

The University of Minnesota

AGRICULTURAL EXPERIMENT STATION THIRTY-SECOND ANNUAL REPORT PART I

Publications, List of Projects, Financial Statement,
and Staff Members

JULY 1, 1923, TO JUNE 30, 1924



UNIVERSITY FARM, ST. PAUL
JULY 1924

LETTERS OF TRANSMITTAL

MINNEAPOLIS, MINN.,
JULY 1, 1924

To His Excellency, J. A. O. Preus,
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, 1924.

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

UNIVERSITY OF MINNESOTA, MINNEAPOLIS, MINN.
JULY 1, 1924

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, 1924.

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

UNIVERSITY FARM, ST. PAUL, MINN.,
JULY 1, 1924

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, 1924.

Respectfully,
W. C. COFFEY, Director

THIRTY-SECOND ANNUAL REPORT
OF THE
AGRICULTURAL EXPERIMENT STATION

W. C. COFFEY, Director

REPORT OF THE DIRECTOR

This report contains a formal statement of the expenditures and the lines of work in the Agricultural Experiment Station during the fiscal year ending June 30, 1924. It therefore serves as the official report of the station for the year under review. In addition to this official report three informal reports will appear at quarterly intervals during 1924-25. They will contain popular discussions on the more important results secured from research projects. The hope is that they will be useful alike to farmers, county agents, extension workers, and all others in immediate need of the recent investigations of the experiment station.

CHANGES IN STAFF

RESIGNATIONS

Agricultural Biochemistry.—G. O. Burr, assistant in biochemistry, resigned to accept appointment as national research fellow in the Department of Anatomy, University of California.

Agricultural Engineering.—G. R. B. Elliott, assistant in drainage, terminated his connection with the University to go into commercial drainage work.

Entomology and Economic Zoology.—John R. Eyer, assistant entomologist, resigned to accept position in extension entomology, Field Laboratory, Northeast, Pennsylvania; Paul M. Gilmer, assistant entomologist, resigned to accept position as instructor in Department of Animal Biology, University of Minnesota; John R. Parker, assistant entomologist, resigned to return to the University of Montana from which institution he had been on leave of absence.

Forestry.—Leland L. DeFlon, assistant in forestry, resigned to accept a position as associate wood technologist, Forest Products Laboratory, Madison, Wis.; G. H. Wiggin, assistant superintendent at Cloquet, resigned to become assistant to the manager of Pike Bay Lumber Company, Tower, Minn.

Horticulture.—John W. Bushnell, assistant horticulturist, resigned to take a position in the Ohio State Experiment Station.

Plant Pathology and Botany.—Henry Hecker, assistant in Agricultural botany, resigned to accept a position as plant quarantine inspector for the United States Department of Agriculture; Charles R. Hursh, assistant in plant pathology, resigned to take up scientific study abroad.

Soils.—Skuli Hrutfrjord, assistant in soils, resigned to accept position as county agricultural agent of Yellow Medicine County.

DEATHS

LeRoy Cady, associate horticulturist, who had been connected with the Experiment Station and College of Agriculture since 1903, died September 12, 1923.

APPOINTMENTS

Entomology and Economic Zoology.—Orville C. McBride and August L. Strand were appointed assistant entomologists; C. B. Philip was appointed assistant parasitologist.

Forestry.—Sidney S. Burton and W. Metcalf were appointed assistants in forestry; Raphael Zon, who came to Minnesota as director of the Lake States Forest Experiment Station with headquarters at University Farm, was appointed director of the Cloquet Forest Experiment Station.

Horticulture.—Clarence E. Cary was appointed assistant horticulturist to fill the vacancy caused by the death of Professor Cady.

PUBLICATIONS

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

REGULAR EXPERIMENT STATION SERIES

No. 205. A Study of Farm Organization in Southwestern Minnesota, by G. A. Pond, Division of Agronomy and Farm Management; and Jesse W. Tapp, United States Department of Agriculture, 135 pages, edition of 5000.

No. 206. Wheat and Flax Combination Crops in Minnesota in 1923, by A. C. Army, Division of Agronomy and Farm Management. 12 pages, 6000.

No. 207. Cornstalk Sirup Investigations, by J. J. Willaman, G. O. Burr, and F. R. Davison, Division of Agricultural Biochemistry. 58 pages, 5500.

No. 208. Investigations in Stump and Stone Removal, by M. J. Thompson and A. J. Schwantes, Division of Agricultural Engineering. 44 pages, 6000.

No. 209. Cost of Producing Apples in Minnesota, by W. G. Brierley, Division of Horticulture. 44 pages, 6000.

No. 210. Methods of Corn Breeding, by H. K. Hayes with C. Lee Alexander, Division of Agronomy and Farm Management. 24 pages, 5000.

No. 211. Co-operative Central Marketing Organization, by J. D. Black and H. B. Price, Division of Agricultural Economics. 112 pages, 6000.

No. 212. Potato Investigations at North Central Experiment Station, 1914-23, by O. I. Bergh, Superintendent. 58 pages, 5000.

ANNUAL REPORT SERIES

Thirty-first Annual Report of the Agricultural Experiment Station, 1922-1923. 28 pages, 2500.

Report of Northwest Substation, Crookston, by C. G. Selvig, Supt. 112 pages, 3000.

Report of West Central Substation, Morris, by P. E. Miller, Supt. 50 pages, 2000.

Report of Northeast Substation, Duluth, by M. J. Thompson, Supt. 36 pages, 1500.

TECHNICAL SERIES

No. 16. Sunflower Rust, by D. L. Bailey, Division of Plant Pathology and Botany, 32 pages, 3000.

No. 17. Factors Influencing the Pathogenicity of *Helminthosporium sativum*, P.K. and B., by Louise Dossdall, Division of Plant Pathology and Botany. 56 pages, 3000.

No. 18. Wheat Scab in Minnesota, by Jean McInnes and Raymond Fogelman, Division of Plant Pathology and Botany. 44 pages, 3000.

No. 19. Viscosity as a Measure of Hydration Capacity of Wheat Flour, by Paul F. Sharp with Ross Aiken Gortner, Division of Agronomy and Botany. 56 pages, 3000.

No. 20. A Study of Wilt Resistance in Flax, by H. D. Barker, Division of Plant Pathology and Botany. 56 pages, 3000.

No. 21. Reaction of Barley Varieties to *Helminthosporium sativum*, by H. K. Hayes and Fred Griffiee, Division of Agronomy and Farm Management; E. C. Stakman and J. J. Christensen, Division of Plant Pathology and Botany. 56 pages, 3000.

AGRICULTURAL EXTENSION SERVICE
SPECIAL SERIES

78. A Home-made Crib Silo, by E. W. Smith, Division of Agricultural Extension. 8 pages, 10,000.

79. Modern Bush Fruit Growing, by Franc P. Daniels, Division of Horticulture. 24 pages, 10,000.

80. The Colt a Profitable Farm Product, by W. H. Peters, Division of Animal Husbandry. 20 pages, 10,000.

81. Bovine Tuberculosis, by M. H. Reynolds, Division of Veterinary Medicine. 16 pages, 8000.

82. Soybeans, by R. E. Hodgson, Southeast Substation, Waseca. 8 pages, 10,000.

83. Care and Feeding of Chicks, by A. C. Smith, Division of Poultry Husbandry. 12 pages, 15,000.

84. Alfalfa on Sandy Lands, by A. C. Arny, Division of Agronomy and Farm Management. 16 pages, 10,000.

85. Potato Growing, by F. A. Krantz, J. G. Leach, A. G. Ruggles, G. A. Nesom, and H. B. White. 20 pages, 10,000.

86. The Minnesota Plan of Marketing Eggs, by E. C. Johnson, Division of Agricultural Extension. 16 pages, 6000.

87. Sheep Raising in Minnesota, by P. A. Anderson, Division of Animal Husbandry. 12 pages, 10,000.

88. Co-operative Central Marketing Organization, by J. D. Black and H. B. Price, Division of Agricultural Economics. (Reprinted from Agricultural Experiment Station Bulletin 211.) 16 pages, 7000.

CIRCULAR SERIES

16. Minnesota's Land Clearing Needs, by A. J. Schwantes and M. J. Thompson, Division of Agricultural Engineering. 4 pages, 10,000.

17. Kill Grasshoppers with Poison Bait, by A. G. Ruggles, Division of Entomology and Economic Zoology. 4 pages, 5000.

Reprint

2. Sources of Information for the Dairy Farmer, by C. H. Eckles, Division of Dairy Husbandry. 2000.

MISCELLANEOUS

Outlines for Club Demonstrations. 12 pages, 5000.

Report of Boys' and Girls' Club Work. 6 pages, 1000.

List of Prize Winners in Boys' and Girls' Club Work. 6 pages, 1000.

Cow-Testers' Handbook, by E. A. Hanson. 16 pages, 2000.

Outline of Pig Club Project. 4 pages, 6000.

Outline for Club Demonstrations. 12 pages, 5000.

Questions and Answers on Marketing. 44 pages, 6000.

Docking and Castrating Lambs, by P. A. Anderson. 12 pages, 6000.

Extension Folders, Nos. 1 to 10, titles in the order named: Soybeans, Building the Dairy Herd, Feeding the Dairy Cow, Feeding and Care of the Brood Sow, Alfalfa—the Crop Profitable, Sweet Clover for Pasture, Care and Feeding of Chicks, Care and Feeding of Pigs, More Money from Your Eggs, Points on Potatoes. Editions from 5000 to 15,000.

Extension Service News, monthly. 4 pages, 1700.

Among Ourselves, for country newspapers, monthly. 700.

News Letter, weekly clip sheet for country press. 1,000.

Western Newspaper Union Letter, published in more than 200 country weeklies.

Miscellaneous publicity, including a weekly letter in manuscript to Associated Press, another to the United Press, and a great variety of material to the daily and farm papers, to the trade papers, and other publications.

JOURNAL SERIES

No. ~~333~~³³⁵. "Relation of the Color of Bark to the Temperature of the Cambium in Winter," by R. B. Harvey. In *Ecology*, Vol. 4, pp. 391-94 (1923).

Temperatures of the cambium were measured by the thermo-electric method on barks of different color, including white birch, red osier, yellow willow, yellow Dart apple, gray-green aspen, gray-brown Antonovka apple, black Jewel plum, and red Faribault apple. The bark of the white birch, and next in order, the red osier, maintained temperatures nearest that of the air when in strong sunlight. Brown, black, or brownish-red bark maintained the highest temperatures in sunlight, while green or yellow barks maintained intermediate temperatures.

Black plum bark may reach temperatures as much as 12.6° C. (22.7° F.) above air temperature in strong sunshine. Black bark may be as much as 4.5° C. (8.1° F.) warmer in sunlight than white bark.

When the air temperature is just below freezing, there is a continual rapid freezing and thawing of black bark with every passing cloud, a condition associated with sunscald, which may not be experienced by bark which reflects the red end of the spectrum. Consequently, light colored barks or those which reflect the heat rays may be less injured by sunscald than dark colored ones.

No. 336. "Cambial Temperatures of Trees in Winter and Their Relation to Sun Scald," by R. B. Harvey. In *Ecology*, Vol. 4, pp. 261-65 (1923).

Measurements were made of the temperature of the cambial tissues of trees in relation to the external temperature, the size of the limb, and the position on the tree. It was found that the bark on the south side of the tree undergoes rapid fluctuations of temperature, freezing with every passing cloud which obscures the sun for a few minutes and thawing rapidly as soon as it is heated by the sun's rays. A rise of more than 10 degrees C. may occur in ten minutes with strong sunlight exposure. This fluctuation is particularly important when it involves the freezing and thawing of the tissues. This accounts for much of the injury by sunscald on the south side of limbs and trunk. The greatest injury is on surfaces exposed to the sun at right angles. There is a lag of temperature in larger limbs and the trunk of the tree corresponding to the greater heat capacity of these parts. Consequently, the bark and sap wood of large limbs and of the trunk do not undergo such violent fluctuations in temperature.

No. 366. "The Physico-chemical Properties of Strong and Weak Flours, VI. The Relation Between the Maximum Viscosity Obtainable by the Addition of Lactic Acid and the Concentration of Flour-in-Water Suspension," by P. F. Sharp and R. A. Gortner. In *Journal of Physical Chemistry*, Vol. 27, pp. 771-88 (1923).

A study was made, the purpose of which was to discover possible correlation between glutenin content and viscosity and loaf volume. Eleven flours were studied. Accurate determination of the amounts of the different proteins in flours is difficult. The nitrogen in various fractions was determined by the Kjeldahl

method and was converted to protein through the use of the factor 5.7. Determinations of total protein, K_2SO_4 -soluble protein, alcohol-soluble protein, K_2SO_4 -soluble-protein centrifuged, and alcohol-soluble protein in the residue after extraction with K_2SO_4 were made in duplicate. The A.O.A.C. method of determining glutenin by subtracting from the total protein the sum of the K_2SO_4 -soluble protein and the alcohol-soluble protein determined on separate samples, gives too low results owing to overlapping solubilities. It is believed that glutenin content is given more accurately by subtracting from the total protein content of the flour the sum of the quantities of protein extracted by 5 per cent K_2SO_4 solution followed by extraction with 70 per cent alcohol. Gliadin and glutenin were found in about equal quantities in wheat flour. The flour concentration-viscosity curve of maximum imbibition produced by lactic acid was shown to be logarithmic. The inorganic electrolytes present in the flour are shown to affect the constants of the logarithmic equation, $\log \text{ viscosity} = a + b$ (log concentration). A relation between the quantity of glutenin, the quality of the glutenin as indicated by the value b of the logarithmic equation, and the loaf volume is shown. Flour strength, so far as the colloidal properties of the gluten are concerned, depends on the quality of the glutenin. A numerical value for glutenin quality is given by the constant b of the logarithmic equation.

No. 367. "The Physico-chemical Properties of Strong and Weak Flours, V. The Identity of the Gluten Protein Responsible for the Changes in Hydration Capacity Produced by Acids," by P. F. Sharp and R. A. Gortner. In *Journal of Physical Chemistry*, Vol. 27, pp. 674-684 (1923).

As a considerable portion of the gliadin can be removed from flour by repeated extraction with distilled water and as very little glutenin is removed by such treatment, the glutenin is the protein to which must be ascribed the main responsibility for the increase in imbibition when flour-in-water suspensions are acted on by acids. The colloidal properties of the glutenin as measured by changes in rate of imbibition and maximum imbibition capacity are markedly altered by treatment with alcohol of a relatively high concentration. A strong flour is apparently characterized by the presence of a glutenin possessing marked colloidal properties, whereas the corresponding colloidal properties of the glutenin of a weak flour are much less pronounced.

No. 370. "The Quantitative Estimation of Chlorides and Sulfates in Expressed Plant Tissue Fluids," by R. A. Gortner and W. F. Hoffman. In *Botanical Gazette*, Vol. 77, pp. 96-102 (1924).

The methods of Wetmore for chlorides in blood and of Benedict for sulfates in urine have been adapted for use on plant saps, with a gain in simplicity and rapidity.

No. 371. "The Physico-chemical Properties of Strong and Weak Flours, VII. The Physical State of the Gluten as Influencing the Loaf Volume," by P. F. Sharp, R. A. Gortner, and A. H. Johnson. In *Journal of Physical Chemistry*, Vol. 27, pp. 942-47 (1923).

The effect of temporary changes of hydrogen-ion concentration of the dough and of treatment with alcohol on the colloidal properties of the gluten are noted as such effects are reflected in the baked bread. Doughs brought to pH of 3 or

11 by addition of acid or alkali and subsequently neutralized lose their baking strength. Wheat loses its baking strength when made into a dough with 70 or 95 per cent alcohol and subsequently dried, remilled, and baked. The baking quality of rye flour is not affected by such treatment. Rye flour contains no protein which responds materially to the imbibitional effect of acid. Thus it appears that the loss of baking qualities resulting from extraction of gliadin from flour by alcohol does not prove that the gliadin plays the major rôle in determining gluten quality. The same results are obtained by treating flour with alcohol without removing anything from it. Thus flour strength, as far as gluten quality is concerned, depends on the colloidal properties of the glutenin. The effect of the alcohol in decreasing loaf volume may be ascribed to its effect on the colloidal properties of the glutenin.

No. 375. "Relation between the Downward Penetration of Corn Roots and Water Level in Peat Soil," by G. R. B. Elliott. In *Ecology*, Vol. V, No. 2 (April, 1924), pp. 175-78.

This discussion is based on investigations on University marsh at the Wisconsin Station, in 1920. The water table was held practically stationary as determined by frequent measurements in test wells spaced ten feet apart. While there seemed to be no restricting influence on the horizontal spread of the roots, their vertical penetration stopped at a distance almost uniformly 18 inches above the water table. Where the water table lay highest, rootlets 6 inches below the surface showed nearly normal but 9 inches below the surface the root hairs had disappeared and the cortex of the roots seemed to have taken on the functions of the hairs, very nearly enveloping particles of the soil. Test of this influence on a vigorous corn plant grown on well drained upland soil and transplanted into conditions where excessive moisture existed without any drainage, resulted in destruction of the root hairs and the stunting of the plant, which never regained its vigor even after good drainage conditions were brought about. The influence of such facts on the design of drainage for peat lands when corn is the crop is evident and very great.

No. 376. "A Revision of the Mutillid Wasps of the Genera *Myrmilloides* and *Pseudomethoca* Occurring in America North of Mexico," by Clarence E. Mickel. In *Proceedings of the United States National Museum*, Vol. 64, Art. 15, pp. 1-51 (1923).

Includes keys to genus and species and description of sixteen new species of *Pseudomethoca*. In the separation of the very similar males, the value of a study of genitalia is brought out.

No. 377. "The Poison and Poison Apparatus of the White-marked Tussock Moth, *Hemerocampa leucostigma*, Smith and Abbott (Lepidoptera), by Paul M. Gilmer. In *Journal of Parasitology*, Vol. X, pp. 80-86 (December, 1923).

The larva of the white-marked tussock moth, one of the commonest of our shade tree pests, is shown to be urticating, its virulence varying with individual susceptibility. Numerous cases of obscure dermatitis have been traced to it.

The poisonous effect is due to the smaller white hairs scattered over the body, chiefly on the lateral tubercles of the first thoracic and last abdominal seg-

ments in the first two instars, and especially in the dorsal white tussocks in the later instars.

The poison is the product of a special gland communicating directly with the hair. It is particularly resistant to chemical agents, being insoluble in all ordinary solvents. Its virulence is increased by acids and decreased by alkalis of low concentration.

No. 382. "The Estimation of Pentoses and Pentosans. I. The Formation and Distillation of Furfural. II. The Determination of Furfural, by N. C. Pervier and R. A. Gortner. In *Industrial and Engineering Chemistry*, Vol. 15, pp. 1167-69, 1255-62 (1923).

The official method for pentoses always gives low results because the concentration of hydrochloric acid during most of the distillation is 18 to 20 per cent, and this concentration has a destructive effect on the furfural. It has been found that complete recoveries of furfural can be obtained by passing a slow current of steam through the mixture during the distillation. A method for determining the furfural has been perfected, employing a standard solution of potassium bromate—potassium bromide, and using an electrometric method for determining the end point.

No. 383. "Methods of Keeping Records of Cereal Breeding Investigations," by J. B. Harrington. In *Proceedings Third Annual Meeting Western Canadian Society of Agronomy* (Saskatoon) 1922. pp. 78-85.

The methods used at the Minnesota station for keeping records of cereal breeding investigations are described in detail. Methods used at other experiment stations in the United States and Canada are contrasted with those used in Minnesota.

No. 386. "Correlation of Wheat Kernel Plumpness and Protein Content," by C. H. Bailey and Julius Hendel. In *Journal of American Society of Agronomy*, Vol. 15, pp. 345-50 (1923).

It has been the general opinion of men engaged in the grain trade that shriveled wheat with a low weight per bushel ordinarily contained a higher percentage of protein than plump, heavy wheat. The data on file in the cereal laboratory, Minnesota Agricultural Experiment Station, and in certain industrial laboratories, bearing on the possible relationship between these two properties, were therefore separated and compiled in correlation tables with a view toward establishing whether or not such a correlation existed. This compilation indicated that no significant correlation existed between wheat kernel plumpness and crude protein (or crude gluten) content when the former was measured in terms of either weight per 1000 average kernels, or weight per bushel.

No. 388. "Effect of Drying and Storage upon the Hydrogen-Ion Concentration of Soil Samples," by C. O. Rost and E. A. Fieger. In *Soil Science*, Vol. XVI, No. 2, (August, 1923) pp. 121-26.

The effect of air-drying and oven-drying upon the hydrogen-ion concentration of soil samples was determined, as was also the effect of moistening and tempering samples of soil which had become air-dry and of storing the fresh

moist samples in air-tight containers. The effect of air-drying upon the reaction of soil samples was tested also by the qualitative potassium thiocyanite method.

From the data reported it is concluded that the only reliable indication of conditions existing in the field is obtained when hydrogen-ion concentration determinations are made with soil samples freshly taken.

No. 389. "Effect of Physical Factors on the Ecology of Certain Insects in Logs," by S. A. Graham. In *Nineteenth Report State Entomologist of Minnesota* (1922), pp. 22-40.

The activities of insects working in logs are greatly influenced by the environmental conditions to which they are exposed. The conditions are in many cases controlled or modified by the action of external physical factors such as light, heat, and moisture.

Differences in food value of different parts of a log result in the definite localization of certain insects within the log and also lead to variation in the rate of insect development. In some cases development is made possible or the rate of development hastened by the presence of micro-organisms in the wood. On the other hand, insect infection often determines to a very marked degree the time and the extent of fungous infection in the log.

Subcortical temperature was found to be very variable in the same log and resistance of different species of insects to high temperature also varied greatly. Another important factor determining the presence and distribution of species was that of moisture conditions.

While the experiments were for the purpose of laying a foundation for future work of an applied nature, they indicate possible formulation of simple, inexpensive, and practical control measures.

No. 390. "Preliminary Notes on the Life History and Control of the Potato Leaf-Hopper, *Empoasca mali* LeB.," by A. G. Ruggles and J. R. Eyer. In *Nineteenth Report of State Entomologist of Minnesota* (1922), pp. 10-14.

The food plants of the potato leaf-hopper were determined to be potato, apple, box-elder, blackberry, raspberry, curly dock, rhubarb, and dahlia. Development of the first brood occurs almost exclusively on potato.

In Minnesota in 1922, adults began to leave their food plants for hibernation on October 12, and had completely disappeared from the fields by November 15. They emerge from hibernation in late May and two generations are developed during the season.

Extensive control tests again showed the most effective method to be that of spraying with liquid bordeaux, 4-4-50 mixture.

No. 391. "Preliminary Notes on the Mutillidae of Minnesota with Descriptions of Three New Species," by Clarence E. Mickel. In *Nineteenth Report of State Entomologist of Minnesota* (1922), pp. 97-113.

Altho the Mutillidae are generally thought of as insects of the arid and semi-arid regions of the tropics and sub-tropics, a single season's work in Minnesota has yielded 22 species, of which 3 are new.

No. 392. "The Red Turpentine Beetle in Itasca Park," by S. A. Graham. In *Nineteenth Report State Entomologist of Minnesota* (1922), pp. 15-21.

Altho the red turpentine beetle is abundant in Itasca Park and its presence on living trees has caused a good deal of alarm, it is really responsible for the death of very few trees. Almost never is brood brought to maturity in living trees. It breeds abundantly in fresh stumps and to a lesser extent in logs. It is never found in slash.

No. 393. "Studies on the Life History and Biology of *Perillus bioculatus* Fabricius, Including Observations on the Nature of the Color Pattern," by H. H. Knight. In *Nineteenth Report of State Entomologist of Minnesota* (1922), pp. 50-96.

Perillus bioculatus feeds almost exclusively on the nymphs and adults of the Colorado potato beetle. The hibernating adults in late spring lay their eggs on leaves of the potato plant. They hatch in 5 to 6 days and after passing through five stages, they become adult, in an average of 19 days in August, 22 to 24 days in September. Two and occasionally three broods mature in a season.

Three very marked color varieties, a white, a yellow, and a red are known for this species. The experiments detailed show that these color patterns were determined by conditions of temperature under which the bugs were reared, rather than by characters inherited from the parents. This influence of temperature is indirect, affecting the physiological processes of the insect. With the ceasing of physiological activity, as in hibernation, no change in color can be observed.

No. 395. "The Chemistry of Milk and Dairy Products Viewed from a Colloidal Standpoint," by L. S. Palmer. In *Industrial and Engineering Chemistry*, Vol. 16, pp. 631-35 (1924).

This paper reviews the various colloidal phenomena met in milk and its products. The subjects discussed are: (1) the protein and salt dispersions of milk; (2) milk secretion; (3) creaming; (4) coagulation by acid, heat, and rennet; (5) whipping of cream; (6) ice cream; (7) churning; (8) cheese ripening; (9) evaporated milk; (10) powdered milk; and (11) casein in the arts and industries.

No. 396. "Derris as a Parasiticide," by Paul M. Gilmer. In *Nineteenth Report of State Entomologist of Minnesota* (1922), pp. 41-49.

The fish-poison derris was shown to be a very efficient insecticide, especially when applied as a powder against ecto-parasites. It is effective, easily applied, not repugnant to the animals or man, and retains its insecticidal properties unaltered in the open air.

No. 398. "The Nutritive Properties of Wild Rice (*Zizania aquatica*)," by Cornelia Kennedy. In *Journal of Agricultural Research*, Vol. 27, pp. 219-24 (1924).

This study of wild rice includes both a chemical and a biological analysis of the cereal. A comparison of the chemical composition of wild rice and cultivated polished and unpolished rice and the distribution of the inorganic elements, is given. The biological analysis shows that the food value of wild rice is similar to that of other common cereal grains. Its proteins have rather low biological value but are of greater food value than those of polished rice. It resembles other cereals in containing inorganic material unsuitable for the promotion of growth and in being very deficient in vitamin A. Charts are given showing the rate of growth of albino rats when fed rations consisting of wild rice with various additions.

No. 400. "Growth and Reproduction of Rats on Whole Milk as the Sole Diet," by L. S. Palmer and Cornelia Kennedy. In *Proceedings of the Society for Experimental Biology and Medicine*. Vol. 20, pp. 506-8 (1923).

Experiments reported in this paper show that male rats can attain normal size on a diet consisting solely of liquid whole milk, but that female rats fail to attain normal size and do not reproduce. Female rats reared to partial maturity on a mixed diet and then changed to milk as the sole diet, attain a normal size and reproduce but do not rear their young unless the mother receives an addition of yeast or alcohol-extracted yeast to her diet. Normal growth and reproduction can be obtained with an "artificial" dry milk consisting of casein, lactalbumin, alcohol-soluble protein, butterfat, ether extract of alcohol-washed casein, and protein-free milk, but the mothers do not rear their young unless the diet is supplemented with yeast or dry alfalfa leaves during the nursing period.

No. 402. "Red as a Protective Color in Vegetation," by R. B. Harvey. In *Minnesota Horticulturist*, Vol. 51, pp. 279-80 (1923).

Red parts of plants reflect the red rays which contain the greater part of the heat energy of sunlight. Fruits or vegetables or trees with red pigments do not become as hot in sunlight as those that are green in color. Red spots on fruits may be 40° F. cooler than green spots on the same fruit. Red pigment is frequently formed only in parts exposed to the sun, hence it seems to have a protective function in preventing sunscald. The soil at the ground level frequently reaches temperatures which will kill plant tissues. Suggestion is made that the production of red pigment at the ground level in flax and prairie grasses may be an adaptation allowing the plants to endure high temperatures.

No. 403. "Conditions for Heat Canker and Sunscald in Plants," by R. B. Harvey. In *Minnesota Horticulturist*, Vol. 51, pp. 331-34 (1923).

Measurements were made of the temperatures of various fruits and vegetables under various conditions to determine the conditions for sunscald and heat canker. The great length of the day in Minnesota with long exposure of plant parts to sunlight results in excessively high temperatures when the moisture available for transpiration is low. Heat canker of flax does not occur when the soil is moist. When the plants are shaded, sunscald of fruits does not occur. Breezes tend to distribute the heat produced by sunlight absorption and hence

prevent sunscald. The temperature of fruits is much higher on the sunny side than on the shaded side. Tomato fruits with darkly pigmented areas at the stem end should be avoided where sunscald is liable to cause commercial losses. The injury in such fruits is much less in the lighter colored areas. Injury may be decreased by shading by leaves of the same plant or by a nurse crop, by increasing the soil moisture or by keeping fruits as far as practicable off the soil.

No. 406. "Flukes of the Genus *Collyriclum* as Parasites of Turkeys and Chickens," by W. A. Riley and H. C. H. Kernkamp. In *Journal of American Veterinary Medical Association*, Vol. LXIV, N.S. 17, No. 5 (February, 1924). 9 pages.

Flukes of the genus *Collyriclum* were found in dermal cysts, chiefly perianal, but in some cases extending over the breast, and on the inner surface of the legs, in 50 out of 100 turkey poults; and at another farm remote from the first, on 46 young chickens. Altho flukes of this genus have been known as rather rare parasites of song birds, they have never before been reported for domesticated fowls.

In both cases here reported the birds had been reared near a lake and those infested had had free run of the lake shore, feeding on various aquatic insects.

Studies of the life history and methods of control are being continued.

No. 407. "Carbohydrate Production and Growth in Plants Under Artificial Light," by R. B. Harvey. In *Proceedings Illuminating Engineering Society* (1923).

Experiments are reported showing that the growth of Easter lilies can be speeded up by continuous artificial light, the plants making better growth than in sunlight. Leaves of the plants which were artificially illuminated contained more starch and more total sugar than those from plants grown in sunlight. A table is given of the light intensities required for the blooming of a great variety of plants. Practical application of artificial light is suggested.

No. 409. "The Humin Formed by the Acid Hydrolysis of Proteins, VIII. The Condensation of Indole Derivatives with Aldehydes," by G. O. Burr and R. A. Gortner. In *Journal American Chemical Society*, Vol. 46, pp. 1224-46 (1924).

Five new condensation products have been prepared from α -methylindole and aromatic aldehydes. These are of the indolidene-methane type. An entirely new series of compounds of the indolidene-methane type has been prepared from α -phenylindole. Only one condensation product of α -phenylindole had been previously described and that was of the rosindole type. All these have been used as intermediates in the preparation of humins.

Forty humins have been prepared and described. Analyses of a part of these bring out the following conclusions:

1. The humins from protein hydrolysis can not be prepared so that they are constant in composition. This substantiates the conclusions of previous workers.

2. All formaldehyde humins have some oxygen in the molecule, while the humins from α -methylindole and α -phenylindole with aromatic aldehydes contain no oxygen and the analyses correspond to the calculated value of one molecular equivalent of indole plus two of aldehyde minus two of water.

3. Tryptophan forms, with both formaldehyde and benzaldehyde, humins which contain oxygen aside from this in the carboxyl group, and the humin

with benzaldehyde give an analysis corresponding to one tryptophan group plus two of the benzaldehyde without the splitting out of any water. The same humin contains by analysis 2.21% of amino nitrogen.

All the accumulated data point to the conclusion that such artificial humins are not simple molecular condensations but that it is possible to isolate at least two intermediate products. These intermediate products have been purified and analyzed, and their structures have been ascertained. The final humin results by the condensation of one molecule of aldehyde with the indolidene methane derivative, but during this condensation some rearrangement apparently takes place, for the resulting humin is extremely resistant to drastic chemical treatment such as alkaline fusion and permanganate oxidation. The data so far available do not permit us to decide as to the structural formulas.

No. 410. "Some Factors Affecting the Keeping Quality of Whole-Milk Powders," by C. D. Dahle. In *Journal of Dairy Science*, Vol. VII, No. 1 (January, 1924), pp. 40-57.

A study of the keeping qualities of three whole-milk powders was made. It was found that powders stored in tin containers showed better keeping qualities after one year's time than those stored in paper containers and opaque glass containers having screw tops. Air, moisture, temperature, and time of storage were the factors contributing to the deterioration of whole-milk powders, and to the destruction of the peroxidase enzyme.

No. 416. "The Effect of Rust Infection upon the Water Requirement of Wheat," by Freeman Weiss. In *Journal of Agricultural Research*, Vol. XXVII, No. 2 (January 12, 1924) pp. 107-118.

An investigation was made of the effect of nutrient salts on the water requirement of wheat infected with *Puccinia graminis tritici* and *P. triticina*. Rust infection lowered the water economy of the host. NaCl , and NaH_2PO_4 did not affect the susceptibility of the plants to either of the rusts. NaNO_3 caused a slight increase in the amount of rust, but apparently did not aggravate the injury caused. KCl retarded the infection in proportion to the diminution in growth of the host.

Plants supplied with CaCl_2 and MgCl_2 were not as easily infected as other plants. Those supplied with CaCl_2 also required less water. The addition of NaNO_3 and CaCl_2 to the Shive R_2C_2 solution caused increase in yield.

No. 417. "Molds in Silage and Their Significance in the Production of Disease Among Livestock," by C. H. Eckles, C. P. Fitch, and J. L. Seal. In *Journal of American Veterinary Medical Association*, Vol. LXIV, N.S. 17, No. 6 (March, 1924), 7 pages.

A study of the mold flora from thirty silos in different parts of the state showed only common harmless molds present. Extended experiments were made in feeding moldy silage to cattle, horses, and sheep. Large quantities of pure culture of all the species found in the thirty silos examined were administered to horses and sheep. The results were negative in all cases.

No. 418. "A Study of Abortion in Mares and Naval-III or Pyo-Septicemia of Foals," by C. P. Fitch. In *Cornell Veterinarian*, Vol. 14, No. 1 (January, 1924), pp. 4-15.

As a result of several years of experimental work the following has been determined: Streptococci and colon bacilli are the causes of abortion in mares and arthritis or navel-ill in foals on this farm. It has been impossible to isolate any germ in certain cases of abortion in mares. The same germ may not continue to cause disease in an individual mare's foals from year to year. Serums or bacterins have been of little if any value as prophylactic or therapeutic agents. The agglutination test has been of little value and in certain cases the results have been misleading. Prenatal infection in certain cases has from a clinical standpoint been strongly suggested.

No. 419. "Starch in Sorghum Sirup," by J. J. Willaman and F. R. Davison. In *Industrial and Engineering Chemistry*, Vol. 16, pp. 609-10 (1924).

It has been found that the major portion of the gum, or alcohol-precipitable material, in sorghum sirup is starch. Some true gum, containing galactan, is also present, as well as the calcium salts of citric acid.

No. 420. "The Effect of Chemical Leavening Agents on the Properties of Bread," by Florence C. Smith and C. H. Bailey. In *Journal American Association of Cereal Chemists*, Vol. 8 (October, 1923), 12 pages.

A study was made to ascertain the effects of the residual salts of various baking powders on the flour with which they were used. For this purpose several types of experiments were carried out. The residual salts were mixed with the flour and their effects noted when glutes were washed from these flours. Glutes were prepared in the usual manner and immersed in solutions of the residual salts. Hydrogen-ion determinations were made on doughs or biscuits containing various baking powders or their residual salts. Doughs containing residual salts were tested in the Chopin extensimeter. From this series of experiments it was concluded that gluten properties, including elasticity and hydration capacity, are affected by baking powder and the residual salts resulting from the chemical reaction of baking powder ingredients. Disodium phosphate, the residual salt resulting from the reaction of monosodium phosphate baking powder, affects gluten more than the residual salts from other types of baking powder. Extensibility of the dough, as measured by the Chopin extensimeter, is diminished appreciably by several baking powders used in these experiments and even more by the residual salts of these same baking powders. Hydrogen-ion concentration of baking powder biscuits is reduced when compared with control biscuits made without baking powder. Monosodium phosphate baking powders have the greatest effect in increasing the alkalinity of the resultant biscuit.

No. 429. "Carotin—The Principal Cause of the Red and Yellow Colors in *Perillus bioculatus* (Fab.) and its Biological Origin from the Lymph of *Leptinotarsa decemlineata* (Say)" by L. S. Palmer and H. H. Knight. In *Journal of Biological Chemistry*, Vol. 59, pp. 443-49 (1924).

It is demonstrated in this paper that the red and yellow colors in the hypodermis of the stink-bug, *Perillus*, are due to deposits of carotin which are derived from the lymph of the potato-beetle grub, which is the chief food of *Perillus*. The lymph of the beetle was found to be colored by carotin exclusively, the

concentration amounting to 0.0136 per cent in the fresh lymph. These results are discussed with reference to their bearing on genetic studies with insect pigments.

No. 430. "Anthocyanin and Flavone-like Pigments as Cause of Red Colorations in the Hemipterous Families Aphididae, Coreidae, Lygaeidae, Miridae, and Reduviidae," by L. S. Palmer and H. H. Knight. In *Journal of Biological Chemistry*, Vol. 59, pp. 451-455 (1924).

Red pigment in both phytophagous and predaceous families of Hemiptera is not limited to one type of substance. Water-soluble pigments appear to be more common than carotin.

The aphid *Triogenaphis rudbeckiae* (Fitch) owes its vermilion color chiefly to an anthocyanin-like pigment, altho small quantities of carotin are also present in the bug.

The red color of the red and black patterned phytophagous box-elder plant-bug (*Leptocoris trivittatus* Say), the milkweed plant-bug (*Lygaeus kalmii* Stal), the bladdernut plant-bug (*Lopidea staphyleae sanguinea* Kngt.), the maple plant-bug (*Coccobaphes sanguinarius* Uhler), and the predaceous assassin-bug (*Eulyes illustris* Stal), is due to a flavone-like pigment.

The results are discussed with reference to the use of insect pigments for genetic studies when the pigments are derived from the food and independent of the synthetic powers of the protoplasm.

No. 431. "Preliminary Report on the Presence of Tubercle Bacilli in the Eggs of Tuberculous Fowls," by C. P. Fitch, R. E. Lubbehusen, and Ruth N. Dikmans. In *Abstracts of Bacteriology*, Vol. VIII, No. 1 (January, 1923), p. 59.

The literature constantly contains references to the transmission of tuberculosis through the eggs of tuberculous fowls. When the subject is carefully looked up it is found that very few eggs have been examined upon which to base statements as to the probability of the transmission of the disease in this manner.

We have examined 438 eggs laid by 19 hens known to be tuberculous, affected with various forms of the disease. In none of these which have been autopsied to date have we found undoubted tuberculosis of the ovaries or oviducts; 288 eggs have been examined by inoculation into thirteen guinea pigs, 10 rabbits, and 77 chickens; 150 eggs have been cultured. The whole egg was used in each case. None of the birds or animals inoculated has developed tuberculosis. Acid-fast bacilli developed in three of the flasks inoculated with the eggs. These three cultures were injected into chickens, none of which developed the disease. These results seem to indicate that tubercle bacilli are not usually transmitted through the egg and that the danger of the transmission of avian tuberculosis in this manner is not great. The work is continuing and eggs from other infected fowls are being examined.

No. 433. "Cost of Apple Production in Minnesota," by W. G. Brierley. In *Proceedings of the American Society for Horticultural Science*, 1923. 4 pages.

A summary of the data obtained by survey of 64 orchards covering the period from 1916 to 1920. Location, general condition, and methods of management of orchards and common varieties of apples grown, are noted.

Low transportation costs and generally favorable markets are held to be advantages for the local grower. Statistics are given as to acreage surveyed, acre valuation, age of trees, trees per acre, yield, and returns. The labor charges and costs of the several orchard operations are noted, together with material costs, fixed costs, and overhead. Total costs per acre and per bushel, gross and net returns are shown. A summary of acre and bushel costs and returns is presented in tabular form.

No. 436. "Temperature as a Limiting Factor in the Life of Sub-cortical Insects," by S. A. Graham. In *Journal of Economic Entomology*, Vol. XVII, p. 377-83 (June, 1924).

The distribution of insect species within a log depends to a very large degree upon the temperature in different parts of the log. The groups most resistant to heat, of which the genus *Chrysobothris* is representative, are found only in the warmer parts; while the species less resistant to heat are found only where extremely high temperatures do not occur. On the basis of temperature it is possible to divide the insect inhabitants of a log into several ecological groups.

No. 437. "The Physico-chemical Properties of Strong and Weak Flours VIII. Effect of Yeast Fermentation in Imbibitional Properties of Glutenin," by P. F. Sharp and R. A. Gortner. In *Cereal Chemistry*, Vol. I, No. 1 (January, 1924), pp. 29-37.

Yeast, during the process of normal bread-dough fermentation, is shown to produce a marked increase in the imbibitional properties of the dough proteins. This increase in imbibition is ascribed chiefly to the properties of the glutenin of the gluten-forming proteins. The viscosity of suspensions prepared from the dough as well as the viscosity of such suspensions treated with lactic acid, markedly increases as fermentation progresses. Malt extract and malt flour, owing to their proteolytic action, greatly decrease the above mentioned effects of yeast fermentation. The effect is related to the quantity of malt added and is also evidenced by a decrease in loaf volume. Difficulty is experienced in washing the gluten from the dough during the later stages of fermentation.

No. 439. "Potato Breeding," by F. A. Krantz. In *Proceedings of Tenth Annual Meeting of the Potato Association of America*. pp. 174-79.

A report of the results in a study of the relative accuracy of the yields of potatoes obtained by using rows of different lengths and different numbers of replications. From the results, the use of rows longer than two rods does not appear to be justified. Replication proved to be an effective means of reducing the size of the probable error, and the agreement between the results obtained for as high as 16 replications agreed very well with mathematical expectation.

No. 442. "The Use of Detailed Cost Studies in Improving Farm Organization in a Community," by G. A. Pond. In *Journal of Farm Economics*, Vol. 6, No. 1 (January, 1924), pp. 69-80.

Detailed cost studies in Steele County have resulted in improved organization of the farms on which they are conducted by pointing out the advantages of labor-saving practices; better farm layout; more productive livestock; and better feeding practices, including more extensive use of leguminous roughages and pastures and the substitution of cheap home-grown feeds for relatively more expensive purchased feeds. Specific examples are cited of increases in the net farm income through the adoption of these practices.

No. 443. "The Principles of Plant Physiology Relative to Frost Damage," by R. B. Harvey. In *American Rose Annual* (1924), p. 54.

A general survey is made of the conditions affecting winter-killing in roses with data showing how favorable characters of the bush—color, waxy covering, and dormancy—may allow the plants to survive. Suggestions are made for the use of artificial test winters in determining more accurately the limits of winter temperature which roses can survive, and in testing the relative hardiness of varieties.

No. 444. "Physical Tests of Flour Quality with the Chopin Extensimeter," by C. H. Bailey and Amy M. Le Vesconte. In *Cereal Chemistry*, Vol. I, No. 1 (January, 1924), pp. 38-63.

The Chopin apparatus is used in a series of studies on flour strength and related problems. This apparatus is so constructed that a dough can be pressed into a thin sheet and this sheet of dough clamped in such position that it can be inflated to take the shape of a sphere. The volume of the sphere is an index of qualities of the flour which are indicative of strength.

When normal flours are used in this apparatus the extensimeter readings are of value as indicating the strength or baking value of the flour. Prolonged mechanical treatment or mixing of a dough decreases the extensibility. The addition of starch to the flour effects the same result. Moisture content of dough affects the extensibility. At a hydrogen-ion concentration equivalent to pH 6, the dough is most extensible. Chlorine treatment of flours tends to decrease the extensibility of doughs prepared from them, owing probably to resultant higher hydrogen-ion concentration. Calcium acid phosphate increases the extensibility, while certain other flour improvers used in the experimental work had slight effects in the opposite direction.

No. 446. "Pioneering in Economic Entomology," by A. G. Ruggles. In *Journal of Economic Entomology*, Vol. XVII (February, 1924), pp. 34-41.

Economic entomologists as scientists should be moderate, not radical. The economic entomologist has evolved from the systematic and morphological entomologist.

The most promising field of endeavor for the economic entomologist today is in the field of ecology. To be equipped for this, broad and deep fundamental training in the sciences is absolutely necessary.

No. 452. "Breeding Efficiency in Purebred Dairy and Beef Cattle," by W. L. Boyd. In *Veterinary Medicine*, Vol. 19, No. 4 (April, 1924).

The valuable purebred animal's worth is determined mainly by her ability to produce calves of equal value.

The forced feeding of dairy cows for the establishment of big records in milk and butterfat production, as practiced by many breeders, is no doubt responsible for decreased breeding efficiency, owing to certain requirements for official testing.

A large percentage of diseases of the reproductive organs which decrease breeding efficiency is due to the invasion of certain micro-organisms into the various organs. Of these *Bacterium abortus* Bang is by far the most important.

Retention of fetal membranes is recognized as the most common symptom of uterine infection.

Treatment of retained fetal membranes demands most skillful and careful handling.

Proper handling of the corpus luteum is a valuable asset to the veterinarian for increasing the breeding efficiency of cattle.

It is commonly considered by constructive breeders that the sire is more than 50 per cent of the herd. Impaired breeding efficiency on the part of the sire is a definite and occasionally a serious cause for lessened or reduced fertility.

The continued practice of rigid herd and stable hygiene is of the utmost importance in maintaining breeding efficiency.

Results of studies at University Farm are tabulated and presented in the charts.

No. 455. "Chronic Productive Pachymeningitis in a Horse," by W. C. Prouse and C. P. Fitch. In *Journal of American Veterinary Medical Association*, Vol. LXV, N.S. 18, No. 1 (April, 1924), 3 pages.

A horse was studied which showed an unusual form of lameness. The animal failed to improve on treatment and was finally killed and autopsied. All the internal organs were normal. The only lesion found was a growth on the meninges of the spinal cord, in the region of the seventh cervical vertebra. This growth was an inch and a half long and about an inch deep. The tissue was yellowish, soft, and the glistening fibers of the spinal nerves could be seen radiating through it. Sections of the tissue were removed and fixed in Zenker's fluid and prepared for microscopic examination. A careful microscopic study of these specimens showed it to be a case of chronic productive pachymeningitis. There were no true tumor processes concerned in it.

No. 457. "The Erickson Apple," by W. G. Brierley. In *Minnesota Horticulturist*, Vol. LII, No. 4 (April, 1924), pp. 103-5.

A technical description of the new seedling apple "Erickson," historical notes, and description of tree and fruit are given.

No. 459. "Viscosity as a Measure of Gluten Quality," by R. A. Gortner. In *Cereal Chemistry*, Vol. 1, No. 2 (March, 1924), pp. 75-81.

It is pointed out that absolute viscosities of flour-water suspensions may yield results which may be wrongly interpreted because the viscosity is the resultant of two factors—the quantity and the quality. The quality factor may be distinguished from the quantity factor by a determination of the constant b in the logarithmic equation, $\log \text{viscosity} = a + b$ (log concentration). At least two and preferably four or more viscosity determinations on suspensions of varying

flour-water concentrations are required for calculating this constant. A specimen calculation is worked out from actual data presented in the paper.

No. 464. "Assimilation-Respiration Balance as Related to Length of Day Reactions of Soybeans," by Frank M. Eaton. In *Botanical Gazette*, Vol. 77 (May, 1924), pp. 311-21.

The experiments described in this paper were undertaken to determine if the assimilation-respiration balance in plants as affected by external conditions was the factor which directed plant growth to either the vegetation or reproduction stages. It was found that high nightly temperatures brought about early flowering in Peking soybeans but did not affect all short-day plants alike. By measurement it was found that the higher nightly temperatures doubled the rate of respiration. Soybean plants given a long day but deprived of carbon dioxide for a part of this day, did not flower earlier than untreated plants, altho they made about the same amount of growth as plants which flowered early as a result of a shortened day and a growth very much less than untreated plants.

It was also found that the rate of elongation of corn at night was nearly proportional to the temperature.

No. 478. "Tile Drainage a Real Source of Profit to the Farmer," by H. B. Roe. In *Agricultural Engineering*, Vol. 5, pp. 75-9 (April, 1924).

Revised and reprinted. Transactions of the American Society of Agricultural Engineers, Vol. 17, No. 4, pp. 49-64. 1923.

Definite dollars and cents facts on the economic advantages of drainage are meager. Those collected by the Minnesota station from several actual projects seem to indicate the following approximate results:

The tillable land area within the present limits of the farm shows an average increase of about one-third as due to complete drainage, with a consequent increase in value of crops that may be considered as giving either an average return of about thirteen and one-half per cent on the drainage investment, or an average increase of about sixty-eight per cent in net farm income.

Straightening of field lines resultant from drainage seems to have increased ease and decreased expense of tillage slightly more than one-third.

Crop increase through planting one to two weeks earlier made possible by drainage, seems to amount to approximately twenty-seven per cent.

EXPERIMENT STATION PROJECTS—1923-24 AGRICULTURAL BIOCHEMISTRY

Cereal and Flour Investigations (C. H. Bailey)
The Strength of Wheat Flour

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

Subproject: Other factors which may be involved in flour strength (C. H. Bailey, R. C. Sherwood, Arnold H. Johnson, Andrew Dingwall, Andrew Cairns, and graduate students)

Investigations of Proposed Official Methods of Analysis (C. H. Bailey, R. C. Sherwood)

- The Biochemistry of Resistance to Disease in Plants (J. J. Willaman, H. O. Triebold)
- Analytical Service (C. H. Bailey, R. C. Sherwood, G. S. Taylor, E. L. McIlhenny)
- Protein Investigations
 Subproject: Studies on humin formation (R. A. Gortner)
 Subproject: Sulfur in proteins (R. A. Gortner, W. F. Hoffman, W. B. Sinclair)
 Subproject: Studies on the prolamines (W. F. Hoffman, R. A. Gortner)
- Chemical Studies of Pollen (Dormant)
- Chemical and Biological Studies in Animal Nutrition (L. S. Palmer, C. Kennedy, O. Mydland)
 Subproject: Factors influencing the vitamin content of milk
 Subproject: Vitamin requirements for growth and milk production
 Subproject: Mineral requirements for farm animals
 Subproject: Factors influencing the stability of vitamins in human and animal foods
 Subproject: Studies on the chemical nature of vitamins A and B
 Subproject: Studies on the quantitative requirements of laboratory animals for vitamins
 Subproject: Studies regarding the functions of vitamins in the animal body.
- Chemistry of the Formation and Manufacture of Dairy Products and Factors Influencing Milk Production and the Composition and Properties of Milk (L. S. Palmer)
 Subproject: A study of the chemistry and physico-chemistry of churning and the factors which influence churnability
 Subproject: Enzymes of milk and their relation to abnormal fermentations
 Subproject: Physico-chemical properties involved in clotting of milk by rennet
- The Biochemistry of Carotinoid Pigment in Animals (L. S. Palmer)
- Corn-Stalk Sirup Investigations (J. J. Willaman)
- The Chemical and Physico-Chemical Properties of Plant Tissue Fluids (R. A. Gortner, W. F. Hoffman)

AGRICULTURAL ECONOMICS

- The Farmers' Co-operative Movement in Minnesota (J. D. Black, H. B. Price)
- Market Business Practice (J. D. Black, H. B. Price, C. M. Arthur, E. C. Johnson, B. A. Holt)
 Subproject: Creameries
 Subproject: Grain elevators
- Methods Employed by Private Agencies in Land Settlement (J. D. Black)
- Methods of Land Valuation with Special Reference to Minnesota (J. D. Black)
- Investigation of the Forces Determining the Prices of Farm Products (Holbrook Working)
- Local Costs of Marketing Livestock (Dormant)
- Relation of Changes in the General Price Level to Prices of Farm Products (Holbrook Working)
- Market Price Investigations (J. D. Black, W. C. Waite)
- Market Price Quotations (J. D. Black, E. W. Gaumnitz)
- Elasticity of Supply of Farm Products (J. D. Black, C. F. Clayton, Holbrook Working)
- Farmers' Incomes in Minnesota (J. D. Black)

- Grain Dockage Investigations (J. D. Black)
- Organization of the Farmers' Supply Service (H. B. Price, J. D. Black)
- Marketing Organization Investigations (J. D. Black, B. A. Holt)
- Organization and Management of Minnesota Creameries, Considered as Local Marketing Agencies (J. D. Black)

AGRICULTURAL ENGINEERING

- Methods and Costs of Drainage Installation and Correlation of Land and Crop Values with Cost of Drainage (H. B. Roe, G. F. Krogh)
- Drainage and Water Control Investigations on Peat Lands (G. R. B. Elliott)
- Determination of the Relative Efficiency of the Differing Depths and Spacing of Drainage Lines (G. R. B. Elliott)
- 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, C. R. Liese, Division of Agricultural Engineering; D. G. Miller, O. C. McGrew of the Federal Department)
- Investigations of Farm Buildings (H. B. White, M. G. Jacobson)
- Investigations in Cost of Clearing Land (M. J. Thompson, A. J. Schwantes)
- Investigations in Developing Newly Cleared Land (M. J. Thompson, A. J. Schwantes)
- Investigations in Land Clearing Methods and Equipment (M. J. Thompson, A. J. Schwantes)
- Heating and Ventilating of Homes (E. A. Stewart)
- Hydro-Electric Farm Plants (E. A. Stewart, J. Romness)
- Farm Building Ventilation (E. A. Stewart)
- Wind Power Electric Lighting Plants (E. A. Stewart)
- Farm Sewage Disposal (E. A. Stewart, A. G. Tyler)
- Investigations of Farm Tractors (J. B. Torrance)
- Land Clearing Investigations (M. J. Thompson, A. J. Schwantes)
 Subproject: Investigations in methods of stone removal
 Subproject: Investigations in costs and methods of clearing state lands
 Subproject: Investigations in plowing under brush
 Subproject: Investigations in power necessary for pulling stumps
 Subproject: Investigations in the utilization of stump wood for fuel
- Utilization of Electricity in Agriculture (E. A. Stewart)

AGRONOMY AND FARM MANAGEMENT

- Breeding of Miscellaneous Field Crops (H. K. Hayes)
- Investigations in Cereal Breeding (H. K. Hayes, Fred Griffiee, H. E. Brewbaker, J. B. Harrington, Lee Alexander, Alma Scheppe)
- Corn Breeding Investigations (H. K. Hayes, Fred Griffiee, H. E. Brewbaker, J. B. Harrington, Lee Alexander, R. E. Hodgson, Alma Scheppe)
- Inheritance Studies with Small Grains (H. K. Hayes, Fred Griffiee)
- Development of Disease Resistant Varieties of Farm Crops (H. K. Hayes, Fred Griffiee, H. E. Brewbaker, J. B. Harrington, Division of Agronomy and Farm Management; O. S. Aamodt, U. S. Department of Agriculture; E. C. Stakman, Division of Plant Pathology and Botany)
- Crop Rotation Investigations (A. C. Arny, F. L. Higgins)
 Subproject: Field C Rotations

- Subproject: Field T Rotations
 Subproject: Alternate and continuous cropping
 Subproject: Effect of crops on those which follow
 Forage Crop Investigations (A. C. Arny, F. W. McGinnis)
 Subproject: Comparison of distance apart to plant corn and soybeans and sunflowers, and stage of maturity to cut for silage purposes
 Subproject: Time, rate, and method of seeding alfalfa, sweet clover, sudan grass, millets, and Canada field peas for pasture and hay
 Subproject: Variety trials of various forage crops and roots
 Subproject: Various legumes and grasses grown alone and in mixtures for hay and pasture, and effect on following crops
 Investigations in the Growing of Small Grains (A. C. Arny, F. W. McGinnis)
 F. H. Steinmetz, W. I. Thomas, J. B. Russell, C. S. Dorchester)
 Co-operative Variety Trials of Farm Crops (A. C. Arny)
 Studies in the Classification of Farm Crops (A. C. Arny, F. L. Higgins)
 Co-operative Seed Production and Distribution (A. D. Haedecke)
 Cost Accounting Investigations on Minnesota Farms (G. A. Pond, R. C. Engberg, A. T. Hoverstad, S. E. Johnson, B. Miller, D. D. Sewall, E. A. Kroeger, R. E. Truman, E. T. Helgeson, C. O. Ruud)
 Comparison of Fence Posts (L. B. Bassett)
 A Study of the Physical Organization of Farms (L. B. Bassett)
 A Study of Farm Organization and Methods on Livestock Farms (L. F. Garey)

ANIMAL HUSBANDRY

- Swine-Feeding Investigations (E. F. Ferrin, M. A. McCarty)
 Subproject: Comparison of various forms of buttermilk for growing pigs
 Subproject: Hogging-off corn
 Subproject: Feeding value of wheat by-products for growing fattening pigs
 Subproject: Value of tankage and skim milk as protein supplements for young pigs at weaning time
 Subproject: Value of ground rye fed with certain supplements as a ration for growing pigs
 Subproject: Marl as a source of calcium for swine
 Subproject: Comparison of protein supplements in rations for pigs following weaning
 Value of Several Rations for Baby Beef Production (H. W. Vaughan, A. L. Harvey)
 Comparison of Several Treatments for Stomach Worms in Lambs with Special Reference to Consequent Growth and Development of Treated and Untreated Lambs (P. A. Anderson)

BEE CULTURE

- Investigations in Queen Breeding and Raising (Francis Jager, G. C. Mathews, J. W. Thompson, F. Dell)
 Subproject: Demonstrating the possibility of commercial queen-raising in Minnesota, its conditions, possibilities, and cost
 Subproject: Investigations into the controlled mating of queen bees
 Subproject: Research into possibilities of Carniolan bees for Minnesota
 Subproject: A study of the laying capacity of queen bees
 Management of Bees (Francis Jager, G. C. Mathews, J. W. Thompson, F. Dell)
 Subproject: Model apiary

- Subproject: Summer and winter results of bees in different locations
 Subproject: Studies in imported pound packages and nuclei for commercial production of honey
 Subproject: Influence of sizes and types of hives on honey production and production of brood
 Subproject: Influence of various kinds of natural and artificial foods in successful wintering of bees
 Studies in Pollen (Francis Jager)
 Subproject: A study of pollen substitutes
 Subproject: A study of gathering and storing natural pollen through winter for spring use of bees
 Subproject: A study of actual benefit derived from bees as pollinators of plants
 Bee Disease Inspection (G. C. Mathews)
 Bee and Honey Survey of Minnesota (G. C. Mathews)

DAIRY HUSBANDRY

- Factors Influencing the Composition and Quality of Minnesota Butter (J. R. Keithley, C. D. Dahle)
 Subproject: 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, T. W. Gullickson)
 Food Requirements for Dairy Cattle (C. H. Eckles, T. W. Gullickson)
 Subproject: Energy requirements for growth
 Subproject: Energy requirements for maintenance of calves
 Subproject: Mineral requirements
 Subproject: Relation of vitamins to the growth of dairy cattle and to milk production.
 Subproject: Milk as the sole diet for calves
 Micro-organisms in Silage and Their Relation to Disease in Livestock (C. H. Eckles)
 Factors Influencing the Vitamin Content of Milk (C. H. Eckles) (Dormant)
 Powdered Milk Studies (H. Macy)
 Subproject: Studies of the bacterial content of powdered milk after varying periods of storage
 Ice Cream Studies (C. D. Dahle)
 Subproject: Factors influencing the viscosity of ice cream

ENTOMOLOGY AND ECONOMIC ZOOLOGY

- Nutritional Requirements of Certain Insects (*Tribolium confusum* Duval)- (Dormant)
 Economic Status of Certain Field Vertebrates in Minnesota (F. L. Washburn)
 Subproject: The frogs of Minnesota
 Subproject: The food habits of birds in relation to gardens
 Parasites and Symbionts of Insects (W. A. Riley)
 Insect Collection (H. H. Knight)
 Subproject: University Farm
 Subproject: Itasca Park

- Insecticides (A. G. Ruggles, J. R. Eyer, Thor Aamodt)
 Subproject: Orchard spraying
 Subproject: Potato spraying
 Subproject: Tree tanglefoot investigations
- 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
- Parasitic and Disease Carrying Insects and Insect Allies (W. A. Riley)
 Subproject: Horseflies (*Tabanidae*)
 Subproject: Poisonous insects
- Effect of Temperature and Humidity on the Grasshoppers *Melanopus atlantis* and *Camnula pellucida* (J. R. Parker)
- The Study of Derris and Related Insecticides for Control of External Parasites of Domesticated Animals (Paul M. Gilmer, O. C. McBride)
- Grasshopper Control (A. G. Ruggles, J. R. Parker)
- Life History and Methods of Control of the Chicken Nematode *Heterakis papillosa* (W. A. Riley) (Dormant)
- Insects of Orchard with Best Means of Combating (A. G. Ruggles)
 Subproject: Plant lice
 Subproject: Apple maggot
- Insectary Work (A. G. Ruggles, Thor Aamodt)
- Life History and Injury of the Potato Leaf-Hopper *Empoasca malit* (A. G. Ruggles, J. R. Eyer)
- Use of Carbon Tetrachloride Either Alone or in Combination with paradichlorobenzene or chloropicrin for fumigating grain in elevators (R. N. Chapman)
- Relation of Insects to Slash (S. A. Graham)
- Effect of Physical Factors upon Insects in Freshly Cut Logs (S. A. Graham)
- Study of the Role of Temperature and Humidity in the Development of Insects in Flour and Other Cereal Products While in Storage (R. N. Chapman)
- Study of Fly Repellants (Paul M. Gilmer, O. C. McBride)
- Effect of Temperature and Humidity on the Wintering of Bees (R. N. Chapman)
- Campaign Against Injurious Field Rodents (F. L. Washburn)
 Subproject: Work against pocket gophers
- Spruce Budworm, *Tortrix fumiferana* (S. A. Graham)
- Studies on the Heredity or Non-Heredity of the Color Pattern in Hemiptera (H. H. Knight)
- Flukes of the Genus *Collyriclum* as Parasites of Poultry (W. A. Riley, H. C. H. Kernkamp)
- Monographic Studies on the Family Miridae (*Hemiptera-Heteroptera*) (H. H. Knight)
- Study of the Hookworms of the Dog and the Domesticated Fox (W. A. Riley, Carl J. Ostrom)

FORESTRY

- Qualitative and Quantitative Survey of Cut-over Lands (T. S. Hansen)
- Demonstration Windbreak Plantation (S. S. Burton, G. H. Wiggin)
- 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) (Dormant)
- 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 (J. H. Allison) (Dormant)
- Studies in Forest Regeneration (T. S. Hansen, G. H. Wiggin, S. S. Burton)
 Subproject: Sowing and planting
 Subproject: Nursery practice
 Subproject: Seed studies
 Subproject: Management
 Subproject: Mensuration
 Subproject: Forest types
- Working Plan for Cloquet (J. H. Allison) (Dormant)
- Blueberry Culture (T. S. Hansen, G. H. Wiggin)
- Preservative Treatment of Fence Posts (J. H. Allison) (Dormant)
- Forest Trees of Minnesota (J. P. Wentling)
- Studies in Yield and Volume (J. H. Allison) (Dormant)
- Studies in White Pine Blister Rust Control (E. G. Cheyney) (Dormant)

HORTICULTURE

- Study of the Inheritance of Characters in Fruits (W. H. Alderman, J. H. Beaumont, A. N. Wilcox, Fred Haralson)
- Hardiness Studies in Fruit Breeding (J. H. Beaumont, W. H. Alderman, A. N. Wilcox)
- Sterility Studies in Fruit Breeding (W. H. Alderman, J. H. Beaumont, A. N. Wilcox)
- University Farm Campus (C. E. Cary)
- Study of Ornamental Varieties and Their Uses (C. E. Cary)
- Breeding and Selection of Vegetables (W. H. Alderman, W. T. Tapley, F. A. Krantz, B. I. Burrell, F. Rohner)
- Blueberry Culture (W. G. Brierley, W. H. Alderman, A. N. Wilcox)
- Co-operative Orchard Management (W. G. Brierley, W. H. Alderman, F. Rohner)
- Fruit Variety Studies (W. G. Brierley, W. H. Alderman, Fred Rohner)
- Cost of Producing Fruits (W. G. Brierley)
- Nut Culture in Minnesota (W. G. Brierley)
- Potato Breeding (F. A. Krantz, W. H. Alderman, W. T. Tapley, F. Rohner)

PLANT PATHOLOGY AND BOTANY

- Plant Disease Survey (E. C. Stakman, R. M. Nelson, J. G. Leach, J. L. Seal)
- Rusts of Cereals (E. C. Stakman, A. W. Henry, C. R. Hursh, J. G. Leach, J. J. Christensen, J. H. Craigie, J. M. Wallace, Division of Plant Pathology and Botany; M. N. Levine, O. S. Aamodt, E. B. Lambert, L. W. Melander, United States Department of Agriculture)
- Cereal and Forage Crop Diseases (E. C. Stakman, J. J. Christensen, A. W. Henry, H. H. Flor, H. A. Rodenhiser)
 Subproject: Imperfects on cereals and roots
 Subproject: Smut treatments
 Subproject: Scab of cereals
 Subproject: Ergot of cereals
 Subproject: Sunflower rust

- Garden Truck Diseases (J. G. Leach, H. C. Gilbert, H. A. Rodenhiser)
 Subproject: Bean bacteriosis and anthracnose
 Subproject: Potato diseases
 Miscellaneous truck crop diseases
- Fruit Diseases (J. L. Seal)
 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. M. Nelson)
 Subproject: Miscellaneous Itasca experiments
 Subproject: The rots of cedar posts and poles
- Seed Studies (A. H. Larson, Ruby Ure)
 Subproject: Weed seed cases
 Subproject: Germination of lettuce seed
- Weeds (A. H. Larson, Ruby Ure)
 Subproject: Perennial sow thistle
- Minnesota Mushrooms (Louise Dosdall)
- Studies in Plant Metabolism and Growth (R. B. Harvey, L. O. Regeimbal, F. R. Davison, F. M. Eaton)
 Subproject: Effect of length of isolation period upon growth and reproduction
 Subproject: Effect of increased CO₂ supply
- Investigations in Respiratory Enzymes (R. B. Harvey)
 Subproject: Oxydo reductase
 Subproject: State of oxidation in tissues
- Physiology of Seed Germination (R. B. Harvey, L. O. Regeimbal)
 Subproject: Physiology of dormancy in seeds
 Subproject: Effects of seed treatment upon germination
 Subproject: Respiration studies on seeds
- Effect of Low Temperature on Plants (R. B. Harvey, L. O. Regeimbal, F. R. Davison)
 Subproject: Varietal differences in frost resistance
 Subproject: Physiological factors concerned in frost injury
- Physiology of Reproduction (R. B. Harvey, L. O. Regeimbal, F. M. Eaton)
- Development of Disease Resistant Varieties of Farm Crops (E. C. Stakman, A. W. Henry, H. Hecker, H. H. Flor, J. J. Christensen, H. A. Rodenhiser, Helen Hart, Division of Plant Pathology and Botany; H. K. Hayes, Division of Agronomy and Farm Management; O. S. Aamodt, M. N. Levine, United States Department of Agriculture)
 Subproject: Development of rust resistant varieties of wheat
 Subproject: Genetics of biologic forms of *Puccinia graminis*
 Subproject: Development of varieties of wheat resistant to bunt
 Subproject: Development of varieties of oats resistant to black stem rust
 Subproject: Development of varieties of corn resistant to root- and stalk-rots
 Subproject: Development of pure lines of corn resistant to smut
 Subproject: Development of desirable agronomic types of barley resistant to *Helminthosporium sativum*
 Subproject: Resistance of wheat varieties to wheat scab
 Subproject: Varietal resistance of wheat, barley, oats, and rye to root- and culm-rots

- Subproject: Production of high-yielding rust-resistant timothy
 Subproject: Flax wilt
 Subproject: Development of varieties of flax resistant to rust

POULTRY

- Effect upon Mortality, Growth, and Feather Development of Feeding White Leghorn Chicks Different Amounts of Different Animal Foods (A. C. Smith)

SOILS

- Fertilizer Experiments (F. J. Alway, C. O. Rost, G. H. Nesom, P. R. McMiller, Skuli Hrutford, G. Bombach, W. Methley)
 Soil Survey (F. J. Alway, P. R. McMiller, J. S. Hall, G. B. Bodman, R. M. Pinckney, E. Fieger, W. Methley)
 Movement of Water in Soils (F. J. Alway, R. M. Pinckney)
 Peat Soils (F. J. Alway, G. H. Nesom, W. Methley, G. Bombach, G. B. Bodman)
 Sandy Soils (F. J. Alway, G. H. Nesom, P. R. McMiller, Skuli Hrutford, G. B. Bodman, W. Methley, G. Bombach)
 Hydrogen-Ion Concentration of Soils (C. O. Rost, E. Jones)
 Soils of the Low-Lime Area (F. J. Alway, C. O. Rost, Skuli Hrutford, W. Methley, G. Bombach, G. B. Bodman)
 Land Classification (F. J. Alway, P. R. McMiller, G. Bombach)
 Agricultural Value of Marl (F. J. Alway, C. O. Rost, G. H. Nesom, P. R. McMiller, W. Methley, G. Bombach, G. B. Bodman)

VETERINARY MEDICINE

- Infectious Abortion and Other Diseases of the Reproductive Organs of Cattle (C. P. Fitch, W. L. Boyd, R. E. Lubbehusen, R. N. Dikmans)
 Subproject: Pathology and bacteriology of sterility
 Subproject: Serological tests in their relation to bovine infectious abortion
 Subproject: Bacterial flora of the vagina and uterus of the cow
 Subproject: 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.
- Contagious Abortion of Mares and Pyaemic Arthritis of Foals (C. P. Fitch, W. L. Boyd)
 Investigations of Obscure Diseases (C. P. Fitch, W. L. Boyd, H. C. H. Kernkamp, R. E. Lubbehusen, R. N. Dikmans)
 Physiological Variations in the Temperature of Cattle (E. A. Hewitt)
 State Regulatory Work (M. H. Reynolds)
 Tuberculin Tests (M. H. Reynolds)
 Subproject: Relative accuracy of the several tuberculin tests
 Subproject: Relative desirability of various possible combinations of these tests
 Subproject: Differing responses to the several tests in relation to extent, activity, or virulence
 Subproject: Significance of slight and atypical reactions
 Subproject: Tuberculin hypersensitiveness in non-tuberculous cattle

Diseases of Poultry (C. P. Fitch, R. E. Lubbehusen, R. N. Dikmans)
 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 in Digestion in Herbivora (E. A. Hewitt)

SUMMARY OF PROJECTS 1923-24

Division.	New	Active	Dormant	Closed
Agricultural Biochemistry ..	10	2	1	1
Agricultural Economics ..	5	14	1	1
Agricultural Engineering ..	1	15	1	1
Agronomy and Farm Management.....	15	..	..	..
Animal Husbandry ..	3	..	..	..
Bee Culture ..	5	..	..	..
Dairy Husbandry ..	7	1	1	1
Entomology and Economic Zoology....	5	25	2	3
Forestry ..	9	6	..	..
Horticulture ..	12	..	..	..
Plant Pathology and Botany.....	15	..	..	..
Poultry ..	1	1	..	..
Soils ..	1	9	..	..
Veterinary Medicine ..	1	10	..	1
	14	150	13	8

CLASSIFICATION OF PROJECTS 1923-24

Division	Research	Experi- mental	Demonstra- tional	Survey	Total
Agricultural Biochemistry ..	10	2	..	..	12
Agricultural Economics ..	15	..	..	..	15
Agricultural Engineering ..	10	5	1	..	16
Agronomy and Farm Management... 10	4	1	..	..	15
Animal Husbandry ..	3	..	..	..	3
Bee Culture ..	3	1	1	1	5
Dairy Husbandry ..	8	..	..	..	8
Entomology and Economic Zoology.. 23	2	..	2	2	27
Forestry ..	7	5	1	2	15
Horticulture ..	6	6	..	..	12
Plant Pathology and Botany..... 10	3	..	2	2	15
Poultry ..	1	..	..	..	1
Soils ..	2	4	..	3	9
Veterinary Medicine ..	8	1	1	..	10
	109	39	5	10	163

FINANCIAL STATEMENT

 THE MINNESOTA AGRICULTURAL EXPERIMENT STATION
 IN ACCOUNT WITH THE UNITED STATES
 APPROPRIATIONS, 1923-1924

Dr.
 To receipts from the Treasurer of the United States in accordance with the appropriation for the fiscal year ending June 30, 1924, under the Act of Congress approved March 2, 1887..... \$15,000.00

Cr.
 By salaries .. \$15,000.00 \$15,000.00

Total Hatch Fund..... \$15,000.00 \$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, 1924, under the Act of Congress approved March 16, 1906..... \$15,000.00

Cr.
 By salaries .. \$15,000.00 \$15,000.00

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

ABSTRACT I--SALARIES

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

SUPPLEMENTARY STATEMENT

To receipts from other sources than the United States for the year ending June 30, 1924:

State appropriations .. \$380,518.80

Sale of farm products..... 49,709.71

Total .. \$430,228.51

EXPENDITURES, CENTRAL AND SUBSTATIONS, 1923-24

	University Farm	Crookston	Morris	Grand Rapids	Duluth	Waseca	Zumbra Heights
Salaries and labor.....	\$231,075.76	\$22,846.35	\$19,234.07	\$12,246.75	\$8,625.96	\$6,331.26	\$7,614.30
Equipment and repairs.....	320.14	200.84	78.88	81.36	173.40	110.67	9.75
Sundry supplies.....	493.13	140.23	330.97	.....	.....	.....	.....
Chemical and laboratory supplies.....	3,715.23	49.95	118.58	.....	20.25	.....	196.98
Laboratory glasses.....	552.31	.....	.....	.....	.....	.....	.....
Advertising, publications.....	4,307.53	458.21	309.73	9.54	183.09	1.08	.....
Freight and express.....	503.82	78.66	142.30	0.69	13.83	19.90	22.90
Feed.....	13,522.11	1,832.00	1,226.67	6,375.72	1,771.74	1,692.03	121.68
Postage.....	1,048.08	216.45	147.01	82.50	49.50	32.88	13.50
Seeds, plants.....	747.48	368.87	209.88	150.48	145.47	72.24	32.43
Stationery, postage, and office supplies...	4,334.25	671.76	277.58	96.78	89.13	24.66	44.82
Book binding.....	121.70	5.31	7.28	.....	.....	.....	.....
General supplies.....	8,249.74	1,328.16	1,120.03	1,712.40	1,502.07	996.33	416.97
Traveling expenses.....	6,008.51	372.27	178.90	105.27	58.02	47.70	18.75
Telephone and telegraph.....	1,837.50	94.30	71.03	71.18	70.54	71.58	44.82
Gas and electricity.....	859.62	307.72	268.01	350.34	66.93	198.27	133.95
Water and ice.....	391.32	49.03	146.45	6.87	7.50	5.63	.....
Laundry.....	332.91	28.64	42.17	.....	.....	.....	.....
Custodial supplies.....	394.59	8.95	21.37	34.77	10.56	20.61	.....
Fuel.....	7,903.72	1,563.30	1,573.88	722.34	91.14	270.69	617.88
Typewriters, adding machines.....	511.32	.....	131.67	169.62	.....	.....	.....
Books.....	862.20	165.90	64.67	.....	.....	.....	.....
Apparatus, instruments.....	1,865.28	.....	10.50	.....	.....	.....	.....
Furniture, furnishings.....	1,114.36	718.98	382.26	.....	39.23	117.03	.....
Tools, implements, machinery.....	2,492.95	763.41	318.54	644.73	1,024.82	239.73	83.55
Buildings and lands.....	9,644.20	1,148.53	958.19	370.56	796.08	1,257.25	68.22
Livestock.....	4,209.11	1,896.58	597.31	7.35	282.87	295.89	.....
Totals.....	\$307,438.87	\$35,314.40	\$27,967.93	\$23,239.25	\$15,022.13	\$11,805.43	\$9,440.50
Total expenditures, \$430,228.51.							

AGRICULTURAL EXPERIMENT STATION

THE BOARD OF REGENTS

The Hon. Fred B. SNYDER, Minneapolis	-	-	-	-	-	-	1928
The President of the Board	-	-	-	-	-	-	
Lorus D. COFFMAN, Minneapolis	-	-	-	-	-	-	Ex Officio
The President of the University	-	-	-	-	-	-	
The Hon. J. A. O. PREUS, St. Paul	-	-	-	-	-	-	Ex Officio
The Governor of the State	-	-	-	-	-	-	
The Hon. J. M. MCCONNELL, St. Paul	-	-	-	-	-	-	Ex Officio
The Commissioner of Education	-	-	-	-	-	-	
The Hon. William J. MAYO, Rochester	-	-	-	-	-	-	1925
The Hon. Milton M. WILLIAMS, Little Falls	-	-	-	-	-	-	1925
The Hon. George H. PARTRIDGE, Minneapolis	-	-	-	-	-	-	1926
The Hon. John G. WILLIAMS, Duluth	-	-	-	-	-	-	1927
The Hon. Egl. BOECKMANN, St. Paul	-	-	-	-	-	-	1927
The Hon. Alice R. WARREN, Minneapolis	-	-	-	-	-	-	1927
The Hon. A. D. WILSON, Guthrie	-	-	-	-	-	-	1928
The Hon. PIERCE BUTLER, St. Paul	-	-	-	-	-	-	1928
The Hon. J. E. G. SUNDBERG, Kennedy	-	-	-	-	-	-	1929

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., in Agr., 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. BIRGH, 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
Fred HARALSON, Assistant Superintendent, Fruit Breeding Farm, Zumbra Heights (P. O. Excelsior)
Raphael Zon, F.E., Director, Forest Experiment Station, Cloquet
W. P. KIRKWOOD, M.A., Editor, and Chief, Division of Publications
Alice McFEELEY, Assistant Editor of Bulletins
HARRET W. SEWALL, B.A., Librarian
T. J. HORTON, Photographer

DIVISION OF AGRONOMY AND FARM MANAGEMENT

ANDREW BOSS, Agriculturist

Section of Plant Breeding

H. K. HAYES, Ph.D., Plant Breeder
 FRED GRIFFEE, M.S., Assistant Plant Breeder
 H. E. BREWBAKER, B.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
 F. L. HIGGINS, B.S., Graduate Assistant
 W. I. THOMAS, B.S., Graduate Assistant

Section of Co-operative Seed Production and Distribution

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

ROSS AIKEN GORTNER, Ph.D., Agricultural Biochemist

Section of Proteins and Colloids

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

Section of Cereal Technology and Analytical Service

C. H. BAILEY, Ph.D., Associate Agricultural Biochemist
 R. C. SHERWOOD, M.S., Assistant Biochemist
 G. S. TAYLOR, B.A., Analyst
 EDWARD L. MCILHENNY, B.S., Special Analyst
 ARNOLD H. JOHNSON, M.S., Strietmann Fellow
 ANDREW CAIRNS, B.S., Fleischmann Fellow

Section of Plant Chemistry

J. J. WILLAMAN, Ph.D., Plant Chemist

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
 OLE MYDLAND, Animal Caretaker

DIVISION OF AGRICULTURAL ECONOMICS

JOHN 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
 CHARLES M. HOWE, M.A., Research Assistant
 G. A. FREDELL, B.S., Research Assistant

DIVISION OF AGRICULTURAL ENGINEERING

WILLIAM BOSS, Agricultural Engineer

Section of Agricultural Physics

E. A. STEWART, B.S., Associate Agricultural Engineer

Section of Drainage

H. B. ROE, B.S.E., Associate Agricultural Engineer
 D. G. MILLER, Senior Drainage Engineer U.S.D.A., B.P.R.
 G. F. KROGH, Assistant in Drainage

Section of Farm Buildings

H. B. WHITE, B.S., Assistant Agricultural Engineer

Section of Farm Mechanics

J. B. TORRANCE, B.S., Assistant Agricultural Engineer

Section of Land Clearing

M. J. THOMPSON, M.S., Associate in Land Clearing Investigations
 A. J. SCHWANTES, Assistant in Land Clearing Investigations

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, B.S., Assistant in Beef Cattle Husbandry

Section of Swine Husbandry

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

Section of Sheep Husbandry and Meats

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

DIVISION OF BEE CULTURE

FRANCIS JAGER, Apiculturist

G. C. MATTHEWS, Assistant Apiculturist

JAMES M. THOMPSON, B.S., Assistant

DIVISION OF DAIRY HUSBANDRY

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

Section of Dairy Products

*J. R. KEITHLEY, M.S.A., Dairy Husbandman

C. D. DAHLE, M.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., Assistant Dairy Husbandman

T. W. GULLICKSON, M.S., Assistant Dairy Husbandman

L. M. THURSTON, B.S., Assistant in Dairy Husbandry

Section of Dairy Bacteriology

HAROLD 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 (State Entomologist)

F. L. WASHBURN, M.A., Economic Entomologist

R. N. CHAPMAN, Ph.D., Associate Entomologist, Stored Products Insect Investigations

H. H. KNIGHT, Ph.D., Assistant Entomologist, in Charge of Collections

S. A. GRAHAM, Ph.D., Research Assistant, Forest Insect Investigations

†J. R. PARKER, M.S., Research Assistant in Entomology

‡A. L. STRAND, B.S., Research Assistant in Entomology

§PAUL GILMER, M.S., Research Assistant in Insecticidal Investigations

||O. C. MCBRIDE, A.M., Research Assistant in Insecticidal Investigations

C. E. MICKEL, M.S., Research Assistant in Entomology

W. E. HOFFMAN, B.A., Assistant in Entomology

C. B. PHILIP, B.S., Assistant in Parasitology

J. R. EYER, M.S., Assistant in Entomology

DIVISION OF HORTICULTURE

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

* Resigned October 1, 1923.

† Resigned March 31, 1924.

‡ Appointed April 1, 1924.

§ Resigned September 30, 1923.

|| Appointed March 1, 1924.

DIVISION OF FORESTRY

E. G. CHEYNEY, B.A., Forester

J. P. WENTLING, M. A., Associate Forester

*J. H. ALLISON, M.F., Associate Forester

RAHAEL ZON, F.E., Director Forest Experiment Station at Cloquet

T. S. HANSEN, B.S. in For., Assistant Forester at Cloquet

S. S. BURTON, B.S., Assistant

Section of Pomology

W. G. BRIERLEY, M.S., Associate Horticulturist

J. A. MIDDLETON, B.S., Assistant in Horticulture

†A. C. HILDRETH, B.S., Assistant in Horticulture

Section of Fruit Breeding

J. H. BEAUMONT, B.S., Assistant Horticulturist

A. N. WILCOX, M.S., Assistant Horticulturist

‡J. H. SHOEMAKER, M.S., Assistant in Horticulture

Section of Vegetable Gardening

§W. T. TAPLEY, M.S., Assistant Horticulturist

F. A. KRANTZ, Ph.D., Assistant Horticulturist

||B. I. BURRELL, B.S., Assistant Horticulturist

¶KENNETH B. LAW, B.S., Assistant in Horticulture

Section of Floriculture and Landscape Gardening

**LEROY CADY, B.S., Assistant Horticulturist

††C. E. CARY, B.S., Assistant Horticulturist

L. SANDO, Florist

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, M.S., Assistant Plant Pathologist

‡‡A. W. HENRY, Ph.D., Assistant Plant Pathologist

‡‡C. R. HURSH, Ph.D., Assistant Plant Pathologist

*LOUISE DOSDALL, Ph.D., Mycologist

* On leave, 1923-24.

† Appointed September 16, 1923.

‡ Appointed November 1, 1923.

§ Resigned October 1, 1923.

|| Appointed September 16, 1923.

¶ From September 15 to October 31, 1923.

** Died September 12, 1923.

†† Appointed October 1, 1923.

‡‡ Co-operating with the Office of Cereal Investigations, Bureau of Plant Industry, United States Department of Agriculture.

J. L. SEAL, M.S., Assistant Plant Pathologist
 H. H. FLOR, B.S., Assistant in Plant Pathology
 H. C. GILBERT, M.S., Assistant in Plant Pathology
 HENRY HECKER, B.S., Assistant in Plant Pathology
 R. M. NELSON, B.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
 M. N. LEVINE, M.S., Pathologist
 E. B. LAMBERT, M.S., Agent
 HELEN HART, Agent

Section of Plant Physiology

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

Section of Seed Laboratory

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

DIVISION OF POULTRY HUSBANDRY

A. C. SMITH, B.S., Poultry Husbandman

DIVISION OF SOILS

F. L. 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.S., Assistant Soils Chemist
 G. B. BODMAN, M.S., Assistant
 WILLIAM METHLEY, Assistant
 REUBEN PINCKNEY, M.S., Assistant
 JAMES S. HALL, Assistant
 ELLA NELSON, 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 X. SICHLER, B.S., Technician