity in whole milk powder. Storage in vacuum and air- and moisture-proof containers was favorable for the retention of the oxidase activity.

No. 413. "Corn Stalk Sirup Investigations," by J. J. Willaman, G. O. Burr, and F. R. Davison. In *Industrial and Engineering Chemistry*, Vol. 16, No. 7, p. 734 (July, 1924).

The object of the investigation was to determine whether a commercial sirup could be made from sweet-corn stalks as a cannery by-product. It was found that the maximum sugar content of the stalks is attained about 10 to 15 days after harvesting the ears for the cannery. The sugar content of the juice at this stage averages about 13 per cent, ranging from 9 to 16 per cent. The method of manufacture of the sirup is about the same as for sorghum sirup, with

some modifications of the control of acidity. A good quality of palatable sirup can be made, which is very acceptable as a cooking sirup but not as a table sirup. The yields per acre are from 3 or 4 tons of stalks from the smaller varieties to 9 or 10 tons from the larger. This will produce from 35 to 110 gallons of sirup. Because of the small yields, cornstalk sirup manufacture could be a commercial success only with the larger varieties.

No. 414. "Adulterated Acid as a Possible Source of Error in Testing Milk by the Babcock Method," by W. E. Petersen. In *Journal of Dairy Science*, Vol. VII, No. 4, pp. 361-69 (July, 1924).

It was found possible to adulterate sulfuric acid with combinations of various fats and fat solvents so as to give a higher fat reading of the Babcock test of milk where such acid was used. Saturated solutions of butterfat in gasoline, benzine, or xylol when added to cold sulfuric acid did not alter the appearance of the acid and remained dispersed in the acid for an hour or more after being thoroly mixed. This makes possible fraudulent practices in connection with testing. Means are pointed out for detecting errors due to this cause.

No. 415. "Condensed and Powdered Buttermilk for Dairy Calves," by C. H. Eckles and T. W. Gullickson. In *Journal of Dairy Science*, Vol. VII, No. 3, pp. 213-21 (May, 1924).

Calves fed powdered buttermilk from the age of two weeks to six months made normal growth and thrived in every way equal to those receiving skim milk. Powdered buttermilk may be used as a substitute for milk with considerable saving when whole milk is marketed. Semi-solid buttermilk gave fair results but was not as satisfactory as the powdered form.

No. 421. "Disease in Cattle Caused by Feeding Sweet Clover Hay," by C. P. Fitch. In *Record of the Proceedings, American Society of Animal Production, Annual Meeting, 1923*, pp. 37-41.

As a result of experimental work it was determined that some sweet clover contains a poisonous substance which will kill young cattle. Older cattle are more resistant, but are not immune. There is some evidence to show that the poisonous substance is produced by the action of molds. This has not been definitely proved. It was determined that sweet clover hay which contains the toxic substance may be fed sparingly if properly supplemented by other feeds. There seems to be no treatment for this disease.

No. 427. "Nutritional Diseases of Cattle and Swine," by H. C. H. Kernkamp. In *27th Annual Report U. S. Livestock Sanitary Association (1923)*.

This includes a discussion of certain diseases in cattle and swine resulting from a deficiency in calcium, phosphorus, and iodine. What

appears to be a phosphorus deficiency disease of cattle has been observed in a rather large area in the northwest section of the state. Swine often suffer from a lack of calcium which results in a disease of the bones and joints and frequently appears as a paralysis. A shortage of iodine in the dietary of pregnant swine, sheep, and cattle usually results in weak, hairless pigs, or goitrous lambs or calves. These diseases can be prevented by the administration of the deficient elements.

No. 428. "Some Modifications of the Picric Acid Method for Sugars," by J. J. Willaman and F. R. Davison. In *Journal of Agricultural Research*, Vol. XXVIII, No. 5, pp. 479-88 (May 3, 1924).

A search for a reasonably permanent color standard for use with the picric acid method for sugars has been unsuccessful. The best standard is an 0.08 per cent glucose solution in saturated picric acid. Heating glucose in a solution of picric acid previous to reduction in a sodium carbonate solution gives a greater color value than without the treatment. When the picramate color is diluted, the intensity of the color is not proportional to the dilution. Therefore the color is always diluted to exactly 10 cc. Clarification of sugar solutions has proved to be unnecessary in a number of cases when the picramate method was used. The color values for eight reducing sugars, in comparison with glucose, have been determined.

No. 435. "Effect of Nitrate Applications Upon the Hydrocyanic Acid Content of Sorghum," by R. M. Pinckney. In *Journal of Agricultural Research*, Vol. XXVII, No. 10, pp. 717-23 (March 8, 1924).

Greenhouse trials showed that increasing amounts of nitrate caused sorghum plants to become larger, darker green in color, and richer in prussic acid, the last effect continuing even beyond the point where the size and color of the plants were affected.

No. 438. "An Analysis of a Bimodal Variation in Size of the Parasite, *Dasymutilla bioculata* Cresson," by C. E. Mickel. In *Entomological News*, Vol. XXXV, pp. 236-42 (1924).

A study of the variation in size of the Mutillid wasp, *Dasymutilla bioculata*. This wasp is parasitic on two species of Bembicid wasps. *Dasymutilla* varies in size from six and five-tenths millimeters to fifteen millimeters. The different sizes group themselves so that there is a series of specimens varying in size from six to ten millimeters, and a second series varying from eleven to fifteen millimeters; and these would ordinarily be taken for two different species. It was found, however, that this difference in size was due to the food material in the body of the host. When *Dasymutilla* parasitizes the smaller of the Bembicid, it produces small specimens of *Dasymutilla*; when it parasitizes the larger species of Bembicid, it produces the large sized *Dasymutilla*. It is shown clearly that what appears from an examination

of the museum specimens of *Dasymutilla bioculata* to be a specific difference in size, is in reality an ecological variation of the bimodal type due to a difference in the quantity of the food supply.

No. 447. "Winter Hardiness of Medium Red Clover Strains," by A. C. Army. In *Journal of American Society of Agronomy*, Vol. 16, No. 1, pp. 268-78 (April, 1924).

In Minnesota, medium red clover seed produced in the northern tier of the North Central and the North Intermountain states gave uniformly low percentages of winter-killing and averaged good yields of hay in both the first and the second cuttings. Seed produced in Tennessee and Oregon did not give as uniformly satisfactory results as that produced farther north. The strains coming from northern Europe winter-killed to a greater extent than the northern-grown native strains, but on a large majority of the plots a sufficient number of vigorous plants remained to give good yields with few exceptions. The results with the strain from Australia were more variable than those from the northern Europe strains. Strains of medium red clover seed produced in France, Chile, and Italy winter-killed 81, 89.5, and 93.8 per cent, respectively, and no measurable yields of hay were secured.

No. 448. "Sorghum as an Indicator of Available Soil Nitrogen," by R. M. Pinckney. In *Soil Science*, Vol. XVII, No. 4 (April, 1924).

Field trials of different rates of application of nitrate indicate that sorghum will prove a good indicator of available soil nitrogen, the color of the leaves and the content of prussic acid both responding to increasing amounts of available nitrogen.

No. 449. "Physical Effect of Alkali on Concrete Measured by Change in Volume," by D. G. Miller. In *Public Roads*, Vol. 5, No. 4, pp. 12-13 (June, 1924).

The action of sulphate waters on portland cement-concrete is accompanied by an increase of volume, and in the experiments described in this paper this change of volume has been measured and used as a basis for comparing the behavior of different specimens in the same solutions as well as the effect of different solutions on similar specimens. This work has no direct bearing on design but has useful application in the laboratory.

No. 450. "Grinding Wood Samples for Analysis," by A. C. Hildreth and R. B. Harvey. In *Botanical Gazette*, Vol. LXXVIII, No. 4, pp. 460-61 (December, 1924).

An ordinary pencil sharpener driven by a $\frac{1}{8}$ h. p. motor, satisfactorily grinds wood samples, as apple twigs, fine enough for chemical analysis and with no loss of material. A 100-gram sample can be ground in five minutes.

No. 451. "Nutritional Studies with the Confused Flour Beetle (*Tribolium confusum*, Duval)," by R. N. Chapman. In *Journal of Gen. Physiology*, Vol. VI, No. 5, pp. 565-85 (May 20, 1924).

Two methods were used in the study—first, in which experiments were carried on with individual beetles in various kinds of flour. Results from these experiments were plotted with instars on the ordinate and time in days on the abscissa, using the results from control experiments in wheat flour to determine the length of the various instars from an "x=y" formula. The rates of growth were found to be much the same up to the time of transformation, when there was a slowing up in certain foods, notably rice flour. In the second set of experiments mass cultures were used with one thousand newly hatched larvae in each culture. The feeds used were synthetic, using a nitrogen-free starch as base and adding various proteins, salts, and vitamins. In all cases it was found that the first parts of the curves were very similar but that there was a slowing of development or death at the time of transformation. Wheat germ more nearly satisfied the requirements for growth and transformation than anything else tried. The vitamin from wheat germ did not seem to supplement deficient diets.

No. 453. "On the Nature of the Color Patterns on Heteroptera with Data on the Effects Produced by Temperature and Humidity," by Harry H. Knight. In *Annals of the Entomological Society of America*, Vol. 17, No. 3, pp. 258-72 (1924).

A study of the factors influencing the variations in pigmentation in the stink bug, *Perillus bioculatus* Fabricius. The pigment concerned was found to be carotin. A maximum amount of pigment is deposited in the body wall under low temperatures, 65° to 75° F. and the minimum is deposited under high temperatures, 85° to 95° F. Increased metabolism does not produce pigment, but on the contrary must consume or otherwise dispose of the materials which under low temperatures are laid down as pigment in the body wall. Humidity as a factor separate from temperature was found not to affect the color pattern of this insect. The physiological activity of the insect upon which temperature operates is thought to be oxidation. Several other species of Heteroptera in five other families were examined to determine the chemical nature of their red pigment. The red color in these species was not due to carotin, as in *Perillus*, but to two other kinds of water-soluble pigments, one an anthocyanin-like pigment and the other a flavone-like pigment. It is concluded that a majority of the yellow and red colored Hemiptera owe their coloration to water-soluble pigments rather than carotin. The black color pattern of *Perillus* which

is due to melanin, was found to behave in a manner similar to the red color pattern when subjected to the same factors that acted upon carotin.

No. 454. "The Comparative Morphology of the Male Genitalia of the Primitive Lepidoptera," by John R. Eyer. In thesis, published by University of Minnesota. In *Annals of the Entomological Society of America*, Vol. 17, pp. 275-328 (September, 1924).

A contribution to the determination of the phylogenetic relationships of the Lepidoptera. It is shown that the development of the different types of genitalia in the primitive Lepidoptera is paralleled by a development of similar ones in the Trichoptera, certain families in each bearing a striking resemblance to each other.

No. 456. "Curing Conditions of Concrete Drain Tile a Factor of Resistance to Sulphate Waters", by D. G. Miller. In *Concrete*, Vol. 24, No. 6, pp. 235-38 (June, 1924).

This paper summarizes results of experiments in the drain tile laboratory of the Division of Agricultural Engineering with portland cement-concrete cylinders in solutions of magnesium sulfate ($MgSO_4$) and sodium sulfate (Na_2SO_4) and emphasizes some of the possibilities of increasing the resistance of concrete to waters of this type by proper curing.

No. 458. "Reactions of Selfed Lines of Maize to *Ustilage zeae*," by H. K. Hayes, E. C. Stakman, Fred Griffie, J. J. Christensen. In *Phytopathology*, Vol. XIV, No. 6, pp. 268-80 (June, 1924).

Corn smut can be controlled by the development of resistant varieties. Resistant strains can be obtained through selection in self-fertilized lines under artificially induced epidemic conditions. The localization of smut on the plant appears to be a strain characteristic, and resistance and susceptibility appear to be conditioned by genetic factors.

No. 461. "Studies in the Value of Vaccines and Bacterins in Immunizing Cattle to *Bact. abortus* (Bang)," by C. P. Fitch and W. L. Boyd. In *Journal of American Veterinary Medical Association*, Vol. LXV, No. 4, 18 pages (July, 1924).

As a result of studies carried on in an experimental herd of cattle for a period of five years with vaccines and bacterin in an attempt to control bovine contagious abortion, the following conclusions were reached: (1) The living vaccine produces some immunity to invasion of the placenta by *Bacterium abortus* Bang. The degree of immunity varies according to the individual and such variations are marked. (2) Bacterins have some immunizing value, but it is small. (3) Living vaccines apparently do not increase the number of animals which eliminate *Bacterium abortus* through the udder or discharges incident to parturition. (4) Abortions occur in animals which have been

treated with vaccines. (5) Cattle have a marked variation in susceptibility to invasion by *Bacterium abortus* (Bang). (6) The incidence of white scours does not seem to be affected by the use of abortion vaccines or bacterins.

No. 462. "A Study of the Presence of *Bact. abortus* in the Milk of Cows Which React to the Agglutination Test," C. P. Fitch and R. E. Lubbehusen. In *Cornell Veterinarian*, pp. 299-302 (July, 1924).

The milk of forty-eight animals, the blood of which reacted to the agglutination test, was examined at frequent intervals over a period of three years. Twenty-nine and one-tenth per cent of this number had *Bacterium abortus* present in the milk at one time. The agglutination titres of the blood of all cows examined was at least as high as 1-100 at the time positive milk samples were taken. The agglutination titre of the blood and milk may be quite different in the same individual.

No. 466. "The Drainage and Cropping of Peat and Muck Lands and Effect on Stream Flow", by G. R. B. Elliott. In *National Reclamation Magazine*, pp. 150-52 (August, 1924).

Open ditch drainage alone increases peak floods, and coupled with cropping of the land, tends to obliterate streams. On the other hand, deep lateral drainage with tile, tends to counteract their action, making of the deeply drained soil a vast reservoir that retains the moisture from heavy precipitation and gives it out slowly and continuously to the streams. This is especially true in peat, which when drained acts as a vast dry sponge and takes up and holds large quantities of flood water in spite of the fact that crops on peat land use much more water than on mineral soil. Deep tile drainage of peat has during the last three years restored the streams over several large areas in Minnesota.

No. 467. "Current Growth in Norway Pine," by T. Schantz Hansen. In *Journal of Forestry* (December, 1923).

This paper covers a study of current growth in an 88-year old stand of Norway pine from 1912 to 1922. During the first five-year period, Norway showed an increase of 22.3 per cent in board feet volume and 17.5 per cent in cubic feet volume. During the second five-year period, there was an increase of only 4.3 per cent in board feet volume and 3.7 per cent in cubic feet volume. Jack pine found in the stand is decadent and showed a consistent loss due to rot, windfall, and breaking. The decrease in the rate of growth in Norway pine is doubtless explainable by the fact that less rain fell during the growing seasons of the second period than during the first.

No. 468. "Notes on *Velia watsoni* Drake, with Some Additions to the List of Aquatic Hemiptera of Kansas," by W. E. Hoffman. In *Canadian Entomologist* (1925).

The life history of *Velia watsoni* Drake (Heteroptera Veliidae). The different stages, egg, five instars, and adults, are described, also the mating habits, fecundity, and longevity. This species is highly predaceous and also cannibalistic. It is long-lived, living over two seasons and laying eggs the second season. The shortest pre-oviposition period was 22 days. This species is semi-aquatic. Most of the specimens taken were found on moist banks several inches away from the water's edge.

No. 469. "Mummification of the Bovine Foetus," by W. L. Boyd. In *Journal of American Veterinary Medical Association*, Vol. LXV, No. 6. 8 pages (September, 1924).

This is a brief summary of information on this disease, including a very interesting and unusual case report. Experimental data indicate that *Bacterium abortus* is a common etiological factor, the other condition may cause dessication of the fetus. Methods of diagnosis, treatment, and prognosis are briefly described. The case report is described in detail.

No. 471. "Important Fungous Diseases of the Common Sunflower," by A. W. Henry and H. C. Gilbert. In *Minnesota Studies in Plant Science, Studies in the Biological Sciences*, No. 5, pp. 295-305 (November, 1924).

Special mention is made of the destructiveness of *Septoria* leaf spot caused by *Septoria helianthi* and downy mildew caused by *Rhysototheca halstedii*. The effect of two other pathogenes, namely, *Puccinia helianthi-mollis* and *Sclerotinia sclerotum*, is also discussed briefly. *Septoria* leaf-spot caused serious defoliation of common sunflowers in Minnesota, especially where the crop was grown for several years in succession on the same land. All varieties tested were attacked. The disease was particularly prevalent during early summer and killed a large percentage of the lower leaves. Rust did not become abundant until later in the season and attacked the upper leaves chiefly. Crop rotation, field sanitation, and the destruction of wild hosts are suggested control measures. Downy mildew caused severe stunting of affected plants.

No. 472. "Some Factors Affecting the Germination of Lettuce Seed," by Alvin H. Larson and Ruby Ure. In *Minnesota Studies in Plant Science, Studies in Biological Science*, No. 5, pp. 289-94 (November, 1924).

The germination of lettuce seed is capricious. This is especially true of the black-seeded varieties. This also leads to large discrepancies in the germination tests of the same seed by the different seed testing laboratories. There was a lack of uniformity in the procedures of making the tests and of an understanding of the peculiarities of lettuce

seed. Seeds were subjected to different treatments as to light, temperature, strata, and soaking. The quickest, highest, and most uniform results were secured by germinating the seeds in a daylight germinator at 30° C. during the day for eight hours and then suddenly transferring them into a dark chamber germinator at 20° C. for sixteen hours. Complete tests were gotten in four days.

No. 473. "Biologic Specialization in *Sclerotinia* sp., the Organism Causing Brown Rot of Fruits," by J. L. Seal. In *Minnesota Studies in Plant Science, Studies in the Biological Sciences*, No. 5, pp. 281-87 (November, 1924).

Beginning in the fall of 1920, collections of *Sclerotinia* were made on various fruits from different parts of the United States. Several of them differed materially in their physiology. Two were selected for intensive study and were designated as biologic forms I and VII. No differentiation was possible on the basis of spore size and shape, but the two forms were readily distinguished by cultural characters. The basis of differentiation was: (1) rapidity in rotting of fruit and nature of rot; (2) character of fruiting pustules on fruit; (3) blackening or non-blackening of fruit; and (4) mode of growth in pure cultures and on various media.

No. 474. "Elasticity of Supply of Farm Products," by J. D. Black. In *Journal of Farm Economics*, pp. 145-55 (April, 1924).

A criticism is given of the "average cost of production" and the "bulk line" idea as an approach to the problem of shifts in agricultural production. A statistical analysis of price changes as related to subsequent output is set forth and its advantages and disadvantages are considered. Special consideration is made of the application of the results of this method of attack to several practical economic problems.

No. 476. "Methods in Making Determinations and Interpreting Results in Grain Grading," by A. C. Arny and C. S. Dorchester. In *Journal of American Society of Agronomy*, Vol. 16, No. 8, pp. 488-506 (August, 1924).

Unequal division of the original sample by some Boerner samplers does not affect the grade of the grain unequally divided. Taking samples for multiple determinations from different halves of the original sample has no advantage as far as accuracy is concerned over taking contiguous samples of the same size or one sample of the same size as the total of the smaller ones. The indications are that samples for percentage determinations of 100 grams in size give significantly greater accuracy than samples of smaller size. Further reduction of variability of determinations may be secured in approximately half of the cases by the use of samples 200 grams in size, but on account of the labor necessary in making separations on this size sample it can not

be considered for use except for corn and in exceptional cases in making foreign material determinations on oats. Even with the utmost care in making determinations on single or duplicate samples of the largest practical size, variability still occurs and the element of chance enters to a considerable extent into the grading of lots of grain which come near the grade limits. To eliminate chance as far as possible in the grading of grain, a system of tolerances is proposed for heat damage and foreign material, based on the variability secured from determinations on a considerable number of samples of various weights taken from wheat containing approximately the grade limits of damage or of foreign material other than cereal grains.

No. 477. "Studies in Wheat Flour Grades. IV. Changes in Hydrogen-ion Concentration and Electrolytic Resistance of Water Extracts of Natural and Chlorine-Treated Flours in Storage," by C. H. Bailey. In *Cereal Chemistry*, Vol. I, No. 3, pp. 133-37. (1924).

Hydrogen-ion concentration of chlorine-treated flours increased in direct ratio to the dosage of chlorine. Natural or untreated flours evidenced an increase in hydrogen-ion concentration during a storage period of two and a half years, the greatest rate of increase being shown during the first year. Chlorine-treated flour increased in degree of acidity less than untreated flour. Electrolytic resistance of water extracts of flour was increased when the flour was treated with chlorine, but was not altered by prolonged storage of the flour.

No. 480. "Laboratory Investigations of the Influence of Curing Conditions and Various Admixtures on the Life of Concrete Stored in Sulphate Solution as Indicated by Physical Changes," by D. G. Miller. In *Proceedings of American Society for Testing Materials*, Vol. 24, Part II, 16 pages (1924).

The paper deals entirely with portland cement-concrete cylinders stored in the laboratory in 1 per cent solutions of sodium sulfate (Na_2SO_4) and, excepting for five series in which the curing was varied, particularly relates to results obtained by adding the probable influence of such additions on the life of concrete drain tile exposed to the action of sulfate-bearing waters in western and southwestern Minnesota.

No. 481. "Biological Notes on *Lethocerus americanus* Leidy," by W. E. Hoffman. In *Psyche*, Vol. 31, pp. 176-84 (October, 1924).

Account of food habits, quantity of food eaten, and probable number of generations of *Lethocerus americanus*, the Electric Light bug, is given. This species feeds on fish, tadpoles, and insects but does not kill fish except for food. There are five instars. Not more than one generation a year occurs in Minnesota.

No. 482. "The Life Histories of Three Species of Gerrids (*Heteroptera Gerridas*)," by W. E. Hoffman. In *Annals of the Entomological Society of America*, Vol. XVII, pp. 419-30 (1924).

Life histories of *Trepobates pictus* H. S., *Gerris buenoi* Kirkaldy, and *Limnoporus rufoscutellatus* Latveille are described, together with brief notes on habitat and rearing methods. The egg stage, and each of the five instars are described for each species and measurements are given. This work was done as part of a study on the evaluation of certain aquatic environment with respect to fish food.

No. 485. "What Can Educational Measurements Do for Home Economics?" by Clara M. Brown. In *Journal of Home Economics*, Vol. 16, pp. 191-96 (April, 1924).

Home Economics teachers are awakening to the definite advantage of objective tests as a substitute for the essay type of examination. They recognize the desirability of using testing instruments which will tend to eliminate the subjective element from grading; which will require more accurate learning on the part of students; and which will give assistance in discovering their weaknesses and abilities early enough for the application of remedial measures.

No. 486. "Construction and Use of Information Tests in Home Economics," by Clara M. Brown. In *Journal of Home Economics*, Vol. 16, No. 5, pp. 251-56 (May, 1924).

Suggestions are given for the construction and scoring of objective tests of the alternative-choice, completion, matching, multiple-answer, and true-false types, and certain difficulties in formulation are pointed out. A bibliography of books and magazine articles dealing with educational measurement is appended; also a list of available home economics tests and scales.

No. 487. "Yeast as a Supplementary Feed for Lactating Cows," by C. H. Eckles and V. M. Williams. In *Journal of Dairy Science*, Vol. VIII, No. 2, pp. 89-93 (March, 1925).

Commercial yeast was fed to eight cows over periods of sixty days at the rate of 25 grams per pound of milk produced, as a supplement to ordinary rations. No increase in milk production was observed and no effect was noticeable upon the condition or appetite of the animals. The conclusion is drawn that ordinary rations used in practice supply a sufficient quantity of vitamin B for milk production.

No. 488. "Yeast as a Supplementary Feed for Calves," by C. H. Eckles, V. M. Williams, and J. W. Wilbur. In *Journal of Dairy Science*, Vol. VII, No. 5, pp. 421-39 (September, 1924).

Six groups of calves were used, including 48 individuals. Yeast was added, from birth to six months of age, to typical rations as used in practice and to rations representing more extreme conditions than ordinarily used. The rations used including the yeast were checked by feeding tests with rats. The addition of vitamin B in the form of dried yeast to rations ordinarily fed on dairy farms did not increase the rate

of growth of calves. No definite effect was observed on the health of the animals used.

No. 489. "Varietal Resistance of Spring Wheats to *Tilletia levis*," by E. C. Stakman, E. B. Lambert, and H. H. Flor. In *Minnesota Studies in Plant Science, Studies in the Biological Sciences*, No. 5, pp. 307-17 (November, 1924).

About 870 spring sown varieties and selections of *Triticum* were grown for two years and a smaller number for five years in order to determine their resistance to bunt, *Tilletia levis*. In general, the vulgare group seemed to be resistant. Great variation occurred between varieties in the same group, especially between those in the *T. vulgare* group. Marquis is resistant, while other varieties—as Kota, Prelude, and Glyndon Fife—are susceptible. There is no real correlation between chromosome number and disease resistance, as the latter is specific and not general.

No. 490. "Enzymes of Thermal Algae," by R. B. Harvey. In *Science*, Vol. LX, pp. 481-82 (November, 1924).

Catalase was found to be absent from a species of *Phormidium* which grows in Hymen Terrace, Yellowstone Park, at a temperature of 73° C. As this temperature is above the killing point for most enzymes, it is suggested that the organism makes use of the physical condition of its environment to substitute the biological catalysts commonly found in other organisms.

No. 492. "A New Species of *Psammophila* Dahlbom and the Allotype of *Psammophila valida* Cresson," by Walter Carter. In *Entomological News*, Vol. 35, pp. 365-67 (1924).

Describes the males of *Psammophila valida* Cresson, a species of sphecoid wasp which was heretofore unknown, and describes a new species of this genus from Arizona. An emendation of a former key to the species is included to show the relationships of the species treated in this paper.

No. 493. "Carbon Dioxide Diffusion Ratio of Wheat Flour Doughs as a Measure of Fermentation Period," by C. H. Bailey and Arnold Johnson. In *Cereal Chemistry*, Vol. I, No. 6, pp. 293-304 (1924).

Two methods are described for quantitatively measuring the rate of loss of carbon dioxide from a fermenting dough. It is suggested that the fermentation period of any particular dough may be estimated by noting the time from mixing to the first explosive discharge of carbon dioxide.

No. 494. "Frequency of Mutations for Chlorophyll-Deficient Seedlings in Maize," by H. K. Hayes and H. E. Brewbaker. In *Journal of Heredity*, Vol. XV, No. 12, pp. 497-502 (December, 1924).

The frequency of the appearance of chlorophyll-deficiencies has been observed in first-year self-fertilized lines of six varieties of maize

commonly grown in Minnesota. The percentages of first-year self-fertilized lines which segregated for chlorophyll-deficiencies varied from 39.4 per cent in Minn. No. 13 to 7 per cent in Northwestern Dent. The large percentages of segregating lines in Minn. No. 13 indicate that recent mutations for chlorophyll-deficiencies have occurred. Four probable mutations for seeding chlorophyll-deficiencies have appeared in 953 selfed lines of maize which were obtained from seven varieties and the progeny of one cross.

No. 495. "The Seed-Corn Maggot and Potato Blackleg," by J. G. Leach. In *Science*, Vol. LXV, No. 1570, p. 120 (January, 1925).

The seed-corn maggot is an agent of dissemination and inoculation of potato blackleg. The bacteria causing the disease are present on the eggs of the insect when deposited on or near the potato seed-piece. The maggot, on hatching, burrows into the seed-piece, introducing the bacteria which rapidly decay the seed-piece and spread into the stem of the growing plant. The bacteria appear to be biologically transmitted and may also hibernate in the pupae of the insect.

No. 496. "Physico-Chemical Studies in Proteins I—The Prolamines, Their Chemical Composition in Relation to Acid and Alkali Binding," by W. F. Hoffman and R. A. Gortner. In *Colloid Symposium Monograph*, Vol. II, pp. 209-368 (1924).

The known alcohol-soluble proteins from wheat, spelt, rye, oats, barley, corn, and kafir; and unknown alcohol-soluble proteins from durum, einkorn, teosinte, and sorghum were prepared and analyzed. Casein and fibrin were also prepared and analyzed. The data on the elementary analyses did not show any striking differences between the various proteins. The nitrogen distribution, the free amino nitrogen, the free carboxyl groups, the true ammonia nitrogen, and the tryptophane and cyctine content of those proteins were studied. There were marked differences between the proteins of different groups, i.e., wheat or corn group. The differences between the proteins belonging to the same group were not sufficient to show any clear-cut subdivisions.

The acid and alkali binding of the various proteins was studied by employing potentiometric methods. It was found that when the hydrogen-ion concentration was greater than pH 2.5 or the hydroxyl-ion concentration was greater than pH 10.5 all of the proteins, regardless of their chemical composition, bound the same amount of acid or alkali. Between pH 2.5 and 10.5 the amount of acid or alkali bound is dependent on the chemical composition of the protein. It is suggested that there are two types of combination between proteins and acid and alkali, (1) a chemical type which takes place between a hydrogen-ion concentration represented by pH 2.5 and pH 10.5, and (2) an adsorption type of combination which takes place when the

hydrogen-ion concentration is greater than pH 2.5 or the hydroxyl-ion concentration is greater than pH 10.5.

A negative temperature coefficient was obtained when the experiments on the binding of hydrochloric acid and sodium hydroxide were carried out at 15°, 25°, 35° C. and when the final hydrogen-ion concentration was more than pH 2.5 or when the final hydroxyl-ion concentration was more than pH 10.5. The ratio was approximately 1:2:3 where the amount bound at 35° is 1. When the logarithms of the equivalents of acid or alkali bound at the different temperatures were plotted against the logarithms of the equivalents of acid or alkali added, the lines for a single protein passed through a common point. For acid this point represented a hydrogen-ion concentration of about pH 2.5 and for alkali a hydroxyl-ion concentration of about pH 10.5. Logarithms of the amount of acid or alkali bound plotted against the equilibrium pH, or the logarithms of the original concentrations, give straight lines if the points about a final pH of 10.5 or below pH 2.5 are used. If these are used to calculate the isoelectric point, it is approximately pH 7 for all the proteins, which is what would be expected if the combination is an adsorption type. The measured isoelectric point or "isoelectric range", however, varies with the chemical composition of the protein.

No. 497. "The Nature of the Substances Adsorbed on the Surface of the Fat Globules in Cow's Milk," by L. S. Palmer and F. Samuelson. In *Proceedings of the Society for Experimental Biology and Medicine*, Vol. XXI, pp. 537-39 (1924).

Using for the most part physical methods of isolation and purification it was found that the adsorbed material is a mixture of a single phosphorus-free globulin-like protein and several phosphatides of as yet undetermined nature. The phosphatides comprise by far the greater part of the raw material, the yield of protein not exceeding 15 per cent of the total. The occurrence of both hydrophilic and hydrophobic colloids on the surface of the fat globules is significant in explaining the stability of both cream and butter types of emulsions, as well as the conversion of the former into the latter.

No. 499. "The Osmotic Concentration, Specific Electrical Conductivity, and Chlorid Content of the Tissue Fluids of the Indicator plants of Touele Valley, Utah," by J. A. Harris, R. A. Gortner, W. F. Hoffman, J. V. Lawrence, and A. F. Valentine. In *Journal of Agricultural Research*, Vol. XXVII, No. 12, pp. 893-924 (March, 1924).

The detailed physical-chemical study of the plant sap properties of the vegetation growing in a selected region near the south end of the Great Salt Lake, which had been studied ecologically by the Office of Alkali and Drought Resistant Investigations of the United States

Department of Agriculture. The present investigation shows that the plant sap properties vary with the types of soil and are closely correlated with the vegetation growing upon different soil types.

No. 500. "The Inheritance of Grain Color in Wheat," by H. K. Hayes and D. W. Robertson. In *Journal of American Society of Agronomy*, Vol. 16, No. 12, pp. 787-90 (December, 1924).

The Marquis wheat strain used in the White Bobs x Marquis cross has two independently inherited factors for red grain color. The Kanred and Minturki wheats used in crosses at the Colorado Agricultural Experiment Station apparently have a third factor for red grain color which is independent in inheritance of the three factors for grain color found in Marquis.

No. 501. "Proline and Tryptophane as Factors Influencing the Accuracy of Van Slyke's Method of Nitrogen Distribution in Proteins," by R. A. Gortner and W. M. Sandstrom. In *Journal of American Chemical Society*, Vol. 47, pp. 1663-71 (1925).

When tryptophane was added to a mixture of 14 amino acids, the analysis of the unboiled sample showed appreciable errors in the basic fraction and in the amino nitrogen and total nitrogen in the filtrate from the bases. The errors in the basic nitrogen affect chiefly the arginine fraction. When the mixture was boiled for 24 hours with 20 per cent hydrochloric acid, the ammonia and histidine fractions showed appreciable errors. Proline added to a similar mixture of amino acids precipitates in part with the phosphotungstic acid and errors are introduced in the arginine, histidine, and lysine fractions. The same results were obtained when the mixture of amino acids was boiled with hydrochloric acid for 24 hours prior to analysis. Both proline and tryptophane may, if present, introduce errors in the Van Slyke method for the nitrogen distribution of proteins.

No. 504. "The Control of Flax Rust (Abstract)," by A. W. Henry and E. C. Stakman. In *Phytopathology*, Vol. 15 (January, 1925).

Flax rust may practically ruin a crop for fiber purposes and may also reduce the yield of seed. Several immune varieties have been found. Numerous strains of Argentine flax are immune and some also are highly rust-resistant. Ottawa 770B, a yellow-seeded, white-flowered variety, also is immune. Several other seed types are either resistant or immune. Rust resistance and wilt resistance are not necessarily correlated. Winona is wilt resistant but susceptible to rust, and rust-immune strains of Williston Golden are particularly susceptible to wilt. As our good fiber varieties like Saginaw, and seed varieties like Winona, are susceptible to rust, these have been crossed with the immune seed types. Rust resistance appears to be dominant

and segregation in the F_2 indicates that immunity can be combined with the desired morphological characters. Telia on bits of flax stems carried with the seed may transmit rust to the following crop. Obviously thoro cleaning of the seed is advisable. Crop rotation and early seeding are also important preventive measures.

No. 505. "Foot- and Root-Rots of Wheat in Minnesota in 1924," by J. J. Christensen and E. C. Stakman. In *Phytopathology*, Vol. 15 (January, 1925).

In Minnesota in 1924, foot- and root-rots killed from 2 to 4 per cent of the plants of common wheat, and from 5 to 15 per cent of the plants of durum wheats after heading. Seedling injury is not included. In many fields of durum 20 to 30 per cent of plants were killed, and in several as many as 75 per cent succumbed. More than seven hundred isolations were made from diseased plants. *Helminthosporium* was obtained from 71 per cent of the plantings; *Fusarium* from 22 per cent; and other fungi from 7 per cent. One hundred and four varieties were grown on sick soil at University Farm, St. Paul. All species and varieties were attacked, but in different degrees. The durumms were most susceptible. The average percentage of killing in fourteen varieties of durum was 78 per cent; and in seventy-one varieties of vulgare wheats, 9.9 per cent. The average percentage of killing for all varieties was 20.1 per cent.

No. 507. "An Immunological and Chemical Study of the Alcohol-Soluble Proteins of Cereals," by J. H. Lewis, H. G. Wells, W. F. Hoffman, and R. A. Gortner. In *Proceedings of the Society for Experimental Biology and Medicine*, Vol. XXII, pp. 185-87 (1924).

The alcohol-soluble proteins from wheat, durum, spelt, einkorn, rye, oats, barley, corn, kafir, teosinte, and sorghum were tested by four different immunological methods, all giving identical results. These methods are the complement fixation test, the uterus strip method, the branchospasm method, and the guinea pig anaphylaxis test. The reactions brought out very clearly the relation of the proteins of wheat and corn types of cereals. The prolamines from emmer, einkorn, spelt, and durum are closely related to gliadin and glutenin from wheat, while those from teosinte and kafir are closely related to zein from corn. The former are more closely related to gliadin than they are to glutenin, while the protein from teosinte is more closely related to zein than is kafir. No reactions were obtained between antisera for the corn group with proteins from the wheat group and conversely.

No. 508. "Evidence of a New Amino Acid in Proteins," by R. A. Gortner and W. F. Hoffman. In *Journal of American Chemical Society*, Vol. XLVII, No. 2, pp. 580-84 (February, 1925).

A new amino acid has been isolated from the protein teosinte. This amino acid was precipitated as the phosphotungstate under the conditions of the regular Van Slyke method of protein analysis after the ordinary bases had been precipitated and removed and the filtrate cooled to its freezing temperature. The pure amino acid was not prepared, as the crystalline preparation contained considerable ash in which barium predominated. The compound isolated was probably the barium salt. The present data indicate an empirical formula of $C_4H_{11}O_3N$ or some multiple of this. The phenylisocyanate was prepared m.p. 140° (uncorr.). The analysis of this derivative agrees with the apparent empirical formula.

No. 509. "Goiter in Poultry," by H. C. H. Kernkamp. In *Journal of the American Veterinary Medical Association*, Vol. LXVII, No. 2, pp. 3-8 (May, 1925).

A report of two cases of simple colloid goiter observed in poultry. These cases were submitted by the same owner within 35 days of each other. The glands were greatly enlarged and quite firm in consistency. Microscopic section revealed large dilated sinuses lined with one and sometimes two layers of low cuboidal epithelium. The acini were in most instances filled with colloid. Few cases of goiter in this species of animal are reported in the literature.

No. 510. "Some Aspects of Truck Growing on Peat Lands in Minnesota," by F. A. Krantz. In *Journal of the American Peat Society*. 3 pages. (April, 1925).

A brief discussion of the adaptability of various vegetable crops to peat soils; the limiting factors involved as compared to mineral soils, and the reaction of the different varieties of each crop. The problems connected with this type of soil are briefly discussed with the experimental work in progress.

No. 511. "Calculating the Average Production of a Dairy Herd," by R. B. Becker. In *Journal of Dairy Science*, Vol. VIII, No. 2, pp. 105-14 (March, 1925).

A comparison of six methods which are in common use for calculating the average production of dairy herds. It was concluded that one uniform method should be employed in such calculation. The inaccuracies of certain methods are pointed out.

No. 512. "Physico-Chemical Study of Cracker Dough Fermentations," by A. H. Johnson and C. H. Bailey. In *Cereal Chemistry*, Vol. 1, No. 7 (December, 1924).

Two devices are described for conveniently measuring the rate of loss of carbon dioxide from fermenting bread doughs. The first method involves two determinations, in one of which the expansion of the dough plus the loss of carbon dioxide gas is registered, while in the

second only the expansion of the dough is recorded. The difference between these values represents the quantity of carbon dioxide lost from the dough, which, when plotted against time, gives a curve representing the comparative rate of carbon dioxide loss. In the second device, involving modifications of the Osterhout apparatus, merely the rate of carbon dioxide loss is observed. The values thus determined, are, however, convenient criteria of the stage of fermentation. After a lapse of 100 to 180 minutes, depending upon the characteristics of the flour and other ingredients of the dough, a sudden increase in the rate of loss of CO_2 will be observed. The comparative time required to effect this change in rate affords a convenient measure of the properties of a flour in a standard formula, and may be correlated with the optimum fermentation period for flours under observation.

No. 514. "Boils" in Wild Rabbits," by W. A. Riley. In *American Fox and Fur Farmer* (January, 1925).

The "boils" often noted in Minnesota rabbits, and especially in jack rabbits, are the immature stages of tapeworms which develop to maturity in dogs. Since it is quite possible that they may also develop in foxes, and since certain other parasites are transmitted from rabbits to foxes, the use of uncooked rabbits for fox food is highly undesirable.

No. 519. "Shall We Teach Science or Practice, or Both?" by W. H. Alderman. In *Proceedings of American Society for Horticultural Science*, pp. 240-43 (1924).

Science and practice are not opposed and must be combined to make the most effective teaching. Beginning courses with undergraduates must contain a large amount of practice, every detail of which can be connected with its scientific background. As students progress from undergraduate to graduate work they should be led to develop their own scientific reasoning and to see the practical significance of scientific research.

No. 520. "A Study of the Proteases of Bread Yeast," by Aksel G. Olsen and C. H. Bailey. In *Cereal Chemistry*, Vol. II, No. 2, pp. 68-86 (March, 1925).

Substantial changes in the physico-chemical properties of gluten of wheat flour in a dough or flour suspension may result from yeast fermentation. Glutenin is the protein presumably chiefly involved in the changes which were studied. Water-imbibing capacity as measured by the viscosity of flour suspensions afforded a convenient criterion of the modification of glutenin which occurred during fermentation with yeast. Reduction in water-imbibing capacity of gluten can not be attributed to proteases contributed by living, normal yeast cells; but rather to the increased hydrogen-ion concentration of the flour suspension undergoing fermentation. Addition of dilute acids to a

yeast-free flour suspension resulted in essentially the same modifications of the glutenin as occurred in normal fermentation with yeast. When dilute alkali was periodically added to the fermenting mixture to prevent increases in hydrogen-ion concentration, the extent of change in water-imbibing capacity of the glutenin was slight.

Retarding the normal metabolism of yeast with such an inhibitor as toluol retarded the rate of increase in hydrogen-ion concentration of the mixture, and therefore in the reduction of the water-imbibing capacity of glutenin present in the mixture. No substantial increase in the nitrogen fractions not precipitated with the copper and tin reagents could be detected during a four-hour fermentation period. This is further evidence that proteolysis had not proceeded very far during this brief treatment with yeast. Progressive solution of the flour proteins during fermentation may be attributed to increasing acidity. Such changes in solubility are practically reversible, as shown by the immediate coagulation of the dispersed proteins on the addition of sufficient dilute alkali to return the reaction of the medium to the iso-electric range of the proteins involved. These several observations indicate that the proteases contributed by sound, normal intact yeast cells (bakers' yeast) are negligible in their effect upon the properties of gluten during a four- or five-hour fermentation period.

No. 521. "On the Relative Value of Certain Methods of Potato Breeding," by F. A. Krantz. In *Proceedings 11th Annual Meeting of Potato Association of America*, pp. 40-44 (December, 1924).

A discussion of the various methods of potato breeding with their limitations and value based on existing evidence.

No. 522. "Preliminary Report on the Respiration of Apple Twigs During the Winter," by J. H. Beaumont and J. J. Willaman. In *Proceedings American Society for Horticultural Science*, pp. 99-104 (1924).

Twigs of a hardy and of a tender variety of apple were enclosed in an apparatus in which the temperature was accurately controlled and by means of which the amounts of CO_2 given off by each could be measured. By comparing the amounts of CO_2 on a basis of weight of twig, volume of twig, number of buds, and length of twig, the hardy variety required the more at the lower temperature but the percentage of increase in CO_2 given off at higher temperatures was greater for the tender variety.

No. 523. "Variations in Yield Between Seed Stocks of a Variety," by F. A. Krantz and A. G. Tolaas. In *Proceedings 11th Annual Meeting of Potato Association of America*, pp. 45-48 (December, 1924).

A report of studies made to determine the factors which influence variations in yield obtained between seed stocks from different grow-

ers in the co-operative test plots at the Northwest substation and the dry matter, nitrogen content, and shape of tubers of seed when planted and the resulting yield, or the yield of the crop from which the seed was obtained. A comparison of yields obtained by growers with test plot yields gave negative correlations. It was further shown that the variations were not due to hereditary differences. The influence of soil heterogeneity on variations in yield in the test plots is discussed and data are submitted which indicate that this was the source of the largest amount of variation in yields.

No. 526. "Notes on *Zygocystis cometa* Stein, A Gregarine Parasite of Earthworms," by C. E. Mickel. In *Journal of Parasitology*, Vol. II, pp. 135-39 (March, 1925).

Zygocystis cometa Stein is a Gregarine parasite in the seminal vesicles of earthworms. Three species of earthworms were collected in the vicinity of St. Paul but only one species, *Helodrilus caliginosus* var. *trapezoides* (Duges) was found to be infected with Gregarine parasites. This species of earthworm was very heavily infected with *Zygocystis cometa*. No correlation was found between the season and the development stages of the parasites. There is a correlation between the degree of development of the host and the development of the parasite. Multiple infection of the blastophores of the earthworms by the sporozoites of *Zygocystis cometa* does not normally occur. Agar impregnated with the sporocystis of *Zygocystis cometa* did not prove successful in infecting earthworms with this parasite.

No. 527. "A New Method for Blanching Celery," by R. B. Harvey. In *Minnesota Horticulturist*, Vol. 53, No. 2, pp. 41-43 (February, 1925).

It was found that the easy blanching varieties of celery could be blanched for market within six days by exposure to ethylene gas in a concentration of one part in one thousand parts of air. Green winter varieties require about ten days for blanching and need two treatments with ethylene. Mosaic and chlorotic leaves are more easily blanched than normal dark green leaves. Practical suggestions for commercial application of the process are given.

No. 530. "Costs and Margins in Marketing," by J. D. Black and H. B. Price. In *Annals of American Academy of Political and Social Science*, 17 pages (January, 1925).

Grain is selected to illustrate the problems and methods involved in analyzing costs and margins in marketing. Variations in costs and margins between agencies rendering similar grain marketing services are given for a particular year and from year to year, and reasons are given for the variations. The studies in costs and margins of the principal research agencies in the field of agricultural marketing are summarized.

No. 533. "Gluten of Flour and Gas Retention of Wheat Flour Doughs," by A. H. Johnson and C. H. Bailey. In *Cereal Chemistry*, Vol. II, No. 2, pp. 95-106 (1925).

Gluten content has an important bearing upon the baking strength of flour. When the percentage of gluten in flour is reduced by dilution with starch, the gas-retaining power of dough made from such flour is impaired. Gas-producing capacity is not necessarily impaired by such additions of starch. Gas-retaining capacity of wheat flour doughs is impaired by treating them with 96 per cent alcohol and with water. Such modifications of properties as are effected by these treatments may be attributed to the alteration of the colloidal condition of the glutenin. Rye flour dough has a low gas-retaining capacity altho the rate of gas production in the dough is high. The inferior gas-retaining capacity is probably responsible for the dense compact loaves that are ordinarily baked from pure rye flour.

No. 535. "Physico-Chemical Studies on Proteins. II. Alkali Binding. A Comparison of the Electrometric Titration of Proteins and Phosphoric Acid with Sodium and Calcium Hydroxides," by W. F. Hoffman and R. A. Gortner. In *Journal of Physical Chemistry*, Vol. XXIX, pp. 769-81 (1925).

Phosphoric acid and the proteins, casein and durummin, have been titrated electrometrically with both sodium and calcium hydroxide and "back titrated" with hydrochloric acid. The alkali titration curves of casein and fibrin show binding of alkali at about pH=5.5, and resemble the curve for a weak acid such as mono-sodium phosphate. Other proteins, of which durummin is a type, behave as much weaker acids, beginning to bind alkali only at about pH=10.0. Curves of the same type are obtained when a protein is titrated with either sodium hydroxide or calcium hydroxide. When phosphoric acid is titrated with sodium hydroxide and calcium hydroxide, the two curves are not similar. In the latter case, both the secondary and tertiary hydrogens are replaced by calcium at the same pH at which di-sodium phosphate is formed. The titration curves of protein plus alkali and of phosphoric acid plus alkali are not identical at similar hydrogen-ion concentrations with the curves formed by a subsequent "back titration" with hydrochloric acid. There is a "lag" in the back titration curves. This "lag" is shown to be due to the reaction not going to completion, resulting in an equilibrium.

$\text{Ca}_2\text{H}_2(\text{PO}_4)_2 + 4\text{HCl} = 2\text{CaCl}_2 + 2\text{H}_3\text{PO}_4$ and the presence of free hydrochloric acid which increases the hydrogen-ion concentration. All three hydrogens of phosphoric acid may be titrated by calcium hydroxide below a pH of 8.0. The bearing of this observation on the graphic structure of di-calcium phosphate and tri-calcium phosphate

is discussed. Tri-calcium phosphate is apparently stable in solution as acid as pH 6.5. This has an important bearing on physiological and biochemical problems.

EXPERIMENT STATION PROJECTS

1924-1925

Agricultural Biochemistry

Cereal and Flour Investigations (C. H. Bailey)

Strength of wheat flour

Subproject: Colloidal properties which may be involved in flour strength (R. A. Gortner, C. H. Bailey, A. H. Johnson, R. C. Sherwood, W. F. Hoffman, Emily Grewe, and graduate students)

Subproject: Other factors which may be involved in flour strength

(A. H. Johnson, C. H. Bailey, R. A. Gortner, H. O. Triebold, R. C. Sherwood, Emily Grewe, Andrew Cairns, and graduate students)

Investigation of Proposed Official Methods of Analysis (A. H. Johnson, R. C. Sherwood)

Biochemistry of Resistance to Disease in Plants

Subproject: Alcohol production by *Fusarium lini* (J. J. Willaman, Houston Letcher, graduate students)

Subproject: Respiration of apple twigs in winter (J. J. Willaman, J. H. Beaumont)

Subproject: The development of enzymes during the germination of wheat (J. J. Willaman, John F. Trost, graduate student)

Subproject: Pectosinase (J. J. Willaman, F. R. Davison, graduate student)

Analytical Service (R. C. Sherwood, G. S. Taylor, Arnold H. Johnson, E. L. McIlhenny)

Protein Investigations (R. A. Gortner, W. F. Hoffman, W. M. Sandstrom, W. B. Sinclair, graduate students)

Subproject: Physico-chemical studies on protein

Subproject: Physico-chemical studies on derived proteins

Subproject: Physico-chemical studies on proteins. Electrical conductivity and ion-concentration studies of protein compounds

Subproject: The electrodialysis of agar

Subproject: An alcohol-soluble protein prepared from rice

Subproject: Evidence of a new amino acid in proteins

Subproject: An immunological and chemical study of the alcohol-soluble proteins of cereals

Subproject: Proline and tryptophane as factors influencing the accuracy of Van Slyke's method of nitrogen distribution in proteins

Subproject: The effect of alkali on cystine

Chemical Studies of Pollen (R. A. Gortner)

Chemical and Biological Studies in Animal Nutrition.

Subproject: A study of certain indolinones (L. S. Palmer, R. A. Gortner, Selmer Dahl)

Subproject: A study of the vitamin requirements of growing calves (L. S. Palmer, C. H. Eckles, graduate students)

Subproject: The antagonism of certain ions in the nutrition of higher animals (L. S. Palmer, J. R. Haag)

Subproject: A study of a nutritional disturbance similar to osteomalacia among cattle (L. S. Palmer, C. H. Eckles, T. W. Gullickson)

Subproject: The anti-rachitic value of mothers' milk (Cornelia Kennedy, L. S. Palmer)

Subproject: Studies on the existence of a fertility vitamin necessary for normal reproduction of rats (L. S. Palmer, Cornelia Kennedy)

Subproject: The fundamental food requirements of animals (L. S. Palmer, Cornelia Kennedy)

Subproject: The inter-relation of carriers of vitamins A and B as affecting growth and tissue change of young animals (L. S. Palmer, Jessie E. Richardson)

The Chemistry of the Formation and Manufacture of Dairy Products and Factors Influencing Milk Production and the Composition and Properties of Milk

Subproject: The colloid chemistry of rennin coagulation (L. S. Palmer, G. A. Richardson)

Subproject: Factors influencing the coagulation of milk by rennin (L. S. Palmer, G. A. Richardson)

Subproject: The gold number of the protective colloids of cow's milk (L. S. Palmer, Otto Johnson)

The Biochemistry of Carotinoid Pigments in Animals (L. S. Palmer)

The Chemical and Physico-Chemical Properties of Plant Tissue Fluids (R. A. Gortner, W. F. Hoffman)

Subproject: Physico-chemical properties of the plant tissue fluids of the native vegetation of Oahu, Hawaiian Islands

Subproject: Chloride and sulfate content of expressed plant tissue fluids

Chemical Studies on Forest Products (J. J. Willaman, W. F. Hoffman, K. W. Franke, D. R. Briggs)

Agricultural Economics

The Farmers' Co-operative Movement in Minnesota (H. B. Price, T. G. Stitts, B. A. Holt, E. W. Gaumnitz)

Market Business Practice (H. B. Price, B. A. Holt, E. W. Gaumnitz)

Marketing Organization Investigations (H. B. Price, Hutzler Metzger, B. A. Holt, E. W. Gaumnitz)

Methods Employed by Private Agencies in Land Settlement (J. D. Black)

Methods of Land Valuation with Special Reference to Minnesota (J. D. Black, Conrad Hammar, A. G. Black)

Investigation of the Forces Determining the Price of Farm Products (J. D. Black, Holbrook Working, T. G. Stitts, B. A. Holt, Lawrence Myers)

The Relation of Changes in the General Price Level to Changes in the Prices of Farm Products (Holbrook Working)

Market Price Investigations (H. B. Price, W. C. Waite, H. B. Rowe)

Market Price Quotations (E. W. Gaumnitz, J. D. Black)

Elasticity of Supply of Farm Products (J. D. Black, Emil Rauchenstein)

Farmers' Incomes in Minnesota (J. D. Black, W. C. Waite, Bryan C. Smith)

Grain Dockage Investigations (H. B. Price)

The Organization of the Farmers' Supply Service (H. B. Price)

The Farmers' Marketing Attitudes (J. D. Black, C. C. Zimmerman)

Agricultural Engineering

- Methods and Costs of Drainage Installation and Correlation of Land and Crop Values with Cost of Drainage (H. B. Roe, J. H. Neal, G. F. Krogh, Dana Cryder)
- Drainage and Water Control Investigations on Peat Lands (H. B. Roe, J. H. Neal, G. F. Krogh)
- Determination of the Relative Efficiency of Different Depths and Spacings of Drainage Lines (H. B. Roe, J. H. Neal, G. F. Krogh)
- Investigation of Causes of Failure of Agricultural Drain Tile, the Means of Obviating Such Failures and Mapping Areas Where Extra Precautions Are Necessary (H. B. Roe, G. F. Krogh, E. J. Bullis, D. G. Miller, P. C. McGrew, J. A. Wise)
- Investigation of Farm Buildings (H. B. White, M. G. Jacobson)
- Investigations in Cost of Clearing Land (M. J. Thompson, A. J. Schwantes, C. E. Johnson)
- Investigations in Land Clearing Methods and Equipment (M. J. Thompson, A. J. Schwantes)
- Heating and Ventilating of Homes (E. A. Stewart, A. G. Tyler)
- Hydro-Electric Farm Plants (E. A. Stewart, Julius Romness)
- Farm Building Ventilation (E. A. Stewart)
- Wind Power Electric Lighting Plants (E. A. Stewart)
- Farm Sewage Disposal (E. A. Stewart, Julius Romness, A. G. Tyler)
- Investigations of Farm Tractors (J. B. Torrance)
- Land Clearing Investigations
- Subproject: Investigations in methods of stone removal (M. J. Thompson, A. J. Schwantes)
 - Subproject: Investigations in cost and methods of clearing state lands (M. J. Thompson)
 - Subproject: Investigations in plowing under brush (M. J. Thompson)
 - Subproject: Investigations in power necessary for pulling stumps (M. J. Thompson)
 - Subproject: Investigations in utilization of stump wood for fuel (M. J. Thompson, A. J. Schwantes)
 - Subproject: Land clearing salvage—stone (M. J. Thompson, A. J. Schwantes)
 - Subproject: Crop production following clearing of virgin land (M. J. Thompson, A. J. Schwantes)
 - Economic limitations of stump removal for pasture (M. J. Thompson, A. J. Schwantes)
- The utilization of electricity in agriculture (E. A. Stewart, Julius Romness, A. G. Tyler, L. F. Garey)

Agronomy and Farm Management

- Breeding of Miscellaneous Field Crops (H. K. Hayes, Fred Griffie)
- Investigations in Cereal Breeding (H. K. Hayes, Fred Griffie, H. E. Brewbaker, S. E. Clarke, Lee Alexander, Alma Schweppe)
- Corn Breeding Investigations (H. K. Hayes, H. E. Brewbaker, S. E. Clarke, R. E. Hodgson, R. S. Dunham, Alma Schweppe)
- Inheritance Studies with Small Grains (H. K. Hayes, Fred Griffie)
- The Development of Disease Resistant Varieties of Farm Crops (H. K. Hayes, E. C. Stakman, O. S. Aamodt, Fred Griffie, H. E. Brewbaker, F. R. Immer)

- Crop Rotation Investigations (A. C. Arny, W. I. Thomas)
- Forage Crop Investigations (A. C. Arny, F. H. Steinmetz, F. W. McGinnis, J. H. Lefforge)
- Investigations in the Growing of Small Grains (A. C. Arny, F. W. McGinnis)
- Co-operative Varieties of Farm Crops at the Branch Stations (A. C. Arny, W. I. Thomas, J. H. Lefforge)
- Studies in the Classification of Farm Crops (A. C. Arny, F. H. Steinmetz, J. H. Lefforge)
- Co-operative Seed Production and Distribution (A. D. Haedecke)
- Cost Accounting Investigations on Minnesota Farms (G. A. Pond, A. T. Hoverstad, S. E. Johnson, T. E. Sundstrom, L. I. Nelson, Bess M. Miller, Estelle A. Kroeger, Mrs. W. E. Kiehne, E. T. Helgeson, R. E. Truman, C. O. Ruud)
- Comparison of Fence Posts (L. B. Bassett)
- A Study of the Physical Organization of Farms (L. B. Bassett)
- Subproject: The farm layout
 - Subproject: The farmstead arrangement
- A Study of Farm Organization and Methods on Livestock Farms (L. F. Garey)
- Hay Standardization (Andrew Boss, W. A. Wheeler, E. C. Parker, F. H. Steinmetz, W. H. Peters)
- Subproject: Palatability tests of wild hay

Animal Husbandry

- Swine Feeding Investigations (E. F. Ferrin, M. A. McCarty)
- Subproject: A comparison of wheat by-products for growing pigs
 - Subproject: The value of tankage and skim milk as protein supplements for young pigs at weaning time
 - Subproject: The value of ground rye fed with certain supplements as a ration for growing pigs
 - Subproject: Marl as a source of calcium for swine
 - Subproject: A comparison of protein supplements in rations for pigs following weaning
 - Subproject: Fattening feeder pigs
- The Value of Several Rations for Fattening Baby Beeves (H. W. Vaughan, A. L. Harvey, Louis Vinke)

Bee Culture

- Investigations in Queen Breeding and Raising
- Subproject: Demonstrating the possibilities of commercial queen raising in Minnesota, its conditions, possibilities, and cost (Francis Jager, G. C. Matthews)
 - Subproject: Investigations into the controlled mating of queen bees (Francis Jager)
 - Subproject: Research into the possibilities of Carniolan queens for Minnesota (Francis Jager)
 - Subproject: A study of the laying capacity of queen bees (G. C. Matthews)
- Management of Bees
- Subproject: Model apiary (Francis Jager)
 - Subproject: Summer and winter records of bees in different locations (Francis Jager)

Subproject: Studies in imported pound packages and nuclei for commercial production of honey (Francis Jager)

Subproject: Influences of sizes and types of hives on honey production and production of brood (G. C. Matthews)

Subproject: The influence of various kinds of natural and artificial foods in successful wintering of bees (G. C. Matthews)

Studies in Pollen

Subproject: A study of pollen substitutes (G. C. Matthews)

Subproject: A study of gathering and storing natural pollen through winter for spring use of bees (Francis Jager)

Subproject: A study of actual benefit derived from bees as pollinators of plants (Francis Jager)

Bee Disease Inspection (G. C. Matthews)

Bee and Honey Survey of Minnesota (G. C. Matthews)

Dairy Husbandry

Factors Influencing the Composition and Market Quality of Butter (C. H. Eckles)

Subproject: The composition of Minnesota butter and methods of obtaining uniformity

Subproject: The presence of peroxidase in butter and its relation to keeping qualities

Raising Calves with the Minimum Amount of Milk (C. H. Eckles)

Feed Requirements for Dairy Cattle (C. H. Eckles, T. W. Gullickson, O. G. Schaefer)

Subproject: The energy requirement for growth

Subproject: The maintenance requirements for growing cattle

Subproject: Feeding bonemeal

Subproject: Vitamin requirements of the growing calf

Subproject: Mineral requirements for growth

Subproject: Sunlight in relation to growth

Feeding Tests with Crops New to Minnesota (O. G. Schaefer)

Subproject: The use of the soybean

Subproject: Sweet clover

Subproject: The utilization of sugar beet tops

Increasing the Production of Dairy Cows by Better Feeding (O. G. Schaefer)

Factors Influencing the Vitamin Content of Milk (C. H. Eckles, L. S. Palmer)

Powdered Milk Studies (H. Macy)

Subproject: Chemical and physical studies of powdered milk

Subproject: Bacteriological studies

Ice Cream Studies (W. B. Combs)

Subproject: Factors influencing the viscosity of ice cream mixes and the relation of viscosity to the yield and quality of the finished product

Subproject: The relation between the gold number of gelatin and the protectiveness afforded ice cream

The Immediate Influence of Various Feeds Upon the Quantity and Quality of milk (W. E. Petersen)

Subproject: The immediate influence of feeds high in oil content upon the per cent of fat in milk

Entomology and Economic Zoology

Nutritional Requirements of Certain Insects (*Tribolium confusum* Duval)
(R. N. Chapman, R. A. Gortner)

The Parasites and Symbionts of Insects (W. A. Riley)

Subproject: The diseases of adult bees

Insect Collection (Erich Horlbog)

Insecticides (A. G. Ruggles)

Subproject: Orchard spraying

Subproject: Potato spraying

Subproject: Tree tanglefoot

The Endoparasites of Man and Domesticated Animals (W. A. Riley)

Insects Infesting Stored Food Products (R. N. Chapman)

Subproject: Measures for protecting flour and other cereals from insect attack

Subproject: The protection of dried fruit from insects

Alfalfa Weevil (A. G. Ruggles, Walter Carter)

Jack Pine Insects (S. A. Graham)

Subproject: Jack pine sawfly, *Neodiprion banksiana*

Subproject: Spruce budworm on jack pine

A Study of Derris and Related Insecticides for the Control of External Parasites of Domesticated Animals (O. C. McBride)

Grasshopper Control (A. G. Ruggles)

Life History and Control of the Chicken Nematode, *Heterakis papillosa*
(W. A. Riley)

Insects of the Orchard with Best Means of Combating (A. G. Ruggles, Thor Aamodt)

Subproject: Plant Lice

Subproject: Apple maggot

Insectary Work (A. G. Ruggles, Thor Aamodt)

Life History and Injury of the Potato Leaf Hopper, *Empoasca mali* (A. G. Ruggles)

Use of Chlorpicrin Either Alone or in Combination with Paradichlorobenzene or Carbon Tetrachloride for Fumigating Grain in Elevators (R. N. Chapman)

Effect of Physical Factors Upon Insects in Freshly Cut Logs (S. A. Graham)

A Study of the Rôle of Temperature and Humidity in the Development of Insects in Flour and Other Cereal Products While in Storage (R. N. Chapman)

Studies of Fly Repellants (W. A. Riley)

Campaign Against Injurious Field Rodents (F. L. Washburn)

Subproject: Work against pocket gophers (*Geomys bursarius*)

Spruce Budworm (*Tortrix fumiferana*) (S. A. Graham)

Studies on the Hereditability or Non-hereditability of the Color Pattern in Hemiptera (W. A. Riley)

Flukes of the Genus *Collyriclum* as Parasites of Poultry (W. A. Riley, H. C. H. Kernkamp)

Monographic Studies on the Miridae (*Hemiptera-Heteroptera*) (W. A. Riley)

A Study of the Tabanidae, or horseflies, of Minnesota (W. A. Riley, C. B. Phillip)

A Study of the Hookworms of the Dog and the Domesticated Fox (W. A. Riley)

Injury to Living Pine by *Dendroctonus valens* (S. A. Graham)

- Truck Crop Insects (A. G. Ruggles)
 Subproject: Tarnished plant bug
 Subproject: Leaf-hoppers on potatoes
 Subproject: Strawberry weevil
 Subproject: Raspberry byturus
 Subproject: Currant borer
 Subproject: Potato flea beetle
 Subproject: Soft snails of the garden
 Subproject: Cutworms

Forestry

- Quantitative and Qualitative Survey of Cut-Over Lands (T. S. Hansen)
 Demonstration Windbreak Plantations (S. S. Burton)
 Windbreak Planting Investigations (T. S. Hansen)
 Effect of Structure, Time of Cutting, and Methods of Seasoning of White Cedar on the Penetration of Preservatives (J. P. Wentling)
 Wood Collection (J. P. Wentling)
 Sylvicultural Studies in Itasca Park (J. P. Wentling)
 Subproject: Nursery studies
 Subproject: Planting studies
 Subproject: Protection studies
 Studies of Minnesota Woods (J. P. Wentling)
 Working Plan for Itasca Park (J. H. Allison)
 Studies in Forest Regeneration (T. S. Hansen)
 Working Plan for the Cloquet Forest Experiment Station Area (J. H. Allison, T. S. Hansen)
 Blueberry Culture (T. S. Hansen, W. G. Brierley)
 Preservative Treatment for Fence Posts (J. H. Allison)
 Forest Trees of Minnesota (J. P. Wentling)
 Studies in Yield and Volume (J. H. Allison)
 Studies in White Pine Blister Rust Control (E. G. Cheyney)
 Forest Survey (E. G. Cheyney)
 Volume Study of White Spruce (T. S. Hansen)
 Thinning of Jack and Norway Pine (T. S. Hansen)
 Effect of Water Level in Swamps upon Tree Growth (T. S. Hansen)

Horticulture

- A Study of the Inheritance of Characters in Fruits (W. H. Alderman, J. H. Beaumont, A. N. Wilcox)
 Hardiness Studies in Fruit Breeding (W. H. Alderman, J. H. Beaumont, A. N. Wilcox)
 Sterility Studies in Fruit Breeding (J. H. Beaumont, A. N. Wilcox, J. S. Shoemaker)
 University Farm Campus (C. E. Cary)
 Study of Ornamental Varieties and Their Uses (C. E. Cary)
 Breeding and Selection of Vegetables (F. A. Krantz, B. I. Burrell, W. H. Alderman)
 Blueberry Culture (W. H. Alderman, W. G. Brierley, A. N. Wilcox)
 Co-operative Orchard Management (W. G. Brierley, W. H. Alderman, F. Rohner)
 Vegetable Investigations at Fens (F. A. Krantz, B. I. Burrell, W. H. Alderman)
 Subproject: Variety trials of vegetables on peat land

- Subproject: The relation of water level to the growth, development and quality of various vegetable crops on peat land
 Subproject: Nutrition studies of various vegetable crops on peat land
 Fruit Variety Studies (W. G. Brierley, W. H. Alderman, F. Rohner)
 Cost of Producing Fruits (W. G. Brierley)
 Nut Culture in Minnesota (W. G. Brierley)
 Potato Breeding (F. A. Krantz, W. H. Alderman, F. Rohner)
 Subproject: A test of varieties and seedlings
 Subproject: Sexual breeding. A study of the inheritance of characters in the potato
 Turf Construction and Maintenance (C. E. Cary)
 Pruning the Apple (W. G. Brierley)

Plant Pathology and Botany

- Disease Survey (Louise Dossdall)
 Rusts of Cereals (E. C. Stakman, J. G. Leach, A. W. Henry, Helen Hart, J. H. Craigie, T. Johnson, M. N. Levine, O. S. Aamodt, E. B. Lambert, L. W. Melander, R. U. Cotter)
 Subproject: Nature of resistance
 Subproject: Biological specialization in cereal rusts
 Subproject: Epidemiology of cereal rusts
 Subproject: Barberry eradication.
 Cereal and Forage Crop Diseases (E. C. Stakman, J. J. Christensen, A. W. Henry, H. A. Rodenhiser, T. Johnson, P. D. Pederson)
 Subproject: Imperfects on cereals and roots
 Subproject: Smut treatments
 Subproject: Scab of cereals
 Subproject: Ergot of cereals
 Subproject: Sunflower rust
 Subproject: Black chaff of wheat
 Garden Truck Diseases (J. G. Leach, H. C. Gilbert, H. A. Rodenhiser, G. B. Sanford)
 Subproject: Bean bacteriosis and anthracnose
 Subproject: Potato diseases
 Subproject: Miscellaneous truck crop diseases
 Fruit Diseases (E. C. Stakman, J. L. Seal, P. D. Pederson)
 Subproject: Experimental apple spraying
 Subproject: Experimental plum spraying
 Subproject: Diseases of small fruits and methods of control
 Subproject: Biology of Sclerotinia spp.
 Dendropathological Work (E. C. Stakman, R. N. Nelson)
 Subproject: Miscellaneous Itasca experiments
 Subprojects: The rotting of posts and poles
 Seed Studies (A. H. Larson)
 Subproject: Weed seed cases
 Subproject: Seed testing survey
 Subproject: Germination of lettuce seed
 Weeds (A. H. Larson, Ruby Ure Crouley)
 Subproject: Perennial sow thistle
 Minnesota Mushrooms (Louise Dossdall)

- Studies in Plant Metabolism and Growth (E. C. Stakman, F. M. Eaton)
 Subproject: Effect of length of illumination period and light intensity upon growth and reproduction
 Subproject: Effect of increased CO₂ supply upon plant growth and reproduction
 Subproject: Salt nutrition
 Subproject: Effect of nightly illumination on control of seedling diseases.
- Investigations on Respiratory Enzymes (R. B. Harvey, L. O. Regeimbal)
 Physiology of Seed Germination (R. B. Harvey, L. O. Regeimbal)
 Effect of Low Temperature on Plants (R. B. Harvey, L. O. Regeimbal)
 Subproject: Varietal differences in frost resistance of crop plants
 Subproject: Physiological factors concerned in frost injury
 Subproject: Desiccation in the frozen condition as a cause of injury
 Subproject: Killing of seed and seedlings of forest trees and horticultural plants by low temperatures
- Physiology of Reproduction (R. B. Harvey, L. O. Regeimbal)
 Development of Disease Resistant Varieties of Farm Crops (E. C. Stakman, H. K. Hayes, A. W. Henry, J. J. Christensen, P. D. Pederson, H. A. Rodenhiser, W. C. Broadfoot, O. S. Aamodt, M. N. Levine)
 Subproject: The development of rust resistant varieties of wheat
 Subproject: The genetics of biologic forms of *Puccinia graminis*
 Subproject: The development of varieties of wheat resistant to bunt
 Subproject: The development of varieties of oats resistant to black stem rust
 Subproject: The development of varieties of corn resistant to root and stalk rot
 Subproject: The development of pure lines of corn resistant to smut
 Subproject: The development of desirable agronomic types of barley resistant to *Helminthosporium sativum*
 Subproject: The resistance of wheat varieties to wheat scab
 Subproject: Varietal resistance of wheat, barley, rye, and oats to root and culm rots
 Subproject: The production of high-yielding rust-resistant timothy
 Subproject: Flax wilt
 Subproject: The development of varieties of flax resistant to rust
- Physiology of Blanching Celery (R. B. Harvey, L. O. Regeimbal)

Poultry

- Effect upon Mortality, Growth, and Feather Development of Feeding Leghorn Chicks Different Amounts of Different Animal Foods (A. C. Smith, A. A. Hoberg)
 Subproject: Effect of different amounts of dried buttermilk
- Liquid Milk as a Food for Young Chicks (A. C. Smith, A. A. Hoberg)
 Subproject: Sweet whole milk
 Subproject: Sweet skim milk
 Subproject: Sour skim milk
 Subproject: Buttermilk

Soils

- Fertilizer Experiments (F. J. Alway, Wm. Methley, G. H. Nesom)
 Peat Soils (F. J. Alway, G. H. Nesom)
 Sandy Soils (F. J. Alway, G. H. Nesom)
 Agricultural Value of Marl (F. J. Alway, Wm. Methley, G. H. Nesom)
 Soils of the Low Lime Area (F. J. Alway, C. O. Rost)
 Hydrogen-Ion Concentration of Soils (C. O. Rost)

- Movement of Water in Soils (F. J. Alway, R. M. Pickney)
 Land Classification (F. J. Alway, P. R. McMiller)
 Soil Survey (F. J. Alway, G. B. Bodman, P. R. McMiller, R. M. Pinckney)
 Soils of the Red Drift (F. J. Alway, G. B. Bodman)

Veterinary Medicine

- Infectious Abortion and other Diseases of the Reproductive Organs of Cattle (C. P. Fitch, R. E. Lubbehusen, W. L. Boyd, Margaret Sichler)
 Subproject: The pathology and bacteriology of sterility
 Subproject: The serological tests in their relation to bovine infectious abortion
 Subproject: Bacterial flora of the vagina and uterus of the cow
 Subproject: Infectious white scours and calf pneumonia
 Subproject: The function of the *corpus luteum*
 Subproject: Production of artificial immunity
 Subproject: Effects of pituitrin on delayed parturition, expulsion of the fetal membranes, and subinvolution of the uterus
 Subproject: Channels of infection in bovine infectious abortion
 Subproject: Elimination of *Bact. abortus* through excretions and secretions
 Subproject: Biological requirements of *Bact. abortus* Bang.
 Subproject: The clean and the infected herd
- Contagious Abortion of Mares; and Pyaemic Arthritis of Foals (C. P. Fitch, W. L. Boyd)
 Investigation of Obscure Diseases (C. P. Fitch, R. E. Lubbehusen, W. L. Boyd, H. C. H. Kernkamp)
 Subproject: The investigation of obscure diseases in the state, with special reference to infectious diseases
 Subproject: Investigation and treatment of diseases affecting the University Farm animals
- State Regulatory Work (M. H. Reynolds)
 Tuberculin Tests (M. H. Reynolds)
 Subproject: Relative accuracy of the several tuberculin tests
 Subproject: Relative desirability of the several combinations of these tests
 Subproject: Differing responses to the several tests in relation to extent of lesions or activity and virulence
 Subproject: Significance of slight and atypical reactions
 Subproject: Tuberculin hypersensitiveness in non-tuberculous animals
- Diseases of Poultry (C. P. Fitch, R. E. Lubbehusen)
 Application of the Benzoate Renal Function Test to Nephritis in Cattle (E. A. Hewitt)
 Chemistry of the Blood and Urine of Animals Affected with Specific and Obscure Diseases (E. A. Hewitt)
 Studies of Digestion in Herbivora (E. A. Hewitt)
 Subproject: The amylolytic action of saliva

FINANCIAL STATEMENT

The Minnesota Agricultural Experiment Station in Account with the
United States Appropriations, 1924-1925

Dr.

To receipts from the Treasurer of the United States in accordance with the appropriations for the fiscal year ending June 30, 1925, under the Act of Congress approved March 2, 1887.....

Cr.

By salaries.....

Total Hatch Fund..... \$15,000.00

Dr.

To receipts from the Treasurer of the United States in accordance with the appropriation for the fiscal year ending June 30, 1925 under the Act of Congress approved March 16, 1906.....

Cr.

By salaries.....

Total Adams Fund..... \$15,000.00

Abstract I—Salaries

Director and other administrative officers.....	Hatch Fund	Adams Fund
Scientific staff.....	\$ 3,000.00	.....
Assistants to scientific staff.....	10,800.00	\$ 7,000.00
Special and temporary services.....	1,200.00	.....
Total	\$15,000.00	\$15,000.00

Supplementary Statement

To receipts from other sources than the United States for the year ending June 30, 1925:

State appropriations.....	\$353,628.91
Sale of farm products.....	80,209.99
Total	\$433,838.90

EXPENDITURES, CENTRAL AND SUBSTATIONS, 1924-1925

	University	Farm	Crookston	Morris	Grand Rapids	Duluth	Waseca	Zumbra Heights	Total
Salaries and labor.....	\$213,862.06		\$22,531.32	\$20,718.21	\$10,964.73	\$8,433.01	\$6,822.57	\$7,570.65	\$290,902.55
Equipment repairs	1,046.17		173.36	179.93	136.71	146.76	100.27	10.13	1,793.33
Chemical and laboratory supplies..	5,549.47		30.62	90.40	.....	3.53	.....	.....	5,674.02
Publications and bulletins.....	5,853.48		7.19	49.52	9.36	5.18	.....	.....	5,924.73
Freight, express, and drayage....	133.49		128.61	201.58	32.76	37.05	.96	12.66	547.11
Feed and provisions.....	13,153.74		3,100.10	1,527.16	5,129.95	1,659.15	1,616.76	141.75	26,328.61
Postage	722.14		271.49	177.88	63.75	35.34	29.43	4.16	1,304.19
Stationery, printing, office supplies	3,996.64		1,024.38	843.22	156.48	37.32	204.27	.....	6,253.31
General supplies	8,737.89		2,511.03	2,012.75	1,390.23	1,335.30	1,346.85	760.28	18,094.33
Traveling expense	6,600.48		661.66	312.38	115.14	107.16	30.45	11.25	7,838.52
Unclassified labor .....	.....		24.57	19.70	.....	666.75	140.94	199.23	1,051.19
Refunds	25.69		19.33	15.96	.....	.....	.....	.....	60.98
Gas and electricity	896.14		191.86	309.78	342.60	50.31	136.11	205.89	2,132.69
Water and ice.....	514.40		155.58	148.71	21.07	6.08	38.49	4.20	888.53
Supplies—custodial	316.29		8.75	131.87	25.65	7.08	10.58	.....	500.22
Laundry	259.01		37.14	69.89	.....	.....	.....	.75	366.79
Telephone and telegrams.....	1,711.97		126.57	97.10	66.39	77.20	48.63	49.95	2,177.81
Fuel	8,308.78		1,602.26	1,448.08	1,773.02	59.83	289.29	641.70	14,122.96
Repairs and maintenance.....	9,298.87		364.21	1,108.83	178.98	903.70	547.17	34.65	12,436.41
Soil investigations	13,446.22		.....	.....	.....	.....	.....	.....	13,446.22
Typewriters and adding machines	1,675.11		156.66	70.00	.....	.....	.....	.....	1,901.77
Books	896.28		220.02	96.89	.....	.....	.....	.....	1,213.19
Apparatus and instruments.....	1,359.68		31.83	176.36	.....	.....	.....	.....	1,567.87
Furniture and furnishings.....	2,190.55		175.49	3,351.63	22.80	67.02	60.75	14.85	5,883.09
Tools, implements, and machinery	2,591.81		424.70	446.52	6.00	160.44	229.35	36.30	3,895.12
Buildings and lands.....	1,603.42		42.66	366.68	.....	164.49	421.50	111.00	2,709.75
Livestock	3,828.01		742.61	69.67	7.80	175.52	.....	.....	4,823.61
	\$308,577.79		\$34,764.00	\$34,031.70	\$20,443.42	\$14,138.22	\$12,074.37	\$9,809.40	\$433,838.90

THE BOARD OF REGENTS

The Hon. FRED B. SNYDER, Minneapolis	- - - - -	1928
The President of the Board		
LOTUS D. COFFMAN, Minneapolis	- - - - -	<i>Ex Officio</i>
The President of the University		
The Hon. THEODORE CHRISTIANSON, Dawson	- - - - -	<i>Ex Officio</i>
The Governor of the State		
The Hon. J. M. McCONNELL, St. Paul	- - - - -	<i>Ex Officio</i>
The Commissioner of Education		
The Hon. MILTON M. WILLIAMS, Little Falls	- - - - -	1925
The Hon. GEORGE H. PARTRIDGE, Minneapolis	- - - - -	1926
The Hon. EGIL BOECKMANN, St. Paul	- - - - -	1927
The Hon. ALICE R. WARREN, Minneapolis	- - - - -	1927
The Hon. JOHN G. WILLIAMS, Duluth	- - - - -	1927
The Hon. A. D. WILSON, Guthrie	- - - - -	1928
The Hon. JULIUS A. COLLIER, Shakopee	- - - - -	1928
The Hon. J. E. G. SUNDBERG, Kennedy	- - - - -	1929
The Hon. WILLIAM J. MAYO, Rochester	- - - - -	1931

THE AGRICULTURAL COMMITTEE

The Hon. MILTON M. WILLIAMS, Chairman	
The Hon. ALICE R. WARREN	The Hon. A. D. WILSON
The Hon. J. G. WILLIAMS	The Hon. J. E. G. SUNDBERG
The Hon. J. M. McCONNELL	President L. D. COFFMAN

THE STATION STAFF

ADMINISTRATIVE OFFICERS

W. C. COFFEY, M.S., Director
ANDREW BOSS, Vice-Director
F. W. PECK, M.S., Director of Agricultural Extension and Farmers' Institutes
C. G. SELVIG, M.A., Superintendent, Northwest Substation, Crookston
P. E. MILLER, M.Agr., Superintendent, West Central Substation, Morris
O. I. BERGH, B.S.Agr., Superintendent, North Central Substation, Grand Rapids
M. J. THOMPSON, M.S., Superintendent, Northeast Substation, Duluth
R. E. HODGSON, B.S. in Agr., Superintendent, Southeast Substation, Waseca
RAPHAEL ZON, F.E., Director, Forest Experiment Station, Cloquet
F. E. HARALSON, Assistant Superintendent, Fruit Breeding Farm, Zumbra Heights, (P.O. Excelsior)
W. P. KIRKWOOD, M.A., Editor, and Chief, Division of Publications
ALICE McFEELY, Assistant Editor of Bulletins
HARRIET W. SEWALL, B.A., Librarian
T. J. HORTON, Photographer
R. A. GORTNER, Ph.D., Chief, Division of Agricultural Biochemistry
J. D. BLACK, Ph.D., Chief, Division of Agricultural Economics
WILLIAM BOSS, Chief, Division of Agricultural Engineering
ANDREW BOSS, Chief, Division of Agronomy and Farm Management
W. H. PETERS, M.Agr., Chief, Division of Animal Husbandry
FRANCIS JAGER, Chief, Division of Bee Culture
C. H. ECKLES, M.S., D.Sc., Chief, Division of Dairy Husbandry
R. N. CHAPMAN, Ph.D., Chief, Division of Entomology and Economic Zoology
HENRY SCHMITZ, Ph.D., Chief, Division of Forestry
W. H. ALDERMAN, B.S.A., Chief, Division of Horticulture
E. M. FREEMAN, Ph.D., Chief, Division of Plant Pathology and Botany
A. C. SMITH, B.S., Chief, Division of Poultry Husbandry
F. J. ALWAY, Ph.D., Chief, Division of Soils
C. P. FITCH, M.S., D.V.M., Chief, Division of Veterinary Medicine

DIVISION OF AGRICULTURAL BIOCHEMISTRY

ROSS AIKEN GORTNER, Ph.D., Agricultural Biochemist

Section of Proteins and Colloids

ROSS AIKEN GORTNER, Ph.D., Agricultural Biochemist
WALTER F. HOFFMAN, Ph.D., Assistant Biochemist
W. M. SANDSTROM, M.S., Assistant

Section of Cereal Technology and Analytical Service

*C. H. BAILEY, Ph.D., Associate Agricultural Biochemist
ARNOLD H. JOHNSON, Ph.D., Assistant Biochemist
R. C. SHERWOOD, M.S., Assistant Biochemist
G. S. TAYLOR, B.A., Analyst
†EDWARD L. McILHENNY, B.S., Special Analyst
‡Z. R. RISTICH, Special Analyst
ANDREW CAIRNS, B.S., Fleischmann Fellow, to September 15, 1924
EMILY GREWE, M.A., Fleischmann Fellow, from October 15, 1924
H. O. TRIEBOLD, B.S., Strietmann Fellow

Section of Plant Chemistry

J. J. WILLAMAN, Ph.D., Plant Chemist
K. W. FRANKE, M.S., Cloquet Wood Products Fellow
D. R. BRIGGS, M.A., Cloquet Wood Products Fellow

Section of Nutrition and Dairy Chemistry

L. S. PALMER, Ph.D., Dairy Chemist
CORNELIA KENNEDY, Ph.D., Assistant Agricultural Biochemist
J. ROY HAAG, M.S., Assistant
F. R. DAVISON, M.S., Assistant
OLE MYDLAND, Animal Caretaker

DIVISION OF BEE CULTURE

FRANCIS JAGER, Apiculturist
G. C. MATTHEWS, Assistant Apiculturist
JAMES M. THOMPSON, B.S., Assistant

DIVISION OF AGRICULTURAL ECONOMICS

J. D. BLACK, Ph.D., Agricultural Economist
H. B. PRICE, Ph.D., Assistant Economist
HOLBROOK WORKING, Ph.D., Assistant Economist
B. A. HOLT, M.A., Research Assistant
EDWIN GAUMNITZ, M.A., Research Assistant
E. C. JOHNSON, B.S., Research Assistant
B. M. GILE, B.S., Research Assistant
C. M. HOWE, M.A., Research Assistant
G. A. FREDRELL, B.S., Research Assistant

* On leave.

† Resigned October 1, 1924.

‡ Appointed to take Mr. McIlhenny's place.

DIVISION OF AGRICULTURAL ENGINEERING

WILLIAM BOSS, Agricultural Engineer and Chief of Division
 H. B. ROE, B.S. in Engr., Associate Agricultural Engineer, Drainage
 A. J. SCHWANTES, Assistant Agricultural Engineer, Land Clearing
 M. J. THOMPSON, M.S., Land Clearing
 E. A. STEWART, B.Pd., B.S., Associate Agricultural Physicist, Agricultural Physics
 A. G. TYLER, Assistant Agricultural Physicist
 H. B. WHITE, B.S. in Agr., Assistant Agricultural Engineer, Farm Structures
 M. G. JACOBSON, Assistant in Farm Structures
 G. F. KROGH, Assistant in Drainage
 J. B. TORRANCE, B.S. in Agr., Assistant Agricultural Engineer, Head Farm Mechanics
 D. G. MILLER, C.E., Drainage Engineer, U.S.D.A., B.P.R.
 E. J. BULLIS, B.S. in C.E., Assistant in Drainage
 P. C. MCGREW, B.S. in C.E., Junior Drainage Engineer, U.S.D.A., B.P.R.
 J. H. NEAL, B.S. in A.E., Assistant Agricultural Engineer, Drainage
 JULIUS ROMNESS, B.S., Assistant Agricultural Physicist

DIVISION OF AGRONOMY AND FARM MANAGEMENT

ANDREW BOSS, Agriculturist

Section of Plant Breeding

H. K. HAYES, D.Sc., Plant Breeder
 FRED GRIFFEE, Ph.D., Assistant Plant Breeder
 H. E. BREWBAKER, M.S., Assistant Plant Breeder

Section of Farm Crops

A. C. ARNY, M.S., Associate Agronomist
 F. W. MCGINNIS, M.S., Assistant Agronomist
 F. H. STEINMETZ, M.S., Assistant Agronomist
 W. I. THOMAS, B.S., Graduate Assistant
 J. H. LEFFORGE, B.S., Graduate Assistant

Section of Co-operative Seed Production and Distribution

ANDREW BOSS, Agriculturist
 R. F. CRIM, B.S., Extension Specialist in Agronomy
 A. D. HAEDECKE, Assistant in Agronomy

Section of Cost Accounting

G. A. POND, M.S., Associate Agriculturist
 A. T. HOVERSTAD, B.S., Assistant

Section of Farm Organization

ANDREW BOSS, Agriculturist
 L. B. BASSETT, Associate Agriculturist
 L. F. GAREY, M.A., Assistant in Farm Management

DIVISION OF ANIMAL HUSBANDRY

W. H. PETERS, M.Agr., Animal Husbandman

Section of Horse Husbandry

W. H. PETERS, M.Agr., Animal Husbandman

Section of Beef Cattle Husbandry

H. W. VAUGHAN, M.S., Assistant Animal Husbandman
 A. L. HARVEY, M.S., Assistant in Beef Cattle Husbandry

Section of Swine Husbandry

E. F. FERRIN, M.Agr., Assistant Animal Husbandman
 M. A. McCARTY, M.S., Assistant in Swine Husbandry

Section of Sheep Husbandry and Meats

P. A. ANDERSON, B.S., Assistant Animal Husbandman

DIVISION OF DAIRY HUSBANDRY

C. H. ECKLES, M.S., D.Sc., Dairy Husbandman

Section of Dairy Products

W. B. COMBS, M.S., Dairy Husbandman
 L. M. THURSTON, B.S., Assistant Dairy Husbandman
 H. C. MOORE, B.S., Assistant in Dairy Husbandry

Section of Dairy Production

C. H. ECKLES, M.S., D.Sc., Dairy Husbandman
 O. G. SCHAEFER, M.S., Associate Dairy Husbandman
 T. W. GULLICKSON, M.S., Assistant Dairy Husbandman
 W. E. PETERSEN, M.S., Assistant Dairy Husbandman
 R. B. BECKER, M.S., Assistant in Dairy Husbandry

Section of Dairy Bacteriology

H. MACY, B.S., Assistant Bacteriologist

DIVISION OF ENTOMOLOGY AND ECONOMIC ZOOLOGY

W. A. RILEY, Ph.D., Entomologist and Parasitologist
 A. G. RUGGLES, M.A., Entomologist
 F. L. WASHBURN, M.A., Economic Zoologist
 R. N. CHAPMAN, Ph.D., Associate Entomologist, Stored Food Products Insect Investigations

*H. H. KNIGHT, Ph.D., Assistant Entomologist in Charge of Collections
 †ERICH HORLBOG, Ph.D., Assistant Entomologist in Charge of Collections
 S. A. GRAHAM, Ph.D., Assistant Entomologist, Forest Insect Investigations
 CLARENCE E. MICKEL, M.S., Assistant Entomologist, Extension
 A. L. STRAND, B.S., Research Assistant
 G. M. STIRRETT, M.S., Assistant in Entomology
 C. B. PHILIP, B.S., Assistant in Parasitology
 †O. C. McBRIDE, A.M., Research Assistant, Insecticidal Investigations
 WALTER CARTER, M.S., Research Assistant

* Resigned September, 1924.

† Resigned April 1, 1925.

‡ Appointed September, 1924.

DIVISION OF FORESTRY

E. G. CHEYNEY, A.B., Forester
 J. H. ALLISON, M.F., Associate Forester
 J. P. WENTLING, M.A., Associate Forester
 RAPHAEL ZON, F.E., Director Forest Experiment Station, Cloquet
 T. S. HANSEN, M.F., Assistant Forester at Cloquet
 E. E. PROBSTFIELD, M.F., Assistant Forester at Cloquet
 L. J. LEFFELMAN, B.S., Assistant
 H. E. BARTELT, B.S., Assistant
 D. A. KRIBS, B.S., Assistant
 ELSA HORN, B.A., Assistant

DIVISION OF HORTICULTURE

W. H. ALDERMAN, B.S.A., Horticulturist

Section of Pomology

W. G. BRIERLEY, M.S., Associate Horticulturist
 A. C. HILDRETH, B.S., Assistant in Horticulture
 J. A. MIDDLETON, M.S., Assistant in Horticulture
 H. P. TRAUB, M.S., Assistant in Horticulture

Section of Fruit Breeding

J. H. BEAUMONT, Ph.D., Assistant Horticulturist
 A. N. WILCOX, M.S., Assistant Horticulturist
 J. S. SHOEMAKER, Ph.D., Assistant in Horticulture

Section of Vegetable Gardening

F. A. KRANTZ, Ph.D., Assistant Horticulturist
 JOHN WALKER, B.S., Assistant Horticulturist
 B. I. BURRELL, B.S., Assistant Horticulturist

Section of Floriculture and Landscape Gardening

C. E. CARY, B.S., Assistant Horticulturist
 L. SANDO (Florist), Assistant in Horticulture

DIVISION OF PLANT PATHOLOGY AND BOTANY

E. M. FREEMAN, Ph.D., Plant Pathologist and Botanist

Section of Plant Pathology

*E. C. STAKMAN, Ph.D., Plant Pathologist
 J. G. LEACH, Ph.D., Assistant Plant Pathologist
 *J. J. CHRISTENSEN, Ph.D., Assistant Plant Pathologist
 *A. W. HENRY, Ph.D., Assistant Plant Pathologist
 LOUISE DOSDALL, Ph.D., Mycologist
 †J. L. SEAL, M.S., Assistant Plant Pathologist
 †H. C. GILBERT, M.S., Assistant in Plant Pathology
 R. M. NELSON, M.S., Assistant in Plant Pathology
 PAUL D. PETERSON, B.S., Assistant in Plant Pathology
 H. A. RODENHISER, M.S., Assistant in Plant Pathology
 WILLIAM BROADFOOT, B.S., Assistant in Plant Pathology

* Co-operating with the Office of Cereal Investigations, Bureau of Plant Industry, U.S. Dept. of Agr.

† Resigned during the year.

‡G. B. SANFORD, M.S., Laboratory Assistant
 †THEORVALDUR JOHNSON, M.S., Assistant in Plant Pathology
 H. H. FLOR, M.S., American Cyanamid Co. Fellow from May 1, 1925
 *HELEN HART, M.A., Assistant in Plant Pathology
 *J. H. CRAIGIE, M.S., Assistant in Plant Pathology

Detailed by the Office of Cereal Investigations, U. S. Department of Agriculture for Co-operative Work

O. S. AAMODT, M.S., Pathologist
 E. B. LAMBERT, M.S., Agent
 M. N. LEVINE, Ph.D., Pathologist

Section of Plant Physiology

R. B. HARVEY, Ph.D., Associate Plant Physiologist
 L. O. REGEIMBAL, M.S., Assistant in Plant Physiology
 †FRANK M. EATON, M.S., Assistant in Plant Physiology
 ‡CARL GUSTAFSON, B.S., Assistant in Plant Physiology

Section of Seed Laboratory

A. H. LARSON, B.S., Seed Analyst
 RUBY URE CROULEY, Assistant Seed Analyst

DIVISION OF SOILS

F. J. ALWAY, Ph.D., Soils Chemist
 C. O. ROST, Ph.D., Associate Soils Chemist
 P. R. McMILLER, M.S., Assistant Soils Chemist
 G. H. NESOM, B.Sc., Assistant in Soils
 G. B. BODMAN, M.S., Assistant
 R. M. PINCKNEY, Ph.D., Assistant
 WILLIAM METHLEY, Assistant
 †J. S. HALL, B.Sc., Assistant

DIVISION OF VETERINARY MEDICINE

C. P. FITCH, M.S., D.V.M., Animal Pathologist and Bacteriologist
 W. L. BOYD, D.V.S., Assistant Veterinarian
 H. C. H. KERNKAMP, D.V.M., Assistant Veterinarian
 M. H. REYNOLDS, M.D., D.V.M., Veterinarian
 EARL A. HEWITT, B.S., D.V.M., Assistant Veterinarian
 R. E. LUBBEHUSEN, B.S., D.V.M., Assistant Pathologist
 MARGARET SICHLER, B.S., Technician

* Co-operating with the Office of Cereal Investigations, Bureau of Plant Industry, U. S. Dept. of Agr.

† Resigned during the year.

‡ Appointed during the year.