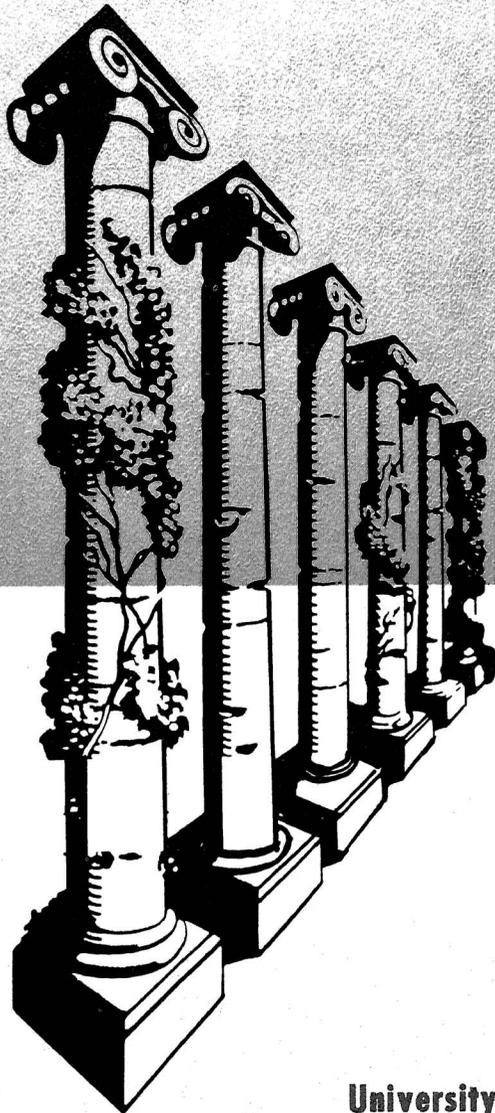


ANNUAL REPORT



1961-62

**University of Missouri
Agricultural Experiment Station
September, 1963
Bulletin 811
E.R. Kiehl, Director
S.B. Shirky, Associate Director**

UNIVERSITY OF MISSOURI
COLUMBIA

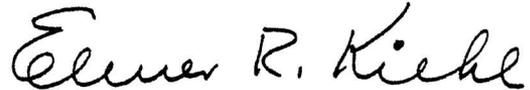
AGRICULTURAL EXPERIMENT STATION
OFFICE OF THE DIRECTOR

Dr. Elmer Ellis, President
University of Missouri
Columbia, Missouri

Dear Sir:

I have the honor to submit herewith, the Annual Report of the Missouri Agricultural Experiment Station for the year ended June 30, 1962.

Respectfully,


Elmer R. Kiehl
Director

AGRICULTURAL EXPERIMENT STATION

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Poultry - Funk, Ernest M., Ph.D.
Rural Sociology - McNamara, Robert L., Ph.D.
Soils - Smith, George E., Ph.D.
Veterinary Medicine - Groth, A. H., D.V.M., M.S.

Outlying Experiment Farms and Research Centers

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Howard Brown, Foreman, North Missouri Research Center
Carl Hayward, M.Ed., Supervisor, Southwest Research Center
Gerald Wright, B.S., Supervisor, Weldon Springs Research Center
Horace Peet, B.S., Superintendent, Hatch Dairy Farm

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FOREWORD

Have you read of the millions of the people of the world who go to bed hungry every evening? Such happenings often seem unreal to us. It's hard to imagine such a situation ever happening on a widespread basis here in Missouri--or in the United States.

We're blessed with an abundance of wholesome, nutritious, and inexpensive food. This makes us much more fortunate than many other peoples of the world.

Some estimates are that as much as two-thirds of the world's population has the daily concern of producing and buying enough food to avoid hunger or actual starvation.

What makes this nation's agriculture different from that of many other countries? What has brought about this miracle of modern American agriculture?

Research! This is the answer in a single word.

****Research** is responsible for the efficiency of our present-day agriculture. Today, one American farmer produces enough food and fiber for 27 people. This means that only seven percent of our population is needed to produce our food supply. In other countries of the world where farming methods have changed little through the centuries, up to 50 percent of the population works at producing an inadequate food supply.

****Research** is responsible for our present low food prices. Today, Americans spend 20 percent of their income on food for their table. This may sound like a big amount to take out of a person's paycheck. But, let's compare it with some of the other countries of the world. The Japanese spend 42 percent of their incomes for food. West Germans spend 45 percent and the Russians spend 56 percent. In other less progressive countries, the major part of disposable income is spent on food.

****Research** is responsible for making agriculture our nation's largest industry. The assets of agriculture are \$214 billion. This is equal to nearly two-thirds of the market value of all corporation stocks on the New York Stock Exchange. This investment in agriculture represents \$24,000 for each farm employee as compared with about \$16,000 for each worker in the manufacturing industries. In a recent year, farmers used enough steel products to make almost five million compact cars, enough electricity to provide power to the six New England states. Farmers used the equivalent of 15 billion gallons of crude oil, more than any other single industry. They spend \$1½ billion for fertilizer and lime.

Research has played an important role in the development of all aspects of agriculture. Prior to the establishment of our system of land-grant agricultural and mechanical colleges in 1862 and agricultural experiment stations in 1887, American agriculture was no more progressive than that of any other major country in the world. But today, through the past 75 to 100 years, the nation's colleges of agriculture and agricultural experiment stations, working closely with the United States Department of Agriculture and private agricultural industries, have been largely responsible for the miracle that has made this country the unchallenged leader in agriculture.

The Missouri Agricultural Experiment Station has been in operation since 1888. In that year, the University of Missouri's Board of Curators established the Station under the provisions of the federal Hatch Act of 1887, introduced in Congress by Representative W. H. Hatch of Hannibal, Missouri.

In its 74 years of operation from 1888 to 1962, the Missouri Station has made significant contributions to the modern-day miracles of agriculture.

Past and present Missouri research with lespedeza; hybrid corn; soybeans; animal production, feeding, breeding and management; insect and weed control; shelter engineering; and in many other areas are familiar

stories to many Missourians. Not as well known but equally important are current research projects dealing with the complex problems of economic and social adjustments.

Agricultural research is a bargain. Today, the federal government allots more than 250 times as much money to research outside agriculture as it does to the system of land-grant college agricultural experiment stations. This means that less than four-tenths of one percent of total federal research appropriations is devoted to agricultural projects.

The significance of research work at agricultural experiment stations far exceeds that which might be suggested by a comparison of the relatively small agricultural research budgets with the total research budget of the federal government.

Associated with a great educational institution such as the University of Missouri, an agricultural experiment station, in addition to being a constant force for truth and new knowledge, is a vital factor in educating and developing scientists and researchers to service industry and government in their respective research enterprises.

The Missouri Agricultural Experiment Station is one of the state's greatest assets. Its research capability is based on an experienced staff and special facilities. This progress report is only a very brief review of the research that was underway at the Missouri Agricultural Experiment Station during the year ending June 30, 1962.

RESEARCH PROJECTS

AGRICULTURAL CHEMISTRY

M. E. Muhrer, Chairman

GROWTH ABILITY IN AN ANIMAL. (D. T. Mayer, J. F. Lasley, C. E. Stufflebeam.) In animal production the inherent ability of an animal to grow rapidly and economically is of primary importance. There is no simple reliable method (or index) available for the selection of young animals on the basis of their potentialities for rapid and economical growth. Growth is a complex mechanism. Biochemical, enzymatic, endocrine, anatomical, and other factors are intimately involved in the process. A biochemical index comprised of several biochemical criteria appears preferable because the biochemical factors involved in growth can be assessed by simple quantitative or qualitative chemical procedures. Efforts are being made to develop such an index.

Data are being collected on 60 yearling hereford bulls, (on full feed) divided into 6 sire groups of 10 bulls per group. Each bull is weighed monthly and at the time blood samples are collected during 154 day experimental period. Glucose, hemoglobin, and non-sugar reducing substances are determined. Considerable variation has been noticed for levels of glucose and non-glucose reducing substances with a smaller variation between sire groups. Blood glucose levels increase and the other reducing substances decrease as the bulls increase in weight.

Cooperation: Department of Animal Husbandry.

(Project 439).

POSSIBLE COBALT AND ZINC DEFICIENCIES IN CROPS PRODUCED IN MISSOURI. (E. E. Pickett, E. Peiter, J. Williams). There is some indication that certain crops produced in Missouri may be deficient in cobalt and in zinc. Analyses of approximately two hundred samples of cattle and sheep feed have been started and are now near completion and summarization. Samples of corn have been reanalyzed for zinc by the atomic absorption method. During the coming year these analyses will be analyzed and the results published.

(Project 147)

THE SCIENTIFIC ACHIEVEMENTS OF GEORGE WASHINGTON CARVER. (M. E. Muhrer, W. P. Carroll). At the request of the United States Department of Interior and with the financial assistance of that department a study was made of "The Scientific Achievements of George Washington Carver". The chief purpose was to establish the rightful place of the Carver contributions in the evolution of present day achievement in the field of utilization of agricultural products. Whatever notes Dr. Carver kept apparently have been lost. Someone unfamiliar with their value may have destroyed them. They may have been destroyed in a fire that ravaged the Carver museum. They may be in the possession of someone who does not realize their value or who does not care to divulge their contents. Most of Dr. Carver's products were not the result of new ideas or procedure; but rather were adaptations of the result of the experiments of scientists other than Carver to raw materials and prevailing conditions. The lack of publications in established scientific journals has prevented the use of his work in a progressive development of future knowledge. Carver had many of the characteristics of a successful scientist: he was well trained; his early training in Missouri was continued in a Kansas high school with later college training in Iowa; he earned an advanced degree from a Land-Grant College. He used his knowledge to solve problems as he found them; he combined two science disciplines, Botany and Chemistry, to help solve his problems. Carver published his findings widely and unlike many scientists, he wrote in the language and literature of the layman and not particularly for scientific journals; therefore he became more popular to the layman than to the scientist.

Publications: Carroll, W. R., M. E. Muhrer. The Scientific Contributions of George Washington Carver.

A special report prepared and submitted to the Department of Interior National Park Service, 1962.

(Project 451).

RUMEN STUDIES. (G. B. Garner, R. A. Bloomfield, M. E. Muhrer, A. L. Donoho, C. W. Welsch). The ability of ruminants to digest fiber has been of immeasurable economic value down through the ages. It is hoped that one or more compounds may be found which will exert a beneficial influence upon the rumen bacteria in their capacity to digest fiber. Better fiber digestion would mean more efficiency in meat and milk production from forages commonly produced in Missouri. Also, the conversion of non-protein nitrogen compounds to protein by a rumen type fermentation would have far reaching economic possibilities.

Ruminants differ from the non-ruminants in that their anatomical make-up provides for the maintenance of microflora capable of synthesizing essential nutrients. The use of unlimited, unprescribed antibiotic supplements may have deleterious effects upon the rumen flora. An effective method of stimulating, or even replacing, desirable microflora would be most valuable. Bacterial growth represents the key to effective non-protein nitrogen utilization. The understanding of species, numbers, and growth characteristics may point the way to effectively utilizing this potential means of increasing protein.

Silage Studies in an Artificial Rumen. Bovine rumen fluid was employed as inoculum. The rumen microorganisms were reconstituted in a volume of buffer equal to one-fifth the volume of the original rumen fluid. This gave better cellulose digestion and more consistent results than the 1:1 reconstitution previously used. Preliminary trials showed that 0.1 mg of homobiotin depressed the activity of biotin by 30-40% when biotin was added at the 0.1-1.0 microgram level. However, 10.0 mcg of biotin overcame the inhibitory effect of homobiotin. It was demonstrated that the inhibitory effect of homobiotin also was overcome by the addition of higher levels of silage extract. This indicated that the silage factor may be identical with biotin.

The Effect of Frequent Feeding on Urea Utilization in Sheep. Previous reports have shown that fed urea was hydrolyzed to ammonia more rapidly than the corresponding uptake of the ammonia by the rumen bacteria. This resulted in a loss of ammonia and consequently a loss for protein synthesis. It was thought that multiple feeding might reduce this loss. Animals were fed sixteen times a day as opposed to twice daily. The urinary nitrogen was significantly decreased but the fecal nitrogen was increased. This caused no change in nitrogen balance. When the biological value was calculated, a significant increase was found but the value was still much lower than was desirable. Even though the nitrogen balance did not show an increased nitrogen utilization, blood urea and blood albumin indicated that the animal had made better use of the fed nitrogen.

Nitrate Nitrogen Metabolism in Sheep. Since nitrate-nitrogen and urea nitrogen are both non-protein nitrogen, the inter-relationship between the two in a ruminant ration was studied. Six western wethers were placed on a urea, molasses, and corn cob ration for two weeks. Three of these animals were then given an additional 1.5% potassium nitrate and the other three animals 1.1% potassium chloride (equimolar potassium). After ten days a nitrogen balance trial was made on each of the animals. A dramatic reduction in nitrogen balance was indicated.

Nitrate Nitrogen Metabolism in Rats. Two groups of female rats were fed the same corn, soybean diet. To one group, 2.5% potassium nitrate was added and to the other 1.8% potassium chloride was added to obtain equimolar potassium levels. After 30 days the thyroid and adrenal glands were removed and weighed. This experiment was repeated using a younger group of rats and a third experiment was used in which the rats were stressed by cold. The potassium nitrate caused a definite increase in the thyroid gland. The adrenal glands were affected only in older rats. The cold stress caused the greatest increase in thyroid weight.

Nitrate and Cold Stress Effect on Weight, Vitamin A Storage, and Thyroid Function in Rats. Dietary KNO_3 had little effect on weight gains of rats maintained at 23°C but significantly decreased the gains of animals maintained at 5°C. The thyroid glands were significantly larger in the KNO_3 fed animals. Histological examination of the thyroid gland revealed hyperplasia and a decrease in colloid. Assay of thyroid function by use of I^{131} was inconclusive. There was no difference in thyroid uptake of the I^{131} after 70 days while the serum PBI^{131} was significantly higher in the KNO_3 fed animals. Liver storage of vitamin A and carotene was decreased in the KNO_3 fed animals.

Thyroid Compensation Under the Influence of Dietary Nitrates. Nitrate is found in many plant species and in well water normally consumed by domestic animals and man. Recent studies have shown that dietary nitrate interferes with normal metabolism of injected I^{131} . Under normal conditions rats fed KNO_3 show a slight depression in the rate of gain. However, when cold stress is applied the rate of gain is significantly decreased. This indicates that rats can compensate for added nitrate under normal conditions but not under cold stress. This investigation is an effort to determine whether or not the thyroid compensates for the nitrate effect on iodine metabolism.

Two trials were run. Trial I: Female rats were divided into two groups and maintained on the same basal diet. To one group 2.5% KNO_3 was added and to the other group 1.8% KCL was added. Seven hours later they were injected with I^{131} . Trial II: Male rats were divided into two groups and given the same treatments as the animals in Trial I. This trial differed, however, in that each animal was injected with tapazole one hour prior to the injection of I^{131} . Since the tapazole allowed the I^{131} to remain as inorganic iodide, measurements of the iodine flushing action of KNO_3 on the thyroid gland could be made. The last injection at 5.5 weeks was made without tapazole so that PBI determinations could be made and compared to Trial I. Trial I indicated that dietary KNO_3 interfered with thyroidal uptake of the injected dose of I^{131} . This de-

creased uptake was also reflected in a decrease in the amount of I^{131} converted to PBI^{131} . Trial II showed that the KNO_3 fed rats were low in their uptake of I^{131} at the beginning, and lost the majority of this I^{131} within 18 hours. At the end of the second week the KNO_3 fed rats had a greater uptake than the KCL group. The greater uptake was not reflected in the ability to overcome the flushing action of KNO_3 . The fourth week showed a slight decrease in the uptake with an even greater decrease in the ability to hold the I^{131} . The thyroid weights were significantly higher in the KNO_3 fed animals with no difference in adrenal weights. The PBI^{131} was higher in the KNO_3 group. The basal KCL fed group of rats showed no apparent effect of feeding KCL over the four week period. The KNO_3 fed rats had a decreased iodine uptake at the beginning but with time overcame this effect. The flushing of thyroidal I^{131} by KNO_3 was still evident and appeared to be increasing at four weeks. Dietary KNO_3 had a significant effect on increasing the weight of the thyroid gland. This appeared contradictory to the data from Trial I. On the basis of the PBI^{131} determination, the nitrate fed animals should be hyperthyroid with respect to the basal animals. Increased thyrotropin should accelerate metabolism and binding of the injected I^{131} . However, if the injected I^{131} and the dietary I^{127} react similarly then the KNO_3 animals should metabolize more of the dietary I^{127} indirectly decreasing the thyrotropin production. The increase in thyroid weight and increase in PBI^{131} at the termination of the experiment did not support this view.

Publications: Bloomfield, R. A., C. W. Welsch, G. B. Garner, M. E. Muhrer (1961). Effect of Dietary Nitrate on Thyroid Function. Science 134:1690.

Bloomfield, R. A., G. B. Garner, C. W. Welsch, M. E. Muhrer (1961). Effect of Dietary Nitrate on Urea Utilization In Vitro and In Vivo. J. Animal Sci. 20:925.

Bloomfield, R. A. C. W. Welsch, G. B. Garner, M. E. Muhrer (1961). Effect of Sixteen Times a Day Feeding on Urea Utilization. J. Animal Sci. 20:926.

Welsch, C. W., R. A. Bloomfield, G. B. Garner, M. W. Muhrer (1961). Effect of Dietary Nitrate on Thyroid and Adrenal Gland Weight. J. Animal Sci. 20: 981.

Bloomfield, R. A., C. W. Welsch, G. B. Garner, M. E. Muhrer (1961). Nitrate Effects on Urea Utilization. (Manuscript prepared for Mo. Exp. Sta. Bulletin).

Bloomfield, R. A., C. W. Welsch, G. B. Garner, M. E. Muhrer (1961). Nitrate and Cold Stress Effects on Weight, Vitamin A Storage, and Thyroid Function in Rats. (Manuscript prepared for a scientific journal).

Bloomfield, R. A., C. W. Welsch, G. B. Garner, M. E. Muhrer (1961). Thyroid Compensation Under the Influence of Dietary Nitrate. (Manuscript prepared for a scientific journal).

Cooperation: Departments of Animal Husbandry, Dairy Husbandry, and Veterinary Medicine; Feed Service Corporation. (Project 152).

SOFT WINTER WHEAT PROTEINS. (C. W. Gehrke, W. G. Godbey, J. M. Poehlman, P. W. Schmidt.) Understanding of the size, shape, and structure of homogenous soft winter wheat proteins should be of value in improving the quality of baked products and possibly, in the development of new uses for agricultural products. Work was initiated in November, 1961. Since that time equipment has been secured and some methods and techniques selected and applied. Starch gel electrophoretic techniques employing 7 M urea have been developed. A chemical method for fractionation of gluten proteins is being studied. Preliminary differential thermal analysis work has been started on whole wheat gluten samples prepared by the Northern Utilization Laboratories at Peoria. These glutes were obtained from Brevor, Clarkan, Blackhawk, and American Banner wheat flours. Each flour possesses a different differential thermal analysis thermogram. It is planned to isolate the various lipid classes from poor and good quality flours and flour fractions obtained by air classification. The lipids will be characterized by silicic acid column and gas chromatography. The gluten proteins will be isolated by chemical and cellulose column, characterized in starch gel studies, and observed by small angle x-ray scattering.

Cooperation: Department of Field Crops; USDA Soft Winter Wheat Laboratory, Wooster, Ohio and USDA Northern Utilization Laboratories at Peoria, Illinois; North Central Region (Project 459).

UNRECOGNIZED GROWTH STIMULANT IN THE GUINEA PIG. (B. L. O'Dell, E. R. Morris, D. P. Nabb, K. D. Singh, W. O. Regan). A factor that stimulates the growth rate, reproductive performance, and disease resistance in guinea pigs has been found. This study is an effort to identify this factor. The method of assay has been improved and the factor has been obtained in soluble form from both cabbage and alfalfa. An unrecognized salmonellosis resistance factor has also been located. Dried, cooked cabbage, included at 10% of the diet, protected as well as fresh cabbage fed ad libitum. There was some evidence that supplementary arginine was protective but to a lesser degree than cabbage. Magnesium deficiency in the guinea pig resulted in elevated blood inorganic phosphorus and decreased hemoglobin and serum protein levels. The

inorganic phosphorus level was lowered within a few days by supplementary magnesium; but hemoglobin returned to normal only after several weeks. Magnesium deficiency depressed the rate in which excess phosphorus was excreted by the kidney. Kidney clearance studies showed that both phosphorus and creatinine clearance values were lower in deficient animals.

Identification of the unrecognized growth factor in plants would be of scientific interest and perhaps of economic importance. Certainly, a salmonellosis resistance factor would be of great economic value. This work will be continued in an attempt to isolate and identify the unrecognized factors described above.

Publications: Morris, E. R., B. L. O'Dell. Magnesium deficiency in the guinea pig. Mineral composition of tissue and distribution of acid-soluble phosphorus. *J. Nutr.* 75, 77 (1961).

O'Dell, B. L., D. P. Nabb, G. B. Garner, W. O. Regan. A salmonellosis resistance factor for the guinea pig. *Proc. Soc. Exp. Biol. Med.* 108, 512 (1961).

Cooperation: National Science Foundation

(Project 149).

ABNORMAL DEVELOPMENT OF THE HORNY LAYER OF SKIN OF SWINE AND POULTRY (PARAKERATOSIS). (D. Oberleas, M. E. Muhrer). Parakeratosis is a nutritional problem on some farms. A better understanding would be of benefit to swine and poultry producers. Recently, phytic acid has been related to zinc absorption and metabolism.

In the interest of economy, rats have been used for preliminary studies on the metabolic aspects of Parakeratosis and zinc-phytic acid interrelationships and have proved satisfactory. It is realized that final tests will have to be made with economic farm animals. In three feeding experiments rats receiving diets containing phytic acid, regardless of source, showed significantly slower growth rates. Several of the experimental animals evidenced Parakeratosis when receiving phytic acids at relatively low zinc intakes. High calcium diets depressed growth slightly more than low calcium diets in the presence of phytic acid. Blood analyses indicated no phytic acid absorption. This indicated Parakeratosis was metabolically a zinc deficiency and that the effect of phytic acid was one of malabsorption.

This work will be continued to include: (1) The role of protein on zinc availability, (2) Intestinal phosphatase, and (3) Inositol phosphates.

Publications: Oberleas, D., M. E. Muhrer, B. L. O'Dell and L. D. Kintner. 1961. The Effects of Phytic Acid on Zinc Availability in Rats and Swine. *J. Ani. Sci.* 20:945.

Oberleas, D., M. E. Muhrer and B. L. O'Dell. 1962. Effects of Phytic Acid on Zinc Metabolism in Swine. *J. Ani. Sci.* (in press February, 1962).

Cooperation: U. S. P. H.

(Project 56).

CHEMICAL AND PHYSIOLOGICAL STUDIES WITH ANIMAL GERM CELLS. (D. T. Mayer, M. Bartek, Y. Matsumoto, D. E. Grogan, C. E. Stufflebeam, C. M. Hendricks). Basic information is necessary to help in the solution of practical and economic problems in natural and artificial breeding of farm animals. Marked differences have been noted in mature and immature spermatozoa in (1) ability to fertilize ova, (2) resistance to cold shock, and (3) metabolic activity. Efforts are being made to discover the causes of these differences.

Comparative Study of the Lipoprotein-Carbohydrate Complex of Mature and Immature Spermatozoa. (Y. Matsumoto, D. T. Mayer). The most marked difference in mature and immature spermatozoa is in the relative resistance to cold shock and other adverse environmental conditions. Since phospholipids and lipoproteins protect spermatozoa from adverse conditions, a study has been made of the lipoprotein-carbohydrate complex in these two types of cells. A dilute solution of sodium hydroxide extracted approximately twice as much lipoprotein-carbohydrate complex from mature cells as from immature cells. The total lipid content of mature cells was about 10% on a freeze-dried basis whereas immature cells showed approximately 17 to 18 percent. These were regarded as striking differences.

The Histone-Like Basic Protein of Bovine Spermatozoa. (D. M. Hendricks, D. T. Mayer). Previous work resulted in the isolation of proteins of mature and immature spermatozoa which were combined as nucleoproteins with the DNA of these cells. The basic protein apparently was a histone. This was compared chemically with thymus histone and the protamine of salmon spermatozoa. The protein in the nucleoprotein of immature spermatozoa was more acidic and more complex with a greater concentration of neutral and acidic amino acids than the more basic and less complex histone of mature spermatozoa. The histones of calf-thymus nuclei and those of mature bovine spermatozoa differed slightly in amino acid ratios and markedly in arginine-lysine ratios, whereas mature and immature spermatozoa were similar in their arginine-lysine ratios but varied in amino acid ratios. The histones of mature mammalian spermatozoa was not a single entity but a mixture of a number of histones. It was expected that the DNA - the carrier of the genes - would be more complex in mammals than in fish, or the nuclei of somatic cells of the same species;

therefore, the heterogeneity of proteins attached to the DNA may reflect complexity of the DNA. This is merely an hypothesis. Studies have been started to test this hypothesis of the process of maturation division and genetic mechanisms. To date, the work has been limited to methodology for the isolation of histones in pure form. This work will be continued using zone electrophoresis, chromatographic techniques, and similar methods.

A Comparative Study of the Nucleic Acids of Immature and Mature Bovine Spermatozoa. (D. E. Grogan, D. T. Mayer). Previous research has shown that mammalian spermatozoa contain no RNA (Ribonucleic acid). Efforts have been centered upon the development of a quantitative method for the isolation of DNA in pure form. Bovine spermatozoa has been shown to contain a high concentration of keratin which is a protein with low solubility in most reagents. Sperm cells have been treated with thioglycolic acid to solublize the keratin prior to extraction of the DNA. The Sloan-Kettering Institute for Cancer Research has helped by supplying information of value in separating the proteins from DNA. A method for the isolation and purification of spermatozoan DNA has been developed which yields a maximum amount of pure protein free DNA. DNA of both mature and immature sperm cells is heterogeneous, that is composed of a number of different kinds of DNA molecules. The DNA of mature and immature spermatozoa were formed to be much alike in their constitution.

Characterization of the DNA of Bovine Spermatozoa. (M. J. Bartek, D. T. Mayer). Differences in the chemical constitution of nucleic acids are the result of differences in the number, type, and linear sequence of the purine and pyrimidine bases in the different nucleic acids. This phase of the study is an effort to determine the number, type and sequence of the purine and pyrimidine bases of the DNA of bovine spermatozoa. The DNA of mature spermatozoa has proved to be the most difficult to purify. The usual methods employed for separating the histones and other proteins from their attachments to the DNA molecule did not result in pure protein free nucleic acid. After many methods were tried a combination of procedures proved satisfactory and a maximum yield of pure DNA has been produced. It is planned to hydrolyze the DNA - separate into constituent molecules - and determine qualitatively and quantitatively the purine and pyrimidine bases using chromatographic and other techniques.

Publications: Miller, L. D., D. T. Mayer, and C. P. Merilan. The Lipids of Spermatozoa I. Isolation and Characterization of Seven Classes of Lipids from Bovine Spermatozoa. Expt. Cell Research (in press).

Bartek, M. J., D. T. Mayer. The Lipids of Spermatozoa II. Isolation and Characterization of the Phospholipids of Boar, Ram, and Bovine Spermatozoa. Expt. Cell Research, 1962.

Orsini - Madera, Frank and D. T. Mayer. The Lipoprotein Carbohydrate Complex of Bovine Spermatozoa. (Manuscript in Preparation)

Cooperation: Department of Dairy Husbandry; U. S. P. H. (Project 81).

IODINE - NITRATE - THYROID RELATIONSHIPS. (G. B. Garner, M. E. Muhrer, D. L. Pugh, A. L. Donoho, R. A. Bloomfield, E. O. Kearly, L. M. Flynn, B. L. O'Dell, K. P. Yaday). Forages supply the bulk of the nutrients for ruminant rations. The continued use of high level fertility; new species introduction; variety changes; and the increased economical pressure to feed ruminants the least costly ration demands the utmost vigilance of all the feed constituents used in the production of animals that ultimately furnish human food. Further studies on the *in vitro* oxidation of carotene by nitrite have indicated spectral changes related to pH of the medium, time, and concentration of nitrite. Beta apo (8' and 12') carotenals appeared more resistant to oxidation by nitrite than carotene. Vitamin A was sensitive to pH and reacted to nitrite in a pattern similar to carotene. The nitrate spaces of bovine and ovine were found to be 20 and 29% respectively when nitrate alone was injected. When urea nitrate combinations were injected the values rose to 32% and 36% respectively.

Ration iodine levels were studied in rats on synthetic diets by assaying for vitamin A stored in the presence of carotene and nitrate. This was a preliminary study and indicated a pathway for studying the thyroid carotene interaction.

Muscle dystrophy could not be induced in guinea pigs by feeding nitrate. However, the dystrophic condition was related to dietary fat sources and the vitamin E level in the diet.

Publications: Garner G. B., *et al.* Urea and Nitrate Ion Clearance in Sheep. J. Animal Sci. 20, 771 (1961). G. B. Garner in "A Century of Nutrition Progress", Library of Congress Catalog card 61-18610.

Cooperation: U. S. P. H.; Moorman Manufacturing Company. (Project 247).

THE SIZE, SHAPE, AND STRUCTURE OF MILK PROTEINS. (C. W. Gehrke, W. G. Godbey, P. W. Schmidt). Heat denaturation of proteins in milk during various processing operations causes severe losses in evaporated milk and other concentrated milk products. In an attempt to solve this problem the stability of

milk proteins is being studied. This has involved the study of the size, shape, and structure of various milk caseins; the thermal stability of the molecules; and the effects of heat on their secondary and tertiary structure. Also studied have been the protein-protein and protein-solvent interactions and the changes in the size, shape, and structure due to rennin action. The small angle X-Ray scattering technique was used in making these studies. The radii of gyration of K- and K₁- casein did not change significantly due to heating at 75°C for 5 minutes, but the intensity of the scattered radiation increased. After standing for 24 hours at 4°C the intensities were back to their original values. Casein fractions, a-, a₁-, a₂-, and a₃- have been prepared by the Hipp et. al. method. Kappa casein has also been prepared by the Wake method. Fractions of a-, K-, and λ- caseins have been isolated by DEAE cellulose column chromatography.

Studies will be made on the effect of heat and rennin on these casein fractions during the coming year.

Publications: Godbey, W. G., C. W. Gehrke, and P. W. Schmidt. Molecular Structural Studies on Casein.

Part I. Small Angle X-Ray Scattering. (Accepted for publication in Journal of Dairy Science, January, 1962.)

Cooperation: Department of Physics

(Project 148).

EFFECTS OF AMINO ACIDS AND MINERALS ON THE GROWTH OF CHICKS. (B. L. O'Dell, C. Limbaugh). It has been observed that chicks fed casein as a source of amino acids have an unusually high arginine requirement. Chicks were fed a 35% casein diet, suboptimal in arginine. The growth rate was stimulated by the addition of glycine, glutamic acid, and leucine but not to the same extent as by arginine. The addition of lysine to the basal ration depressed growth markedly, but this depression was overcome in a competitive manner by excess arginine but not by the other amino acids used. Soy protein contained sufficient arginine to support a maximum growth rate, but the addition of excess lysine produced symptoms typical of arginine deficiency. This indicated a true arginine-lysine antagonism.

The growth rate of chicks fed the basal diet which contained 0.4% of potassium was stimulated to a remarkable degree by salts of weak acids such as potassium acetate and potassium carbonate but not by potassium chloride. Since KCL did not improve the growth it appeared that excess cations were required for metabolism of high nitrogen diets. Phytic acid, a constituent of plant but not an animal protein, decreased the availability of zinc. There was an interaction between calcium, phytic acid, and zinc: that is, calcium decreased zinc availability in the presence but not in the absence of phytic acid. The work on the metabolism of arginine and zinc will be continued.

Publications: O'Dell, B. L., J. M. Yohe, J. E. Savage. Interaction of calcium and phytic acid on zinc availability. Poultry Sci. 40, 1438 (1961).

O'Dell, B. L., B. C. Hardwick, G. Reynolds, J. E. Savage. Connective Tissue defect in the chick resulting from copper deficiency. Proc. Soc. Exp. Biol. Med. 108, 402 (1961).

Cooperation: Department of Poultry Husbandry; Monsanto Chemical Company

(Project 137).

INTRA-UTERINE EMBRYO SURVIVAL IN RATS. (D. T. Mayer, J. F. Lasley, M. S. Fahim.) The factors influencing litter size in swine are of great economic importance. In order to reduce expense, basic studies have been made with rats. These studies have now been completed on the factors affecting inter-uterine embryo survival. The results show: (1) the administration of progesterone and estradiol (1:2000 ratio) significantly increased embryonic survival and increased uterine growth (increased in DNA in uterus); (2) thyroxine, even in females with a low thyroid secretion rate (TSR) had no effect on number of viable embryos but tended to increase uterine growth; (3) vitamin B₁₂ had no beneficial effects; (4) no correlation existed between TSR and embryonic survival; and (5) rats varied greatly in TSR. The results of these pilot, or exploratory, experiments with rats have provided results which will be applicable to future research in experiments with the litter size in swine. In the next experiments, swine will be used.

Publications: Mayer, D. T., B. R. Glasgow, A. M. Gawienowski. Metabolites of Progesterone and their Physiological Significance in the Urine of Pregnant and Non-Pregnant Sows and Gilts. Journal of Animal Science 20, 66-70, 1961.

Cooperation: Department of Animal Husbandry.

(Project 223).

IMPROVED METHODOLOGY FOR DETERMINING VITAMIN A AND FOLIC ACID. Requests for assays of vitamin A in feeds, feed supplements, blood plasma, or liver occur most frequently during the late fall, winter, and early spring months. During these months many days of high humidity occur which interfere with the use of the Carr-Price method. An assay method usable under all weather conditions would be most helpful.

Assays of vitamin A in 130 samples, (feed, blood, liver) were used as bases of studies to improve methodology. Results computed from corrected Beckman DU absorbancies of hexane extracts of "A" from ovine

plasma and liver agreed (\pm 10%) with Carr-Price data, obviating the use of the inconvenient and at times unreliable SbCl_3 test. Tests showed that column chromatography concentrated "A" and permitted its separation from contaminants (e. g. - carotenoids) in the extracts. The fluorescence of "A" in UV light facilitated a quick check for "A" in the hexane fractions. A thorough literature search was made to find methods used or suggestions for assays of the folic acid family (folic acid, citrovorum factor, p-aminobenzoic acid, pre-folic A, tetrahydro folic acid, etc.) as a prelude to experiments designed to improve extraction and assay of folic acid activity. Information from this literature will be summarized and correlated. Exploratory laboratory work has been done to improve these assays.

Publications: Holst, W. O., L. M. Flynn, G. B. Garner, W. H. Pfander. Dietary Nitrite Vs. Sheep Performance. *J. Animal Science* 20, No. 145, p. 936 (1961).

Cooperation: U. S. P. H.

(Project 212).

RELATIONSHIP OF MATERNAL NUTRITION, CONGENITAL NUTRITION, AND CONGENITAL MALFORMATIONS. (B. L. O'Dell, B. A. Erickson, W. Woods). Studies relating maternal nutrition and congenital nutrition and congenital malformation involved minerals, vitamins, drugs, and carbohydrates. A mild zinc deficiency produced by feeding a soy protein diet increased bone defects but did not cause hydrocephalus. A high level of copper in the diet accentuated zinc deficiency. A combination of zinc and vitamin B_{12} deficiencies was at least additive in detrimental effect. Copper deficiency caused severe edema and subcutaneous hemorrhage among the newborn, but no hydrocephalus. The addition of a high level of zinc to the copper deficient diet caused hydrocephalus. A low incidence of hydrocephalus occurred among the offspring of dams that consumed whole-milk diet. This was probably due to lactose in as much as the addition of lactose to a purified, "simulated-milk" diet produced hydrocephalus whereas glucose did not. Aureomycin added to a stock diet at a level of 0.1% during the gestation produced 1.6% hydrocephalus; penicillin produced none. The lipid concentration in livers of control newborn rats was about 2% of the wet weight at birth and it was not affected by maternal vitamin B_{12} deficiency. When allowed to nurse, the concentration in the control livers nearly doubled within 12 to 18 hours, but there was little change in deficient livers. Presumably the deficient animals did not nurse either because milk was unavailable or they were unable to do so. Liver lipid in weanling rats born to dams fed a vitamin B_{12} deficient diet was nearly double the concentration in controls whereas the phospholipid concentration in brain was decreased. These observations were not affected by dietary methionine suggesting that B_{12} plays a role unrelated to methyl group synthesis. It is planned to make histological studies and biochemical analysis of tissues from aged rats fed the materials described above.

Publications: O'Dell, B. L., B. C. Hardwick, G. Reynolds. Mineral deficiencies in milk and congenital malformations in the rat. *J. Nutrition* 73, 151 (1961).

Erickson, B. A., B. L. O'Dell. Major dietary constituents and vitamin B_{12} requirement. *J. Nutrition* 75, 414 (1961).

Cooperation: U. S. P. H.

(Project 151).

IMPROVED METHODS TO DETERMINE HERBICIDE RESIDUES. (C. W. Gehrke.) Work in this area is new and an effort is being made to utilize gas chromatographic methods for the determination of residues of herbicides. Literature has been reviewed and conferences have been held with representatives of some of the manufacturers of herbicides. Preliminary gas chromatographic studies have been made on some substances.

Cooperation: Departments of Field Crops and Horticulture.

(Project 473).

STARCH MODIFICATION FOR NON-FEED USE. (G. B. Garner.) This is a new project just being started in cooperation with the North Central Region. Starch is the number one surplus agricultural product in this country. Progress to divert starch into non-feed uses or to improve its food value for export markets will have a beneficial effect for the American farmer. Efforts are to be made to modify starch with nitrogen, in the hope that the resulting compound will be in a food classification that is in short supply (world wide protein shortage) or that a new compound could be developed that would have useful properties in non-food use.

Cooperation: North Central Region.

(Project 488).

FORAGE TESTING. (G. B. Garner, A. L. Donoho.) Forages constitute a major portion of ruminant rations and the inherent variability in the quantity and quality of each nutrient make accurate ration formulation difficult. The major nutrients, protein and fiber, are easily determined by chemical techniques. More accurate formulation of rations can be based upon such analyses. As a service to farmers formulating rations a project has been developed to provide analyses upon request and upon the payment of a fee approximating

the cost of the work. As of January 31, 1962, a total of 303 samples had been analyzed for moisture, protein, and fiber. Digestible protein and total digestible nutrients were calculated by the Penn State Method. Protein was determined by the Kjeldahl Method and fiber by a modified method developed at this station last year. Nineteen percent of the samples received were corn silage, 21% alfalfa hay, 25% grain and grain mix, and 16% other hays (but not including mixed legume grass). Protein ranged from 4.4 to 16.6% for silages, 11.9 to 22.9 for alfalfas, fiber ranged from 11.3 to 39.0 for all silages, and 19.0 to 34.5 for all alfalfas. Nitrate value also was checked and 22% of the forages tested were diphenylamine positive. Quantitative values ranged from 0.02 to 2.55% KNO_3 equivalent. Fifteen samples were above 0.3% and six above 0.5%.

Publications: The nature of this work has been described in various news articles and media.

(Project 476).

AGRICULTURAL ECONOMICS

Wendell McKinsey, Chairman

RELATION OF RECREATIONAL RESOURCES TO INCOME IN THE MISSOURI OZARK REGION. (F. Miller, R. D. Fenley, R. Bird). The Ozark plateau of Missouri has long been recognized as an area where natural recreational opportunities are abundant but where agricultural resources are somewhat limited. There is much interest in developing the recreational resources of this area.

Two studies have been completed. One dealt with the contributions of the tourist trade; the other with the contributions of summer residents to the economy of Taney County. Primary data was obtained from 797 operators of retail and service establishments. This information was combined with secondary data to determine the proportion of the tourist dollar that goes to rural people; the relative importance of the tourist trade to the area; and the characteristics of the operators and employees of retail establishments; the opportunities afforded rural people to increase their incomes from the tourist trade; and the potential income to the people in the area from this source. Data were obtained from 54 summer residents and combined with the secondary data to determine the extent of the contribution of summer residents to the economy. In 1960 the summer residents of Taney county owned 16% of the residential property and at the peak of the vacation period were equal to 10% of the population. The average time that the summer residents spent in Taney county was 106 days and they spent \$1,188 on the average for items while they were in the County. Their total annual expenditure was \$590,000. It was estimated that by 1975 the summer residents in this county will be expending \$2,297,000 for living expenses; \$73,548 in taxes; and possibly over \$5,000,000 annually for the construction of new homes. They may represent over 50% of the total population during the summer months. It is planned to make a sample survey of recreational facilities in the Ozark area to determine the capital invested in each major type of recreational facility per man employed.

Publications: Bird, R., F. Miller. Where Ozark Tourists Come From and Their Impact on Local Economy.

Missouri Agriculture Experiment Station Research Bulletin No. 798, May 1962.

Bird, R., F. Miller. Contributions of Tourist Trade to Incomes and People in Missouri Ozarks. Missouri Agriculture Experiment Station Research Bulletin No. 799.

Bird, R., F. Miller. Contributions of Part Time Residents to the Economy of Taney County Missouri.

Missouri Agricultural Experiment Station Research Bulletin No. 814.

Cooperation: Rural Development Branch, Farm Economics Division, Economic Research Service; U.S.D.A. (Project 425).

EFFECTS OF CLIMATE ON RESOURCE USE. (J. P. Doll, M. S. Stauber, D. H. Silva, J. D. McQuigg). By computing evapotranspiration, soil moisture budgets were determined. Drouth days determined by using these budgets were correlated with corn yields from one of the plats from Sanborn Field at Columbia, Missouri to discover which had the highest correlation with yields. Total drouth days during the season were not satisfactory measures of the weather input for corn. Subdividing drouth days by months did not improve the correlations to any degree. When drouth days were divided into weeks 68% of the variation was explained using one method and 52% by another. Correlation of weekly rainfall with corn yield explained 75% of the variation. Drouth days occurring during the last week in June and during July had the highest detrimental effect on corn yields at Columbia. Rainfall during this same period had the most beneficial effect. The measuring of weather inputs will be continued, especially with "rainfall distribution" and its effect upon yield.

Publications: McQuigg, J. D., J. P. Doll. Weather Variability and Economic Analysis. Missouri Agricultural Experiment Station Bulletin, No. 771, 1961.

McQuigg, J. D., J. P. Doll. Economic Analyses Involving Random Weather Inputs. Journal of Farm Economics, November 1961.

Ewalt, R. L. A Comparison of Selected Measures of Drouth. A Master's thesis submitted to the Graduate School, University of Missouri. (Project 389).

WATER RESOURCES. (M. Gaffney, T. Crocker). Concern with the use and management of water resources has been rapidly increasing throughout the nation and especially in the North Central states. Farmers in the North Central area are very much interested in the use of water for agricultural irrigation; and the number of acres under irrigation has increased greatly in the last 10 years. A proposed system has been developed and published for economical allocation of water and economic pricing of transport utility networks. The results indicated how limited water supplies may be devoted to the most economical uses.

Publications: Gaffney, M. The Unwieldy Time Dimension of Space. American Journal of Economics and Sociology 20 (5):465-81 (October 1961).

Gaffney, M. Ground Rent and the Allocation of Land Among Firms. A paper presented to the North Central Tenure Research Committee; Farm Tenancy Sub-Committee, Chicago, April 12, 1961 In Symposium on Farm Rentals.

Gaffney, M. Land and Rent in Welfare Economics. Chapter 8. Land Economics Research Symposium. To be published by the Farm Foundation and Resources for the Future, summer 1962.

Gaffney, M. Water Law and Economic Transfers of Water; A reply. Scheduled for publication, Journal of Farm Economics, May 1962.

Gaffney, M. Water Supply. A review of a recent book by the same name, for publication in the Appraisal Journal, April 1962.

Gaffney, M. Comparison of Market Pricing and Other Means of Allocating Water Resources. A paper presented before the Southeastern Water Law Conference, November 7-10, 1961, University of Georgia, Athens, Georgia.

Gaffney, M. Containment Policies for Urban Sprawl. A paper presented before the Seminar on Urbanization in the Missouri River basin; sponsored by the Ford Foundation, October 26, 1961, Kansas City, Missouri. (Project 363).

TRENDS IN THE AGRICULTURAL DEVELOPMENT OF MISSOURI. (J. P. Doll, E. H. Hudson, K. E. Miller). The broad and rapid changes in agriculture taking place in Missouri should be described in order that this information may be available to all who may have need for it (individuals, farm organizations, agricultural industries, research and extension workers). Such information may also be useful in anticipation of future needs in the various areas of the State.

A substantial amount of economic data relative to Missouri Agriculture has been compiled and tabulated on IBM cards. This information is now available. Changes for the entire State and for crop reporting districts have been completed and trends have been compared to trends in the United States. Data collected and preparation of a manuscript is under way. Changes in the agriculture of the various counties of Missouri have been studied. Because of the large number of counties only data from selected counties can be used. Another study is under way relating to the determination of farm income in Missouri counties. Methods are being studied to develop information to show the best procedure for analyzing secondary data to determine county farm incomes. County incomes are being computed for 10 counties (at least one in each crop reporting district) for two years, 1949 and 1959. Apparently the data available is adequate to compute reasonably satisfactory estimates of county incomes. Addition information will be collected and placed on IBM cards to complete the series. If the methods developed prove satisfactory, estimates of farm income for additional counties will be undertaken.

Publications: Saig, E. N., J. P. Doll. Agricultural Production Trends in Missouri Counties. A manuscript prepared for publication as Missouri Agricultural Experiment Station Research Bulletin

USE OF FARM RESOURCES. (F. Miller, D. L. Williams, R. Bird). Farming has become a high volume, low margin business. Improvements in farm organization and operation have become essential. Methods of gaining control of land and capital equipment so that they can be used in efficient combinations with labor and management, offer a good key to the solution of the adjustment problem.

Data from the Marshall soils area of Northwest Missouri and adjoining states and from the Southwest Missouri dairy area were analyzed. Livestock-share tenants operated larger businesses, received

larger total incomes, and had larger output per unit of resource input than did owner-operators or crop share cash tenants. These findings were not conclusive as to whether or not the varying rates of output per unit of input were due to scale of operations alone. There is a need to have information as to the qualitative and managerial influences as well as the quantitative aspects of resources. In Southwest Missouri labor earnings of dairy farmers were significantly related to output per cow. Labor earnings and the percent of feed that was purchased had significant negative correlations for both Grade A and Grade C producers; indicating that it was unprofitable to purchase feed for dairy cows at the prices paid and received. A final report on this project will be prepared.

Publications: Two manuscripts, one entitled "Scale of Farming Operations and Efficiency of Resource Use Under Alternative Tenure Arrangements" and the other entitled "Factors Affecting Income on Dairy Farms in Southwest Missouri" have been prepared.

Cooperation: Agricultural Economics Departments of the Iowa Agricultural Experiment Station; the Nebraska Agricultural Experiment Station; and the Kansas Agricultural Experiment Station; the Land and Water Research Branch, Economics Research Service, U. S. D. A. ; the Farm Foundation.

ANALYSIS OF AREA ECONOMIC DEVELOPMENT. (J. R. Tedford). There is much interest in economic growth and development, particularly as it relates to "underdeveloped" areas. This project was designed to assess agricultural potential in certain areas of Missouri. However, after preliminary studies were made the project was discontinued because of limitations in personnel and funds. This does not mean that work in this area is unimportant; it does mean that it should not be undertaken until adequate resources are available. It will require a substantial amount of work. (Project 475).

REGULATORY DEVICES IN THE USE OF RESOURCES. (F. Miller, J. T. Sanderson, F. L. Mann). Efforts of individual owners and tenants to maximize immediate income have resulted in highly intensive uses of most of the agricultural land in the United States. The output of wheat, cotton, corn, tobacco, and other agriculture products as a result exceeds the quantity that can be sold on a free market at satisfactory prices. There is great need for a plan to minimize this situation.

This work deals with the laws of Missouri and Nebraska that permit an agency of the State or Federal government to purchase permanent cropping rights in land to control the output of surplus commodities. The work has been completed and is now in process of summarization for final publication.

Publications: A preliminary report has been mimeographed for review. It has not been approved as the official publication of the cooperating agencies.

Cooperation: Nebraska Agricultural Experiment Station; Agriculture Law Center of University of Iowa (Project 440).

A PROGRAM FOR COLLECTING AND DISSEMINATING AGRICULTURAL MARKETING INFORMATION. (J. F. West, W. J. Free). Improvement in the present market news reporting system is needed. Growth of direct selling and the bypassing of traditional wholesale markets has indicated the need for the development of a system of recording of local prices for use by producers and shippers in evaluating price offers. Accurate and reliable information about supplies and prices would increase the efficiency of the pricing system and benefit both consumers and producers.

The State was divided into 8 areas and priorities were assigned to the areas and to the commodities produced within each of the areas. The areas were delineated on the basis of crop reporting districts, concentration of production of various commodities, adaptability of commodities produced in an area to reporting by an area reporter, and the flow of products to market. Priorities in assignment of area reporters were based on commodities produced, price variations, availability of other market information, and the existing market structure. A proposed plan was developed and submitted to the Missouri Department of Agriculture for use in carrying out the market information program. Surveys of farmers and marketing firms will be conducted to provide an indication as to needs and to evaluate the program now being conducted by the Missouri Department of Agriculture.

Cooperation: Marketing Economics Division, ERS, U. S. D. A. ; Marketing Division, Missouri State Department of Agriculture (Project 458).

CHANGING PATTERNS OF MISSOURI LIVESTOCK MARKETS. (D. Brewer). Meat animals contribute one-half of the cash income of Missouri farmers. Five public stock yards markets and about 200 local markets including auctions are located within the State. These marketing agencies along with the processing plants, transportation agencies, and other allied services are dependent upon the livestock industry of the State. The efficiency of these marketing agencies to perform the services of marketing, processing, and distribution of

livestock and meat products is of great importance to the farmers of Missouri. Since 1940 there have been substantial changes in patterns of livestock markets; some have shown decisive gains and others have become less important. The number of country dealers has reduced sharply. Local markets, auctions, and packing plants have all showed substantial increases in numbers. Some markets were of major importance in total volume handled but at the same time were of minor importance for a specific class of livestock. Slaughter cattle and calves were sold through terminal markets in a very high percentage of the cases studied. Major markets for the sale of feeder livestock were the auction markets. Livestock sold for breeding and herd replacement purposes was handled primarily by interfarm sale. Farmers use a different set of criteria and are more selective of markets when purchasing livestock than when selling. Nearly all livestock marketed by Missouri farmers was transported by truck. Small lots of livestock marketed within 50 miles of the farm were for the most part, transported by the farmer's own truck. When size of lots, or distance was increased commercial trucks were used more frequently. More variation was noted in the type of truck ownership in transporting hogs to market than for cattle or calves. Seasonal marketing patterns were evident for most classes of livestock but some classes did not show a well defined pattern. On several farms a definite program of marketing animals throughout the year was followed. A variation existed between different sections of the State in percentage of marketings sold in any one month. Market news was of vital importance to livestock producers. Radio was the most important single source of market news.

Publications: Brewer, D. Market Outlets Used for Sale and Purchase of Cattle and Calves. Missouri Agricultural Experiment Station Bulletin, No. 782.

Brewer, D. Characteristics of Missouri Livestock Auction Markets. Missouri Agricultural Experiment Station Bulletin, No. 781. (Project 289).

LIVESTOCK MARKETS IN MISSOURI. (C. L. Cramer, J. G. West, G. Nance). During the past ten years the market structure for livestock in Missouri has been affected by technological changes which have occurred. These changes have affected the size of the producing units and the quality of the product produced. The St. Louis area livestock industry has been studied in an effort to provide information for making long run decisions in the livestock and meat business of the St. Louis area. The work included an analysis of livestock production; estimates of livestock market organization; potential demand for livestock and meat; estimated location of marketing firms; and the impact of technological change on the market structure.

A description of the relative importance of hog markets of each type was developed for a selected area in Missouri. The use of various type hog markets was associated with the number of hogs sold, with the age of farm operations, and with the distance from alternative market outlets. Market preference varied with the quality of hog to be marketed; with terminal market; and with direct sales to packers. This is an Agricultural Marketing Act project. The studies on this project have indicated the need for major changes in the project plan and therefore this project is being closed and a new project developed (No. 496).

Cooperation: University of Illinois, Southern Illinois University; Agricultural Committee of the St. Louis Chamber of Commerce. (Project 381).

EFFICIENCY OF MISSOURI LIVESTOCK MARKETS. (C. L. Cramer, K. E. Miller). The livestock marketing process is constantly changing. These changes occur as existing firms and new firms provide services demanded as a result of technological developments. In some situations the re-organization of facilities and procedures are easily accomplished. In other instances this is extremely difficult. Studies have been conducted which showed operating cost per unit of livestock for each function performed by a stockyard company. The results this year were compared with those from prior years to determine if new procedures affected unit labor costs. In all cases improvement was recorded in the efficiency of marketing procedures for cattle, hogs, and sheep.

A plan has been developed whereby the data necessary for analysis of county origin of livestock receipts of a livestock market was secured. This data has been placed on IBM cards and will be available for analysis. An analysis of cost and effectiveness of solicitation has been completed. The variation in the solicitation cost per animal unit received ranged from 19.7 cents to 47.5 cents. The percentage of livestock "seen" which was later received ranged from 8.5% to 34.0%. The work on this project has been completed. (Project 362).

USE OF MEATS IN THE RESTAURANT INDUSTRY. (H. D. Naumann, H. Hedrick, M. Mangel, C. Pudelkewicz, R. Baldwin, C. Rodgers, J. Clifford, B. Christy, B. Korschgen, V. J. Rhodes, H. Leach, H. C. Little, J. W. McKinsey, G. Nance, J. West, C. Braschler, D. Alexander). Retailers and institutional eating places (factories, schools, hospitals, restaurants, hotels, clubs, and other institutions) are vital links to the farmer in the marketing chain from him to consumers. From 1/6 to 1/5 of the U. S. civ-

ilian food supply is marketed through eating places. In cooperation with the restaurant industry, studies have been undertaken to establish facts concerning the use of meats in this industry. This is an Agricultural Marketing Act project.

Use of the "Roast" Method of Preparation for Shoulder Clods and Chuck Rolls. The "Roast" method involves a prerost followed by grilling of slices of meat. Paired U. S. Good grade cuts of beef were used. One roast of each pair was cooked to an internal temperature of 110°F and the other was cooked to 120°F. Analyses of variants showed significant differences between methods in general acceptability and flavor for chuck rolls, but not for shoulder clod roasts. Significant differences among judges were demonstrated for ratings of tenderness and general acceptability of the chuck rolls and for general acceptability of the shoulder clods. There were no significant differences among animals or positions of slices for any characteristic considered for either type of roast.

Restaurant Survey. Eighty-seven restaurants in four metropolitan areas were classified by types: service, drive-ins, cafeterias, and short order. The number of employees ranged from 1 to 240 with an average of 25 employees per establishment. The average cost per meal was \$0.96. Daily sales volume appeared to be the most valid and useful measure of the size of the restaurant. Daily gross sales ranged from \$18.00 to \$3,825.00 with an average of approximately \$520.00. Beef sales accounted for more than 50% of the total meat sales. Pork and poultry meat shared equally for slightly more than 33%. Fish constituted about 10% and only a few restaurants offered lamb on their menus. Location, daily sales volume, and type of restaurant did not affect individual restaurant utilization of meat by type. Menu prices were not varied in response to short-run changes in prices of different meat items. Very few of the restaurants made any effort to substitute low price meat items for relatively higher priced items in response to short-run changes in price relationships. If this is generally true the major function of a pricing system is not optimally operative in this section of the food marketing channel. If the pricing system is to perform its proper function of guiding production and consumption of the various different types of meats, the restaurant industry will need to be encouraged to become "price conscious" with respect to both substitution and menu pricing of the various different items. Operators and managers of restaurants did not appear to be actively concerned with new ideas in meat processing or merchandising. The restaurants studied presented a picture difficult to classify for purposes of future research. Several variables including daily sales volume, type of restaurant, location, and number of employees appeared to be useful for some of the classification purposes. Efforts to classify restaurants to account for variation and proportion of total meat sales accounted for by different meat items met with only very limited success. Variation in proportion of total meat sales accounted for by different meat items appeared to be a random variable. It is believed that factors affecting this variable can be delineated by research involving case studies of specific restaurant operation.

Publications: Alexander, D. Factors Affecting Meat Buying Practices in the Restaurant Industry. A thesis submitted in fulfillment of the requirement for the degree Master of Science, Graduate School, University of Missouri, 1962.

Customer Attitude Surveys. The analysis of the preliminary "Customer Attitude" survey of cooperating cafeterias and restaurants in the Kansas City area has been completed. A total of 1,123 respondents answered various questions concerning their eating-out habits and attitudes toward the various services and food offerings of the cooperating firms. This survey indicated that they ate beef at least 60% of the time; poultry, 20%; fish, 13% and pork, 7%. Services of importance were listed as follows: 21%, atmosphere; 36%, quality of food; 15%, fast service; 11%, good parking; 13%, near work; and 4% were tourists. Fifty-six percent ate out one or more times per week and 28% indicated that they ate out 2 or 3 times per week. At the request of 19 cafeterias customers' surveys have been conducted using postal card questionnaires. Responses have been received from 13,602 people. The data are now being analyzed.

Case Studies of Individual Restaurants. Detailed case studies of the meat utilization of 8 restaurants and one cafeteria have been completed and the data is now being tabulated. An effort was made to secure cooperation of food service establishments in the Missouri recreational areas of the Lake of the Ozarks and the Southwestern part of Missouri for purposes of an analysis of meat utilization and facilities available. Twelve food service operators were contacted by personal interview; 7 of these were unwilling or unable to cooperate; 5 tentatively agreed to cooperation but later ceased because of the amount of work involved; and 1 firm furnished some data which are now being processed.

Aggregate Time Series Analysis. To supplement the study of individuals and groups of firms in the restaurant industry, some analysis of the trends in food consumption expenditures at the restaurant level was deemed desirable and data has been collected from the U. S. Department of Commerce Report for the period, 1929 through 1960. These data are now being analyzed.

Work will be continued on heat penetration during roasting; the completion of analysis of data now available from the survey on meat buying and utilization practices of schools, hospitals, and other mass feeding institutions; and the study of retail buying and handling of meat.

Cooperation: Departments of Animal Husbandry and Home Economics; The Missouri Restaurant Industry.
(Projects 385, 386, 387).

IMPROVING THE QUALITY OF MEAT. (M. Mangel, R. Baldwin, H. D. Naumann, M. Bailey, V. J. Rhodes, C. Rodgers, D. Christy, B. Korschgen, P. F. Gould, J. Hendrix). A detailed report will be found in the Home Economics section.
(Projects 348, 349, 350).

IDENTIFICATION IN LIVE SWINE OF FACTORS CAUSING INCREASED VALUES IN CARCASSES. (H. D. Naumann, S. Zobrisky, J. W. McKinsey, V. J. Rhodes, G. Nance, W. E. Meyer, W. G. Moody, E. Pfuehler, W. C. Stringer). A detailed report will be found in the Animal Husbandry section.
(Projects 383, 384).

LIVESTOCK SHIPMENTS BY RAIL AND TRUCK. (D. Brewer). Transportation costs make up a major portion of the total marketing costs for livestock and meats. Schedules have been developed to obtain specific data on truck transportation rates and costs of livestock shipment by origin, by destination, and by species. These have been mailed to the cooperating state representatives in the designated geographical regions along with instructions for obtaining desired data. Information has been received from 18 states. Rail rates and other costs of livestock shipments between specific points of origin and destination are being assembled. Schedules from all participating states have been edited and coded for IBM processing and analyzing. Data on 290 loads of livestock routed for approximately 111 different interstate destination points were collected in Missouri. Work will be continued toward the final determination of truck transportation costs and rate data. The relative use of truck and rail transportation will also be established.

Cooperation: Agricultural Marketing Service and Agricultural Research Service, U. S. D. A. ; North Central Regional Livestock Marketing Committee (NCM-25)
(Project 421).

COTTON MARKETING IN MISSOURI. (J. W. McKinsey, W. R. Summitt, J. C. Grady, V. A. Metcalf). The estimated value to farmers of the 1960 cotton crop was \$73,000,000. Cotton production practices and techniques have resulted in larger yields per acre. Many changes have occurred in the cotton marketing organization and facilities. The number of gins has declined sharply because of developments in transportation and ginning equipment. It is important that improvements resulting in increased efficiency be adopted. A survey of gin equipment and facilities has been essentially completed as a starting point for analyzing present marketing channels for Missouri cotton. Alternate systems have been studied searching for methods of improving the marketing of Missouri cotton. The work in this area is contributing to a cooperative regional project with the Southern States and the Missouri station has endeavored to determine the effects of storage prior to ginning on the quality and value of cotton lint. Twenty-five bales of cotton were stored in trailers and cotton houses; each bale was sampled monthly and the grade and staple length determined; moisture tests were made frequently during storage. Additional tests have been made for fiber strength, for length, fiber fineness, fiber elongation, and some spinning tests have been made. Analysis of these data is in progress. Work in seed cotton storage will be repeated to gain further information applicable to different climatic conditions. Alternatives will be introduced into the present marketing systems and the result analyzed in an attempt to suggest a more efficient (lower cost) marketing method.

Publications: A manuscript is in preparation on the "Storage of Cotton Before Ginning".

Cooperation: States of the Southern Region; Ginning Laboratory ARS, U. S. D. A., Stoneville, Mississippi; Anderson Clayton Cotton Co., Houston, Texas; Arkansas-Missouri Ginners Association; New Madrid State Bank; Individual Ginners and Cotton Producers.
(Project 462).

DAIRY MARKETING IN MISSOURI AND THE NORTH CENTRAL REGION. (S. F. Whitted). In recent years new technology, integration, and market innovations have been reflected in significant developments in the marketing structure for the procurement, processing, and distribution of dairy products. Surplus Grade A milk in the North Central markets increased during the period 1950 to 1957 averaging 37% of the producer receipts. During the early part of the period the ratio of surplus skim milk to butterfat was high. However, approximately equal utilization of the two components occurred during the latter part of the period. This shift reflected the increased popularity of low-fat fluid products and the reduced use of cream. Northern markets tended to have a greater proportion of surplus skim milk and the southern markets a larger proportion of butterfat. Excess skim milk was more difficult to handle than excess butterfat because of its bulkiness and more limited alternative uses. The increasing Grade A surpluses caused larger portions of manu-

factured products to be made from Grade A as compared to ungraded milk. Seasonality of surpluses also was a problem. In 5 markets with the greatest seasonal variation, excess butterfat in the peak month was 4 times that in the low month. In the 5 with the least seasonal markets this was 3 times. Data have been collected on the number of milk producers in Missouri by county and by plant to which they ship.

Publications: A North Central Regional publication has been prepared entitled: Surplus Grade A Milk in the North Central Markets.

Cooperation: North Central Regional Dairy Marketing Research Committee (NCM-26) (Project 422).

ALTERNATIVE SYSTEMS OF HANDLING AND PROCESSING MILK PRODUCED IN MISSOURI. (S. F. Whitted, J. Martin, F. A. Lasley). In the principal dairy area of Missouri, 38% of the farm income is from the sale of dairy products. Nearly 50,000 people, 1/10 of all the persons resident in the area, received income from dairy operations. Improvement in transportation facilities and quality control in milk production have made it possible to ship milk greater distances. Some parts of Missouri are surplus milk producing areas and new technology has made it possible to distribute milk over a wider area. However, this desirable result has not automatically occurred. Actually, constantly stiffer competition from other surplus producing areas is happening.

A complete enumeration of can and bulk routes in plants in Southwest Missouri showed 54 plants receiving milk from routes serviced by 812 can and 56 bulk trucks collecting milk from over 25,000 farms. Competition in procurement has resulted in overlap and cross-hauling with subsequent high per unit costs. The average community had four alternative outlets for milk. Studies were made on the volume per truck, volume per stop, seasonality, miles on route, time on route, investment, number of patrons, and density of supply. The procurement area of each plant was outlined and measured from information secured by personal interview and summary of records for 109 can trucks, 34 bulk trucks, plant personnel of 54 plants, the State Department of Agriculture, the State Veterinarian, and the Milk Market Administrator. Flow patterns were developed for milk in the area by counties. The information developed will be prepared and published in bulletin form. Alternative means of assembly will be analyzed with respect to specific situation and with special reference to changing market conditions (physical, structural, institutional, and economic).

Publications: A thesis to be submitted for the requirements for the Doctor of Philosophy degree, Graduate School, University of Missouri entitled, Economic Analysis of Milk Assembly in Southwest Missouri, has been prepared. (Project 429).

POTENTIAL ECONOMIES FROM CONCENTRATION OF DAIRY PRODUCTION. (J. G. West, C. Kirtley). Studies of the cost of producing and marketing agricultural products have indicated a relationship between the concentration or density of production in an area and the per unit cost of the activities involved. These economies are in addition to those achieved by individual farm units. Evidence has indicated that these savings are important. Items used in production may be obtained at lower prices if the input supplier is selling a large volume within a relatively small geographical area.

Census data from counties in Southwest Missouri have been used to select two counties for an intensive study. One of these counties has a rather concentrated dairy production while in the other county, dairy production is not nearly as great. Secondary data on cost of inputs have been assembled for use in analyzing the relationship between costs and density of production. These included costs, such as grinding and mixing of dairy feed, at various levels of operation with respect of volume. Preliminary work on the development of survey schedules has been completed. These schedules were formulated so as to supplement the secondary data which have been accumulated. An analysis of trends in dairy production and production of inputs used in dairy production has been made for the two counties selected. Additional data is being collected for mapping the input market areas within the counties. Surveys of farmers and firms marketing inputs will be continued. (Project 424).

CHANGING STRUCTURE OF THE FRUIT AND VEGETABLE MARKET. (J. C. Grady). Procurement policies and the total marketing process for fruits and vegetables are becoming more closely integrated and concentrated. Studies have been initiated to secure information on the present structure of the fruit and vegetable market. More direct procurement was occurring and terminal markets where most of the wholesale firms were located have continued to decline in percentage of total business and also in numbers of carlot equivalents. The number of retail food outlets dependent upon wholesale and jobber services was declining. There has been a decline in the number of farms supplying fruits and vegetables, especially in the areas adjoining St. Louis and Kansas City. High land prices attributable to suburban and industrial developments, and retirements of the older aged farmer groups were the major reasons for this. This project is being completed and closed.

Cooperation: Department of Horticulture (Project 392).

CARNATION AND CHRYSANTHEMUM GRADES. At the beginning of this work there were no recognized grades and standards. The establishment of grades would enable producers, consumers, and market personnel to be more certain of the quality of the products in market channels. This project was established to determine the feasibility of establishing and using such grades. Difficulty has been encountered in securing cooperation. One grower, who was also an owner and operator of three wholesale houses and one retail outlet has given good cooperation. Over 5,000 bunches of carnations have been graded into three grades. These grades were varied among varieties and also between different greenhouses. The price differentials were not significant as compared to the non-graded competing product. The most favorable comparison has been the movement of the graded product prior to the sale of the ungraded product. Orders from distant retailers have favored the graded product. It is thought that if a larger supply were graded a wider price spread between the grades would result.

Chrysanthemums of both the standard and spray forms have been tested to a limited degree. Grades for spray chrysanthemums have not been accepted as readily as those for the carnation and standard chrysanthemum. Spray chrysanthemums having multiple flowers per stem are not as readily gradable. The commercial trade and producers have a tendency to vary quantity more than quality in response to price changes. This has been a North Central Regional Project which has been completed and therefore Missouri's contributing project will be closed.

Cooperation: North Central Region, U. S. D. A. , A. M. S.

(Project 328).

EGG QUALITIES PREFERRED BY CONSUMERS. (L. A. Voss, Q. D. Banks). In the last ten years the per capita consumption of eggs has decreased from 387 to 350 eggs per year. Improving the acceptability of eggs may increase the per capita consumption. This project is an effort to determine the qualities desired by consumers. A study in the St. Louis area on consumer preference for shell eggs has been completed and the following points determined: (1) Grade A eggs were preferred over Grade B; (2) Medium yolk color was preferred over light yolk color; (3) Grade and yolk color had approximately the same amount of influence on the evaluation of eggs; (4) The preferences for grade A over grade B and medium color over light color were statistically significant; (5) Grade B eggs were completely satisfactory to over one-half of the consumers in the study; (6) There was a slight preference for medium yolk color over either dark or light yolk colors and the number that preferred light colors and dark colors were approximately equal; (7) Blood spots and taste influenced the value of eggs. Eggs will be in a better competitive position if the industry can develop a practical method of identifying yolk color and then labeling packages so consumers can choose yolk colors. Lowering the minimum standards of grade A and marketing as grades A and AA (leaving out the present B grade) would meet the desires of most consumers.

Publications on this project will be completed and further studies on color preferences will be started. This is an Agricultural Marketing Act project.

Publications: Banks, Q. D. Consumer Preference for Two Grades and Two Yolk Colors of Eggs. A thesis presented toward the requirements for the degree, Doctor of Philosophy, Graduate School. University of Missouri, February, 1962.

Cooperation: Department of Poultry Husbandry

(Project 382).

SUPPLY OF EGGS IN MISSOURI. (J. R. Tedford). The Midwest has been the principal surplus egg production region in the country. While egg production has continued to increase in many of the states comprising the West-North Central region, Missouri's total egg production has decreased. The problem of egg supply and production response is important to the egg industry in Missouri. A larger volume of shell eggs are being imported into Missouri than was the case 5 or 10 years ago. Many of the shell egg and processing egg firms have or are considering the development of coordinated egg production and marketing programs. Work in this area is in its initial stage and has consisted primarily of planning and background development.

(Project 474).

METHODS OF COORDINATING EGG PRODUCTION AND MARKETING PROGRAMS. (L. Voss). In 1960, Missouri producers received over \$38,000,000 from the sale of eggs. Firms in Missouri egg marketing operations received an estimated \$25,000,000 for services in 1960. The sale to egg producers of goods and services needed for egg production has been estimated at approximately \$20,000,000 per year. Flock size in Missouri is increasing but many small production units have quit. There is great need to coordinate production with marketing needs. The North Central Region has undertaken work in this area under NCM-31. Detailed plans for the region have been developed and field tested. Interview lists of coordinated egg production work and marketing programs now operative in Missouri have been compiled and field work will now be undertaken.

Cooperation: States of the North Central Region; the Missouri State Department of Agriculture
(Project 460).

EGG BREAKING AND DRYING IN MISSOURI. (L. A. Voss). Approximately 6-7% of the egg production of the United States is processed. During the spring period 40-45% of the egg production in the west North Central States is utilized by processors. There are 108 federally inspected plants in the United States; 14 of these are in Missouri. In addition there are 17 plants not under federal inspection. Studies have shown that the traditional supplies of current receipt eggs from small flocks were no longer adequate to supply the mid-west egg processing industry. It has become evident that processors must have an adequate egg supply throughout the year for a year around operation. This plan of operation has the following advantages: 1. Less speculative risk than with seasonal production; 2. The cost per pound of eggs processed would be reduced through: a. Greater productivity of labor by the use of breaking machines; b. Less assembling costs; c. Greater volume through the plant; d. Less shell egg storage inventory; e. Less volume of frozen egg storage; and f. Less interest on shell and frozen egg inventory.

The total estimated savings by the use of eggs of contract production and from the use of modern equipment was from 5-8 cents a dozen or 4-6 cents a pound of liquid. Also, a lower bacterial count and a better yolk color (produced by feeding) would improve the competitive position of the processor.

This project is a contributing project to the North Central Regional Project NCM-14.

This project has been completed and with final publication of results will be closed.

Publications: Voss, L. A. Liquid Egg Yields from Some Missouri Random Sample Test Entries. Poultry Science, Volume 40, No. 5 -September, 1961.

Voss, L. A. Procurement Methods In Relation to Egg Processing Costs. A dissertation presented in fulfillment of the requirements for the degree of Doctor of Philosophy. University of Missouri, March 1962.

Cooperation: North Central Region. (Project 316).

MISSOURI GRAIN MARKETING FIRMS AND THEIR PLACE IN THE MARKET STRUCTURE. (D. N. Harrington, J. W. McKinsey, G. Van Winkle, J. G. West). In 1958, Missouri farmers produced \$420,000,000 worth of the four feed grains, wheat, and soybeans. About \$250,000,000 worth of these grains, entered the grain marketing channels to various degrees. Great changes have occurred in production, harvesting, and marketing methods. There is need to have accurate information concerning these changes as they affect the service rendered by grain marketing firms. This study was developed as a North Central Regional Project NCM-30. A review of the literature and research to date on the problem has been completed. A survey has been made of the population of grain processors and terminal and sub-terminal elevators operating in Missouri to obtain information on changes in plant size, location, ownership, and other items since a similar survey was made in 1954. These surveys have been tabulated and analysis is now in progress. A study on the changing structure of the two major grain markets in Missouri will be initiated.

Cooperation: States of the North Central Region (Project 461).

TRANSPORTATION OF GRAIN. (D. M. Harrington, J. W. McKinsey). The five year upward trend in percentage of Missouri grain moving by truck from local grain buyers was changed in 1959 by a reduction in freight rates on coarse grain by the railroads. Larger volumes of corn are moved by truck from Missouri local markets than any other one grain (14.0 million bushels). This was probably due to the fact that the distance corn shipments move from the area of production was relatively shorter than for soybeans and wheat. Soybeans were second in volume of grain trucked with 7.1 million bushels. Wheat was third with 6.5 million bushels moving by truck. In 1959, 27.6 million bushels of all grains were trucked from local markets while the railroads moved 77.5 million bushels.

This project was a contributing project to a North Central Regional Project NCM-19 and with the completion of publications on the Regional project this project will be closed.

Cooperation: North Central Region; USDA. (Project 299).

FARM ENTERPRISE COSTS AND RETURNS. (F. E. Justus, Jr., A. R. Hagan, B. B. Khare, J. W. McKinsey). New developments in agriculture and changing economic conditions are constantly influencing the incomes of Missouri farmers, therefore farmers must constantly seek ways of becoming more efficient. Constant studies in costs and returns for the different farm enterprises are therefore necessary.

Cost and Returns on Cotton. A total of 27 detailed input-output records on the 1960 cotton crop were summarized early in 1961. These summaries indicated: (1) It cost \$133.97 per acre to produce cotton in 1960. The average cost amounted to \$21.89 per cwt. of lint; (2) There was great variation in costs; individual farms varied from \$15.36 to \$27.47 per cwt. of lint; (3) Labor and machinery costs amounted to 54.2% of the total

cost of producing cotton; (4) The average lint yield on the farms studied was 623 pounds per acre and the average price received was \$30.34 per cwt. of lint. Total receipts from lint and seed averaged \$209.79 per acre; (5) For each \$100.00 spent for the use of land, labor, and capital, a return of \$156.40 was received; (6) Great variation in net returns were reported, the range being from \$33.00 to \$191.65; (7) Production cost per acre were higher on the smaller cotton enterprises; (8) On a cwt. of lint basis, the total cost of production averaged lower on the small enterprises; (9) High cotton yields were most important; (10) One of the major factors in obtaining high cotton yields was the proper use of commercial fertilizer; (11) Harvesting costs averaged \$8.87 per cwt. of lint on farms employing hand picking exclusively, \$7.56 on farms employing both machine and hand picking, and \$5.78 on farms employing only machine picking; (12) On farms employing hand picking exclusively, the total labor requirement was 94 hours per acre. On farms employing both hand and machine picking, 56 hours per acre and on farms employing only machine picking, 20 hours per acre.

The Cost of Producing Hogs. Enterprise records kept by 14 hog producers were summarized. The results obtained while limited due to the small number of units in the records do give some understanding of the costs and returns of hog production under Missouri conditions. The summary showed: (1) The average cost production on the farms studied was \$12.84 per cwt. of pork produced. Of this total cost of production, feed was the major item amounting to \$10.07 per cwt. of pork; (2) Net returns averaged \$1.79 per cwt. and \$49.24 per sow. Labor returns averaged \$2.54 per cwt. of pork produced; (3) Large producers showed the net return of \$2.70 per hour of labor used, medium producers \$2.04 per hour, and the small producers \$2.00 per hour. The small producer sold more pigs per sow but the large producers compensated for this by handling more sows per unit of labor; (4) Greater use of labor saving equipment and other economies of large scale labor use was evidence on the larger operations (over 50 sows). It took the large producers .72 hours of labor per cwt. of pork produced compared with .90 hours of labor per cwt. for the small scale producers.

Publications: Justus, F. E. Jr., A. R. Hagan, B. B. Khare, J. W. McKinsey. 1960 Cotton Production Costs and Returns. A mimeographed publication for use by county extension personnel in Southeast Missouri.

Miller, Frank D. Production Costs and Labor Requirements of Swine Production in Northwest Missouri in 1958 and 1959. An unpublished master's thesis completed in June, 1961.

Cooperation: Cooperative Extension Service

(Project 110).

SUPPLEMENTARY IRRIGATION IN MISSOURI. (F. Miller, T. Jones, M. Stauber). Analysis of weather data shows that there are dry periods of sufficient duration to reduce the yield and quality of farm crops in Missouri almost every year. Supplementary irrigation, sometimes in comparatively small amounts, may make a substantial difference in the value of the crop produced.

Information has been secured concerning the investment in irrigation equipment and the costs of applying irrigation water to corn, cotton, and soybeans using different methods of water distribution in Southeast Missouri. The fixed investment in irrigation equipment averaged \$7,122 per farm or \$56 per capacity acre. Forty-six of the 65 farmers who supplied records applied water to an average of 57 acres per farm in 1959. Thirty-eight applied water to an average of 73 acres per farm in 1960. Cotton was the major irrigated crop accounting for over 50% of the irrigated acreage in both 1959 and 1960. Corn ranked next to cotton and soybeans were third. Fixed charges averaged 80% of the total irrigation costs for the surface portable pipe and sprinkler systems, and 65% for the trailer boom and giant sprinkler systems. In 1959, 20% of the 65 farmers increased net farm incomes by irrigating cotton, corn, and soybeans. Farmers obtained a greater return from applying water to cotton, corn, and soybeans in 1960 than in 1959, 42% increasing their net farm income. During the coming year it is planned to estimate the drouth hazard and frequency of need for supplemental irrigation for corn, cotton, and soybeans in Southeast Missouri. An effort will be made to determine optimum applications of water for most profitable crop yield responses.

Publications: Miller, F., T. L. Jones, M. Stauber. Economics of Irrigation No. 2. Missouri Agricultural Experiment Station Research Bulletin No. 812, March 1962.

Jones, T. L., F. Miller. Irrigation Practices and Costs in Southeastern Missouri. Missouri Agricultural Experiment Station Bulletin No. 795, February 1962.

Cooperation: Farm Economics Division, Economics Research Service; U. S. D. A.

(Project 426).

THE ECONOMICS OF FERTILIZER ON CORN. (J. P. Doll, J. T. Sanderson). Corn is the most widely cultivated crop in Missouri and contributes more to the agricultural income of the State than any other crop. Total value of the Missouri corn crop approximates \$275,000,000 per year. Corn is produced in sizable quantities in all parts of the State. Large quantities of fertilizers are used in its production. This work is designed to aid farmers in determining the optimum use of fertilizer.

Experiments have been established at the North Missouri Research Center; on leased land on the A. H. Orr farm at Malta Bend, at Columbia, and at the Southeast Missouri Research Center. Corn was planted at various populations per acre and treated with varying applications of nitrogen. At the North Missouri Research Center, top yields were obtained at 16,000 plants and 150 pounds of nitrogen per acre; for the Orr farm 16,000 plants and 200 pounds of nitrogen; at Columbia, yields were limited by poor stands and the response to nitrogen was low; at the Southeast Missouri Research Center 20,000 plants at 200 pounds of nitrogen gave the most economical yields. At both the Orr farm and Southeast Missouri Research Center the curve was still rising, so there is need to try increased populations and applications. These experiments will be continued at each location.

Publications: Kroth, E. M., J. P. Doll. Response of Corn Yields to Nitrogen Fertilization and Plant Population in Missouri. Progress Report No. 1. Missouri Agricultural Experiment Station Special Reports.

Cooperation: This project is a joint project between the departments of Agriculture Economics and Soils (Project 455).

NEW TECHNOLOGY IN CROP AND LIVESTOCK PRODUCTION. (F. E. Justus, D. B. Ibach, E. A. Leonard, D. C. Huffman, R. D. Alexander). Missouri farmers are constantly exposed to new technology: such as new kinds and sizes of machinery; new crop varieties; and new livestock and crop production techniques. There is need to know the economic effect of these new technologies at the earliest possible time. Work on this project has been in Northeast Missouri and an effort has been made to estimate the changes in yield, output, costs, and returns that would result from adoption of specified levels of new technology. Two linear programming endeavors have been started; (1) to determine optimum farm organization solutions for modal farm situations under present level of crop technology and under an "improved" level of technology; (2) to determine the resources needed (land, labor, and capital), to obtain given levels of net income on dairy farms, beef farms, beef-hog farms, etc. in an area. Coefficients for these programs have been established and are currently being computed. This project is being terminated and the work subdivided into new projects.

Publications: Huffman, D. C., F. E. Justus, Jr. Farm Machinery Investment and Use Based on a Study in Northeast Missouri. Missouri Agricultural Experiment Station Bulletin, 774, December 1961.

Cooperation: U. S. D. A. (Project 379).

FAMILY FARM ADJUSTMENTS TO MEET TECHNOLOGICAL AND SOCIOLOGICAL CHANGES. (A. R. Hagan, F. Miller, C. E. Klingner, C. L. Gregory, H. E. Lionberger, R. P. Beasley, C. L. Scrivner, G. B. Thompson, L. F. Tribble, N. Hesemann, W. Hutcherson, W. Ross, R. Laughlin). During the past two decades farm families in Missouri and in other parts of the country have been forced to make many adjustments in order to maintain a financially successful farm business and a desirable standard of living. Many of these adjustments have been quite complex involving technologic, economic, and sociologic changes of an interrelated nature. Work on this project is centered on the family farm as an operating unit and includes an analysis of the management and the use of all factors of production, land, labor, capital, and management both for individual operating units and for an entire area. The Blackwater area in Cooper county was selected for this study. It comprises all of Lamine and Blackwater townships in the Northwest corner of Cooper county, includes approximately 175 farm families, and represents a wide range of farm problems from the standpoint of farm size, quality of land, types of farming, and levels of farm income. The data collected in 1960 have been summarized and analyzed on the basis of economic classes of farms. Part-time and part-retirement farm units constituted a very high percentage of the farms, 47%. Returns to capital, labor, and management were low. There was under-employment of labor in most economic classes. Cattle farms predominate the area and returns on these farms were low. These items constituted major adjustment problems in the area. Rainfall and run-off data for 1960 and 1961 have been summarized for a 200 acre "Burge Branch" hydrology study. More recently the collection of water samples for measuring sediment losses from erosion during each rainstorm has been initiated. A beef cattle labor, feed, and cost study has been started with 34 cattle producers cooperating. Budgeting and programming studies to compare the economic effects of alternative farming systems will be continued. Hydrology studies will be continued. The beef cattle enterprise will be completed and a special study of the personal factors affecting farm family adjustments will be undertaken.

Publications: Scrivner, C. L., J. C. Baker. Soils of Lamine and Blackwater townships of Cooper county. Missouri Agricultural Experiment Station Bulletin, No. 772.

Cooperation: Departments of Soils, Agricultural Engineering, and Animal Husbandry; U. S. Geological Survey, Water Resources Division; Quality Water Branch; Missouri Division of Geological Survey and Water Resources. (Project 390).

SUCCESSFUL MANAGEMENT OF LOCAL AGRICULTURAL FIRMS. (D. N. Harrington, G. Van Winkle). In 1955-56, 266 farmer cooperatives had a net business volume of \$290,000,000 in Missouri. These cooperatives had the common problem of adapting their operations and practices to the needs of those for whom they handle goods and services. Managers of 25 local farm supply and marketing cooperative associations were interviewed; some of the findings were as follows: (1) Managers needed and were interested in additional training in management; (2) There was a need for better training programs for all cooperative employees and directors; (3) There was a need for directors of cooperative associations to establish more definite objectives and policies to guide the managers in operation of the business; (4) No written instructions or job descriptions were available for new employees at local cooperative associations; (5) Attendance at annual meetings usually was low; (6) Only 20% of the presidents of the boards of directors prepared and circulated an agenda for the annual meeting; (7) In making operational changes, the manager usually felt the need for approval of the Board of Directors for his proposed plan and therefore usually presented the plan to the Board of Directors for their consideration; (8) Control of credit ranked first among the major problems of cooperative managers. Manuscripts are to be prepared for publication.

(Project 393).

THE IMPACT OF PUBLIC POLICY PROGRAMS ON THE POULTRY INDUSTRY. (J. G. West). The federal government has at various times supported certain poultry products through storage programs and disposal programs both foreign and domestic. These efforts have involved expenditures of considerable public funds. Federal programs applicable to the poultry industry, have been sporadic. An effort is being made to determine the impact of these programs. An analysis of the history of past purchase programs and the effects of these programs on prices and incomes of producers has been completed. Additional analyses of the potential effects of purchase programs in conjunction with other programs have been made. This was the result of an interest in poultry marketing orders and the concern over secondary outlets for poultry products. Tentative results from the analyses indicated that purchase programs could serve as a limited outlet for surplus production, but would be limited to the needs of the direct distribution program; for example: The purchase of turkeys for distribution to school lunches reached an all time high in 1961 but in total it amounted to only 3% of all production.

Cooperation: North Central Region

(Project 339).

THE GENERATION OF FARMER ATTITUDES TOWARD GOVERNMENT FARM PRICE PROGRAMS. (J. G. West, E. H. Hudson, J. Squibb). Government programs affecting prices and income received by Missouri farmers are expected to continue for some time. These programs have definite implications for marketing firms as well as for the farmers themselves. Very little is known about how farmers attitudes toward these programs are generated.

A survey of farmers was conducted in two Missouri counties in order to obtain information on the relationship between the characteristics and attitudes of farmers and their participation in different types of land retirement programs. Schedules were obtained from 58 farmers in Greene county and 64 farmers in Saline county. Saline county was selected because feed grain production was of major importance and Greene county was selected because a more diversified agriculture was practiced. The analysis of these surveys is now under way. Preliminary reports showed that participation in the conservation reserve and the subsequent effects on volume of marketing was greatest in the more diversified area than was true in the case of the feed grains area. The analysis of results from the surveys will be completed and published.

Cooperation: North Central States

(Project 391).

REAL ESTATE PRICE AND ASSESSMENT TRENDS. (Frank Miller, F. Dobson, D. L. Williams.) A total of 743 real estate transfer records from Boone, Lawrence, Macon, and Nodaway counties have been edited and an outline prepared for final analysis and the writing of a manuscript. The data showed great inequalities in assessment values in rural areas and between residential, industrial, and business property in transition areas adjacent to centers of population.

With the completion of the manuscript and publication as an Experiment Station Bulletin, this project will be closed.

(Project 61).

LAND TENURE STUDIES. (F. Miller, J. W. Gould, H. Bohling, F. Dopson). The use of mechanical power has increased the rate of accomplishing farm work in geometric progression and raised operating costs to a level that makes high incomes necessary for survival in the farm business. There is a high percentage of part-time farms in many parts of Missouri as well as in many sections of the North Central Region. There is need for accurate information as to: how much investment is required for a successful farm

business; what type of arrangement can be made so that a young man can become a junior partner in a farm business; how can a young man be financed for a start in the farm business; what adjustments in land use can be made that will reduce the supply of surplus farm products without lowering farm income; how can services rendered by a small town be maintained in a reducing farm population situation; and many other similar questions. The following information has been secured: (1) about 75% of Missouri farm businesses are inadequate for producing labor incomes above \$3,000; (2) owner operators have smaller farms; less total capital invested; and receive lower business incomes than do part-time owners, cash, and crop share, or livestock share tenants; (3) only 62.3% of the 168,684 farms in Missouri were classed as commercial businesses in 1959; (4) of these commercial units, 46.1% sold less than \$5,000 worth of products; 13.8% sold less than \$2,500 worth; (5) under Missouri conditions from 240 to 320 acres of crop land and pasture are needed to give the operator of a grain, grain-beef, or grain-hog farm above \$3,000 income for his labor and management after paying interest on the investment in the business; (6) the investment required to set up a business of this size is beyond the savings or inheritance of most young men who would like to farm. Areas will be selected at random in two counties of Northern Missouri where 200 farmers will be interviewed to get information about the specific tenure arrangements, business organization, goals, values, and obstacles.

Cooperation: States of the North Central Region; Economic Research Service, U. S. D. A. ; the Farm Foundation (Project 467).

LAWS RELATING TO THE TRANSFER OF FARM REAL ESTATE. (F. L. Mann, F. Miller). Present trends in agriculture in Missouri are toward consolidation of farm lands into larger operating units. These changes will require revisions in methods of financing the transfer of rights in land and in the operating procedures of lending agencies. This work is a part of a North Central Regional study. The laws relating to installment land contracts and other low equity transfer devices in the North Central states have been analyzed and summarized. The installment land contract gives the buyer and seller considerable freedom in framing an agreement that will fit their own particular circumstance. In Missouri the "Deed of Trust" provides similar flexibility. The laws applicable to farm partnership arrangement have been set forth. Further legal investigations business unit from one generation to another, especially from father to son, has been summarized. Various types of arrangements have been considered and the practical steps to be taken by a farm business owner and a young partner in setting up a partnership agreement have been set forth. Further legal investigations will be made into the various methods of financing farm businesses including such devices as Land Trust, Credit Union, and various corporate arrangements.

Publications: Mann, F. L. A Comparative Study of Laws Relating to Low Equity Transfers of Farm Real Estate in the North Central Region. Missouri Agricultural Experiment Station Research Bulletin No. 782, North Central Regional Publication No. 136.

Cooperation: States of the North Central Region; Law School, University of Missouri; Agricultural Law Center, University of Iowa; A. R. S. , U. S. D. A. (Project 427).

AGRICULTURAL ENGINEERING

Harold Walton, Chairman

UTILIZATION OF ELECTRICITY ON MISSOURI FARMS. (K. L. McFate, M. M. Jones). Nearly 97% of Missouri farms have central station electric service available. This provides low cost energy that can profitably be used to lower production costs or to improve the quality of farm products. The average cost in 1960-61 of drying 10,900 bushels of shelled corn and milo on two Missouri farms was \$0.028 per bushel. With the added fixed costs calculated at 10% of the initial investment total drying costs were \$0.063 per bushel, 11.6% greater than drying with LP Gas units. The cost of operating one drying system to dry 110 tons of chopped alfalfa was \$0.61 per ton. On another system 100 tons were dried at an operating cost of \$0.63 per ton. These grain driers used electric heat. On a 70 cow Southwest Missouri dairy an investment of \$2,700 eliminated 280 man hours, and eliminated lifting 1.4 million pounds of grain and feed annually. To mix, grind, and convey a year's supply of feed, 520 kwh of electricity (\$10.40) are used. The cost of operating a circulating waterer for 36 pens at the swine testing station was \$108.70 for one year's time or 29.6 cents per day. In a chick brooding study in Newton county, 10,300 birds were started on August 1, 1961. Of these, 9,910 were sold at 8 weeks, 6 days of age and at an average weight of 3.5 pounds. Electricity was used

for brooding costs at \$0.00276 per bird. Another experiment gave similar results. Production costs (excluding use of growers' facilities) were 13.45 cents and 14.51 cents per pound respectively. A two fan ventilation system used \$3.52 of electricity to control temperature and humidity in a 14 stall farrowing house located in Warren county. It is planned to continue experiments with hay drying and feed handling. Also further study will be given to electric brooding and ventilation systems; and to determine the effect of artificial night light on fattening lambs.

Publications: McFate, K. L. Electric Heat for Missouri Homes. University of Missouri Extension Division, Circular 741, July 1961.

McFate, K. L. Insulation and Ventilation for Missouri Homes. University of Missouri Extension Division Circular 747, October 1961.

McFate, K. L., E. J. Constein. Your 4-H Electric Program. University of Missouri Extension Division, 4-H Circular 180, January 1962.

McFate, K. L. Principles and Equipment for Planning Grain Handling Systems. Farm Electrification Leaflet No. 12.

McFate, K. L. Mechanizing the Dairy Farm; Mechanizing the Beef Cattle Farm. Manuscripts covering systems, planning, and equipment used on dairy and beef farms presented at the annual Cattle Feeders Conference at Colorado State University, Fort Collins, Colorado.

McFate, K. L. Equipment Needed for Farmstead Mechanization. March 1961. A manuscript presented at the first annual Farm Machinery Dealers Conference. University of Missouri, College of Agriculture.

McFate, K. L. Farm Electric Project News Letter. A periodic News Letter reporting the activities on the utilization of electricity on Missouri farms. Three such letters were prepared during the year.

Cooperation: Missouri Farm Electric Utilization Council. (Project 282).

FARM ANIMAL SHELTERS. (M. D. Shanklin, R. L. Bedwell, A. F. Butchbaker, L. V. Hahn, I. L. Berry, H. V. Walton, J. C. Wooley, M. Shute, R. E. Stewart). A study of the interactions between farm animals and the environment is basic to the problem of improved design for animal shelters. Unfavorable environments invariably cause decreased production by farm animals. It is possible to prevent or moderate these production losses by creation of favorable environments within structures designed for these purposes. A study of animal reactions to climate provides basic data which can be related to the whole field of environmental physiology.

The Effects of Acclimation on Milk Production. In climatic work there is danger that acclimation of an animal to its environment may partially or completely mask the measurements sought. Therefore, an effort has been made to determine the effects of acclimation on milk production and various physiological measurements of lactating Holsteins. Preliminary indications are that Holstein cattle varied considerably in their ability to acclimate to environmental conditions of a temperature of 84°F and 50% relative humidity. High producing animals tended to maintain their production level equal to or greater than low producing animals at the cost of increased rectal temperature.

Temperature Humidity Effects. Studies on the temperature humidity effects on milk production at 45° and 65°F were initiated in October 1961. Preliminary data do not show any obvious differences in milk production in this temperature range, although at the lower temperature and higher relative humidity (95%) the level of feed ingestion was lowered by some of the animals.

Radiation Cooling in Cattle Under Field Conditions. A radiation cooling structure has been constructed and is ready for operation.

Heat Partitioning Calorimeter for Small Animals. This calorimeter has been under construction for some time and as of March 1, 1962 has been completely assembled. Calibration will soon be started.

Publications: Bedwell, R. L. Influence of Radiant Heat Sink on Thermally-Induced Stress in Dairy Cattle.

A thesis submitted in partial fulfillment of the requirements for the degree, Master of Science, Graduate School, University of Missouri, August 1961.

Berry, I. L. Factors Affecting Insulation Values of Bovine Hair Coats. A thesis submitted in partial fulfillment of the requirements for the degree Master of Science, Graduate School, University of Missouri, June 1961.

Johnson, H. D., A. C. Ragsdale, R. G. Yeck, J. F. Jones. The Effects of Constant Environmental Temperatures 50° and 80°F on the Feed and Water Consumption of Brown Swiss, Holstein, and Jersey Calves During Growth. Missouri Agricultural Experiment Station Research Bulletin No. 786, 1961.

Yeck, R. G., I. L. Berry, H. H. Kibler. Vaporization Rates of Brown Swiss, Holstein, and Jersey Calves at Air Temperatures Ranging from 33° to 95°F. Journal of Dairy Science, 44:1191, 1961.

- Johnson, H. D., H. H. Kibler, A. C. Ragsdale, I. L. Berry, M. D. Shanklin. Role of Heat Tolerance and Production Level in Responses of Lactating Holsteins to Various Temperature-Humidity Conditions. *Journal of Dairy Science*, 44:1191, 1961.
- Berry, I. L., M. D. Shanklin, H. D. Johnson. Dairy Shelter Design Data Based on Milk Production Decline as Affected by Temperature and Humidity. American Society of Agricultural Engineers. Chicago, Illinois, December 12-15, 1961.
- Kibler, H. H., R. G. Yeck, I. L. Berry. Vaporization Rates in Brown Swiss, Holstein and Jersey Calves during Growth at Constant 50° and 80°F Temperatures. Missouri Agricultural Experiment Station Research Bulletin No. 792, 1961.
- Johnson, H. D., A. C. Ragsdale, I. L. Berry, M. D. Shanklin. With Technical Assistance from Sandra McLarney. Effect of Various Temperature-Humidity Combinations on Milk Production of Holstein Cattle. Missouri Agricultural Experiment Station Research Bulletin No. 791, 1962.
- Cargill, B. F., R. E. Stewart, H. D. Johnson. Effect of Humidity on Total Room Heat and Vapor Dissipation of Holstein Cows at 65, 80 and 90°F. Missouri Agricultural Experiment Station Research Bulletin No. 794, 1962.
- Berry, I. L., M. D. Shanklin, H. D. Johnson. Physical Factors Affecting Thermal Insulation Properties of Hair Coats of Dairy Cattle. *Journal of Dairy Science*.
- Shanklin, M. D., R. E. Stewart, H. D. Johnson. Effects of Growth and Environmental Temperature on Surface Temperature and Hair Density of Dairy Calves. Missouri Agricultural Experiment Station Research Bulletin, manuscript being prepared.
- Johnson, H. D., I. L. Berry, C. P. Merilan, M. D. Shanklin. Feed and Water Consumption Responses of Lactating Holstein Cows to Various Temperature-Humidity Conditions. Missouri Agricultural Experiment Station Research Bulletin, manuscript being prepared.
- Yeck, R. G., H. H. Kibler, I. L. Berry. Vaporization Rates in Holstein, Brown Swiss and Jersey Calves Raised at 50° and 80°F. Missouri Agricultural Experiment Station Research Bulletin, manuscript being prepared.
- Bedwell, R. L., M. D. Shanklin. Influence of Radiant Heat Sink on Thermally-Induced Stress in Dairy Cattle. Missouri Agricultural Experiment Station Research Bulletin, manuscript being prepared.
- Berry, I. L., M. D. Shanklin, H. D. Johnson. Physical Factors Affecting Thermal Insulation of Livestock Hair Coats. Missouri Agricultural Experiment Station Research Bulletin, manuscript being prepared.
- Cooperation: Department of Dairy Husbandry; ARS, U. S. D. A.; States of the North Central Region; NSF (Project 136).

TILLAGE METHODS WITH CORN. (M. M. Jones, C. L. Day, J. S. McKibben, G. P. Gentry). Growing concern over the amount of "packing" occurring in our soils along with the urgent need to reduce production costs has focused attention upon minimum tillage. The methods of minimum tillage are all comparatively new and little has been done to development equipment especially suited to these methods. Replicated plot studies were conducted at Columbia and at Elsberry to compare three methods of tillage, three methods of weed control, and three strip-till fertility placement methods. Wet weather at Columbia prevented the completion of the primary tillage on the strip-till plots and the completion of the fertilizer placement study. Wheel track planting which has been out-performing conventional methods did not produce yields up to those produced by conventional methods this year at Columbia. The Elsberry studies were on a much more permeable soil than the Columbia plots. The yields from both wheel track planting and strip-tilling were a little higher than those produced by conventional methods but were not significantly higher.

Cooperation: ARS, U. S. D. A.; Departments of Field Crops and Soils (Project 272).

FORAGE HARVESTING. (C. L. Day, D. B. Brooker, J. S. McKibben). Missouri farmers produce many tons of high quality hay each year. Unfortunately much of this hay suffers a serious loss in quality during harvesting, storage, and feeding. These losses usually are caused by the loss of leaves from handling and from rain damage. An analysis of Missouri weather data to determine the percentage of time that weather could be expected to be favorable for harvesting hay or silage has been completed and the results published. Tests have been made to determine the effect of various factors on the resistance of hay to air flow. Emphasis has been placed on the effects of chopping, crushing, or crimping. An apparatus for measuring voids in porous material has been devised and tested. The development of a distributor for placing chopped hay in a mow has been continued. An analysis of hay harvesting costs by different methods has been started; the two methods of primary interest involved baling as contrasted to chopping. It is planned to continue the work on resistance of hay to air flow. Work is to be started on a device for removing chopped hay from storage.

Publications: Borgman, E., D. B. Brooker. The Weather and Hay Making in Missouri. Missouri Agricultural Experiment Station Bulletin, No. 777. (Project 138).

GRAIN DRYING. (D. B. Brooker, J. D. McQuigg). Crop drying has become an accepted farm practice and many questions are received relative to recommendations for design and operation of drying equipment. An analysis of weather data has been under way for some time and is being continued. The purpose of this analysis is to determine: (a) The daily average of the BTU per pound of air available for drying if the air is forced through a grain mass of known moisture content and (b) the daily average of the temperature of the portion of the grain mass that would be the last to dry. Also, studies have been made on the resistance to air flow versus average moisture of corn in the bins. When the corn had the highest average moisture content the resistance to air flow was the least, increasing until approximately 13% was reached. There was some indication that when average moisture was reduced below 13% the resistance began to decrease. This was counter to what was expected. The amount of shrinkage appeared to be linear with average moisture content. Considering 0 shrinkage at 21.25% of moisture there was approximately 11% shrinkage when the corn was dried to an average moisture content of 12%. A comparison was made between the drying rate predicted by weather analysis and the actual drying rate. The rates predicted compared favorably with actual rates until the average moisture in the bin was reduced to 12 or 13%. The analysis of weather data will be continued and an attempt to correlate the weather data with the data from the supplemental heat drying tests will be undertaken.

Publications: Brooker, D. B. Pressure Patterns in Grain Drying Systems Established by Numerical Methods. Transactions of the ASAE, Vol. 4, No. 1, pages 72, 73, 74, and 77, 1961.

Cooperation: Department of Soils; U. S. Weather Bureau (Project 225).

METHODS OF PACKAGING CROPS. (D. B. Brooker). Field losses at harvest time and subsequent deterioration of crops in storage are important cost factors. Field losses can be materially reduced if the crops are harvested early when the moisture content is high. Early harvesting at high moisture levels is dependent on development of systems and equipment for handling, storing, and feeding. Plastic film containers have been used in an effort to seal high moisture crops and improve their storing qualities. Forty-five bags of alfalfa and corn silage stored in plastic film containers in 1960 were examined in March 1961. Most of these bags contained silage that was unfit for feed. Spoilage was attributed to insect damage to the bags and to movement of moisture within the bags that left the top silage dry and the bottom silage saturated. Twenty-four bags were filled with alfalfa silage in 1961 with modifications to: (1) Obtain a more dense silage; (2) Reduce insect damage; and (3) Determine the cause of moisture movements. Silage density was increased by passing the material through a modified baler. The storage area and the outside of the bags were sprayed with chlordane solution. Clear vinyl plastic bags were used. Bags 4 feet in diameter were filled to a depth of 5 feet and contained approximately 1,600 pounds of alfalfa silage. No insect activity has been observed to date but two of the bags stored in the building now show heavy mold growth at the top. This was attributed to the lack of an air tight tie on the bag top. This work will be continued. (Project 410).

EQUIPMENT AND PROCEDURES FOR THE CONTROL OF WEEDS AND BRUSH. (C. L. Day, M. R. Gebhardt). Control of weeds is a major problem in crop production. Chemical methods of weed control have become important in recent years. An indiscriminate use of chemicals may result in crop damage, poor weed control, and contaminated products. It is important that the rate of application of chemicals be carefully controlled. Herbicides in the granular form have recently become popular but equipment for properly metering these granules has not been perfected. Weed control in soybeans included a study of the effects of row spacing and pre-emergence chemical treatments, and a comparison of five different weed control methods in standard 40-inch rows. A comparison of different weed control methods in corn plots with seedbeds prepared by different methods indicated that full season chemical control was the only effective method during wet seasons when mechanical cultivation was limited. A study has been made of the effect of rainfall (or irrigation) on pre-emergence chemical applications, both liquid and granular, on corn. Laboratory tests have been made to determine the physical characteristics of some granular herbicide carriers.

Cooperation: ARS, U. S. D. A. ; Department of Field Crops (Project 153).

TERRACE DESIGN AND EFFECT ON POWER, LABOR, AND MACHINE COSTS. (R. P. Beasley, D. K. McCool, B. H. Nolte, C. F. Cromwell). Farmers have objected to terraces because of point areas between them, close spacing between terraces, crooked crop rows planted parallel to terraces, wet spots in terrace channels, and the increased time required and difficulty of farming terraces with modern machinery. Improvement in the design of terraces will help.

Improving Terrace Design. Twelve experimental terraces were constructed on the University South farm and six on a farm near Versailles, Missouri. An improved method of construction was used and the point row area between terraces on the University farm was 12%, as compared to 35% had conventional terraces been constructed. The terraces on the six farms near Versailles were all constructed parallel; and had conventional terraces been used, 19% of the area would have been in point rows. The time required to produce a row of crop on 5 fields terraced by the improved method was computed and compared to the time that would have been required had conventional terraces been used. The reduction in time due to the improved terraces was 20%, 15%, 21%, 10%, and 18%.

Terrace Channel Design. It is necessary to vary the grade and the depth of cut in different sections of a terrace. The maximum grade that can be used in any section is determined by the hydraulics of flow in that section and the erodibility of the soil. Past methods of terrace channel design have assumed a uniform flow. However, the flow is not uniform, but increases from the upper to the lower end of the terrace. Electronic computers now make it possible to analyze channels with spatially varied flow. The erodibility of the soil will limit the grade that can be used in a terrace channel. An estimate has been made of the maximum velocity that a soil can withstand without eroding. Channels have then been designed so that this velocity was not exceeded. Velocity, however, is an indirect measure of the force exerted on the soil by the flowing water. A direct measure of the force exerted on the channel bed is the tractive force. When this force is of such magnitude as to cause erosion, it is designated as the critical tractive force. A computer technique has been devised by which spatially varied flow and the tractive force theories have been utilized in selecting the maximum grade that could be used on any section of a terrace channel. Determination of the maximum grade has been made by two different terrace cross sections, five values of permissible tractive force, and five rates of inflow.

Runoff and Channel Capacity Studies (McCredie). Runoff was measured from four terraces having a total drainage area of 9 acres. Precipitation during 1961 was 41.4 inches which is 3.39 inches above normal. The runoff of 11.32 inches during the year was the greatest amount recorded since the area was in continuous corn starting in 1957. The peak rate of runoff was 1.14 inches per hour resulting from a 4.44 inch rain storm during a 3 day period. This storm was followed by a two week period without rain. In 1957 a similar storm of 4.23 inches but coming when the soil was saturated, produced a peak rate of 3.2 inches per hour runoff. Observation following these major runoff periods indicated that erosion between the terraces was not excessive.

Effects of Terraces on Power, Labor, and Machine Costs. In all cases the time required to produce a row crop on the fields with the improved method of constructing terraces was reduced substantially, varying from 10 to 21% depending upon the field.

Improved Design of Terrace Outlets. Observations have indicated that there were very poor survival of the seedings of brome, Reed's canary, switch, and foxtail grasses made on outlets during the fall of 1960. Studies have been started to determine the feasibility of using mechanical control structures to supplement or replace vegetation for control of runoff from terraces.

Publications: McCool, D. K. A Theoretical Approach to Terrace Channel Design. A thesis submitted in partial fulfillment for the requirements for a Master of Science Degree, Graduate School, University of Missouri.

McCool, D. K., R. P. Beasley. Terrace Channel Design Using the Spatially Varied Flow and Tractive Force Theories. Missouri Agricultural Experiment Station Research Bulletin No. 778.

University of Missouri Cooperative Extension Service Folder 109. Terrace Specifications, 1960.

Cooperation: A. R. S., U. S. D. A.

(Project 43).

HYDROLOGY OF SMALL WATERSHEDS. (R. P. Beasley, W. N. Reynolds). There is widespread interest in the conservation, protection, development, use, and regulation of our soil and water resources. The extent to which soil, nutrient, and water losses from a watershed can be reduced by cultural practices and by mechanical erosion control practices needs to be evaluated. Runoff from the 212 acre Burge Branch watershed was 3.27 inches for the year ending September 30, 1960 and 9 inches for the year ending September 30, 1961. Rainfall for these periods was 30.41 and 52.60 inches respectively. The peak discharge during 1960 resulted from a rainfall of 2.25 inches and the peak discharge during 1961 resulted from a rainfall of 6.08 inches. At McCredie on a 154 acre watershed the total runoff for 1961 was 8.82 inches and the total rainfall was 60.58 inches. The evaporation and seepage losses for the 16 acre reservoir and the 1 acre reservoir were 44.75 and 60.58 inches respectively. Samples from 24 leaking ponds in 10 counties were collected and tested for hydraulic conductivity. The effects of compaction, addition of various dispersing agents, and emulsions on hydraulic conductivity were determined. These studies will be continued during the coming year.

Publications: Reynolds, W. N. A Continuous Suspended Sediment Sampler for Use on Intermediate-Sized Watersheds. A thesis submitted in partial fulfillment of requirements for the degree of Master of Science, Graduate School, University of Missouri, April 1961.

Cooperation: ARS, U. S. D. A. ; U. S. Geological Survey; Department of Agricultural Economics (Project 227).

A SIMPLIFIED WATER FILTERING SYSTEM. (M. M. Jones, M. D. Shanklin). Many areas of Missouri have inadequate ground water supplies. People in these areas have often been deprived of many of the conveniences offered by running water in the home. A possible source of water in these areas is the farm pond. The use of surface water requires careful management of the watershed and of treating equipment. Simplified construction procedures have been perfected and plans are available for the use of steel basement forms for making concrete filters and storage reservoirs for treating pond water for domestic use. These new plans have been printed and are available. Studies will be continued on the development of simplified filtering and treating systems.

Publications: Jones, M. M., M. D. Shanklin. Plans for a Simplified Pond Water Filter. A supplement to Missouri Agricultural Experiment Station Bulletin No. 691.

Cooperation: Missouri Division of Health; Department of Dairy Husbandry (Project 155).

DISTRIBUTION, APPLICATION, AND USE OF WATER. (C. F. Cromwell, Jr., R. P. Beasley, J. F. Thornton, G. A. Thompson). Irrigation to supplement natural rainfall has proved to be a beneficial practice in many areas of the State. This practice when properly managed, can prevent moisture from becoming a limiting factor in crop production. A 30 foot tilting flume has been constructed in the laboratory. This flume was designed as a model of an irrigation furrow and a flow meter was used to measure water into experimental furrow models. A flume with a continuous recorder measured the discharge from the furrow. Two furrow shapes have been used: V, and 20 inches flat bottom. These tests were made at 5 flow rates varying from 2 to 80 gpm and 6 slopes from .0625% to 2.0% and with 5 coatings on the model. Analysis of the data at this time is incomplete. These tests will be continued.

Cooperation: Eastern Soil and Water Management Research Branch, ARS, U. S. D. A. ; Department of Soils (Project 395).

DRAINAGE OF AGRICULTURAL LANDS. (C. F. Cromwell, Jr., R. P. Beasley). Missouri had over 3,000,000 acres in 318 organized drainage districts listed in the 1950 census report. Approximately 70,000 acres depended on pumping plants for drainage. In addition there were about 150 organized levee districts. Much of the remainder of the 8,000,000 acres of bottom lands in Missouri are subject to damage from excess water at certain seasons. A study of ground water stages as affected by river stage has been undertaken at the Southeast Missouri Research Center. This study indicated that high river stages should have relatively little adverse effect on planting and cultivation of crops in the western half of the research farm. Difficulty may be expected every 5 to 10 years with crop planting and cultivation in the higher part of the eastern half of the farm; and troublesome ground water elevations may be expected frequently on about 60 acres on the lower portion of the eastern half of the farm.

Publications: Cromwell, C. F., Jr. Agricultural Engineering Research in Southeast Missouri. Special Report No. 1, 1960. (Project 423).

ANIMAL HUSBANDRY

A. J. Dyer, Chairman

THE INFLUENCE OF THE PHYSICAL FORM OF A RATION ON RUMINANT DIGESTION AND FEED USE. (W. H. Pfander, W. A. Hargus, R. L. Preston, C. Baile). There is widespread interest in the value of rations prepared in various ways. Efforts are being made to determine the best physical form for rations. Lambs have been individually fed in stall in barn twice daily; (1) shelled corn 60% and alfalfa pellets 40%; (2) complete ration pelleted (ground corn). Groups of lambs also have been fed: (1) a complete ration pelleted (ground corn) twice daily; (2) complete ration pelleted (ground corn) full fed; (3) complete ration mixed (steam cracked corn) twice daily; (4) concentrate (using steam cracked corn) in a. m. ; timothy hay at noon; concentrate in p. m. ; (5) concentrate (using cracked corn) in a. m. ; timothy hay at noon; concentrate in p. m. ; (6) complete ration mixed (cracked corn) full fed. Daily gains were not greatly different except for those fed

the shelled corn, alfalfa pellet ration. These gains were surprisingly low. Those fed the pelleted ration gained slightly less than those fed the mixed rations. The lambs fed a concentrate containing steam cracked corn in the morning and evening and roughage at noon gained the greatest. There was only a slight difference between those individually fed twice daily and those groups fed twice daily. The complete mixed rations resulted in lower dressing percentages. Individually fed lambs also had lower dressing percentages. Highest grades resulted when the concentrate containing steam cracked corn was fed in the morning and the evening and roughage at noon. Very much greater intramuscular fat resulted when lambs were group fed compared to individually fed. Steam cracked corn gave greater amounts of intramuscular fat than did cracked corn. Digestion trials were run on two lambs from each lot. These lambs were slaughtered at the end of the digestion trial with the exception of two lots that were receiving identical rations to one of the other lots. Complete slaughter records were maintained. The work on this project has been completed and the project is being closed.

Publications: Preston, R. L., W. H. Pfander. Performance of Fattening Lambs Fed Various Forms of Corn. J. An. Science 20:947, 1961.

Cooperation: North Central States (NC-25); Department of Agricultural Chemistry; Department of Dairy Husbandry (Project 250).

RATIONS FOR FATTENING CATTLE. (G. B. Thompson, A. J. Dyer, J. W. Cowan, L. Schake, W. E. Loch). Missouri ranked fifth among the states in the total number of beef cattle and calves on farms on January 1, 1960. Beef cattle are very important to the economy of the State. The demand by consumers and meat packers for tender beef with a high ratio of lean meat to fat, is increasing. This study is to determine the effects of nutrition on these carcass characteristics.

Feeding High Moisture Ensiled Corn to Beef Cattle. A feeding trial with yearling steers was conducted to compare a high moisture roughage (corn silage) with a dry roughage fed with a full feed of high moisture corn to fattening cattle. Yearling cattle full fed high moisture rolled, shelled corn with: (1) corn silage; (2) ground corn cobs; or (3) mixtures of silage and cobs made fast, efficient gains and 38% of them yielded choice carcasses at 112 days. The cattle fed corn silage made slightly faster gains and appeared to carry more finish at market time than cattle fed dry ground corn cobs. Cattle performance with mixtures of corn silage and cobs was about equal to silage alone. Silage was a satisfactory roughage for fattening yearling cattle full fed 20% moisture rolled, shell corn.

Silage and Corn Cob Rations for Sheep. A preliminary trial was conducted with lambs to test silage versus corn cob rations. The sheep were fed 111 days. Those on the silage ration gained 39.3 pounds and those on the corn cob ration gained 42.7 pounds.

The Effects of Protein and Energy Levels in Winter Rations for Beef Calves. Steer calves fed liberal winter rations containing adequate protein produced the best carcasses and were most economical of the four winter rations evaluated. Feeding low energy, low protein, winter rations produced the lowest quality carcasses with the greatest fat trim; and were less economical to produce than steers fed more liberal winter rations. Full feeding corn with adequate protein increased gain and produced the highest grading carcasses after a subsequent fattening phase. However, gains were less economical and fat trim greater than with a slightly less liberal winter ration. Steers implanted with diethylstilbestrol during the fattening phase, gained faster than unimplanted steers and produced carcasses with less fat trim and higher retail yields. Gain response to implants was greater for steers previously fed adequate protein winter rations. Implantation during the fattening phase did not affect marbling scores or carcass grades of steers previously fed liberal winter rations containing adequate protein. Carcass grades and marbling scores of steers fed low protein winter rations regardless of energy rations were lower for steers implanted during the fattening phase than for unimplanted steers. Further studies will be continued on the effects of nutrition on the quality of carcasses produced.

Publications: Cowan, J. W. Feeding Value of High Moisture Corn. A thesis submitted in partial fulfillment of the requirements for the degree, Master of Science, Graduate School, University of Missouri 1961.

Thompson, G. B., J. W. Cowan. Feeding High Moisture and Ensiled Corn to Beef Cattle. Missouri Agricultural Experiment Station, Special Report No. 5, April, 1961.

Thompson, G. B., R. L. Preston, H. B. Hedrick. Winter Rations for Carcass Quality. Journal Animal Science, 20:4:954, 1961.

Thompson, G. B., R. L. Preston, H. B. Hedrick. Winter Rations for Quality Beef Production, Missouri Agricultural Experiment Station Special Report, No. 5, April, 1961.

Thompson, G. B., G. Boswell, J. E. Comfort. Results of Feeding Yearling Steers at Two Protein Levels with Feed Additives. Missouri Agricultural Experiment Station, Special Report No. 5, April, 1961.
Cooperation: Department of Agricultural Chemistry, Experiment Station Laboratories; School of Veterinary Medicine (Project 237).

NUTRITION OF RUMINANTS. (W. H. Pfander, R. L. Preston, J. E. Blakeley, W. A. Hargus, C. F. Nockels, N. Worker). The ruminant as a producer of meat, milk, and wool must be able to compete efficiently in the overall utilization of energy and specific products stored in plants. The increasing value of land and capital equipment, necessitates higher efficiency in utilization of roughage and other feeds.

Total digestible nutrients predicted from percentage of nitrogen and percentage of crude fiber did not correlate well with that determined in sheep. A great limitation in the forage test for productive rations was the failure to estimate intake. Between the worst and best forages tested, differences in TDN content were 33%; in voluntary intake, 250%. Crickets and in vitro techniques may help predict intake of ruminants. The maximum DM loss from corn silage in a trench was 20% on the top six inches. At lower levels the loss did not exceed 6%. When animals were abruptly changed from hay to grain, there was a marked increase in fecal K and in percentage fecal NFE. The protozoa were largely removed within 48 hours. Homologs of stilbestrol with little estrogenic effect improved N balance. The mode of action was postulated to be at the site of urea reutilization. Rations high in corn supported better performance when they contained sodium and potassium bicarbonates. Ground limestone and sodium meta bisulfite did not improve the TDN content of high moisture rolled corn. Rumin papillae development under several rationing programs was studied. Development was not related to any known chemical tested. Silage prepared from male sterile corn was not very palatable to sheep. The forage evaluation work will be continued and the factors regulating and influencing nitrogen metabolism will be studied.

Publications: Brewer, L., R. L. Preston, W. H. Pfander. Effects of Growth Hormone and Diethylstilbestrol on Nitrogen Metabolism in Ruminants. Fed. Proc. 20:372, 1961.
Preston, R. L., W. H. Pfander. Cellulose, Starch, and Nitrogen Levels for Maximum Cellulose Digestion by Rumen Organisms In Vitro. Fed. Proc. 20:372, 1961.
Brewer, L. Ruminant Nitrogen, Sodium, and Potassium Metabolism. A thesis submitted in partial fulfillment of the degree, Master of Science, Graduate School, University of Missouri, 1961.
Pfander, W. H. Fatty Acids and Energy in Ruminant Nutrition. Proceedings of the Centennial Nutrition Conference, Kansas City, Missouri, pages 176-192, 1961.
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Cooperation: Departments of Agricultural Chemistry, Dairy Husbandry, and Agricultural Engineering; American Dehydrators Association; U. S. P. H. (Project 168).

MINERAL REQUIREMENTS OF RUMINANTS. (W. H. Pfander, R. L. Preston, M. F. Brink). There is limited factual information available on the mineral needs of farm animals and the factors affecting mineral content of farm feeds. The importance of mineral balance has been demonstrated. These studies are designed to help prevent deficiencies in mineral levels.

Potassium Requirements. Cross-bred wether lambs were divided into four groups of different dietary potassium levels: 0.1, 0.3, 0.5, and 0.9%. The feeding trial lasted 220 days. Lambs receiving 0.5% potassium gained faster, ate more feed, and were more efficient than those in the other groups.

Analysis for Certain Mineral Concentrations in Rumen Fluid from Cattle and Sheep on Various Rations. Rumen fluid analyses on samples collected from cattle and sheep on various rations have been completed. These analyses included some or all of the elements in the following list: P, Ca, Na, K, Cl, Mg, Mn, Zn, Fe, Cu, Mo, Co. The Cl concentration appeared to be the most constant. However, it was apparent that the level of Cl was affected by the type of roughage fed. Rations high in readily fermentable carbohydrate resulted in markedly lower Na levels. Lambs fed the ration used in the potassium studies showed trace

element levels decidedly higher than those on the other rations. Since their performance was probably sub-optimal, a subclinical toxicity of one of these trace elements may have been present.

Grass Tetany. Data from four experiments have been summarized. Four lambs consuming different added amounts of calcium were used: 0.175, 3.8, and 7.6 grams calcium per day. Ten grams of urea nitrogen was fed with the a. m. feeding. Blood samples showed $\text{NH}_3\text{-N}$ and urea-N levels increased after feeding as expected. Three sheep showed a faster increase in blood urea and a smaller increase in $\text{NH}_3\text{-N}$ than did the fourth sheep. These three sheep were fed the additional levels of calcium. Two sheep consistently had higher blood K levels but all this was not related to calcium intake. Blood phosphorus levels tended to decrease following feeding while calcium and magnesium were quite variable. No consistent pattern could be detected. Blood K and Na were relatively constant following feeding. This experiment was repeated without the feeding of urea. As expected, blood $\text{NH}_3\text{-N}$ and urea-N showed little change following feeding. This was also true for Na and K. Blood P was also relatively constant. Blood Mg levels were somewhat more constant. However, blood Ca was still quite variable following feeding. The experiment was repeated except that additional limestone was fed as well as urea. Two of the four sheep showed a faster conversion of fed urea-N to blood urea. They also did not show as high an increase in blood $\text{NH}_3\text{-N}$. Blood K and Na were relatively constant, whereas blood P decreased when urea was fed. Blood Mg levels were relatively constant while Ca was quite variable. The feeding of additional Ca did not appear to alter the results. In another experiment the lambs were placed on wheat pasture for 21 days; blood $\text{NH}_3\text{-N}$ increased; blood urea-N levels increased; blood K and Na remained relatively constant; blood P tended to decrease; blood Mg remained fairly constant; and Ca was quite variable. Lambs were infused intravenously with large doses of buffered phosphate (Na salt). Several lambs showed severe tetany shortly following this infusion and three lambs died. Upon autopsy, the only common lesions found were small white lesions present in the myocardium. Similar lesions have been found in cattle which died from grass tetany. Plasma analysis showed a marked reduction of plasma Ca and Mg; thus it appears that a calcium tetany was produced by the infusion of phosphate salts.

Molybdenum Toxicity. Four lambs were fed 1 gm. SO_4 with varying amounts of copper and molybdenum. It appeared that 50 ppm added copper was toxic; which was overcome with 20 ppm added molybdenum. Little effect was noted with 20 ppm added molybdenum only.

Fescue Foot. Some symptoms are common between selenium toxicity and fescue foot. Two fescue samples, free of the toxic principle, and two which had produced fescue toxicity were tested. Analyses indicated that selenium did not explain fescue foot in cattle.

Phosphorus Metabolism and Excretion. These studies were made with the aid of P-32. The results have been divided into two phases; data secured prior to the injection of P-32; and data collected following injection of P-32. Data processing has been completed for most of the first phase. The data for the second phase is still being calculated. Counting procedures and standardization have required a substantial amount of time but a procedure has been developed whereby daily fecal collections can be quantitatively counted without prior chemical digestion and sample preparation. Work will be continued on potassium requirements and phosphorus metabolism in ruminants.

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Brink, M. F., W. H. Pfander. Effect of Potassium on Rumen Function. J. An. Sci. 20:966, 1961.

Erwin, Thompson, Pfander. Calcium Requirements of Ewes. Missouri Agricultural Experiment Station Research Bulletin No. 763, 1961.

Cooperation: Station Chemical Laboratory; Station Spectrographic Laboratory; Department of Agricultural Chemistry; A. E. C. (Project 248).

FORAGE UTILIZATION BY CATTLE AND SHEEP. (W. H. Pfander). Advances in nutrition depend on theoretical advances in bacteriology, biochemistry, physiology, and related sciences and on the availability of methods. Work is being concentrated on the biochemistry of nitrogen utilization in detail. This is a new project and is a contributing project to the North Central Regional Project NC-63. Plans have been made for the division of work among the cooperating North Central Stations and the work is now starting.

Cooperation: States of the North Central Region (NC-63). (Project 493).

BEEF CATTLE BREEDING. (J. F. Lasley, J. E. Comfort, A. J. Dyer, R. E. Cooper, C. Stufflebeam, L. W. Eaton, V. G. Dev). The production and sale of beef cattle is one of the major sources of income to livestock men in Missouri and in other regions of the United States. Beef is one of the most important

sources of meat for the people of the United States because it is palatable and highly nutritious. Much of the improvement in the efficiency of production and quality of beef cattle must come through the application of breeding methods and principles.

Comparison of Two Systems of Breeding. Two breeding lines of cattle have been established: selection in one line is for weight for age; and in the other for both type score and weight for age. Purebred Hereford cows were divided into two lines so as to equalize the breeding as nearly as possible. Six bulls were used in the 1960 season; three on each line. The four sires producing calves with heavier weaning weights were used again in 1961. The calves sired by one bull averaged 46 pounds heavier than calves from two sires that produced the lightest weights (equal).

Estimation of Carcass Quality and Meatiness in the Live Beef Animal. Scores and measurements were made on 47 Herefords to determine the correlation between live animal measurements and carcass measurements. The six live animal measurements showing the highest correlation with the total percentage of primal cuts in the carcass were birth weight, circumference of fore shank, width through the shoulders, length from the shoulder to the hook bones, fat covering score, and slaughter grade. The last two measurements were negatively associated with lean cut yield with the first four showing a positive relationship. Estimating of the rib-eye area in the live animal using an ultrasonic sound instrument accounted for approximately 36% of the actual rib-eye variation in the carcass. The ability of different judges to predict carcass quality and meatiness in the carcass by scoring the live animal was studied. Certain judges were more accurate in estimating particular carcass characteristics than others. While all the judges tended to see things alike, they were not always correct in what they saw based on an actual carcass evaluation. Judges also tended to agree more closely with each other on the same day than they did with themselves on different days.

Breeding Efficiency in Beef Cattle. Records on a total of 262 different grade Hereford cows during the period 1951-1960 have been studied. Eleven different purebred Hereford bulls were mated to these cows during this period. The calf crop at birth for the ten year period was 98.6% and the calf crop at weaning was 93.4%. The extremely high calving percentage was due to the fact that nearly all cows that failed to settle during the breeding season were sold in the fall of the season. Thus, very few open cows were allowed to remain in the herd over the winter months. The most frequent reason for selling cows was that they had become too old to be productive. This age varied from 8-13 years, with the average age of disposal 10.64 years. Death losses amounted to less than 1% per year during the ten year period. The year of breeding and the bull to which the cows were exposed, both had a highly significant effect on the length of the calving interval. About 90% of calving intervals were less than 400 days in length and the modal group was that which ranged from 331 to 340 days.

Genetic Defects in Cattle. A congenital hoofless condition in purebred Angus calves in a Missouri herd was reported. The affected calves did not live more than one week because they could not stand to nurse their dams. The pedigrees were studied and all traced to a particular bull through both their sire and their dam. It was concluded that the defect was caused by a single autosomal recessive gene with complete penetrance but with variable expressivity. Since the hooves of calves are composed of the protein, keratin, this was evidence that genes act through the production of specific proteins.

An investigation was made of the mode of inheritance of sterility in Duchess Shorthorn cattle which were famous in the last part of the 19th century. Very intensive inbreeding and linebreeding had been practiced in the formation of this family of cows. This suggested that the sterility in this family was of a genetic nature. More recent knowledge of how genes act on the role of the anterior pituitary hormones in reproduction gives support to the theory that sterility in the Duchess cows was genetic. A study of the records gave evidence that the trait was not inherited as a single recessive trait. It was indicated that epistasis might be involved with a dominant epistatic gene not directly responsible for the hormone production, but having an inhibiting effect on another pair of genes causing the sterility. No evidence was available to determine whether or not the trait appeared in bulls.

Techniques for Identifying "Dwarf Free" and "Dwarf Carrier" Beef Cattle. Twenty-five Hereford cows pedigree clean and nine carriers of the dwarf gene were studied to determine the effect of the dwarf gene on the rate of alkali denaturation of hemoglobin. The temperature of the denaturing solution was found to have an effect upon the rate of hemoglobin denaturation. As the temperature increased the rate of hemoglobin denaturation also increased. When centrifugation of the hemolyzed blood cell was increased from 2550 to 2950 rpm the rate of hemoglobin denaturation also was increased. The resistance to the effects of the alkali was reduced at the higher speeds. The denaturation values for blood samples tested after 48 hours in refrigeration were not consistent with the values for the same sample when tested fresh. However,

the difference was not significant. Also, no significant differences were found between mean values of hemoglobin denaturation for blood samples taken on different days and tested within the first three hours after sampling. Correlation values were figured for hemoglobin denaturation values of heifers in the feed lot with their individual rates of gain and type scores. As the values for rate of gain and type score increased the resistance of the hemoglobin to alkali denaturation decreased slightly. The correlation was not statistically significant. Comparative rates of hemoglobin denaturation were determined for several species: cows, horses, sows, ewes, dogs, and chickens. Each specie was found to have a characteristic rate of hemoglobin denaturation. The influence of the dwarf gene on proteins in the blood serum was studied by means of a micro paper electrophoresis technique. The albumen-globulin ratio and the percent albumen and gamma globulin of the total serum protein showed no consistent pattern. The total protein in serum did show an overall pattern. It rose about 1% of the total serum in carrier animals by one hour after insulin, and dropped slightly in the dwarfs. Studies on the two breeding lines will be continued.

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Comfort, J. E., J. F. Lasley. Twenty-third Annual Spring Livestock Day Report. Missouri Agricultural Experiment Station Special Report No. 5, April, 1961.

Foley, C. W., J. F. Lasley, J. E. Comfort. Leucocyte Numbers in Normal and Dwarf Beef Cattle Before and After Insulin Injections. Missouri Agricultural Experiment Station Research Bulletin No. 762, December, 1960.

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Stufflebeam, C. E. Hemoglobin Studies and Dwarfism in Beef Cattle. A thesis submitted in partial fulfillment for the degree, Master of Science, Graduate School, University of Missouri, 1961.

Greiman, B. J. Subjective and Objective Live Animal and Carcass Evaluation and the Influences of Sire, Sex, and Hormone Treatment on Beef Cattle Performance. A thesis submitted in partial fulfillment of the requirements for the degree, Doctor of Philosophy, Graduate School, University of Missouri, 1961.

Subramanian, R. Breeding Efficiency in Beef Cattle. A thesis submitted in partial fulfillment of the requirements for the degree, Master of Science, Graduate School, University of Missouri, 1961.

Dev, V. G. Genetic Defects in Cattle. A thesis submitted in partial fulfillment of the requirements for the degree, Master of Science, Graduate School, University of Missouri, 1961.

Cooperation: North Central States (NC-1); Animal and Poultry Research Branch; ARS, U. S. D. A. ; U. S. P. H. (Project 198).

GENETIC AND ENVIRONMENTAL VARIATION IN FEEDER CALVES. (J. E. Comfort, J. F. Lasley, A. J. Dyer, L. W. Eaton). A large portion of the million beef cows in Missouri produced feeder calves. Both heredity and environment are of high importance in producing quality beef efficiently. Much additional work is needed before breeding principals are clearly understood and before they can have the most practical value in commercial beef herds.

Sire effects were studied in the grade Hereford herd at Weldon Springs. One hundred four calves were produced by four sires. Weaning weights ranged from 303 to 331 pounds at 210 days. There was no consistency in birth or weaning weights attributable to the use of "open" herd or "closed" herd sires. The progeny test steers are being used in feeding tests and the carcasses will be studied at a later date. January-March calves, the result of multiple sire matings by 8 Hereford fulls, were only 1 pound heavier at weaning time than were fall calves in 1960-61. Angus Hereford crossbreds, calved in late November and December, were 12 pounds heavier than fall Herefords. Grade cows have been bred to four sires in further progeny tests.

Publications: Greiman, B. J., J. E. Comfort, J. F. Lasley. Pre-Weaning, Fattening, and Carcass Performance of Six Sire Groups of Herefords. Missouri Agricultural Experiment Station Special Report No. 5, April, 1961.

Greiman, B. J. Subjective and Objective Live Animal and Carcass Evaluation and the Influences of Sire, Sex, and Hormone Treatment on Beef Cattle Performance. A thesis submitted in partial fulfillment of the requirements for the degree, Doctor of Philosophy, Graduate School, University of Missouri, 1961. (Project 396).

BULL TESTING. (A. J. Dyer, H. B. Hedrick, C. Angell, R. K. Levitt). This is a testing service for breeders to help locate efficient animals of desirable qualities in the various breeds of cattle. There is a demand for production tested bulls for use in purebred and commercial herds. A total of 36 bulls and 32 steers have been tested this year under the adopted plan.

Publications: Mimeographed data on each individual goat and steer has been prepared and distributed.

Cooperation: School of Veterinary Medicine

(Project 400).

INCREASING THE SIZE OF LITTERS IN SWINE. (J. F. Lasley, B. N. Day, E. W. Gibson, J. D. Neill)

The economic loss to the livestock industry that occurs through impaired fertility and embryonic death is large in magnitude but frequently not evident to the livestock producer. Breeding animals are maintained for the single purpose of producing offspring. If the animals fail to accomplish this purpose, an economic loss results. A loss due to complete sterility usually is evident, but low breeding efficiency is difficult to determine. This work is an effort to increase the size of litters in swine.

Follicle Stimulating Hormone. Sexually mature Poland China gilts were injected intravenously with 30 Armour Units of follicle stimulating hormone (Armour's FSH). The conception rate in this group of gilts was 33% higher than for the control gilts. Also, these gilts ovulated an average of 1.1 more ova than the control gilts. However, average litter size on the 25th day of gestation was 0.5 of a pig larger for the control gilts which is in contrast to previous findings. The differences observed in ovulation rate and litter size were not statistically significant. Conception rate was markedly higher in the treated gilts but no improvement was observed in litter size.

Human Chorionic Gonadotrophin. Previous studies had indicated that a follicle stimulating hormone injection was not an effective means of inducing super ovulation when administered during estrus. This suggested that the influence of FSH on ovulation occurred at some stage of the estrous cycle prior to the time of estrus. Therefore, the type of exogenous hormone employed was changed to a luteinizing hormone. Poland China gilts were injected intramuscularly with 250 I. U. of human chorionic gonadotrophin (HCG) immediately following the onset of estrus. This treatment failed to improve reproductive performance.

Gonadotrophic Hormones. The type of hormones used and the stage of estrous cycle when the hormones administered were varied in an effort to induce superovulation. The injection of 30 AU of follicle stimulating hormone on the 18th day of the cycle was not found effective. A similar response occurred in gilts administered 45 AU of FSH of the 17-19th day of the estrous cycle. Gilts were injected with pregnant mare serum (PMS) at a dose level of 1,000 I. U. per animal. The injection was made on the 17th day of the cycle. Only two of 11 gilts failed to show estrus following treatment. An average of 13.5 ova were shed at the first post-treatment estrus. Cystic ovaries were observed in two gilts. Gilts were injected with 500 I. U. of HCG, three days following an initial injection of 1,000 I. U. of PMS. The results were encouraging since 3 of 4 gilts showed estrus and the average ovulation rate was 22 ova. Further studies will be conducted.

The influence of Antibiotics at the Time of Breeding on Litter Size. Previous studies indicated that feeding high levels of antibiotics at the time of breeding increased litter size. An effort was made to determine the effect of antibiotics on litter size when administered as a uterine flush at the time of breeding. Although a slightly higher conception rate was noted in treated animals early embryonic mortality rate was not decreased. Litter size on the 25th day of pregnancy was lower in the treated animals but this was primarily the result of a sampling difference in ovulation rate.

The Maintenance of the Corpus Luteum in Gilts. Sexually mature non pregnant gilts were used to study the effect of stage of estrous cycle on the ovarian response of hysterectomy. Estrus was not detected in any of the animals following hysterectomy, and close agreement was observed in most animals between the number of corpora lutea marked at the time of hysterectomy and the number of marked corpora lutea present at the time of slaughter. However, the results were inconclusive since the total number of corpora lutea counted in 7 of the 9 gilts at the time of hysterectomy did not equal the number observed following slaughter. This discrepancy may have resulted from experimental error since some difficulty was encountered in identifying individual corpora lutea in some animals or it may have resulted from ovulations occurring subsequent to hysterectomy even though estrus was not manifested.

Luteotrophic Influence of Placental Fluids. Allantoic fluid was collected from pregnant sows 25 days after mating. The fetal membranes were homogenized and filtered and the filtrate was added to the allantoic fluid. Streptomycin was added to the fluid at the rate of 40 mg. per 50 mls. of fluid and penicillin at the rate of 25,000 units per 50 mls. The fluid was stored in vitro at a temperature of approximately 40°F. By using an inseminating pipette the fluid was introduced into the cervix of a non-pregnant animal as near to the uterine body as possible. A treatment influence on the regression of the corpora lutea seemed

evident in two gilts even though complete maintenance of luteal tissue did not occur. The use of more concentrated fractions of the placental fluid is suggested and further studies are needed.

Publications: Day, D. N., F. E. Romick, J. F. Lasley. Reproductive Performance in Gilts Administered Follicle Stimulating Hormones. Journal Animal Science, 22:968, 1961.

Cooperation: Department of Agricultural Chemistry; School of Veterinary Medicine; Regional Swine Breeding Laboratory, U. S. D. A.; U. S. P. H.; Jensen Salsbery Laboratories (Project 222).

PHYSIOLOGICAL RESPONSE TO INBREEDING AND HETEROSIS. (B. N. Day, J. F. Lasley, A. J. Dyer, F. E. Romack). The development of more effective mating and selection systems offers an excellent method for making permanent improvement in the efficiency of livestock enterprises. The formulation of good breeding plans is dependent on additional knowledge of the genetic and physiological factors responsible for variations. Inbreeding and cross-breeding have been demonstrated to be valuable tools for improving livestock through inheritance. This work is to develop a more thorough understanding of the physiological factors associated with these breeding systems.

A method has been developed for determining the thyroxine secretion rate of swine. This procedure has been used to establish the thyroid activity of 75 pigs. The daily thyroxine secretion rate was found to range from 0.05 mg. to 0.8 mg. per 100 pounds of body weight. The average daily thyroxine secretion rate of 58 growing-finishing pigs, was 0.46 mg. per 100 pounds of body weight. Further studies will be made on factors influencing the thyroxine secretion rate of swine. Two inbred lines of swine will be established.

Publications: Day, B. N., J. F. Lasley, H. E. Addleman, L. F. Tribble. The Leucocytic Response of Swine to Stilbestrol and a Progesterone-Estradiol Combination. Missouri Agricultural Experiment Station Research Bulletin, No. 775, 1961.

Cooperation: Department of Dairy Husbandry; Regional Swine Breeding Laboratory (U. S. D. A.) (Project 276).

SELECTION OF SWINE FOR THIN BACKFAT. (J. F. Lasley, B. N. Day, L. F. Tribble, K. O. Zoellner, R. C. Gray). Improvement of swine through breeding to produce animals of high efficiency in feed conversion and also a high percentage of desirable carcass cuts is very important to the swine industry. Efforts are being directed toward producing swine with a high percentage of lean meat.

Selection for thinner backfat has been continued in two lines of Poland pigs. In 1961, pigs were produced from the second generation of selected parents in the spring and the fall lines. Accumulative selection differentials for backfat probes at 174 pounds body weight have averaged 4.85 millimeters for boars and 2.40 millimeters for gilts. The accumulative responses from selection have averaged 2.21 millimeters for boars and 2.98 millimeters for gilts. After two generations of selection in the spring line, average backfat probes have been reduced 15.4% in boars and 17.8% in gilts. One generation of selection in the fall line resulted in an average reduction of 9.9% for boars and 12.5% for gilts. Work will continue on this selection study through another generation.

Publications: Zoellner, K. O. A Genetic Study of Selection for Thinner Backfat in Swine. Submitted in partial fulfillment for the requirements for the degree, Doctor of Philosophy, Graduate School, University of Missouri, 1961.

Heidenreich, C. J., L. F. Tribble, S. E. Zobrisky, J. F. Lasley. Carcass Evaluation in Live Hogs. Missouri Agricultural Experiment Station Research Bulletin No. 766, 1961.

Cooperation: Animal Husbandry Research Division, Swine Branch; U. S. D. A. (through Regional Swine Breeding Laboratory) (Project 3).

PERFORMANCE TESTING OF SWINE. (R. K. Leavitt, A. J. Dyer). Swine breeders are striving for efficiency in production by selection of improved breeding stock. This work is to test breeding stock. The number of pens tested during the winter of 1960-61, was 55 and during the summer of 1961 was 68. In the fall of 1961, 61 pens were started. Those that have met the adopted standards have been sold in public sale at the end of each test period. Test results, including carcass data, have been used in an educational manner to encourage producers to use meat type sires that will produce efficient offspring with desirable quality carcasses. In February, 1961, 65 head were sold at an average price of \$213; in March, 1961, 41 head were sold at \$123; August, 1961, 63 head at \$166; and September, 1961, 60 head at \$200. It has been estimated that 90-95% of the tested boars have gone into commercial herds with the majority being used in cross breeding programs. In the August and September sales, 30% of the boars sold went to buyers who had purchased boars in previous sales. The testing service will be continued and the fatback probe on boars has been lowered from 1.4 inches to 1.35 inches effective in 1962.

Publications: Pen data, individual animal data, and carcass data have been mimeographed and distributed. (Project 365).

SURVIVAL AND GROWTH OF BABY PIGS. (L. F. Tribble, A. J. Monson). The number of pigs raised per litter represents profit potential for the producer. The loss of pigs from birth to weaning is large and represents substantial financial loss to producers. An effort is being made to increase the number of pigs per litter and to reduce the death losses in pigs from birth to weaning.

Trials to determine the effect of different levels of protein during gestation have been completed. The results have been variable. One trial indicated that one-half pound of a 45% protein supplement per head per day was adequate. Another trial showed that 1 1/4 pounds of supplement per head per day farrowed and weaned more pigs than those fed lesser amounts. Pigs and gilts fed zinc weighed more at weaning time. Feeding high levels of antibiotics at breeding time showed approximately 18% more pigs per litter. However, there was one trial which did not indicate this advantage. The value of sugars, flavors, and odors in rations for young pigs was studied. The pigs showed a preference for sugar and for certain flavors and odors as compared to the basal ration. The work on rations for sows during gestation will be continued. Feeding and management practices prior to breeding will also be studied.

Publications: Dean, B. T., L. F. Tribble. Reproductive Performance of Swine Fed Different Planes of Energy During Gestation. Missouri Agricultural Experiment Station Research Bulletin, No. 774, 1961.

Dean, B. T. Factors Affecting Reproductive Performance of Swine. A thesis submitted in partial fulfillment of requirements for the degree, Doctor of Philosophy, Graduate School, University of Missouri, 1961.

Dean, B. T., L. F. Tribble. Effect of Feeding Therapeutic Level of Antibiotics at Breeding on Reproductive Performance of Swine. J. An. Sci., in press, 1962. (Project 355).

PROTEIN NUTRITION OF SWINE. (L. F. Tribble, N. H. Schnarre). The supplementation of farm grown grain with high protein feeds represents a substantial investment to swine producers. Information is needed on the protein requirements of a ration that is well fortified with vitamins, proteins, and antibiotics. As essential amino acids become commercially available, the possibility of using these amino acids to improve low quality proteins needs to be studied.

The addition of lysine to either 12% or 16% protein rations proved of no benefit to weaning pigs. Twelve percent protein was not as good as 16% protein for pigs up to 125 pounds in weight. After that weight, 12% protein rations proved more desirable. Therefore, the combination of 16% protein from weaning to 125 pounds, and 12% from 125 pounds on to market weight was the most satisfactory. The addition of 3% of blood meal to a 12% protein ration produced gains in pigs equal to those obtained from a 16% protein ration. In one trial, protein level in the ration had no effect on backfat probes of the pigs. Pigs fed barley gained slightly faster when the barley replaced corn pound for pound than when fed at the same protein level on corn rations. Work will be continued on protein level and amino acid supplementation. (Project 141).

ECONOMIC TRAITS OF SWINE. (L. F. Tribble, R. K. Levitt). Development of the swine industry so that the consuming public may be provided with pork of excellent quality; and at the same time provide increased efficiency to the swine breeder is of great economic importance to the State of Missouri. There is wide variation in swine production as shown by the rates of gain at the Missouri Swine Testing Station. These gains have varied from .87 pounds to 2.74 pounds per day and the efficiency of gain has varied from 277.7 pounds to 343 pounds of feed per 100 pounds of gain. The percentage of lean cuts has varied from 42.6% to 52.14%. Backfat thickness has varied from 1.2 to 2.0 inches. The weight of hams has varied from 24 pounds to 32.6 pounds and dressing percentages have varied from 73.05 to 78.4%. Data has been collected on rate of gain and feed efficiency by various periods from 65 to 200 pounds. A detailed statistical analysis is under way. Data will be collected from additional tests conducted at the swine evaluation station and analyzed.

Cooperation: Kansas City Stockyards; St. Joseph Stockyards; Missouri Bus and Truck Association; Missouri Production Credit Association (Project 398).

METHODS OF SHEEP PRODUCTION IN MISSOURI. (C. V. Ross, A. J. Dyer, W. H. Sellers). The opportunities in sheep production in certain sections of Missouri appear to be extraordinarily good providing production methods which exploit the natural advantages of abundance of pasture and feed, mild climate, and excellent markets. Few classes of livestock can equal sheep in the efficiency of converting pasture and high quality roughage to saleable products.

Supplementing Corn Silage with Dehydrated Alfalfa Pellets for Wintering Pregnant Ewes. Ewes were divided into three uniform groups, placed in dry-lot, and fed corn silage plus dehydrated alfalfa pellets and shelled corn. The dehydrated alfalfa pellets and corn were fed at three different levels to effect a different protein intake by each group of ewes and the corn was added to equalize the energy consumed. All ewes produced strong lambs. The following results were secured: (1) There was a wide range of tolerance for protein levels by pregnant ewes wintered on pasture and corn silage; (2) The form of the protein appeared to be

relatively unimportant; (3) Ewes carrying twins were more affected by protein levels than those carrying singles; (4) Yearling ewes were more affected by shortage of protein than mature ewes; (5) In all cases, fleece weights were reduced by low protein rations. In another test, data were secured showing that the source of crude protein was relatively unimportant for supplementing corn silage for pregnant ewes.

Acceptability of Creep Rations by Suckling Lambs. Lambs preferred a creep ration composed of 60% ground corn, 30% soybean oil meal, and 10% bran over all other feeds offered them. The inclusion of dehydrated alfalfa meal reduced palatability of the ration to a marked degree. Pelleting a relatively unpalatable ration resulted in doubling the consumption of this ration, but on mixtures which were well liked the benefits from pelleting were relatively less.

Shelled Corn Versus Two Palatable Pelleted Creep Rations for Suckling Lambs. A mixed pelleted formula contained 60% ground yellow corn, 30% soybean oil meal, and 10% ground dehydrated alfalfa pellets. At the end of five weeks feeding this ration was changed since the lambs had failed to eat the pelleted ration readily. The new ration consisted of 60% ground yellow corn, 30% soybean oil meal, and 10% wheat bran. One lot of lambs had free access to corn placed in a creep, the other lot had free access to the two pelleted rations described above. During a 62 day feeding trial, the lot on shelled corn gained 28.35 pounds and the lot with access to the two mixed rations gained 34.37 pounds.

Early Weaning in Dry Lot Versus Pasture for Early Lambs. Early spring lambs were divided into two uniform groups to determine the effect of weaning lambs at an average age of 75 days, then feeding in dry lots versus creep feeding lambs suckling their dams on pasture. The lambs weaned and fed in dry lot gained 40% faster than those which ran with ewes on pasture. The lambs in dry lot were obviously fatter and had more bloom. Eighty-seven percent of the dry lot lambs graded good or above at the end of the test; whereas only 48% of the pasture lambs graded as well. None of the lambs in dry lot had more than a trace of stomach worm eggs in feces while 50% of those on pasture had infections that were clinically significant.

Comparison of Mineral Mixes for Lambs on Pasture. Lambs were divided into two lots and grazed on parasite infested pastures. Lot 1 had access to a 90% salt, 10% phenothiazine mix; lot 2 had access to two mixes: one containing 60% salt, 30% steam bone meal and 10% phenothiazine, and the other the same except for the substitution of dicalcium phosphate for bone meal. Pastures were poor and all lambs lost weight. Three lambs died from parasites in the first lot and no deaths occurred in the other lot.

A Comparison of Standard Phenothiazine, Fine Particle Phenothiazine, and Rurlene for Worming Grazing Lambs. Very heavy infection of stomach worms was observed on lambs treated with standard phenothiazine. Fine particle phenothiazine proved more satisfactory. Rurlene was superior to the others. Later when the lambs were finally slaughtered, they were observed to be carrying a heavy load of nodular worms.

Comparison of Meatiness and Economic Factors of Progeny of Four Rams. The progeny of four outstanding Hampshire rams were compared from birth to time of slaughter. A total of 73 lambs were individually fed in dry lot until they reached 96 to 100 pounds in weight and graded low choice alive. There were significant differences in progeny even among outstanding rams. Differences in wool weight in progeny of the sires were also significant.

It is planned to compare supplements containing urea with supplements containing soybean oil meal. Supplements containing auromyecin will also be tested with controls. Other ration tests will also be made. Progeny tests with rams will be continued.

- Publications: Ross, C. V., M. L. Karr, R. L. Pavey. Creep Feeding Studies with Lambs. Missouri Agricultural Experiment Station Research Bulletin, No. 772, June 1961.
- Ross, C. V., G. C. Shelton. Practical Tests with Anthelmintics for Grazing Lambs. Missouri Agricultural Experiment Station Research Bulletin, No. 773, June 1961.
- Ross, C. V., W. H. Sellers, S. E. Zobrisky. Meatiness and Feed Lot Traits of Sheep Progenies. Journal of Animal Science, 20:4:910-911.
- Zobrisky, S. E., W. G. Moody, C. V. Ross, H. D. Naumann, H. B. Hedrick. Live Animal and Carcass Indices of Lamb Composition. Journal of Animal Science, 20:4:922.
- Ross, C. V., W. H. Sellers. Palatability of Creep Rations for Suckling Lambs. Journal of Animal Science 20:4:922.
- Rae, J. C., C. V. Ross. Effect of Anthelmintics, Hexestrol Implants, and Hours on Pasture on Grazing Lambs. Journal of Animal Science, 20:4:962-963.
- Ross, C. V., M. L. Karr. Effectiveness of Anthelmintics for Grazing Lambs. Journal of Animal Science, 20:4:963.

Sellers, W. H. Progeny Testing of Rams for Growth and Development, Feed Lot Traits, and Meatiness. A thesis submitted in partial fulfillment for the requirements for the Master of Science degree, Graduate School, University of Missouri.

Cooperation: William Cooper and Nephews, Incorporated

(Project 142).

REPRODUCTION OF SHEEP. (C. V. Ross, J. R. Brooks, M. G. Moose). Missouri is especially well adapted for the production of early spring lambs. Winters are relatively mild; there is an abundance of forage; adequate grain production; and a long grazing season. In past years, Missouri has been one of the leading states in sheep production, but recently has been declining. A big deterrent to early lamb production has been the failure of ewes to settle early in the fall.

Three experiments have been conducted to test the effects of a combination of environmental temperatures and thyroxine therapy on the semen quality of 13 Hampshire Rams. Temperatures of approximately 80°F caused a marked decline in fertility. The daily injection of L-thyroxine did not significantly affect semen quality. Neither goitrogenic inhibition of the thyroid nor surgical thyroidectomy were found to influence semen quality. Body temperatures in rams subjected to 95°F temperatures, could be lowered by dipping them in a water bath. Spraying for periods up to 11 minutes had little effect on body temperatures, although respiration rate was reduced. Dipping at intervals of four hours when temperatures were 80°F or above did not significantly improve breeding efficiency of rams. Further studies will be made on cooling rams and the effects of obesity and exercise.

Publications: Brooks, J. R., C. V. Ross. The Effect of Ambient Temperature and Thyroxine Therapy on Semen Quality of Rams. A paper submitted for publication to the Journal of Animal Science.

Brooks, J. R., G. W. Pipes, C. V. Ross, C. W. Turner. The Effect of Temperature on the Thyroxine Secretion Rate of Rams. A paper submitted for publication to the Journal of Animal Science.

Brooks, J. R. The Influence of the Thyroid Gland and Ambient Temperatures on Fertility of Rams. A thesis submitted in partial fulfillment for the requirements for the degree, Doctor of Philosophy, Graduate School, University of Missouri, 1961.

Cooperation: Department of Dairy Husbandry

(Project 354).

LAMB FEEDING STUDIES. (C. V. Ross, J. C. Rae). Expenses in small lamb feeding feed lots, have risen much faster than efficiency. This has caused many feeders to discontinue operations. Some large feeders by mechanizing and self feeding complete rations, have increased their efficiency to a level where quite satisfactory returns can be achieved.

Concentrates have been fed to compare a 35% ration with a 56%. Meal has been compared with pelleted rations; and crude protein has been compared at 10, 12, 14 and 16% levels. Lambs fed the higher concentrate rations, made faster and more efficient gains and had higher carcass grades. Gains were greater on increasing levels of protein up to 14%. Lambs fed pelleted rations made faster gains but the feed efficiency was not significantly better. Grades were significantly higher. Lambs failed to make satisfactory gains on supplemented silage. No difference was noted between phenothiazine and ruelene treated lambs. There was no response to a cobalt supplement. There was no difference in gains due to environmental temperatures used. Sheared lambs made faster gains than wooled lambs in warmer temperatures and poorer gains in the cooler temperatures. More detailed studies will be made on temperature effect on requirements for protein, concentrates, and roughage.

Publications: Rae, J. C. Studies of Factors Affecting Performance of Fattening Ovine. A thesis submitted in partial fulfillment for the requirements for the degree, Doctor of Philosophy, Graduate School, University of Missouri, 1961.

(Project 356).

PILOT STUDIES. (Members of the staff of the Department of Animal Husbandry). From time to time unexpected and unpredictable conditions develop on livestock farms in Missouri. These need to be investigated immediately. If a major problem exists, further extensive efforts will be directed toward it. In some cases a few simple tests may provide the answers.

Stiffness in Cattle. (A. J. Dyer, W. H. Pfander). A type of stiffness in cattle was observed on several farms in Northeast Missouri. On one farm about 10% of the animals were affected. The most severely affected animals had swollen shoulders and stiff hind limbs and were in pain when they moved. Samples of the feeds being used were brought to Columbia and fed to yearling wethers. After 21 days two of the animals developed a stiffness similar to that seen in the animals on the Northeast Missouri farm. Within 30 days all experimental animals were stiff. This may be the first time that a similar stiffness to that seen in ruminants under field conditions has been produced experimentally. Samples of feed, feces, urine, blood, liver, and

bone are being analyzed for minerals and vitamins. It is anticipated that a special project directed toward the solution of this problem will be undertaken during the coming year.

Cooperation: U. S. P. H.

(Project 447).

IDENTIFICATION IN LIVE SWINE OF FACTORS CAUSING INCREASED VALUES IN CARCASSES. (H. D. Naumann, S. Zobrisky, J. W. McKinsey, V. J. Rhodes, G. Nance, W. E. Meyer, W. G. Moody, E. Pfuehler, W. C. Stringer). All segments of the livestock and meat industries as well as the consuming public are vitally interested in improved methods of accurately evaluating live animals and their carcasses. The ability to meet consumer meat preferences should reflect advantageously back to the producer, processor, and others. This is dependent upon more precise evaluation of the live animal. This problem becomes more critical each year with increased emphasis on diets, convenience, automation, processing, and merchandising efficiency. The utilization of surplus animal fats is also a factor. The future of breeding, production, and livestock marketing will be influenced profoundly by the accuracy of the evaluation of live animals and their carcasses.

An economic analysis indicated that the slaughter of hogs at lighter weights was often uneconomical under present hog pricing practices. An analysis of wholesale meat prices by cuts; and of the yield of trimmed cuts as a function of livegrade and weight has been started in order to appraise live pricing practices. Four separate studies involving a total of 445 animals were conducted to determine the proportion of lean and fat in live animals, using the high frequency sound technique. Relationships between the estimated (high frequency sound) and actual proportions of lean and fat were found to be: (1) high; (2) significant; and (3) of practical utility. This is an Agricultural Marketing Act project.

Publications: Moody, W. G., B. M. Day, H. D. Naumann. High Frequency Sound Estimates of Meatiness in Swine. *Journal of Animal Science* 20:922, 1961.

Zobrisky, S. E., W. G. Moody, C. V. Ross, H. D. Naumann, H. B. Hedrick. Live Animal and Carcass Indices of Lamb Composition. *Journal of Animal Science*, November 1961.

Cooperation: Department of Animal Husbandry

(Projects 383, 384).

IMPROVING THE QUALITY OF MEAT. (M. Mangel, R. Baldwin, H. D. Naumann, M. Bailey, V. J. Rhodes, C. Rodgers, D. Christy, B. Korschgen, P. F. Gould, J. Hendrix). A detailed report will be found in the Home Economics Section. (Projects 348, 349, 350).

USE OF MEATS IN THE RESTAURANT INDUSTRY. (H. D. Naumann, H. Hedrick, M. Mangel, C. Pudelkewicz, R. Baldwin, C. Rodgers, J. Clifford, B. Christy, B. Korschgen, V. J. Rhodes, H. Leach, H. C. Little, J. W. McKinsey, G. Nance, J. West, C. Braschler, D. Alexander). A detailed report will be found in the Agricultural Economics section. (Projects 385, 386, 387).

BEEF STORAGE TEMPERATURES AND LENGTHS OF STORAGE TIMES. (V. J. Rhodes, H. D. Nauman, I. Delaney, R. Baldwin, M. L. Rosencranz, C. Harris, W. C. Stringer, P. Benson). The production, distribution, and marketing of meat and meat products is of major importance to the economy and well being of the nation. Deterioration in storage affects the acceptability of many products. This investigation is an effort to establish the storage and distribution life of meat and meat products. Work this year has been with beef. A survey of homemaker practices of meat storage in the refrigerator-freezer has been completed. A random sample of 123 families of five socio-economic groups was used. The results have been tabulated and are now ready for statistical analysis regarding types of equipment, storage practices, sources of information, and family characteristics.

A pilot study indicated the need for additional information on the length of storage period. Samples of ground beef were stored under conditions simulating home practices. Five market samples prepared with four different wraps and stored for two periods of time were evaluated. Moisture and fat determination and bacterial counts were conducted on all samples. The results are now being summarized.

A study has been completed on the influence of display time, temperature, and microflora on the shelf life of prepackaged beef. Steaks which were held at 30°F remained acceptable two days longer than those held at 40°F. Firm steaks continued desirable two days longer than soft fleshed steaks. Restriction of microflora growth with antibiotics and antimycotics resulted in greatly extended persistence of characteristic red meat color. Strict sanitation practices also yielded the same result. This project has been completed and manuscripts are now in preparation. This is an Agricultural Marketing Act Project.

Cooperation: Departments of Agricultural Economics and Home Economics

(Projects 334, 335, 336).

INDICATIONS OF MEATINESS. (S. Zobrisky, A. J. Dyer, H. B. Hedrick, W. G. Moody). There is a lack of information on the factors which influence body composition of meat animals and tenderness of meat. Carcass improvement is being held back by the lack of adequate objective as well as subjective measures for

carcass evaluation. The accumulation of information now available from consumer research studies indicates that the consumer places more emphasis on the tenderness of meat than any other eating characteristic. Also, meat moving into the retail trade must have a high lean yield along with other quality factors.

Data have been collected involving 70 lamb, 106 pork, and 144 beef carcasses. Data, also, have been analyzed from an additional 695 beef carcasses. Evaluation of steer and lamb carcasses by sire groups showed differences in carcass characteristics attributable to sire influence. Data from swine carcasses indicated that breed, season, and sex influenced meatiness. Anatomical growth and development studies of swine showed that live animal and carcass measurements were positively associated. Continued work with ultrasonics showed that rib eye area and fat thickness can be accurately measured in live cattle. Evaluation of beef carcasses from the beef cattle testing program revealed a wide variation in carcass characteristics, especially in quality. The beef rib eye area per 100 pounds decreased and fat thickness increased as carcass weight increased. Studies will be continued to determine factors affecting growth and development of swine; and sire influences on lamb and beef carcass characteristics.

Publications: Hedrick, H. B., W. E. Meyer, M. A. Alexander, S. E. Zobrisky, H. D. Naumann. Estimation of Rib Eye Area and Fat Thickness of Beef Cattle with Ultrasonics. *Journal of Animal Science*, Volume 21, 1962 (in press).

Moody, W. G., C. V. Ross, H. D. Naumann. Live Animal and Carcass Indices of Lamb Composition. *Journal of Animal Science*, 20:922, 1961.

Moody, W. G., L. F. Tribble, H. D. Naumann. Meatiness of Swine as Influenced by Breed, Season, and Sex. *Journal of Animal Science*, 20:923, 1961.

Alexander, M. A. A Study of Various Objective and Subjective Methods of Determining Beef Carcass Composition and Quality. A thesis submitted in partial fulfillment for the degree, Master of Science, Graduate School, University of Missouri, 1961.

Meyer, W. E. A Study of Meatiness and Quality in Beef Cattle. A thesis submitted in partial fulfillment of the requirements for the degree, Master of Science, Graduate School, University of Missouri, 1962.

Cooperation: Eli Lilly and Company (Project 397).

MEAT QUALITY STUDIES. (M. E. Bailey, R. Macy, R. W. Frame). The criteria for quality in meat varies greatly among individuals. Essentially, such factors as tenderness, flavor, aroma, juiciness, appearance, and nutritional values are considered important. Some of these factors are governed by such things as heredity and pre-slaughter treatments. Others are controlled by post-slaughter treatments such as aging, processing techniques, storage methods, cooking, and retail handling. This work is concerned with the methods of evaluating post-slaughter treatments.

Studies have been made of the purines, pyrimidines, phosphoric acid esters, carbohydrates, and amino acids in extracts from beef, pork and lamb. The following phosphate esters and N-ring compounds were identified in one or more of these tissues: Fructose-1, 6-diphosphate, ADP, AMP, ATP, glucose-1-phosphate, phosphoethanol-amine, inosine, creatinine, hypoxanthine, phosphoserine, IMP, glucose-6-phosphate and DPN. Carbohydrates found in meat from all three species were glucose, ribose, and maltose. The following amino acid like compounds were found in meat extracts of one or more of the three species: phosphoserine, phosphoethanolamine, taurine, aspartic acid, threonine, serine, glutamic acid, glycine, alanine, asparagine, citrulline, cystine, valine, methionine, isoleucine, leucine, tyrosine, phenylalanine, tryptophan, lysine, histidine and arginine. Studies will be continued of the carbohydrate and nitrogenous components and their interactions during cooking. Work will be initiated on the effects of animal stress on quality factors in meats.

Publications: Frame, R. W. Studies of the Photo Oxidation of Nitrosomyoglobin. A thesis submitted in partial fulfillment of the requirements for the degree, Master of Science, Graduate School, University of Missouri, 1961. (Project 432).

MEAT TENDERNESS STUDIES. (M. E. Bailey, F. C. Parrish). Consumer research studies on meat and meat products indicates that the tenderness of meat is the most important single factor in determining quality and desirability. At present tenderness can only be measured by sensory methods and the factors directly responsible for the various degrees of tenderness have yet to be defined. This work is an effort to delineate some of these factors.

Detailed studies have been made on the properties of muscle proteases (cathepsins). One of the major problems concerned with meat tenderness during aging is the elucidation of the mechanisms involved in the resolution of rigor mortis. Two theories have been proposed; the first is involved with the enzymatic degradation of proteins to yield substructures more highly associated with water; and the second implicates certain types of ionic shifts, primarily of the alkali metals which allow proteins to become more

highly saturated with free water. An important question in connection with the first theory is whether or not autolytic proteases (cathepsins from muscle tissue) contribute appreciably to proteolysis during the so-called "aging" period; and also, are these enzymes important in tenderizing meats. Proteolytic enzymes secreted by certain types of micro-organisms are also involved.

Effect of Inorganic Solvents on the Extraction of Cathepsins. Various inorganic solvents were compared with water as extraction media. There was very little difference in the catheptic activity of samples extracted with the various solvents used. Acetate buffer-extracted protein had slightly greater activity than the other solvents when activity was determined at 274 mu. Water and phosphate buffers were also effective in removing cathepsins from muscle but were not quite as good as the acetate buffer.

Protein Concentration in Extracts Necessary for Optimal Activity of Pork Cathepsin. Various dilutions of crude extracts and ammonium sulfate fractions from pork muscle were tested to determine the appropriate dilution necessary for optimal activity measurements when denatured hemoglobin was used as substrate. In most cases the reactivity of undiluted enzyme extracts from pork tissues were not linear with time. This indicated insufficient substrate present to saturate the enzyme; or possibly that the protein extract contained some inhibitor even after dialysis. Since it was impractical to use higher concentrations of substrate, the enzyme extract was diluted prior to analysis for activity. Reactivity of subsequent dilutions of the enzyme sample were always linear with time up to 4 hours and when appropriate corrections were made for dilutions the reactivities were approximately equal. Cathepsin activity of pork muscle extracts was also determined following fractionation with ammonium sulfate when several dilutions of a fraction from a 40 to 70% saturated ammonium sulfate cut were analyzed. The reactivities were linear during the two hours of reaction time and were proportional following corrections for dilutions.

Optimum PH of Porcine Cathepsin. The effect of PH on the activity of porcine muscle proteases was studied. Several experiments were run and in general it was found that there was a PH optimum between 3.8 and 4.0.

Effect of Metal ions on Activity of Pork Cathepsin. Various metal ions were added to the reaction mixture to determine their effect on activity. Ferrous ammonium sulfate stimulated the greatest amount of activity at both concentration levels so further investigations of the effect of this salt have been initiated. The results indicated that if rigor-mortis was resolved during aging by proteolysis, and supposing that the muscle caphepsins were important in this respect, it might be possible to increase their activities through the addition of ferrous ions.

Thermal Inactivation Investigations. The effect of heating at a temperature of 65°C on the activity of porcine caphepsins has been studied. The half life of the enzyme at this temperature under the conditions used was approximately six minutes. This indicated that the enzyme was only slightly resistant to heating at this temperature. Further studies involving thermal effects on the activity of pork cathepsin consisted of examination of tyrosine produced by the reactions system when temperatures ranged from 25 to 50°C. The activities of the enzymes were progressively increased until the temperature reached 45°C, after which they progressively decreased. The optimal temperature appeared to be around 45°C.

Purification Procedures. Initial purification procedures involved the use of ammonium sulfate. Maximum purification by this method was obtained by precipitating protein from aqueous extract of pork muscle with ammonium sulfate saturated at the level of 50 to 60%. The total increase in activity was 40%. This fraction was then dialyzed and further fractionated with the DEAE cellulose using column chromatography. The most active fraction obtained indicated that the total purification was approximately 10 fold but the total protein recovered was too small to be used for further fractionation studies.

Synthetic Substrates. Synthetic substrates were used in an effort to characterize pork muscle proteases more thoroughly. Preliminary results indicated that it possibly catalyzed the hydrolysis of the amid bond in L-glycyl-L-phenylalany amid. The analytical methods used were inadequate to give a quantitative determination.

Publications: Bailey, M. E., H. B. Hedrick, F. C. Parrish, H. D. Naumann. L. E. E. Cramer

Shear Force as a Tenderness Measure of Beef Steak. A manuscript prepared for publication in the Journal of Food Technology. (Project 327).

DAIRY HUSBANDRY

J. E. Edmondson, Chairman

THE INFLUENCE OF FREQUENCY OF FEEDING ON MILK PRODUCTION. (C. P. Merilan, A. C. Ragsdale, J. R. Campbell, J. D. Sikes, G. A. Hindery, F. A. Martz, M. E. Oetting, H. S. Peet, L. R. Rainey). The efficiency of dairy farm operation must be increased to maintain satisfactory net incomes for dairymen and to stimulate consumption of dairy products by maintaining relatively low prices to consumers. The complex interrelationships between appetite, feed intake, feed quality and composition, and metabolic and productive status of the animal should be thoroughly understood in order to achieve the greatest efficiency of feed utilization. This study is to determine the effects of frequency of feeding on production. The feeding of both hay and grain two times a day was compared with feeding four times a day. Increased frequency of feeding resulted in increased production of milk, milk fat, milk solids not fat, and total solids. Body weight was not affected. Total feed intake was increased when fed more frequently. Different grain hay ratios were tested but no significant effects were found. Additional feeding trials involving 16 Jersey cows, 24 Jersey heifers, 100 Guernsey cows, and 80 Guernsey heifers are in progress. These studies will be continued to determine the effect of feeding systems on efficiency and mechanisms of feed utilization.

Publications: Campbell, J. R., C. P. Merilan. Effects of Frequency of Feeding on Production Characteristics and Feed Utilization in Lactating Dairy Cows. *Journal of Dairy Science*, 44(4):664-667, April, 1961.

Johnson, H. D., O. Wayman, H. H. Kibbler, A. C. Ragsdale, I. L. Berry, C. P. Merilan. Effects of Temperature and Controlled Feeding on Milk Production and Related Physiological Reactions in Cattle. *J. Animal Science*, 20(4):974, November, 1961.

Oetting, M. E., C. P. Merilan. The Effect of Concentrate: Roughage Ration on the Production Performance of Lactating Holsteins. Manuscript has been completed. (Project 55).

MICRO ORGANISMS IN DAIRY CATTLE NUTRITION. (C. P. Merilan, K. W. Bower, J. R. Campbell, F. A. Martz, M. D. Cunningham). The determination of the specific role, the requirements, and the capabilities of each micro-organism in the rumen flora as well as the synergistic and antibiotic relationships of the rumen micro population will provide a sounder basis for dairy cattle nutrition practices. Chemical analyses and biological values of feedstuffs give only a partial picture of their nutritive value for ruminants. This study is to aid in providing methods for the isolation and identification of rumen micro-organisms and in evaluating the activities of the rumen population in relation to the maintenance and production requirements of the dairy cattle.

The development of a simple rapid method for the estimation of forage digestability has been attempted by suspending feed samples in nylon bags into rumen fistulated animals. A 24 hour incubation period was found to be most satisfactory for the determination of dry matter loss and thus the microbial digestion of the forage. Feeds used included wheat straw, first cutting alfalfa from two different sources, and dehydrated alfalfa pellets. There were significant differences in rumen digestion between different sources of alfalfa hay. The digestion of samples suspended in one cow was significantly different from the digestion of another cow. Apparently there was no significant difference between digestion due to a change from alfalfa to grass rations. There was considerable variation for the digestion of the same samples from day to day. A substantial amount of time has been devoted to the development of specially designed equipment for this work.

Publications: Blenden, D. C., C. P. Merilan. Isolation of Clostridia by Crystal Violet Inhibition of Aerobic Spore-Forming Bacteria. *Am. J. Vet. Res.* 22 (90):944, September, 1961.

Cooperation: Departments of Agricultural Chemistry and Animal Husbandry; School of Veterinary Medicine; States of the North Central Region, (NC-25). (Project 246).

THE ROLE OF HORMONES AND ENZYMES IN GLAND GROWTH AND LACTATION. (C. W. Turner, G. Pipes, R. Anderson, H. C. Damm, D. R. Griffith, C. E. Hendrich, S. Djojosebagio). The economical and efficient production of milk depends upon animals with either high genetic potential productivity or upon replacement therapy with hormones which will cause them to be potentially higher producers.

Growth of the Mammary Gland. DNA value was used as an indication of growth in the rat mammary gland. In normal pregnant rats the injection of thyroxine stimulated an increased DNA value greater than in control animals. Administration of estradiol benzoate plus progesterone in ovariectomized rats stimulated gland growth equal to that occurring during pregnancy. Continued injections did not significantly increase growth but it did prevent involution. In the rat, estrogen and progesterone are effective stimulators of mammary gland growth. In the normal biosynthetic pathway pregnenolone precedes progesterone and 17 α -hydroxy-

progesterone and rostenedione and testosterone follow in sequence. The mamogenic effectiveness of these steroids were compared with progesterone. On the basis of DNA values they were: 29.0%, 26.5%, 35.8%, and 33.0% as effective. When rats were adrenalectomized as well as ovariectomized the amount of adrenal hormone required for normal mammary gland growth with estrogen and progesterone was 100 ug prednisone or 100 to 250 ug hydrocortisone acetate. While adrenal hormones were not gland stimulating in themselves, they played an important part in the general metabolism of the animal. Again an increase in DNA has been obtained in normal lactating rats during the initial three days of lactation. Ovariectomized females were brought into milk secretion with hydrocortisone acetate and lactogen alone or in combination. Growth hormone was not effective in this respect. When estrogen and progesterone were administered at the higher levels in combination with hydrocortisone acetate and the growth hormone, the mammary gland DNA increased. All animals showed evidence of heavy milk secretion. This suggested that these three hormones were responsible for the additional development of the mammary gland after parturition. In male and female mice maximum growth of the mammary gland was induced by estradiol benzoate and progesterone. However, the maximum DNA obtained in female mice was only a little over one half that observed at the end of normal pregnancy, and in male mice slightly less than one half. The DNA method of measuring mammary gland growth has been extended to the dairy calf.

Involvement of Mammary Gland. DNA has been used as a measure of the involution of the lactating mammary gland of the rat. DNA decreased 42% in 5 days and 85% in 10 days after weaning. Estrogen alone appeared to augment involution during early stages; but with estrogen and progesterone, involution was retarded during the latter period. Oxytocin, lactogen, and hydrocortisone acetate were studied to determine their roles in preventing involution. All three hormones appeared to maintain varying degrees of milk secretion in the cells but oxytocin was ineffective in maintaining cell numbers. Lactogen and hydrocortisone, however, were effective in retarding loss of cells and the effect was graded in relation to dose.

Intensity of Milk Secretion. The effect of parathyroid hormone on lactation intensity in normal rats was determined. Milk yield increased 54.6% and litter weight 11% over control group by the 20th day. The DNA of mammary glands of the experimental animals at 20 days was significantly greater than controls. This suggested that the treatment either stimulated increased growth of glands or prevented involution. Estrogen and progesterone alone and in combination have been administered to normal and ovariectomized lactating rats. Estrogen alone reduced milk secretion approximately 50% and the DNA of the mammary gland approximately 25% below normal. In combination milk secretion was reduced approximately 80% but maintained DNA values equal to the normal. Progesterone alone did not affect milk secretion but increased DNA values 10% above control values. Litter weights were reduced in proportion to milk secretion. In addition to the studies of involution, intensive study will be given to the role of parathyroid and adrenal hormones in mammary gland growth and lactation.

Publications: Griffith, D. R., C. W. Turner. Normal Growth of Rat Mammary Glands During Pregnancy and Early Lactation. Proc. Soc. Exp. Biol. & Med. 106:448-450, 1961.

Damm, H. C., C. W. Turner. Long-Term Effect of Estrogen and Progesterone on Mammary Gland Growth in 3-Methylcholanthrene Treated and Non-treated Ovariectomized Rats. Proc. Soc. Exp. Biol. & Med. 106:820, 1961.

Griffith, D. R., C. W. Turner. Thyroxine and Mammary Gland Growth in Rat. Proc. Soc. Exper. Biol. and Med. 106:873, 1961.

Anderson, R. R., A. D. Brookerson, C. W. Turner. Experimental Growth of Mammary Gland in Male and Female Mice. Proc. Soc. Exper. Biol. & Med. 106:567, 1961.

Cooperation: U. S. P. H. ; American Cancer Society

(Project 28).

ENDOCRINE-GENETIC INTERRELATIONS IN MILK SECRETION. (C. W. Turner, R. R. Anderson, G. Pipes, A. C. Ragsdale, R. Williams, C. P. Merilan, C. E. Hendrich, W. R. Miller, J. Grossie, K. Himeno). Current methods for the genetic improvement of dairy cattle may not be effective because they have not taken into consideration the role of the endocrine glands in milk secretion or in the contribution of each hormone or group of hormones which make large yields of milk possible. Selection now is based primarily upon total lactational yield. Perhaps the greatest progress in breeding superior dairy cattle may result when it is possible to: (1) determine the role of each hormone and the synergistic effects of hormones in relation to udder growth, intensity of milk secretion, and milk harvest; (2) determine the actual hormone secretion rate of individual animals in relation to the optimum secretion rate of the important hormones; and (3) determine the mode of inheritance of the hormone secretion rate of the more important hormones influencing high milk yield. The titles of the publications prepared from the results of these studies indicate the scope and progress of the work.

- Publications: Stahl, P., C. W. Turner. Seasonal Variation in Thyroxine Secretion Rates in Two Strains of New Hampshire Chickens. *Poultry Sci.* 40:239, 1961.
- Turner, C. W., G. W. Pipes, B. N. Premachandra. Effect of Glucocorticoids on Thyroid Function of Cattle. *J. Dairy Sci.* 44:163, 1961.
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Cooperation: Department of Animal Husbandry; Atomic Energy Commission (Project 80).

THE EFFECT OF ENVIRONMENT ON MILK PRODUCTION, GROWTH, AND RELATED PHYSIOLOGICAL REACTIONS. (H. D. Johnson, A. C. Ragsdale, H. H. Kibler, C. P. Merilan, R. K. Bergman, R. C. Lundgren, N. K. Yousef). The Missouri Agricultural Experiment Station has long been interested in the effects of climate on cattle. Missouri has very wide temperature fluctuations with resultant economic losses in depressed milk production and expense for shelter from cold and heat. This problem therefore, demands a careful study of the temperature regulating mechanisms and physiological responses of individuals of various breeds of cattle. This information will furnish a firm scientific basis for modifying environment by engineering (shelter) methods and for modifying animals by biologic (breeding) methods. The following information is a summary of work not covered in published or prepared reports.

Acclimation Effects on Milk Production, Body Temperatures, and Related Physiological Reactions.

Body temperature measurements have been made on lactating Holstein cows to find the time required for adjustment (if possible) from a temperature-humidity condition of 65°F, 50% relative humidity, to one of 84°F, 50% relative humidity. In general, the cows with the highest milk production tended to show the greatest rise in body temperature and the greatest drop in milk production.

Effect of Heat Acclimation on Adrenal Corticoids in the Bovine. The adrenal corticoids are always implicated in any response to stress and in acclimation to a changing environment. Efforts have been started to determine how they are influenced by temperature and by acclimation to temperature. To determine this, urine excretions from cows have been collected at periodic intervals under two different environmental temperatures. The urine volume was measured and sampled and will be analyzed for nitrogen, potassium, sodium, phosphorus, creatine, and creatinine. From these data it may be possible to obtain some indirect indications of adrenal corticoid activity and how it has been affected by environmental temperature. Two cows have been injected with hydrocortisone-1, 2-H³ and successive blood samples withdrawn in order to determine the turnover rate of hydrocortisone under different environmental temperatures. The endogenous hydrocortisone level will be determined by tracer-chromatography techniques. It is hoped that from these data more direct indications of the effect of temperature on hydrocortisone secretion in the bovine may be secured.

Controlled Feeding Investigations with Special Emphasis on Separating the Nutritional and Temperature Effects on Environment. Is milk decline at high temperatures due to the high temperatures or merely to the effects of high temperature on feed consumption? Cows were fed by rumen fistula the quantity of feed that they refused at a high temperature 85°F. The results showed that temperature depressed milk production even though the feed was maintained at the same level. Water consumption was greater, body weight greater, and metabolism did not decline as much in the fistula fed animals. The controlled feeding did not significantly increase body temperature.

Effects of Temperature and Control Feeding on Thyroxine I¹³¹ Degradation Rates and Serum Protein Fractions of Dairy Cattle. Higher environmental temperatures and humidity depressed thyroxine I¹³¹ degradation rates of lactating dairy cattle under ad libitum feeding conditions. To determine if this *in vivo* decline in thyroxine I¹³¹ degradation was due to the lowered (voluntary) feed intake or the direct temperature effects, ad lib and control fed cows were exposed for three week periods alternately to 65°F, 50% relative humidity, and 88°F, 50% relative humidity for six periods. The results indicated that thyroxine I¹³¹ degradation rates were depressed by high environmental and body temperatures rather than feed quantity differences.

Temperature-Humidity Index. It is apparent that comfort is a function of both temperature and humidity. The temperature-humidity index formula used by the U. S. Weather Bureau has been used in this study. As the temperature-humidity index increases milk production decreases. The higher producing cows declined more but still gave a greater amount of milk at a temperature-humidity index of 80 than did lower producing cows.

Temperature-Humidity Effects on Feed and Water Consumption of Lactating Cows. Data indicated that humidity influenced the animal response greatly about 65°F. Various measures have been used as expression of environment such as vapor pressure, dew point, and wet bulb. Water consumption for individual cows increased significantly at increasing temperatures for varying numbers of cows. There also were significant decreases for individual cows in feed consumption. The number of individual cows which were significant varied with the amount of stress the temperature-humidity conditions produced in the individuals. Total digestible nutrient consumption declines varied markedly with rising body temperature while water consumption showed no consistent change.

Temperature-Humidity Effects in the "Comfort Zone" (45° - 65°F). A temperature of 40°F as contrasted with 65°F did not significantly alter the level of milk production; thus, the animals were definitely within the "comfort zone". The level of feed intake at the 40°F, 95% relative humidity was depressed approximately 20% on all cows. Many indirect environmental factors could have contributed to this lessened desire for feed.

Physiological and/or Genetic Evaluation of Cattle. Physiological evaluation tests have been initiated on 12 cows and standardized with regard to environmental factors. It is hoped that the measured responses to these tests will provide information that will characterize the individual cows with respect to their sensitivity to heat and the mechanism responsible for this sensitivity. The responses of the cows tested showed differences between individual cows which were quite significant.

Investigation of Temperature Effects by Continuous Metabolic-Endocrine Measures. A helmet to completely enclose the head and upper neck region of a cow is being constructed. This helmet has provisions in connections for open circuit gas analysis by gas chromatography (O₂, CO₂, CH₄). The experimental animal will be infused with various hormones and metabolites and the calorogenic responses observed at various environmental temperatures.

Livestock and Their Environment. Based on results from six animals of each of six breeds (Brown Swiss, Holstein, Jersey, Brahman, Santa Gertrudis, Shorthorn), Holstein and Shorthorn animals showed

the greatest heat discomfort at the higher temperatures. The levels of heat production were highest in Holstein and Santa Gertrudis. This suggested that the Santa Gertrudis would be more heat sensitive except their ability to vaporize moisture from the respiratory tract and skin was relatively higher. The percentage of water intake that was vaporized at high temperatures emphasized striking differences in the Brahman which vaporized as much as 60%, about 40% for the Santa Gertrudis, and the others which vaporized less than 30%. These data suggested the many ways in which the various breeds respond to temperature.

Temperature and Age Effects on Metabolic-Endocrine Reactions. Rats were used for these experiments. Male rats living at a "cold" temperature (48°F) lived to an average age of 443 days. The group living at a "comfortable" temperature (83°F) lived to an average age of 646 days. It appeared that the shortened life span of the cold exposed rats may have been influenced by their high metabolic rates. Average life time 24 hours rates for the cold exposed and the control rates respectively were: oxygen consumption, 15.9 and 12.6 liters; feed consumption, 41.1 and 23.9 grams; water consumption, 65.8 and 50.2 grams. Average lifetime totals for feed consumption were greater for the cold exposed than for the control rats in spite of their shorter life. During the early growth period of the animals, thyroid function was significantly higher in the cold exposed group. Thereafter no detectable difference was observed due to temperature until approximately 500 days of age when again the cold exposed animals displayed a higher thyroid function. The incidence of lesions and testicular atrophy was much greater in the male rats maintained at the cold temperatures. Nephritis and periarteritis nodosa were the greatest causes of death. Salmonellosis was frequently associated with the above factors.

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BREEDING FOR HERD AND BREED IMPROVEMENT (FOREMOST GUERNSEYS). (A. C. Ragsdale, C. P. Merilan, J. E. Edmondson, J. D. Sikes, L. R. Rainey, F. A. Martz). The average life of dairy herds in this country is approximately 7 years and very few herds exist longer than a quarter of a century. In view of the relatively slow reproductive rate of dairy cattle, this rapid turnover in breeding herds represents a major problem. The Foremost Guernsey herd established in 1922 at Hopewell Junction, New York by Mr. J. C. Penney, a native Missourian, is one of the outstanding Guernsey herds in the United States. His gift of this herd to the University of Missouri in 1953 has made available for study, further development, and perpetuation of some of the most productive and highly prized blood lines in the Guernsey breed. Investigations with this herd and farm present an opportunity to provide new and practical information on the value of various dairy cattle breeding, herd management, and dairy farm management practices.

There was no effect on body weight due to feeding two times, four times, or seven times daily. However, feed consumption and dry matter digestibility were greater for the four times and seven times frequency feedings. Increasing trends in milk, milk fat, solids not fat, and total solids production were shown with increased feeding frequency. Trials with feeding roughages two times as compared to four times daily have been completed and the data is now being analyzed. Also, feeding grain two times daily as compared with four times daily while roughages are fed only two times daily is now being studied. Another comparison is being made between feeding hay two times daily versus silage four times daily while grain is fed twice daily. Comparisons are also being made to determine whether or not better production is secured under loose housing conditions if cows are separated into age groups. Comparisons are being made between urea and soybean meal as a nitrogen source on two times daily versus six times daily feeding schedules. Guernsey heifers between the ages of 12 and 19 months are being used to study needed nutrient supplementation for growing and wintering on corn silage or oat and mixed hay. A highly significant negative correlation coefficient was found for the relationship between the blood serum inorganic phosphorus and age. One hundred thirty-six cows completed records in 1961 averaging 9,555 pounds of milk and 432 pounds of fat on a 305 day, 2x M. E. basis. As a matter of interest, over 2,000 individuals visited the Foremost Farm during the year.

Publications: Campbell, J. R., C. P. Merilan. Effects of Frequency of Feeding on Production Characteristics and Feed Utilization in Lactating Dairy Cows. J. Dairy Sci. 44:664-667, April, 1961.

Cooperation: Mr. J. C. Penney (Project 200).

DAIRY CATTLE BREEDING. (C. P. Merilan, A. C. Ragsdale, J. D. Sikes, B. F. Kelso, K. W. Bower, B. Lail, M. E. Oetting, L. R. Rainey, R. Rumans). Improvement in dairy cattle productivity has occurred slowly and improved feeding and management practices have been responsible for a major share of the increased productivity. Slow reproduction rates; highly heterozygous genetic makeup; and lack of specific selection methods and indices have contributed to the difficulty of developing improved strains of dairy cattle. Thus, there is great need for intensive study of the various genetic factors which affect characteristics such as milk production and reproduction. These studies are a part of the North Central Regional Dairy Cattle Breeding project (NC-2). The Guernsey, Holstein, and Jersey herds continue to be used in a line breeding program in conformity with the NC-2 project plan. All animals have been officially tested for milk and butterfat production, and official type classification has been made on the Holstein and Guernsey herds. Blood serum inorganic phosphorus data have been summarized for Guernsey, Holstein, and Jersey females in the University of Missouri herds. Highly significant negative correlation coefficients were found for the relationship of blood serum inorganic phosphorus with age. Correlation coefficient values for blood serum inorganic phosphorus versus 4% FCM were significant at the 1% level when the deviation below the computed

breed mean were analyzed for the Guernsey and Jersey breeds. Individual feeding of nine lactating cows showed a significant difference for grain consumption when consuming 10 pounds of alfalfa hay. There was a significant difference in hay consumption when the same animals were offered 30 pounds of hay. Preliminary results, using limited numbers of twins and daughter-dam comparison showed wide variation in their preference for roughage and/or concentrates. Milking rate determinations were made on the Holstein and Jersey herds. The required milking times ranged from 3 to 13 minutes. The first 8 daughters of a senior Holstein sire had an average milking time of 5 minutes. Blood serum inorganic phosphorus values below the breed average can be used as an aid in selection of dairy animals. Animals with slow milking rates can be removed from the herd. Studies will be continued in the same areas.

Publications: Kelso, B. F. In Vivo Determination of Thyroid Lob Size and I^{131} Release Rate in Young Dairy Animals. A thesis submitted in partial fulfillment for the requirements for the degree, Doctor of Philosophy, Graduate School, University of Missouri.

Sikes, J. D. Blood Serum Inorganic Phosphorus in Guernsey, Holstein, and Jersey Cattle. A thesis submitted in partial fulfillment for the requirements of the degree, Doctor of Philosophy, Graduate School, University of Missouri.

Sikes, J. D. Usefulness of Certain Body Measurements for Predicting Milk Production of Dairy Animals. North Central Regional Publication No. 133.

Cooperation: States of the North Central Region (NC-2) (Project 35).

THE USE OF ARTIFICIAL INSEMINATION ON DAIRY CATTLE. (C. P. Merilan, K. W. Bower, L. D. Miller, J. D. Sikes, W. F. Hoffman, P. S. Rao, D. Grogan). Artificial insemination represents the best available means for extending genetic influence of superior sires to large numbers of dairy cattle. The problems of artificial insemination are centered largely about the need for increased efficiency and particularly increased conception rate on first service. Substantial portions of the report of the work in this area have been covered under Project 81 in the Department of Agricultural Chemistry. Studies have been initiated to provide basic information on spermatozoa which will aid in developing improved methods for storage and fertility evaluation. Differential thermal analysis curves have been obtained on various chemical mixtures of known concentration to establish technique parameters for analysis of biological samples of unknown composition. Results from mixtures including dioxan, alcohol, gelatin, and water as well as from biological samples containing egg yolk and bovine semen indicated that vacuum pumping rates, and rates of bath temperature increase markedly affected the resolution obtainable with a differential thermal analysis technique. In dehydration studies on bovine spermatozoa, occasional spermatozoa were found to exhibit motility following lyophilization and rehydration, but factors responsible for variable results have not been determined to date. In the coming year, emphasis will be placed on physical and biochemical changes occurring in spermatozoa during dehydration and rehydration.

Publications: Miller, L. D., D. T. Mayer, C. P. Merilan. The lipids of Spermatozoa. A manuscript has been completed. I. The Isolation and Characterization of Seven Classes of Lipids.

Cooperation: Department of Agricultural Chemistry (Project 54).

BREEDING, FEEDING, AND MANAGEMENT OF DAIRY CATTLE AT THE HATCH FARM. (A. C. Ragsdale, H. S. Peet, C. P. Merilan, J. R. Campbell, J. D. Sikes). The Hatch Farm has been in operation for many years since it was given to the State of Missouri by the heirs of Colonel William H. Hatch, the member from Missouri who introduced the "Hatch Act" in Congress in 1887. This act established the Agricultural Experiment Stations in each of the states. This farm has served the dairy farmers of the area as a research and demonstration farm. Breeding programs have been evaluated and management practices developed with particular reference to selection techniques in breeding, locating, and developing superior individuals; cow families; and strains of Jersey cattle giving consideration to the inter-relationship between production, type, disease resistance, longevity, feed consumption, capacity, and related physiological functions. Information has also been secured concerning the efficient production and effective use of high quality pastures, hay, silage, and siling crops. The use of modern equipment has been demonstrated. Since much of the research now underway is closely related with research located at Columbia, the Hatch Farm will be used to the best advantage by fitting it into the total dairy research program with the more appropriate phases located on the Hatch Farm. This project is being closed. (Project 64).

OFFICIAL TESTING OF DAIRY CATTLE. (J. D. Sikes). This is a service project to provide Herd Improvement Registry and Advanced Registry testing for the purebred dairy cattle breeders in Missouri. Official production records are made available for use in: locating brood cow families, proving of sires, making daughter-dam comparisons, and in planning breeding programs. This service was used by 41 breeders of registered purebred animals in Missouri. There were 23 Holstein herds, 1040 cows; 8 Jersey herds, 255

cows; 7 Guernsey herds, 400 cows; 2 Brown Swiss herds, 24 cows; 1 goat herd, 1 doe. The advanced registry form of testing was utilized by only four breeders. Three Holstein cows produced over 20,000 pounds of milk and over 832 pounds of butterfat. The high Jersey cow produced 12,571 pounds of milk and 731 pounds of fat in 305 days 2x M. E. A Guernsey cow produced 14,227 pounds of milk; 680 pounds of fat in 305 days 2x M. E. This work will be continued during the coming year.

Cooperation: National Purebred Dairy Cattle Association; the Milk-Goat Record Association

(Project 134).

SEROLOGICAL REACTIONS OF STRAINS OF STAPHYLOCOCCUS AUREUS. (J. E. Edmondson, E. L. McCune, J. Brechbuehler). Organisms of the genus staphylococcus have long been known to thrive in the environment found on dairy farms, in the udders of cows, and on milking equipment. Satisfactory criteria for separation of pathogenic and nonpathogenic strains have not been developed.

Approximately 200 cultures have been isolated from aseptically drawn foremilk of both normal and abnormal bovine udders. Both hemolytic and nonhemolytic cultures suspected of being staphylococci were selected for biochemical testing and classification. Much emphasis was placed on hemolysins, coagulase production, mannitol fermentation, and salt tolerance. Eleven known strains or species of staphylococci from the Culture Bank and American Type Culture Collection were added to the study. Bacterins were prepared for 29 cultures to be used in rabbit injections. Antisera were harvested 5 to 10 days after the last injection. The untreated antisera were stored at -20°C until needed. Antigens were prepared from 5 hour old cultures by harvesting the cells in sufficient 0.85% saline to provide a dense suspension. Each antiserum was diluted to different strengths for testing the different antigens by the microscopic slide agglutination test. The antisera produced against coagulase negative strains were very low in titre and were discarded because of low specificity, mucoid reactions, ropiness, or flocculation. Sixteen antisera were used to measure reactions against 29 organisms of the family Micrococcaceae. The reactions were of wide range indicating low specificity of the untreated antisera used. The classification of cultures by microscopic slide agglutination was not possible at this stage. Work will be continued during the next year.

Publications: McCune, E. L. Serological Studies of Staphylococcus Aureus and Related Bacteria Associated with the Bovine Mammary Gland. A thesis submitted in partial fulfillment for the requirements of the degree, Master of Science, Graduate School, University of Missouri, 1961.

Cooperation: School of Veterinary Medicine

(Project 446).

UDDER INFLAMMATION IN DAIRY CATTLE. (R. T. Marshall, K. P. Sinha). Mastitis is presently the most costly dairy cattle disease. The recent development of the California Mastitis Test has given the farmer a tool with which he can determine the extent of inflammation within individual quarters of his dairy animals with high accuracy. Comparisons have been made between quarters in cows which have been milked separately using the California Mastitis Test and leucocyte count as measures of inflammation. Nineteen animals with completely normal and 13 with at least one quarter scoring California Mastitis Test-four and at least one quarter normal to the California Mastitis Test were milked using a specially designed quarter milker. A total of 170 samples were taken. Each was subjected to a series of 14 tests for composition. Monthly mastitis tests have been run on over 100 animals to provide a basis for choosing experimental animals in the future. A preliminary analysis of data obtained in the study of 48 samples from 12 normal animals was made to evaluate methods, procedures, and preliminary results. In all cases more than 90% of the variation in composition of the various constituents and/or properties tested could be explained by cow differences. Only for lactose and total nitrogen were there significant differences except for some complex interactions. Over 7% of the variation of percent lactose was due to right and left half differences. Nearly 5% of the variation in total nitrogen was due to differences between the two front and the two rear quarters. No individual quarter composition variations were significant. Yield data showed that the primary differences were between front and rear sections of the udder. Nearly 73% of the total variation was due to this factor. Only about 21% was due to variations among cows of this rather homogenous group. As soon as a sufficient number of samples have been taken, comparisons will be made between normal variation and the milk samples from cows with inflamed quarters.

Publications: Sinha, K. P. A Study of the Composition of Milk Secreted from Individual Normal Quarters of Cows. A thesis submitted in partial fulfillment for the requirements for the degree, Master of Science, Graduate School, University of Missouri, 1961.

(Project 445).

MERCHANDISING MILK AND MILK PRODUCTS THROUGH SUPER MARKETS AND FOOD STORES. (W. H. E. Reid). There has been a great increase in the volume of milk and milk products merchandised through super market and food stores. This system of marketing has presented new problems. Some of the practices used reflect unfavorably upon the acceptance of milk and milk products by the consuming public. Studies

have been made of the management practices relating to the processors of milk and milk products; to super market management; to the possibility of developing educational programs in the interest of processor, management, super market personnel; and to develop new methods for merchandising milk and milk products through super markets and food stores. Some processors and super market managers have used information acquired from this study which has aided with new methods and techniques. The principle findings have been concerned with management practices, methods of influencing public attitudes and purchasing, the development of consumer educational programs, and the improvement of store personnel attitudes. Some new methods of merchandising have been tested. Difficulty has been experienced in securing cooperation in which all factors could be controlled and since it seems that work has progressed as far as feasible under present conditions, this project has been terminated. A technical paper is now under preparation.

Cooperation: Missouri Butter and Cheese Institute Inc.

(Project 453).

AUTOMATIC MERCHANDISING OF DAIRY PRODUCTS THROUGH VENDING UNITS. (J. E. Edmondson, D. S. Shelley). Information is needed upon automatic merchandising of different types of dairy and other foods through multiple unit vending machines. Consumer acceptance of milk, chocolate milk, and lemonade from coin operated vending machines was tested in a captive market. Vendors were located in the University dormitories, the men's gymnasium, the library, the Administration Building, and in an office building. Sales percentages were 40.3, 30.1, and 29.6 for chocolate milk, homogenized milk, and lemonade respectively. Maximum sales of all products occurred in October during three of the years, while the maximum was in November for one year. Minimum sales were experienced in June, July, and August (the vacation months). The effect of Christmas holidays on December sales was marked. Sales from January through May were essentially constant. The limiting of milk consumption in University cafeterias increased sales from vendors. Sales during one year of restricted consumption in the dormitories were 23% higher than during one year when there was no such restriction. A selected adult population was compared to a student population as to preference. The adults chose milk or chocolate milk 7.3 to 1 over lemonade while the student ratio was 2.8 to 1. These studies will be continued.

Cooperation: Department of Agricultural Economics

(Project 452).

LOW CALORIE DAIRY FOODS. (R. T. Marshall, D. Shelley, J. E. Edmondson). Developments in the fields of nutrition and health during recent years have led to an increased consumer demand for palatable low calorie foods which provide adequate quantities of protein, vitamins, and minerals. Certain low fat dairy products have become increasingly popular due to this demand.

Homogenized cottage cheese had a longer shelf life after flavoring compounds were added than did either the creamed curd or the dried curd. Studies have been made with cottage cheese dips and dressings. Where body texture, color, and appearance defects developed they appeared sooner in cheese dips than in creamed cottage cheese or in the dry curd from which the dip was made. The primary defect associated with cheese dips was a tendency to separate into two fractions, the whey and the solids portions. Blue cheese flavored dips did not keep for an extended time. A storage temperature of 40°F resulted in shelf life extension of several days over storage temperature of 50°F. Studies will be continued with the evaluation of commercially palatable cheese dips with special emphasis on the calorie and bacteriological content and the keeping quality.

(Project 454).

ENTOMOLOGY

Phillip Stone, Chairman

ENTOMOLOGY MUSEUM. (W. R. Enns, H. E. Brown, L. Haseman, P. C. Stone, C. W. Wingo, R. A. Hart). An orderly system of identification of insects is necessary to serve the needs of Missouri. Large numbers of insects are sent to the Experiment Station each year for identification. The museum is of primary importance in this work. The insect collection of Dr. E. P. Meiners of St. Louis was willed to the University of Missouri and was brought from St. Louis to the museum in Columbia. This collection consisted of approximately 40,000 specimens together with the correspondence of Dr. Meiners with many renowned entomologists. This has been a significant addition to the museum. Also, 960 comstock drawers were constructed and the 80 steel cabinets in the museum have now been almost filled. For the first time, a field expedition involving a trip to Texas was undertaken. Insect larvae and mites secured on this trip added significantly to the collections in the museum. Acarological collections have been increased by more than 3,000

specimens. The larvae collections have been increased by approximately 500 specimens and the spider collection by about 100 specimens. During the year approximately 2,000 insects were identified and reports written. More than 100 collections of aphids were made during the year. All collections have been routinely fumigated, at approximately six month intervals and repellents added. The specimens stored in liquids have been checked and alcohol or other appropriate preservatives added when necessary.

The Role of Protein Fractions in Insect Hemolymph in Taxonomy and Systematics. The approach has been via electrophoretic separation of hemolymph proteins. A technique perfected for the Durrum cell equipment currently in use utilizing both freshly drawn hemolymph samples and similar samples preserved by quick freezing. Techniques have been developed that are satisfactory to produce the necessary amounts of hemolymph from an individual insect. The insect needs to be approximately as large as the common lady bird beetle. One micro liter sample is sufficiently large so that the hemolymph can be satisfactorily separated. It stores well in frozen capillary tubes. A card filing system has been developed in which eight capillary tubes are held on one modified 3 by 5 inch file card. Over 3,000 samples can thus be stored in the freezer in an area of the size of a shoe box. Any sample can be located quickly and removed without endangering others. During the period of collecting about 500 protein patterns were developed from live beetles as a check on the hemolymph in capillary tubes held in frozen storage. Identification of the beetles and the measurement of the protein patterns to determine the fractions separated for each species has just started. Cooperation: Entomological Research Division; U. S. D. A. (Project 36).

INSECTS IN MISSOURI. (P. C. Stone, H. E. Brown, W. R. Enns, M. L. Fairchild, K. Harrendorf, L. Haseman, L. Jenkins, D. E. Short, C. W. Wingo). Major insect outbreaks appear and reappear in cycles. Therefore it is necessary to provide a continuous survey of the State to provide information upon insect populations that are occurring in large numbers from time to time. During the year, various members of the staff have distributed insect information at group meetings, on television, on radio, by news articles, and by other publications. Specific information has been developed on the face fly, the brown spider, the corn ear worm (sweet corn), the corn borer complex, and systemic insecticides for wheat insects, nematodes, and others. Many insects have been sent to the Station for identification. Timely insect information has been prepared and distributed. A weekly report to fruit and vegetable growers has been sent to 485 interested people. Records have been kept for future information on the abundance and scarcity of insect pests in Missouri.

Publications: Swartwout, H. G., W. R. Enns. Suggestions for Spraying Commercial Apple Orchards - 1962. Missouri Cooperative Extension Service Circular No. 756, January, 1962.

Enns, W. R., H. G. Swartwout. Suggested Peach Spray Programs. Missouri Cooperative Extension Service Circular No. 762, January, 1962.

Swartwout, H. G., W. R. Enns. 1962 Suggestions for Spraying Grapes. Missouri Cooperative Extension Service Circular No. 759, February, 1962.

Enns, W. R., H. G. Swartwout. Insect and Disease Control on Strawberries. A manuscript prepared for publication.

Swartwout, H. G., W. R. Enns. Spraying Outdoor Roses. A manuscript has been prepared for publication. Members of the staff. Articles for the Missouri Vegetable News. Four articles have been prepared and published at irregular intervals by the Extension Vegetable Specialist.

Members of the staff. Insecticides and miticides for Missouri Fruit Growers. A mimeographed publication prepared for, and distributed at the annual meeting of the Missouri State Horticultural Society, January, 1962.

Swartwout, H. G., W. R. Enns. Spraying Raspberries. A manuscript has been prepared.

Harrendorf, K., G. W. Thomas. 1962 Cotton Insects Control. A manuscript has been prepared for publication as a cooperative extension circular.

Neville, P. F., P. C. Stone, T. D. Luckey. Cricket Nutrition II. An Unidentified Factor in the Nutrition of Acheta domesticus. Journal of Nutrition, Volume 74, No. 3, July, 1961.

Peters, D. C., A. K. Burditt, Jr., M. L. Fairchild. The Biology and Control of the European Corn Borer in Missouri. Missouri Agricultural Experiment Station Research Bulletin No. 757, 1961.

Chiang, H. C., J. L. Jarvis, C. C. Burkhardt, M. L. Fairchild, G. T. Weekman, C. A. Triplehorn. Populations of European Corn Borer, Ostrinia nubilalis (Hbn.), in Field Corn, Zea mays (L.), in the North Central United States. Missouri Agricultural Experiment Station Research Bulletin, No. 776, and North Central Regional Publication No. 129, 1961.

Members of the staff. A publication has been prepared showing insect observation and results of investigations on cotton, soybeans, and vegetables at the Southeast Missouri Experimental Fields at Diehlstadt for 1961.

Jenkins, L. A summary of nematode work on cotton was sent to the cotton disease conference at Memphis, January, 1962.

Jenkins, L. A summary of the results from the use of chemical dips on bare root nursery stock was sent to the Conference of the American Association of Nurserymen, Washington D. C., February, 1962.

Daugherty, D. M. Unusual Mite Description by C. V. Riley. Journal of the Kansas Entomological Society. Cooperation: Department of Horticulture, Agricultural Extension Service; Shell Chemical Company; American Cyanamid Company; Missouri Pest Control Association (Project 30).

FRUIT, VEGETABLE, AND ORNAMENTAL PLANT INSECTS. (W. R. Enns, L. Haseman, J. D. Davis, G. N. Clark, J. R. Northcutt, W. S. Nance). The successful production of fruits and vegetables and the growing of ornamental plants in Missouri are dependent upon the satisfactory control of insects and mites which attack these crops. The increasing complexity of insect and residue control problems makes it necessary to maintain sustained investigations in these areas.

Fruit Insect Situation 1961. The entire season was unusually cool with an excess of rainfall. This had a marked effect in reducing destructive insect populations. Apple aphids were abundant in early spring and aphid pomi was troublesome all season. Plum curculio populations were light. Red-banded leafroller populations were very light in all generations. An unusual development was a heavy brood of fruit tree leafrollers which appeared late in May. These were particularly noticeable on terminal foliage of young apple trees although very few were seen on sprayed trees. This was the heaviest brood seen in Missouri for many years. The first codling moth adult was trapped in Southeast Missouri on May 15th but in general infestations State wide were light and easily controlled. European red mite threatened to be a serious problem but did not develop. Various species of stink bugs were troublesome especially in the latter part of May. Oriental fruit moths were scarce or absent early in the season. The first larvae appearing in Southeast Missouri on June 1 in peach terminals. About the first of June, grapes in the Steelville and Rosati area began showing typical symptoms of grapevine rootborers. This was perhaps the most serious insect pest in Missouri this season. No effective control measure has as yet been developed. Grape mealybugs were in light populations and were easily controlled. There was no severe attack by Grape Berry Moths. Strawberry leafrollers and strawberry weevils appeared in moderate numbers in early June in all areas of the State. No serious infestation of peach tree borers was reported. Green June beetles were present in mid to late season and caused some damage. Forbes Scale and Lecanium Scale was present in only one or two orchards and chemical control was very effective. No unspotted Tentiform leafminers were reported.

The Efficiency of Acaricides for Control of European Red Mites on Apples. Four materials were tested: Chlorbenside, Tedion, Kelthane, Genite. All four materials proved effective.

The Use of Guthion for the Control of Insects and Mites on Peaches. Apparently Guthion was as effective as Parathion for peach insect control.

A Simplified General Purpose Spray Program to Control Insects, Mites, and Diseases in a Small Home Orchard. A single insecticide, Sevin, plus a single fungicide, Zineb, were used in the basic program. Results indicated that satisfactory results could not be achieved with a single insecticide-fungicide combination. Insect free fruit can be produced, however, for such a combination, if used for the so called "summer sprays". The early season combination must be different. A general purpose apple and peach spray program has been developed which will control most insects and diseases.

Leafrollers on Apples. Three treatments consisting of Eradex, AR-TDE, and Bayer 37344 were used on a mixed population of leafrollers consisting of both red banded and fruit tree rollers. In seven days all larvae had disappeared but dead larvae were found in the AR-TDE plots and in the Bayer 37344 plots two days after spraying.

The Bacterial Causative Organisms of Fireblight. In order to attack this problem it was necessary to develop a method of rearing apple aphids in the laboratory. This method has been developed. It has been demonstrated that aphids can transmit fireblight. Studies have been made on the virulence of the organism when taken into the body of the aphid. Theoretically there is a possibility that the organism can change from an avirulent form to a virulent form under certain conditions and probably the reverse is true. In vitro studies of the effect of the extracts of aphids on reconstituted lyophilized bacterial colonies of virulent and avirulent strains have been started. Preliminary trials have resulted in some evidence that the aphid extract exerts a suppressive effect on avirulent strains of the bacteria and stimulates the virulent ones.

Control of the Grape Vine Rootborer in Missouri. Larvae and pupae of the grape vine rootborer have been collected in vineyards near Steelville and observed. The first adult, a female, emerged in the laboratory on July 21, 1961. On July 26 the first adult also a female, was seen in the field. August 1, 1961 marked the peak of emergence in the field and the last adult observed was on September 1, 1961. The adults mated

in the field during the warmest period of the day. At the height of infestation, the adults could be seen flying rapidly over the tops of the vines. Egg laying began immediately following mating. Hatching occurred 14 to 21 days following egg laying. The young larvae were not particular as to where they started their feeding on the vine. The age of the vine seemed to make very little if any difference. Apparently this borer is distributed throughout Missouri.

The Use of Soil Insecticides to Control the Grapevine Rootborer. A number of insecticides have been tested but it is extremely difficult to evaluate control of this insect because the larvae grow in the roots of the plant for at least two seasons. Therefore, evaluation of the effects of the insecticides used will have to be delayed until one or more additional years have passed.

The Use of Various Sprays to Control Insects on Vegetable Crops in Southeast Missouri. These experiments were conducted at the Diehlstadt field in Southeast Missouri. Various spray materials and rates of application were used on cabbage, kale, kohlrabi, broccoli, cauliflower, leaf lettuce, bibb lettuce, tomatoes, squash, and snap beans. All were found to have some degree of efficiency.

The Possible Transference of Insecticides Applied to the Soil in Vineyards to the Plants and to the Fruit. Eight insecticides have been applied to grapes: Aldrin, Dieldrin, Heptachlor, Trithion, Chlordane, Diazinon, Guthion, and Sevin. Samples of the grapes have been taken at intervals and submitted to the various manufacturers for residue analysis. To date no analyses have been reported. However, the National Grape Cooperative, before accepting grapes from the treated plots, performed residue analyses and no contaminants were found.

Tests with the Insecticide "Sevin". The insecticide "Sevin" has been used on a large number of vegetables. Residue analyses have been reported on 15 of 34 samples collected. This insecticide seems to hold great promise for use on vegetables because it is relatively non-toxic to man. It is effective against a wide range of vegetable insects and seems to be relatively non-phytotoxic except under very hot and humid conditions.

Publications: Swartwout, H. G., W. R. Enns. Suggestions for Spraying Commercial Apple Orchards. Missouri Cooperative Extension Circular No. 756, January, 1962.

Enns, W. R., H. G. Swartwout. Suggested Peach Spray Programs. Missouri Cooperative Extension Circular No. 762, January, 1962.

Swartwout, H. G., W. R. Enns. Suggestions for Spraying Grapes. Missouri Cooperative Extension Circular No. 759, February, 1962.

Enns, W. R., H. G. Swartwout. Insect and Disease Control on Strawberries. Manuscript now in preparation.

Swartwout, H. G., W. R. Enns. Spraying Outdoor Roses. Manuscript now in preparation.

Swartwout, H. G., W. R. Enns. Spraying Raspberries. Manuscript in preparation.

Cooperation: Department of Horticulture; Missouri Cooperative Extension Service; Grape Producers in Missouri; Manufacturers of Insecticides. (Project 31).

THE EUROPEAN CORN BORER IN MISSOURI. (M. L. Fairchild, A. Keaster, D. V. Allemann). The major pest of corn in the United States is the European corn borer which has been found in all counties in Missouri. The European corn borer population in the spring was slightly higher in 1961 than in 1960 in both Carroll County and New Madrid County. As the season progressed the borer populations became heavier in both counties except (in New Madrid) where agronomic practices caused a decrease in the borer population late in the fall. The corn borer went through three complete generations and a partial fourth generation at Sikeston. It successfully overwintered in lambs-quarter, jimson weed, pokeweed, pigweed, horsetail, ragweed, wild cotton, and cocklebur. Work will be continued on the biology, ecology, and effects of predators and parasites on the European corn borer.

Publications: Peters, D. C., A. K. Burditt, Jr., M. L. Fairchild. The Biology and Control of the European Corn Borer in Missouri. Missouri Agricultural Experiment Station Research Bulletin No. 757, 1961.

Chiang, H. C., J. L. Jarvis, C. C. Burkhardt, M. L. Fairchild, G. T. Weekman, C. A. Triplehorn.

Populations of European Corn Borer in Field Corn in the North Central United States. Missouri

Agricultural Experiment Station Research Bulletin No. 776, North Central publication No. 129, 1961.

Cooperation: States of the North Central Region (NC-20); ARS, U. S. D. A. (Project 270).

PLANT AND ANIMAL TOLERANCE TO SOIL INSECTICIDES. (C. Wingo, M. A. Pickard). There is need for information concerning the accumulation of insecticides in soils and their effect on associated plant and animal life.

Soil plots treated with excessive amounts of dieldrin and heptachlor in 1957 were planted to corn and wheat in 1961 to measure the effects of the insecticides remaining in the soil. No significant effect on ger-

mination, plant growth, or yields was found. Chemical analysis of these treated soils showed approximately 10% of the 100 pounds of heptachlor applied per acre in 1957 remaining in 1961. Of the 100 pounds of dieldrin applied per acre in 1957, 43% remained in 1961. Soils treated with 10 pounds per acre 1957, contained 11% of the applied heptachlor and 26% of the applied dieldrin in 1961. Plots treated with heptachlor were found to contain heptachlor epoxide in amounts approximately equal to the amounts of heptachlor found in these soils. No effect was found on the succession of clovers, grasses, and weeds due to the presence of these insecticides in the soil. Analysis of the treated soil will be continued to establish rates of disappearance of the insecticides from cultivated and uncultivated soils. The effect of the insecticide residues on plants and animals will be studied.

Cooperation: States of the North Central Region (NC-19).

(Project 283).

INSECT PESTS OF SMALL GRAIN. (H. E. Brown, L. Haseman, L. Jenkins, P. C. Stone, M. W. Gilmore, J. D. Munson). The principal insect pest of wheat in Missouri is the Hessian fly. Occasionally there are other insect pests of importance to small grains.

Heptachlor has been used in an effort to control the Hessian fly. This material in a 5% granulated formulation was applied by two methods: (1) drilling with a seed at the time of planting and; (2) as a broadcast application after the plants were up. Three rates were used: One-half pound, one pound, and two pounds per acre. All of these treatments significantly decreased the Hessian fly population and one of them, the two pounds per acre broadcast, increased grain yield. An experiment was initiated in the fall of 1960 to test the effect of Hessian fly control on grain yield in relation of date of planting and variety of wheat. Applications at the rate of one pound per acre of the systemic phosphate insecticides used, phorate and Di-Syston, gave a protective period of between 45 and 55 days. Under conditions of very heavy infestation excellent control of the Hessian fly was obtained where the protective period requirement was not greater than 50 days; but grain yields were not significantly increased by insect control. Studies on Hessian fly control will be continued.

Cooperation: Department of Field Crops; Missouri Cooperative Extension Service; U. S. D. A. (Project 102).

INSECT PESTS OF CORN, SORGHUM, AND STORED GRAINS. (P. C. Stone, H. E. Brown, L. Haseman, A. Keaster, M. L. Fairchild, D. E. Short, D. V. Allemann). There are many insects in Missouri that feed on the leaves, stalks, and roots of corn or sorghum. It has been estimated that insect damage reduced corn yields by approximately 10%. Grain sorghum is becoming a more important crop in Missouri and therefore many insects which affect sorghum adversely.

Based on stand counts Diazinon at 1.0 and 2.0 pounds per acre controlled the soil insect complex. Particle sizes, concentrations, and type of carriers have very little effect on corn rootworm control obtained with granular insecticides in the row. Winter application of soil insecticides was not as effective as broadcast applications in the spring. The stage of plant development must be considered when timing applications of insecticides for second brood European corn borer control. Topical applications to corn earworm larvae indicated "Sevin" was more effective than DDT; but a combination of the two gave better results than either alone. There was no significant difference in earworm control in sweet corn with DDT and "Sevin". One application of phosdrin, endrin, dimethoate, dylox, malathion, and C4072 increased sorghum grain yields up to 40%. Two applications were apparently phytotoxic to sorghum. Selections have been made for lines of corn resistant to corn earworm and European corn borer. The European corn borer can be reared continuously, but the corn earworm is difficult to rear through more than two generations in the laboratory. Definite black cutworm moth flights (or generations) were found in the Northern part of Missouri. A continuous flight occurred throughout the summer in the Southeastern part of the State. Spring development of the European corn borer was 15 to 20 days earlier in Southern Missouri than in the Central part of the State. Only 2.5% of the corn borer larvae collected in the fall of 1960 were parasitized by *Lydella grisescens*. Thirty-two percent of the borers collected in Carroll County in the fall were infested by *Perezia Pyraustae* while 16% to 37.5% collected in New Madrid in 1960 and 1961 were infested.

Publications: Peters, D. C., A. K. Burditt, Jr., M. L. Fairchild. The Biology and Control of the European Corn Borer in Missouri. Missouri Agricultural Experiment Station Research Bulletin, No. 757.

Cooperation: Department of Field Crops; Crops Research Division; ARS, U. S. D. A.; Velsicol Chemical Corporation; Hercules Powder Company; Shell Chemical Company (Project 269).

CHEMICAL CONTROL OF ARTHROPOD PESTS OF LIVESTOCK. (C. W. Wingo, O. L. Benson). The livestock produced on Missouri farms comprises the most valuable crop raised. The control of internal and external insect and arachnid parasites of farm animals is an important management problem in livestock farming. Losses due to insect infestations and resultant diseases can be quite large.

House fly control experiments in farm-type buildings with dimethoate-treated strings failed to give adequate control. The biology and field control of the face fly was studied. Rearing attempts in the laboratory were generally unsuccessful with the face fly. The addition of honey to the basic diet was found to increase egg production in laboratory rearing studies. In the field, it was found that increased wind velocity and decreased relative humidity reduced the extent of face fly populations on cattle. Cattle activity also caused a decrease in face fly population. Resting cattle had approximately 50% more flies on them than actively grazing cattle. The hibernation and seasonal activity related to movement from hibernation were studied. Females entered hibernation in an unfertilized state with ovaries inactive. The males in hibernation were found to be without mature sperm. Two parasitic wasps were found to be parasites on the face fly. *Aphaereta pallipes* (Say) were found to parasitize as high as 84% of face fly larvae. *Eucoila* sp. was found to parasitize *Sarcophaga querula*. Preliminary studies indicated that there was a possibility of using larvae of *Orthellia caesarion* as a laboratory host of rearing *Aphaereta pallipes* in the laboratory for field distribution. Control studies of the face fly using baits, backrubbers, and sprays with a wide range of toxicants were generally unsatisfactory.

Cooperation: Departments of Animal Husbandry and Dairy Husbandry.

(Project 46).

THE CONTROL OF COTTON INSECTS. (K. Harrendorf). The cotton producing area of Missouri is located on the Northern edge of the cotton belt. Therefore, the insect problems are different from those found farther South. Insect damage in Missouri is usually more sporadic and of less intensity. Missouri cotton producers need accurate information on damage caused by cotton pests and whether or not control measures are justified. Lack of information has resulted in the omission of control measures when they were needed and also in the unnecessary application of insecticides.

Trithion and ethion at .375 pounds per acre resulted in spider mite control comparable to .5 pounds per acre. The residual action of the lower dosages did not appear as effective as the higher rate but gave adequate control 17 days after treatment. Spot treatment of spider mite infestations with granular phorate at 2.0 pounds per acre applied broadcast with a "cyclone" seeder resulted in excellent control of mites in 9 of 10 treatments. Broadcast applications of granular phorate and DiSyston at 1.5 and 2.0 pounds per acre gave excellent control of spider mites in the treated area. Fume drift was effective in controlling mites a considerable distance from the treated areas. The effectiveness of fume movement was affected by wind currents. Control was obtained as far as 48 rows away from the treated zone in a leeward direction. A preliminary evaluation of certain cotton biotypes revealed several sources of resistance to injury by the spider mite. Control of thrips on late planted cotton did not result in increased yields. These studies will be continued on the control, habits, and seasonal abundance of cotton insects.

Publications: Harrendorf, K., G. W. Thomas. Cotton Insect Control, Missouri Cooperative Extension Service Circular, in press, 1962.

Cooperation: Department of Field Crops

(Project 214).

NEMATODES OF MISSOURI. (L. Jenkins). Nematodes cause damage to many fruit, garden, and field crops in Missouri. The root-knot nematode is a serious pest of tomatoes, watermelons, muskmelons, cucumbers, carrots, okra, parsnips, beets, beans, sweet potatoes, cotton, sugar beets, and soybeans. It is also an important pest of nursery stock. The soybean cyst nematode is present in six Southeastern counties in Missouri. This pest is so severe that quarantines have been placed on all fields known to be infested.

Permanent nematode slides have been made for reference and to determine the species of nematodes present in different areas of the State. A new nematocide known as Penn Salt TD-183 gave promising results on cotton. DD as a soil fumigant doubled the yield of sugar beets on sandy soil where root-knot nematodes were a problem. The sucrose content of the check plot was 9.75%; and of the treated plot, 14.4%. American Cyanamid 18133 again was used as a dip on bare root nursery stock to control the root-knot nematode. One hundred percent control was obtained at a concentration that caused no phytotoxicity on 30 out of 41 varieties of fruit trees and ornamental shrubs. Some tomato plants developed in the tomato breeding project have proved very resistant to root-knot nematode. Watermelons, cucumbers, and Nugget sweet potatoes were increased in yield by the use of a soil fumigant. The nematode collection will be continued as will greenhouse and field tests.

Publications: Jenkins, L. Annual Report of Southeast Missouri Experimental Fields.

Jenkins, L. A Summary of Nematode Work on Cotton. A paper prepared for the Cotton Disease Conference, Memphis, January, 1962.

Jenkins, L. A Summary of Results from the Use of Chemical Dips on Bare Root Nursery Stock. A paper prepared for the Conference of the American Association of Nurserymen, Washington D. C., February, 1962.

(Project 312).

LEGUME AND GRASS INSECTS. (P. C. Stone, J. D. Davis, D. M. Daugherty). The growing of soybeans is a major industry in Missouri. Information is needed concerning insect populations which justify insecticidal control. There is evidence indicating that much damage as a result of stink bugs puncturing green pods and sucking juices from the developing seeds. Damage to soybeans by the brown stink bug was studied in screen cage tests. The number of underdeveloped soybeans was significantly greater in cages infested with the brown stink bug than in uninfested cages. Immature beans in the middle third of plants showed progressively increased numbers as stink bug density increased. The period of maximum damage occurred during the four weeks beginning with the first bloom. The lower third of the plant was more extensively damaged than the other two-thirds. Studies with stink bugs and the damage caused by them to soybeans will be continued.

Cooperation: Grain and Forage Insect Section, Entomology Research Division; U. S. D. A. (Project 369).

THE SPOTTED ALFALFA APHID. (M. L. Fairchild, D. V. Allemann, D. Berry, D. E. Short). At the time work started with the spotted alfalfa aphid, infestations were serious in Missouri. However, unusually wet weather recently has prevented the development of economic infestations and the work in this area therefore has been curtailed. This project was a part of a North Central Regional Project (NC-38). Since this pest is no longer of the importance it once was the regional project has been terminated and therefore, this study, Missouri's contributing project, also is being discontinued.

Publications: A paper on the Biology and Occurrence of the Spotted Alfalfa Aphid in Missouri is being prepared.

Cooperation: States of the North Central Region, (NC-38); ARS, U. S. D. A. (Project 309).

NUTRIENTS FOR CRICKETS. (P. C. Stone, L. Haseman, F. R. Nelson, A. R. Chauthani). Basic research is needed in the area of nutrition and population dynamics of insects. The house cricket has been chosen for this study because it is a tame species which is adapted to laboratory rearing and is closely related to many species which are crop pests.

One-day-old crickets have been reared on diets of cerophyl and cerophyl plus varying amounts of sodium. Simultaneously, the Department of Biochemistry in the School of Medicine has reared one-day-old crickets from the same general culture to the adult stage on the same diets. At maturity many of the crickets reared on these diets were analyzed for sodium. Females and males at maturity had been retained on the same diets to determine the number of nymphs they would produce. Also, progeny of crickets fed on one of the best, and on one of the poorest diets have been reared through the second generation in order to observe growth, survival, and maturity. Fifteen tests have been carried out to compare the size, survival, and growth of young crickets on five different grasses: Timothy, orchard grass, fescue, alfalfa first cutting, alfalfa third cutting, and a check diet of Cerophyl. These tests indicated that the house cricket may be useful in checking the nutritive value of grasses. Ten inbred lines of crickets developed during the past few years have been maintained in separate large cultures. One hundred one-day-old nymphs of each of the ten inbred lines have been reared on the same diets and under identical ecological conditions. The survival of the crickets in one inbred line was less than 75% in each experiment. Some of the other inbred lines had survival which was consistently above 90%.

Publications: Neville, P. F., P. C. Stone, T. D. Luckey. Cricket Nutrition II. An Unidentified Factor in the Nutrition of Acheta Domesticus. Journal of Nutrition, Volume 74, No. 3, July, 1961.

Cooperation: Departments of Soils, Field Crops, Agricultural Chemistry, Animal Husbandry, and Horticulture; School of Medicine; Department of Biochemistry (Project 74).

THE BIOLOGY AND CONTROL OF CARPENTERWORMS. (W. R. Enns, R. L. Johnsey, P. C. Stone). Carpenterworms have caused substantial damage to Missouri produced lumber. A substantial amount of information has been acquired on the amount of degrading of this lumber due to injury by carpenterworms and other borers. Only moderate progress has been made in studying the life cycle and biology of carpenterworms. Artificial control methods attempted have proved negative. It has been shown that carpenterworms can complete their growth in two years. Larvae have been found as high as 40 feet above ground. A method of rearing larvae under artificial conditions has been developed. The direct loss to trees considered worth taking to the mill has been established to be approximately 10%. An estimate has been made that an additional 10% of trees were left where cut because of damage from carpenterworms. Also, the decay associated with borers constituted approximately another 10% loss. Thus, carpenterworms may damage as high as 30% of Missouri lumber production. Owing to lack of funds and personnel, this project is being discontinued.

Cooperation: U. S. Forest Service; U. S. D. A. (Project 321).

SUGAR BEET PRODUCTION IN MISSOURI. (D. Green, C. M. Woodruff, L. Jenkins). See report under Department of Field Crops.

Cooperation: Departments of Field Crops, and Soils (Project 492)

FIELD CROPS

Emmett Pinnell, Chairman

HYBRID CORN FOR MISSOURI. (M. S. Zuber, Charles Hayward, D. V. Singleton, A. C. McBride, J. P. Thomas, J. G. Hooks, P. J. Loesch, Jr., V. L. Ferguson). Corn breeding investigations were started at the Missouri Agricultural Experiment Station in 1935 and have added greatly to the value of the corn crop for Missouri agriculture. Knowledge of the best plant density for corn breeding experiments was highly desirable. Therefore, studies to determine this were made. Four thousand plants per acre were found most suitable. Progress has continued on the development on hybrids with low ear placement. Seeds have been treated with fungicides and stored for periods of 1, 4, 7, and 10 months. The lowest germination occurred after storage of one month. Diplodia stalk rot studies showed good agreement only about half the time presumably due to the interaction of stalk rot response with the four growing seasons tested. In 1961, no association was found between diplodia induced stalk rot, field stalk lodging, and premature plant death. Two in-breeds have been released, Mo. 12 and Mo. 13. Four hybrids, Mo. 881, Mo. 1023, Mo. 5402W, and Mo 4077W were released for double cross seed production. Amylose starch synthesis was found to be only slightly affected by different nitrogen levels or plant densities. High amylose hybrids yielded slightly over 100 bushels per acre; about 20 bushels less than normal dent corn hybrids. Inheritance studies of amylose synthesis have been conducted. Corn breeding studies will be continued next year.

Publications: Chinwuba, P. M., C. O. Grogan, M. S. Zuber. Interaction of Detasseling, Sterility, and Spacing on Yields of Maize Hybrids. *Crop Science* 1:279-280, 1961.

Zuber, M. S., C. O. Grogan. A New Technique for Measuring Stalk Strength in Corn. *Crop Science* 1:378-380, 1961.

Zuber, M. S. What Limits Corn Yield. *Crops and Soils*. Vol. 13, Aug.-Sept., 1961.

Singleton, O. V., M. S. Zuber. 1961 Missouri Hybrid Corn Yield Trials. Missouri Agricultural Experiment Station Special Series No. 11, 1962.

Singleton, O. V., M. S. Zuber. A preliminary report for the 1961 Missouri Corn Performance Trials. *Field Crops Miscellaneous Report No. 22*, December 1961.

Zuber, M. S., O. V. Singleton, P. J. Loesch, A. C. McBride. Report of the 1961 Missouri Cooperative Corn Investigations. *Field Crops Miscellaneous Report No. 25*, February, 1962.

Loesch, P. J., O. H. Calvert, M. S. Zuber. Interrelationships Between Diplodia Stalk Rot and Several Morphological Traits Associated with Lodging in Corn. (in press).

Cooperation: Hercules Powder Co.; Corn Industries Research Foundation; Quaker Oats Company (Project 85).

HEREDITY IN CORN. (M. G. Nuffer, E. H. Coe, G. Y. Kikudome, G. G. Doyle, E. S. Bretz, G. M. Reddy, G. Ficsor). Research in plant breeding depends upon an understanding of the laws of genetics. There is great need for developing our knowledge of basic genetics. A complete understanding of the mechanics of heredity is needed. This work is designed to contribute to the knowledge in this area.

The Genetic Control of Mutation. Even though the discovery of mutator systems was made several years ago, the nature of the material causing mutability or the mechanics of its action has not been determined. One hypothesis requires that heterochromatin (the suspected agent) moves about in the chromosome complement causing a recessive allelic expression and a mutable condition to arise at each new position or gene locus at which it alights. The covering action remains in force until the second entity called a mutator or activator causes the cover to move to a new site at which time the gene becomes active again, thus producing what appears to be a mutation from recessive to dominant. Experimental evidence obtained this year tends to discredit this hypothesis. It has been found that certain agents (X-ray and ultra-violet light) which destroy heterochromatic elements do not destroy the so-called covering action as they should do if the above hypothesis were true. Furthermore, the covered of mutable loci are extremely stable in the absence of their mutator factor. Several new chemical mutagens have been tested: ethyl methane sulfonate, diethyl sulfate, glycidol, epichlorohydrin and colchicine. Ethyl methane sulfate was the only one to produce significant results. It produced greater effects with less damage than X-ray.

Analysis of Gene Structure at Selected Loci. Compound loci have been used extensively to solve problems regarding gene mutation. They have been found especially useful because the mutation behavior of one component of a compound locus can be studied while using the other as a marker.

Cytogenetic Analysis of the Activity of Heterochromatin. It has been known for many years that the "Dotted-1" gene had an intimate association with the terminal heterochromatic knob of the short arm of

chromosome number nine. In 1955, "Dotted-2" genes were discovered in chromosome number six and "Dotted-3" genes in chromosome number seven. An effort has been made to determine whether or not these two new "Dotted" genes have similar knob associations as does "Dotted-1". The X-irradiation technique has been employed trying to synthesize various intercalary deficiencies involving the knob segment. Several overlapping deficiencies should allow the identification of the cytological location of the "Dotted" genes. Two radiation experiments have been executed. The first yielded no recoverable progeny. The second trial although still far from completion appeared to give more promising results. Several of the ears harvested gave indication that it has been possible to remove the "Dotted" genes.

The Mechanism of Genetic Control of Biochemical Processes. The sequence of biochemical action of the genes controlling synthesis of anthocyanin pigment in maize has now been determined through use of the complementary relationship between these genes and interactions between tissues. Just as there is complementary interaction leading to pigment production in hybrids between different genetic types; there also, can be complementary interaction between live tissues of these types presumably through simple diffusion of precursors from one tissue to the other.

Analysis of New Genetic Phenomena. An objective grading test shows that repeated selection for divergent plant color does not change the basic pattern of B' inheritance. Greatly simplified classification of B, B', and b is possible by use of seeding observations in proper genotypes and with proper conditions; cob color in appropriate genotypes is a convenient and clear criterion of B expression also. Confirmatory tests established unequivocally that B' segregates from b in normal fashion, without exception. The effects of B' are not changed by the presence of a heterozygous translocation that has a break near B. The relationship between the mutable allele, B^V, and the B' phenomenon may be important and is being examined; these two systems presently seem to be unrelated. The B line that is being used as stable but convertible B parent has been tested for mutation to B'; no B' mutants were observed in over 900 examined gametes.

The Relationship Between Pairing Affinity of Chromosomes and Their Structural Homology. The following problems have been studied: (1) Preferential pairing in tetraploids and trisomics which are heterozygous for an inversion. Numerous stocks have been synthesized on the trisomic and tetraploid levels which contain a great variety of paracentric inversions. This is an effort to determine the effect of chromosome structural dissimilarity on pairing affinity; (2) Preferential pairing in trisome 3 plants which contained two standard chromosomes 3 and a chromosome 3 from an exotic line. A high degree of preferential pairing was observed in some trisomes which was probably indicative of structural dissimilarity between standard and exotic chromosomes; (3) The synthesis of artificial allotetraploid corn. Initial steps have been taken to develop an allotetraploid corn strain which would breed true for chromosome number. Thus, any sterility resulting from aneuploidy could be eliminated and in addition the new strain would be a true breeding single cross hybrid; (4) Numerical non-disjunction in tetraploid corn. This is the 3 to 1 separation of the chromosomes of a quadrivalent. This event is the cause of aneuploidy in the progeny of eutetraploids. The frequency of numerical non-disjunction can be determined by crossing a quadriplex (AAAA) by a nulliplex (aaaa) and testcrossing the progeny to determine their genetic constitution. The frequency of numerical non-disjunction has been determined for chromosomes 2 and 9; (5) The effects of aneuploidy in tetraploids on gene segregation and phenotypic character. A stock for identifying the aneuploids of chromosome 3 was synthesized; (6) The detection of non-homologous crossing over. Plants which are heterozygous for certain pericentric inversions exhibit a high frequency of non-homologous pairing. Non-homologous crossing over may be detected by observing anaphase bridges. Results of this phase of the work are still inclusive; (7) The duplication of specific chromosome segments by crossing translocations involving the same chromosomes and also by the use of overlapping inversions. Numerous crosses were made of translocations in an attempt to duplicate chromosome segments containing the y₁ and wx loci. It is hoped that the duplication of these genes will modify the chemical composition of the corn endosperm. Attempts have been made to acquire more inversions by irradiation.

Miscellaneous. Preliminary investigations have been started on the extraction of active DNA (the basic hereditary material) from corn pollen, and on the possibility that certain infectious viruses may become identified with the hereditary substance when properly incorporated in the cell.

Publications: Coe, E. H., Jr. A Test for Somatic Mutation in the Origination of Conversion-type Inheritance at the B Locus in Maize. *Genetics* 46:707-710.

Coe, E. H., Jr. Some Observations Bearing on Plasmid Versus Gene Hypothesis for a Conversion-type Phenomenon. *Genetics* 46:719-725.

Coe, E. H., Jr. Allelism at the C Locus in Maize. *Genetics* 46:859.

Kikudome, G. Y. Cytogenic Behavior of a Knobbed Chromosome 10 in Maize. *Science* 134:1006-1007.

Nuffer, M. G. Mutation Studies at the A₁ Locus in Maize. I. A Mutable Allele Controlled by Dt. Genetics 46:625-640.

Reddy, G. M., E. H. Coe, Jr. Complementary Interaction and Gene Action Sequence in Anthocyanin Synthesis in Maize. Genetics 46:892.

The following notes have been submitted for inclusion in the Maize Genetics Cooperative News Letter:

Coe, E. H., Jr. Haploid Induction; Anti-inhibitor Effect of bz₂: a correction.

Coe, E. H., G. M. Reddy. Endosperm Culture.

Doyle, G. G. Non-homologous Crossing Over.

Kikudome, G. Y. A Small Telocentric Fragment; Comparison of two K10 Chromosomes; Test of the Heterochromatic Nature of Ds.

Nuffer, M. G. Location of New Positions of M; Differences in Male and Female Transmission for Heterozygotes involving the wx 9 Translocation Series.

Reddy, G. M. Gene Action Sequence in Anthocyanin Synthesis.

Cooperation: ARS; U. S. D. A.; NSF

(Project 48).

HYBRID CORN TESTING. (M. S. Zuber, O. V. Singleton). It is highly desirable to have unbiased information concerning numerous corn hybrids currently being sold in Missouri for use by farmers. Under this program all retailers of hybrid seed corn may submit hybrids of their choosing for testing in one or more of several districts. A fee is charged for this service. The climatic conditions of the 1961 growing season were very favorable for corn. The estimated average yield of 62 bushels per acre in Missouri was established for the State. Stalk and root lodging were exceptionally high in some areas. The average of all official tests was 109 bushels with the highest district yield being in District 6 with 128.8 bushel per acre yield. The lowest district yield was in District 4 with a 95.2 bushel yield. Numerous open and closed pedigree hybrids have been tested for 3 to 5 year periods. From these a number of hybrids can be selected with high yields and relatively high lodging resistance.

Publications: Zuber, M. S., O. V. Singleton. 1961 Missouri Hybrid Corn Yield Trials. Missouri Agricultural Experiment Station Special Report No. 11, 1961.

Cooperation: Crops Research Division, ARS, U. S. D. A.; Missouri Cooperative Extension Service

(Project 310).

HYBRID SORGHUM TESTING. (M. S. Zuber, O. V. Singleton, A. C. McBride). This is a service designed to help seedmen of Missouri who are willing to pay for having their varieties rated in comparison with competitive strains. A fee is charged for this service. In 1961, grain sorghum performance trials were conducted in five locations in Missouri. Forty-four different hybrids and varieties were tested with 30 of them being tested at all 5 locations. The average yield at the different locations ranged from a low of 95 bushels per acre at Spickard to 165 bushels at Palmyra. At Spickard, hybrid yields ranged from 75 bushels to 122 bushels and at Palmyra, the same hybrids ranged from 134 bushels to 197 bushels per acre.

Publications: Zuber, M. S., O. V. Singleton, A. C. McBride. Sorghum Performance Trials in Missouri in 1961. Missouri Agricultural Experiment Station Special Report No. 10, 1961.

Cooperation: Crops Research Division, ARS, U. S. D. A.

(Project 351).

DISEASES OF FIELD CROPS IN MISSOURI. (T. D. Wyllie, O. H. Calvert, R. E. Pettit). Every year there are substantial losses that occur in the production of field crops in Missouri due to crops diseases. Work in combating these diseases must be a continuing program.

Corn ear rot in the field was correlated with laboratory "Pairing" studies; stalk root rot was not.

Earlier rating than 30 days after inoculation had less rotting and repeatability was low. Wide differences were found for Diplodia strains for sporulation, pathogenicity, and a growth factor inducing premature sprouting of infected kernels. Inhibiting culture contaminants did not prevent ear and stalk rot when mixed with the inoculum. A new inoculation machine was designed. Rhizoctonia, Leptodiscus and Fusarium continued to be associated with birdsfoot trefoil root rot. Plant growth chamber studies were initiated. From soybean germ plasma assayed for bug blight, P. I. 's 154, 194; 84, 751; 88, 444; 92, 713; var. Hill and Lee appeared resistant. The oil spray method was successfully employed for rust nursery inoculations. Methodology for maintaining Peronospora manshurica and Meloidogyne incognita acrita on living plants for screening soybean selections was developed. Population dynamics of the root-knot nematode were determined. Rhizoctonia and fusarium root rot were severe in plants less than 20 days old. Correlative evidence for pathogenicity and toxin production was found for Rhizoctonia, especially isolates from birdsfoot trefoil and pea. Cercospora beticola damaged sugar beet plots.

Publications: Loesch, P. J., O. H. Calvert, M. S. Zuber. Interrelationships Between Diplodia Stalk Rot

and Several Morphological Traits Associated with Lodging in Corn. Submitted for publication in Crop Science, 1962.

Calvert, O. H. et al. Soybean Diseases. Agricultural Experiment Station Special Report 3, 1961.

Wyllie, T. D. Effects of Metabolic By-Products of Rhizoctonia solani on the Roots of Soybean Seedlings. Phytopathology, in press, 1961.

Calvert, O. H. et al. Report of the 1960 Cooperative Corn Disease Studies. Field Crops Miscellaneous Report number 21, June, 1961.

Cooperation: Department of Entomology; Field Crops Research Branch, ARS, U. S. D. A. ; U. S. P. H.

(Project 469).

IMPROVED COTTON VARIETIES. (W. Sappenfield, L. Treece). Cotton is the major cash crop in Missouri's seven Southeastern Delta counties. It dominates the economy of the area. The high economic importance of cotton and the numerous difficulties attending cotton production and processing demand research for varieties particularly well adapted to Missouri. The cotton producing area of Missouri is in the Northern limit of the cotton belt. Missouri's fertile delta soils and lowered insect problems provide conditions favorable for large yields more easily obtained through the use of well adapted varieties.

An improved early fusarium wilt-root knot nematode resistant variety will be released soon to registered seed growers. Initial increase of another variety tolerant to verticillium-wilt is being produced at Iquala, Mexico. This variety is equal to Rex in yield but has better fiber. Progress has been made toward the development of a high yielding, early maturing, disease resistant strain, with superior spinning fiber. The varieties which were grown at: (1) Portageville were lightly infested with wilt and nematodes but severely infested with bacterial blight; (2) Diehlstadt were infected with fusarium wilt, root-knot and bacterial blight and (3) Dry Bayou were infested with verticillium wilt. One strain produced top yields at these three locations. Another strain produced excellent yields at Dry Bayou. Variety recommendations for 1962 are Rex, Fox 4, Auburn 56, Deltapine Smooth Leaf, Delfos 9169 (sandy loam non-wilt soil); Auburn 56, and Rex (sandy soils with fusarium wilt-root knot nematodes); Rex, Auburn 56, Fox 4, Deltapine Smooth Leaf (loam and clay loam soils with verticillium wilt) and Rex (clay soils). Fundamental studies are being continued on the genetic diversity in breeding; fusarium wilt, root knot nematode, and verticillium wilt relationships; measuring resistance to verticillium wilt; bacterial blight resistance; cold tolerance; varietal maintenance; natural crossing; glandless cotton seed; progeny testing; and adaptation of Missouri-bred varieties.

Publications: Sappenfield, W. P. Cotton Variety Improvement for Southeast Missouri. Missouri Agricultural Experiment Station Special Report No. 8, 1-31, 1962.

Sappenfield, W. P. Cotton Varieties for Southeast Missouri. Missouri Agricultural Experiment Station Special Report No. 12, 1-4.

Sappenfield, W. P. Fusarium Wilt Root Knot Nematodes, and Verticillium Wilt Resistance in Cotton; Possible Relationship and Influence on Cotton Breeding Methods. Plant Disease Reporter, in press, 1962.

Cooperation: Cotton and Cordage Fibers Research; Crops Research Division, ARS, U. S. D. A.

(Project 160).

DISEASES OF COTTON. (O. H. Calvert, T. D. Wyllie). In the development of new varieties of cotton, consideration must be given to resistance to the diseases which affect cotton. Host-parasite interrelationships must be considered and new chemicals designed for the effective control of cotton diseases must be tested. Machine planted cotton seed treatments were lost this year due to the weather. Results of in-the-hopper applications of fungicides indicated that acid-delinted seed emerged and survived significantly better than reginned seed when treated with recommended fungicides: Captan, 10%, Captan-PCNB 10-10% and Captan-PCNB-Zineb 10-10-10%. Other fungicides that produced significantly better stands were: Hercules 3944, Naugatuck B720, Panogen EPI77D and Chemagro Dexon. Release has been planned for a new variety for next year, Auburn M. It is an early maturing fusarium wilt-root-knot nematode resistant cotton composed of two sister strains selected from Auburn 56, and equal to Auburn 56. Transference of race 1 and race 2 blight resistance to major breeding lines has been continued. Observations continued to suggest a positive relationship between fusarium-wilt root-knot nematode resistance and tolerance to verticillium wilt. However, the converse was not necessarily true. The estimated reduction from full yield due all the diseases was 5.3 percent more than last year. Damages were high, due to both seedling diseases and the Alternaria-Cercospora complex. In the work for next year, increased emphasis on measuring actual versus theoretical application rates of in-the-hopper fungicides will be made. Observations will also be continued with the Alternaria-Cercospora disease complex.

Publications: Brown, N. et al. Cotton Diseases in Field Crops Research in Southeast Missouri. Missouri

Cooperation: Hercules Powder Company; Ansul Chemical Company

(Project 322).

WEED CONTROL AND DEFOLIATION IN COTTON. (O. H. Fletchall, R. D. Hicks). The fertile soils and humid seasons of the Missouri cotton area provide optimum conditions for the vigorous growth of weeds. Hand picking is an expensive operation in cotton production and effective defoliation is essential to the mechanization of the picking operation.

Defoliation of early cotton was equal to or better than for the intermediate or late varieties. One solution of the problem of poor defoliation under low temperature conditions may be the use of earlier maturing cotton so that defoliation can be accomplished before low temperatures occur. Indications were found that surfactants may have a role other than improving wetting when used with cotton defoliant. The use of low rates of Diuron with added surfactants showed promise as a directed post-emergence treatment for weed control in cotton. Studies will be continued on the effects of environment on the action of cotton defoliant.

Publications: Fletchall, O. H., E. J. Peters, R. D. Hicks, F. S. Davis, R. E. Talbert. Recommendations for Weed Control in Field Crops. Agricultural Experiment Station Bulletin No. 762, 1961.

Hicks, R. D., O. H. Fletchall. The Substituted Dinitro-Aniline Trifluralin for Weed Control in Cotton. WSA. Abs. p. 10, 1961.

Fletchall, O. H. Herbicides for the Future. Summary of remarks at a meeting of the Midwest Agricultural Chemical Association, Des Moines, Iowa, September 15, 1961.

Cooperation: Crops Research Division, ARS, U. S. D. A.; Union Carbide Company; Ansul Chemical Company. (Project 332).

SOYBEANS FOR MISSOURI. (L. F. Williams, A. Matson, T. D. Wyllie). Information on the performance of new and standard soybean varieties adds to the income of soybean growers and safeguards the reputation of Missouri soybeans for industrial use. Resistance to phytophthora root rot and to bacterial pustule-wildlife was added to the Clark variety and is now ready for distribution in Missouri and other interested states. Progress has been made in adding resistance to downy mildew and cyst and root-rot nematode to both Clark and Scott. Out of 900 plant introductions tested for seed quality factors in 1960, 90 have been selected and tested cooperatively with Delaware. Of these, 9 had excellent ratings from both areas. Out of 120 plant introductions selected for high protein content and tested cooperatively with Illinois and Indiana in 1960 and 1961 the best averaged 5 to 7% higher in protein content than commercial varieties. F₁ and F₂ crosses between 20 of the best of these and Clark and Scott were studied. High protein content appears to be recessive as F₁ protein content was well below the parental mean in all crosses. Yield of all but one F₁'s was above the high parent. Two years testing of varieties and introductions for resistance to bud blight (TRSV) virus has isolated four highly resistant strains. Of these, two have a good commercial type and should prove useful in breeding. These studies will be continued.

Cooperation: U. S. Regional Soybean Laboratory, ARS, U. S. D. A.; Danman Mills Inc. (Project 49).

THE QUALITY OF SOYBEAN SEED. (L. E. Cavanah, D. Green). Low quality of the soybean seed crop affects the value. Contributing factors to low quality are drouth, improper harvesting, processing and handling procedures, and infection by seed borne pathogens. There is need for the development of improved germination tests which will evaluate the potential of soybean seed for producing good field stands. Harosoy, Shelby, and Clark soybeans were planted at six different times at Columbia. These seeds also were germinated using standard procedures and planted in the field to observe the percent emerged normal seedlings. Results of these two evaluations indicated that the later dates of planting, which matured after the hot dry summer weather had ended, produced better quality seed. Harosoy and Shelby soybeans were harvested at varying dates and at three combine cylinder speeds. Harvest dates, delayed after normal maturity, lowered the soybean seed quality; increased cylinder speed also lowered the seed quality. A method of "cold testing" was developed which predicted relative field stand of soybeans better than did the standard laboratory germination test.

Publications: Cavanah, L. E. Progress Report on Factors Affecting Soybean Seed Quality. A mimeographed report on the Regional Project (NCM-23), Facilitating the Marketing of Seeds Through Improved Testing and Handling Procedures.

Green, D. E. Soybean Seed Quality as Affected by Date of Planting and Harvest Methods. A paper presented at the twelfth Annual Meeting of Seed Certification Officials, Foundation Seed Personnel, and Extension Agronomists of the North Central States.

Soybean Seed Quality. An article released through the Missouri Farm News Service.

Green, D. E. Factors Affecting Soybean Seed Quality. A thesis submitted in partial fulfillment of the requirements for the degree, Master of Science, Graduate School, University of Missouri.

(Project 376).

THE CYTOGENETICS OF WHEAT. (E. R. Sears, M. Muramatsu, L. M. S. Sears, A. Acosta). Wheat is a polyploid with a much more complicated inheritance pattern than some other economically important crops. The aneuploid material now available in wheat, however, makes possible a genetic analysis of a highly effective sort. As a result information and methods of considerable potential value to the wheat breeder have been obtained. The principles involved may also contribute to the breeding of many other crop plants which are polyploid.

A number of X-Ray induced transfers of stem-rust resistance and hairy neck from rye to wheat have been characterized as to their effect on the wheat phenotype, with only one transfer (involving hairy neck) appearing free of deleterious effects. The Hope gene on chromosome 1D for stem-rust resistance has been located on the short arm by studies involving telocentrics and isochromosomes. The construction of a linkage map for chromosome 6B has been started with the assignment of Sr11 (stem-rust resistance from the variety Timstein) and Ki (pollen killer) to the long arm, where B₂ (awn inhibitor) was already known to lie. Corroded (co) is located in the short arm. The number of different telocentrics obtained for the short arm of chromosome 3B has been raised to 16, and 6 of these have already been combined with the telocentric for the long arm, for eventual determination of the rate of somatic loss of the various telocentrics.

Publications: Sears, E. R., W. Q. Loegering. A Pollen-Killing Gene in Wheat. *Genetics* 46:897, 1961.
Sears, E. R., M. Okamoto. Chromosomes involved in Translocations Obtained from Haploids of Common Wheat. *Canadian Journal Genetics & Cytology* 4(1), in press, 1962.

Okamoto, M. Identification of the Chromosomes of Common Wheat Belonging to the A and B genomes. *Canadian Journ. Genetics & Cytology* 4 (1), in press, 1962.

Cooperation: Crops Research Division, ARS, U. S. D. S.; National Science Foundation (Project 261).

SOFT RED WINTER WHEAT IN MISSOURI. (J. M. Poehlman, Charles Hayward, A. Matson, G. E. Brown, P. Hoskins, R. Cunningham, Carl Hayward, N. R. Panigrahi). Wheat is an important crop in Missouri and is grown more extensively than any other small grain. Improved varieties to meet present day conditions are of great help to wheat growers.

Breeding work has been concentrated on short, stiff-strawed varieties of soft wheat resistant to loose smut, leaf rust, and hessian fly. Parent materials for short straw have been Norin 66 from Japan and Etoile de Choisy from France. Norin 66 lines have been produced in the second round of crosses with best selections coming from Redcoat crosses. Etoile de Choisy lines were stiffer but less promising for yield. A semi-dwarf mutant from Thorne-Clarkan x Etoile de Choisy was crossed with a tall productive strain and F₂ and F₃ generations studied for heritability, degree of dominance, and expected genetic advance in maturity, plant height, and date of heading. The semi-dwarf parent seemed ideal for incorporating early maturity and short plant height into otherwise suitable varieties. X-ray and thermal neutron radiation studies have been started. Speltoids, dense heads, and lax heads were the most frequently observed mutations but these were accompanied with sterility. Slight variations in height, maturity, yield, and leaf rust were also found. Some of the latter mutant types have potential use as varieties and are being continued in the variety test. Short early strains now developed will be advanced to yield tests. New wheat loan programs stressing premiums on strong gluten wheats emphasize the need for high protein hard wheats and greater winter hardiness for soft wheats.

Publications: Kerr, E. D., J. M. Poehlman, H. E. Brown. Method of Phorate Application and its Effect on Hessian Fly Control, Germination, and Forage and Grain Yields of Wheat. *Agronomy Journal* 53: 300-303, 1961.

Hayward, Charles F. X-Ray and Thermal Neutron Irradiation of Soft Red Winter Wheat, *Triticum Aestivum*. A thesis submitted in partial fulfillment for the degree, Doctor of Philosophy, Graduate School, University of Missouri, June 1961.

Panigrahi, N. R. Estimates of Heritability Dominance, and Genetic Advance in a Wheat Hybrid with a Semi-dwarf Parent. A thesis submitted in partial fulfillment of the degree, Doctor of Philosophy, Graduate School, University of Missouri, August 1961.

Poehlman, J. M., Charles Hayward, Carl Hayward, P. Hoskins, A. Matson. 1961 Small Grain Variety Tests in Missouri. *Field Crops Miscellaneous Report No. 21*, October 1961.

Cooperation: States of the North Central Region (NCM-28); Crops Research Division, ARS, U. S. D. A.; North Central Regional Plant Introduction Station (NC-7) (Project 202).

ALFALFA IMPROVEMENT FOR MISSOURI. (E. L. Pinnell, Carl Hayward, R. Hicks). During recent years alfalfa and alfalfa mixtures have provided more than half the total hay production in the United States. Recently alfalfa has become the leading hay crop in Missouri. Much Missouri land is well suited for the successful production of alfalfa and the acreage could well be expanded. Culver and Cody varieties released by the Indiana and Kansas Stations have been judged suitable for recommendation to Missouri farmers. The second year of water tolerance tests revealed that varieties differed in susceptibility to root rot induced by the flooded conditions that occur in parts of Missouri and that varietal differences in root rot scores were correlated from season to season. Varietal trials will be continued.

Publications: Murphy, W. J., E. L. Pinnell. Certified Alfalfa the Profit Factor in Livestock Farming.

Missouri Cooperative Extension Service Circular No. 732, 1961.

Cooperation: Departments of Soils and Entomology

(Project 241).

OATS FOR MISSOURI. (J. M. Poehlman, Charles Hayward, Carl Hayward, A. Matson, G. E. Brown, P. Hoskins, R. Cunningham). Oat breeding must be a continuous activity if the productivity of the crop is to be maintained. Current varieties become mixed, deteriorate in purity, and minor genetic mutations occur over a period of years. They become less resistant to prevalent diseases as a result of mutation, hybridation, and changes in the disease organisms themselves.

Nodaway, a new early variety with plump white seed and stiff straw has been distributed. This variety is resistant to smut, moderately resistant to crown rust, carries ABC genes for stem rust resistance but is susceptible to yellow dwarf. Heritability of yellow dwarf tolerance has been studied in a cross between two Missouri varieties. Tolerance was found to be quantitatively inherited. Winter oats selections from "hardy on hardy" bulk crosses have been made and are being tested. Many of these possess hardiness 10 to 15% greater than currently grown winter varieties. Good yield and seed quality is present in the hardy strains but many may be too tall and nearly all lack needed disease resistance. Lack of smut resistance is perhaps the most serious fault. Approximately 100 new lines were advanced to yield tests. Composites of bulks, hardy varieties, and new selections have been irradiated in an attempt to utilize outcrossing in a recurrent selection program. Attempts to widen adaptation of Nodaway and improve yellow dwarf resistance in this variety will be the principal objective in oat breeding work for next year. Some increases will be started of superior winter oat strains for possible distribution.

Publications: Sechler, D. T. Root Development and Lodging Resistance in Oats. Missouri Agricultural Experiment Station Research Bulletin 769, May, 1961.

Brown, G. E. Heritability of Resistance to Barley Yellow Dwarf Virus in Oats. Thesis submitted in partial fulfillment of the degree, Master of Science, Graduate School, University of Missouri, 1961.

Poehlman, J. M., Charles F. Hayward, Carl Hayward, P. Hoskins, A. Matson. 1961 Small Grain Variety Tests in Missouri. Field Crops Miscellaneous Report No. 21, October, 1961.

Cooperation: Oat Section, Crops Research Division, ARS, U. S. D. A.

(Project 203).

WINTER BARLEY FOR MISSOURI (J. M. Poehlman, Charles Hayward, Carl Hayward, A. Matson, G. E. Brown, P. Hoskins, R. Cunningham, D. N. Borthakur). The acreage of winter barley planted in Missouri has increased greatly in the last several years. This increase was made possible by the development of improved varieties for strong winter survival. Barley is an excellent grain for the rapid fattening of livestock in summer when the supply of corn is short. It has a comparatively light draft on soil fertility and since it is a winter crop there is small loss of soil by erosion. Barley also serves well as a nurse crop for legumes or grasses. It is excellent for fall and spring pasture. Nearly all of the barley grown in Missouri is from seed from Missouri B-475 a Tennessee winter type with good yield, hardiness, and smut resistance. Improvements in straw strength and hardiness are needed and preliminary increases have been made from varieties which show promise. These, along with crosses between B-475 and introductions from Korea are being evaluated. The Korean introductions shortened the stem and spike internode and awn length. They have short, stiff straw but yield potential is low due to reduced tillering and smaller seed size. The Korean barleys also have the potential for increasing winter hardiness. Crosses of B-475 with Kearney, Dicktoo, and Ludwig are also being studied. Some of these crosses show promise. The potential utilization of Missouri winter barley for malting is a promising area for research which has been started. The best practices for growing malting barley with existing varieties and the breeding program for improved varieties will be determined.

Publications: Barthakur B. C. Response of Normal and Uzu Varieties of Barley to Fertility Level and Seeding Methods. A thesis submitted in partial fulfillment of the requirements for the degree, Master of Science, Graduate School, University of Missouri, 1961.

Poehlman, J. M., C. F. Hayward, Carl Hayward, P. Hoskins, A. Matson. 1961 Small Grain Variety Tests in Missouri. Field Crops Miscellaneous Report No. 21, October, 1961.

Poehlman, J. M. A Versatile Nursery Seeder. Manuscript submitted to Agronomy Journal.

Cooperation: Crops Research Division, ARS, U. S. D. A. ; Anheuser Busch Inc.

(Project 90).

THE IMPROVEMENT OF PASTURES AND LEGUMES. (A. G. Matches, Carl Hayward, R. Hicks). A very high percentage of the total cash income received by Missouri farmers comes from the sale of livestock and livestock products. Pastures supply much of the feed for cattle and sheep and some of the feed for hogs and poultry. One-third of Missouri farmland is used for pasture. At least five million acres of the unimproved permanent pastures can be made to produce substantially larger yields of livestock products at a lower unit cost. The improvement of Missouri's pastures is a major need.

At Columbia yearling Hereford heifers rotationally grazed on orchard grass-ladino clover pastures, gained 292 pounds per acre and 1.50 pounds per heifer per day over a total of 187 days with a computed effective TDN consumption of 1,574 pounds per acre. On rotationally grazed timothy-Kentucky bluegrass-birdsfoot trefoil-voluntary ladino clover pastures, heifers gained 346 pounds with the daily gain of 1.71 pounds over 202 days with a consumption of 1,792 pounds of TDN. At Mt. Vernon, long yearling Angus and Hereford heifers gained 191 pounds per acre and 1.61 pounds per heifer day on orchard grass-birdsfoot trefoil; 207 and 1.73 pounds on orchard grass-ladino clover; 209 and 1.76 pounds on tall fescue-ladino clover; and 152 and 1.28 pounds on tall fescue-lespedeza pastures. Pasture effective TDN estimates were 1070, 1165, 1166, and 1067 pounds respectively. Pastures were grazed 116 days with an average of 118.9 heifer days per acre. Rotation grazing was used. An orchard grass alfalfa pasture at Sikeston produced 353 pounds of beef per acre with an average of 1.35 pounds daily gain per steer.

Cooperation: Department of Animal Husbandry; Crops Research Division, ARS, U.S.D.A. (Project 213).

SPECIES AND VARIETIES OF GRASSES FOR USE IN MISSOURI. (A. G. Matches, C. Hayward, R. Hicks). New grasses made available by plant introduction and by plant breeding need to be tested for adaptability to the climatic conditions and soils of Missouri.

A total of 19 sudan grass varieties and hybrids have been tested and while differences were not significant the best yielding produced over 5,300 pounds of dry matter per acre. Twelve orchard grass varieties were tested and did not differ significantly. The best variety produced 3,214 pounds. Five tall fescue varieties also, did not differ significantly and the average dry matter yield per acre was 2,672 pounds. Significant variety differences were found in the Reed Canarygrass test. Of the 8 varieties evaluated, Alabama was the highest yielding with 4,436 pounds of dry matter per acre. No disease of any consequence was observed during the 1961 season. This work will be continued.

Publications: 1962 Recommended Varieties for Missouri. Missouri Cooperative Extension Service Folder No. 108, 1962.

Cooperation: Crops Research Division, ARS; U. S. D. A.

(Project 220).

TREFOIL IN MISSOURI (J. D. Baldrige). The longevity of trefoil in the Southern part of the corn belt has been below expectation. Root and crown rot have been major factors contributing to losses in stand. Sources of resistance, or greater tolerance to these diseases are urgently needed to develop better varieties for this region. Fifty-nine plant introductions have been tested for resistance or tolerance to common root rot. By locating the tests on diseased soil areas and by defoliating four times in the second year, each time in early bloom at a two inch height heavy uniform development of root rot occurred resulting in heavy plant losses. Only 31% of the plants survived by August of the second year, and 9/10 of these were badly rotted. Under this severe epidemic all accessions were heavily rotted yet small significant differences in persistence and amount of root rot resistance existed among them. The best ten were inferior to three Missouri entries which represented the improvement from one cycle of selection for persistence. During the coming year a new test of plant introductions for screening accessions that have not been evaluated previously for root rot resistance will be undertaken.

Cooperation: Forage and Range Branch, ARS, U. S. D. A. ; North Central Regional Plant Introduction Project (NC-7)

(Project 420).

IMPROVEMENT OF BIRDSFOOT TREFOIL AND LESPEDEZA. (J. D. Baldrige). Birdsfoot trefoil has been long recognized as a valuable hay and pasture legume in Europe. It has great potential as a long-lived legume for the Northern portions of the United States including North Missouri. It is a tap-rooted perennial which is productive, palatable, nutritious, and non-bloating. It is tolerant of heat and drouth and is reasonably tolerant of poorly drained soils if grown with blue-grass. Annual lespedeza is grown on millions of

acres in Missouri; far exceeding the combined acreage of all other legumes. It is being grown in a relatively unimproved form. The benefits from improved varieties would be large.

In the development of birdsfoot trefoil for Missouri conditions, root rot has been a major problem. New selections have been made from surviving plants grown in root rot infested nurseries at Columbia, Mo. and at Beltsville, Maryland. Some of these selections have proved superior to commercial varieties in persistence in cultivated nurseries. The progress that has been made in selection for greater resistance encourages further work. A new strain of annual lespedeza developed jointly by the Missouri and Arkansas Agricultural Experiment Stations outyields Korean lespedeza by 32%. It will be released under the name of "Summit". Work will be continued in the improvement of birdsfoot trefoil and lespedeza.

Publications: Shahani, M. N. Stand Loss Studies in Birdsfoot Trefoil. A thesis submitted in partial fulfillment of the requirements for the degree, Master of Science, Graduate School, University of Missouri, 1961.

Cooperation: Arkansas Agricultural Experiment Station; Forage and Range Branch, ARS; U. S. D. A.

(Project 221).

THE IMPROVEMENT OF MISSOURI FARM SEEDS. (L. E. Cavanah, W. E. Aslin, F. E. Forsyth, D. Green, C. Hayward, E. Pinnell, V. Stanway). The breeding and development of new and superior varieties and strains of plants for crops and pastures adds greatly to the wealth of the State when they are properly multiplied and distributed. When new varieties or strains have been developed, the increase, maintenance, and distribution to farmers of such superior plants is the final essential procedure in the whole process of plant improvement. This year some 31,400 acres were inspected in the field for seed qualities such as freedom from mixtures, freedom from hazardous weeds, and freedom from diseases. Sufficient seed was approved in the program to plant approximately three-quarter million acres of crop land. This work was in cooperation with the Missouri Seed Improvement Association. Nodaway spring oats were distributed to 20 growers and were planted on 1,271 acres for further distribution. Testing of seeds for their seeding quality included over 12,000 tests.

Publication: Two issues of a certified seed directory.

Cooperation: The Missouri Seed Improvement Association

(Project 19).

MUTATION STUDIES IN ARABIDOPSIS THALIANA. (G. Redeï, Y. Hirono). Progress in plant breeding is dependent upon advances in fundamental genetics. Much information has been obtained about the nature of radiation induced mutations in higher plants. Most of the changes are deleterious but some are favorable. The life-cycle of most agricultural crops is generally long and, in most cases, not more than two generations a year may be grown even with the use of greenhouse facilities. Basic genetic studies, therefore, usually require a number of years for completion. Therefore, a small plant, arabidopsis thaliana which completes its life-cycle in 30 to 40 days from seed to seed is highly advantageous for basic studies. The small size of the plants permits culture techniques to be used that require small amounts of space.

A new vitamin B₁ requiring mutant of arabidopsis has been detected. Almost 400,000 gametes with marked chromosomes have been tested but no intralocus recombination was found at the gl locus. Additional mutations were obtained at the ch locus (controlling chlorophyll b production by using a somatic screening technique). Compounds of ch alleles seem slightly higher in chlorophyll a content than the higher mutant (allelic complementation). The mutagenic effects of 5-bromouracil have been studied on almost 60,000 progenies and six stable and two variegating mutants have been obtained. Trisomics were produced to correlate genetic linkage with particular chromosomes. This work will be continued.

Publications: Redeï, G., L. M. Steinitz-Sears. X-Ray Mutants with High Selective Advantage. Genetics 1961:46:892-893 (abst).

Redeï, G. Supervital Mutants of Arabidopsis. Genetics 1962:47 (in press).

Redeï, G. Single Locus Heterosis. Zeitschrift Fur Vererbungslehre 1962:93 (in press).

Cooperation: N. S. F.

(Project 331).

THE CONTROL OF WEEDS. (O. H. Fletchall, R. E. Talbert, Carl Hayward, W. D. Aycock, E. J. Peters, J. F. Stritzke, R. D. Hicks). Weeds cause tremendous losses in all parts of the country. Usually more vigorous and more numerous than cultivated plants, they are highly competitive for light, water, and nutrients. Weeds also frequently cause losses by supporting insects and diseases damaging to crops.

Simazine and atrazine were inactivated in soil most rapidly when conditions were favorable for microbial activity. Both herbicides were detected in small amounts one year after the initial treatment of two pounds per acre. The adsorption of both simazine and atrazine by soil constituents was positively correlated with organic matter content, clay content, and cation exchange capacity. Decreased temperature increased adsorption and organic exchangers adsorbed larger quantities than clay exchangers. Corn yields were found

to be reduced 1.4 bushels per acre for each one hundred pounds of weed growth. Johnsongrass treated with 2 1/2 pounds per acre of dalapon required retreatment in about one week. For each additional increase of 1 1/4 pounds per acre the interval could be lengthened about 1 week until a maximum interval of 6 weeks was obtained. Soybeans in the greenhouse treated with amiben were not affected by night temperatures ranging from 40 to 60°F during germination. Amiben did not directly affect nodulation of soybean roots. Yields of soybeans from 24 inch rows were greater than from 8-, 16-, 32-, and 40-inch rows. Increases in soybean yields occurred from cultivation even when weeds were adequately controlled by amiben. Aerial spray to kill brush, followed by seeding with fescue and lespedeza or native grasses produced an 8 to 10 fold increase in forage yield. Fescue was more tolerant to dalapon than orchard grass and orchard grass was more tolerant than timothy. Studies of the behavior of herbicides in soils will be continued, along with weed control studies for specific crops.

- Publications: Fletchall, O. H., E. J. Peters, R. D. Hicks, F. S. Davis, R. E. Talbert. Recommendations for Weed Control in Field Crops. Missouri Agricultural Experiment Station Bulletin 762, 1961.
- Peters, E. J. Establish Legumes with Herbicides. Hoards Dairyman, p. 378, April 10, 1961.
- Peters, E. J. Weed Control in Seedling Legumes. Ag. Chem. Short Course Proc. (Univ. of Mo.) 1:18-19 1961.
- Peters, E. J., F. S. Davis, D. L. Klingman, R. E. Larson. Interrelations of Cultivations, Herbicides and Methods of Application for Weed Control in Soybeans. WEED'S 9(4):639-645, 1961.
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- Murphy, W. J., O. H. Fletchall, E. J. Peters. Effect of 2, 4-D and Related Compounds on Seedling Grasses. pp. 11-12 Weed Society of America Abstracts, 1961.
- Peters, E. J. Pre-emergence Weed Control in Soybeans. North Central Weed Control Conference, Research Report, p.-61, 1961.
- Murphy, W. J., O. H. Fletchall, E. J. Peters. Effect of 2, 4-D and Related Compounds on Seedling Grasses. North Central Weed Control Conference Research Report, p.-75, 1961.
- Peters, E. J. Herbicides for Weed Control in Alfalfa. North Central Weed Control Conference Research Report, p.-76, 1961.
- Fletchall, O. H. Simazine and Atrazine Residues in Soil. Talk presented at Thirteenth Illinois Custom Spray Operator's Short Course. January 25, 1961, in Urbana, Illinois.
- Fletchall, O. H. Johnsongrass Control. Ag. Chem. Short Course Proc. (University of Missouri) 1:51-53, 1961.
- Fletchall, O. H. Food Additive Contaminants from Agricultural Sources. Talk presented at Ninth Annual Food Technology Short Course (University of Missouri) 1961.
- Fletchall, O. H. Watch Out for Johnsongrass. Tape recording made on February 6, 1961, for release to radio stations in Missouri.
- Fletchall, O. H. Johnson grass Control on Highways. Talk presented at Thirteenth Illinois Custom Spray Operators' Short Course. January 25, 1961, in Urbana, Illinois.
- Fletchall, O. H. Recommendations to the Missouri State Highway Department for Preliminary Planning for the 1961 Johnsongrass Control Program.
- Fletchall, O. H. Residues from Pesticides Used in Accord with Missouri College of Agriculture Recommendations. Summary of remarks presented at the meeting on Pest Control, Pesticides and Wildlife at Columbia, Missouri, on July 14, 1961.
- Fletchall, O. H. Herbicides for the Future. Summary of remarks at a meeting of the Midwest Agricultural Chemicals Association in Des Moines, Iowa, on September 15, 1961.
- Talbert, R. E. Weed Control in Corn and Sorghum. Ag. Chem. Short Course Proc. (University of Missouri) 1:16-17, 1961.
- Talbert, R. E., O. H. Fletchall. Chemical Weed Control in Grain Sorghum. NCWCC Res. Rpt. 8:64, 1961.
- Talbert, R. E., O. H. Fletchall. Rate of Inactivation of Atrazine and Simazine in Field Plots as Determined by Bio-assay Techniques WSA Abs. p. 5, 1961.
- Hicks, R. D., O. H. Fletchall. The Influence of Rate and Treatment Interval of Dalapon Sodium Salt, on Johnsongrass Control. NCWCC Res. Rpt. 8:12, 1961.
- Hicks, R. D., O. H. Fletchall. The Effect of Adding Surfactants to Dalapon Sodium Salt, for Johnsongrass Control on Non-crop Land. NCWCC Res. Rpt. 8:14, 1961.
- Hicks, R. D., O. H. Fletchall. The Influence of Volume of Spray on Dalapon Sodium Salt, for Johnsongrass Control. NCWCC Res. Rpt. 8:14, 1961.

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Cooperation: Crops Research Division, ARS, U. S. D. A. ; Missouri State Highway Commission; Dow Chemical Company; Geigy Chemical Company; Amchem Products Inc. (Project 156).

THE EFFECT OF NATURAL GROWTH SUBSTANCES ON BUD ACTIVITY OF PERENNIAL WEEDS. (O. H. Fletchall, E. J. Peters, F. S. Davis, J. F. Spritzke). Perennial plants such as Johnsongrass, wild garlic, field bindweed, and iron weed are serious weed problems in the North Central Region including Missouri. Much of the persistence of these weeds is due to the production of dormant, vegetative buds.

Bio-assays with aerial bulblets indicated no growth inhibitors present in the outer protective leaves of minor offset bulbs of wild garlic. Dormant minor offset bulbs of wild garlic began to sprout before September 1 if moisture was adequate, and reached a peak in numbers sprouted during early October. It is planned to study the extracts of minor offset bulbs by chromatography to determine the nature of the endogenous growth substances in dormant and sprouting conditions.

Cooperation: States of the North Central Region (NC-10); Weed Investigations, Grazing lands, Crop Protection Research Branch, Crops Research Division, ARS, U. S. D. A. (Project 388).

SUGAR BEET PRODUCTION IN MISSOURI. (D. Green, C. M. Woodruff, L. Jenkins). Sugar beets have been grown in the western and mountain states under irrigation and in eight central and northern states without supplementary irrigation. Until recently Cuba supplied a large quantity of sugar for use in the United States. The loss of this source of sugar increased public interest in sugar beets for Missouri. Therefore, preliminary studies were started on the production of sugar beets.

Variety Tests. Variety tests were conducted at two locations: Lexington and Portageville. Six varieties were tested at each location. The seed was secured from two commercial sugar companies and from the U. S. D. A. The average yield was 13.8 tons per acre at Lexington and 10.8 tons per acre at Portageville. The range at Lexington was from 12.3 to 15.3 tons per acre and from 8.9 to 11.9 tons per acre at Portageville. Average sugar content for the varieties ranged from 12.0 to 13.5 per cent at Lexington and from 12.9 to 15.0 per cent at Portageville. The mean apparent purity percentage was 85.1 per cent at Lexington and 79.3% at Portageville. The effect of variety on sugar percentage was significant. Apparently there was an increase in both sugar and purity as harvest was delayed.

The Effect of Fertilizers on Sugar Beets. Preliminary investigations indicate that the production of sugar beets in Missouri will require special consideration of plant diseases, as well as the problems of varieties, fertility requirements, cultural methods, and pest control. Uniform stands of beets were necessary to produce beets of acceptable sucrose content. Irregular stands contributed to the development of large sized beets which were low in sucrose as compared with the smaller more uniform sized beets of the good stands. Nitrogen fertilizer applied at the time the beets were blocked produced inferior beets as compared with those produced when nitrogen was spread at the time the beets were planted. Rates of nitrogen applications ranging from 75 to 100 pounds per acre seemed most appropriate for sugar beets on sandy loam soils. Potash applied at rates ranging from 0 to 400 pounds K_2O produced no significant effects. Planting on a smooth seedbed contributed to the incidence of black rot as a consequence of poor surface drainage. Many beets developed large crowns above the surface because of compact conditions of the soil. Leaf eating insects damaged the beets severely where beets were not sprayed regularly. Keeping the beets free of weeds required a large amount of hand labor. Beets harvested late in the season contained a greater percentage of sucrose than those harvested in mid October. Variety responses differed with one of the monogerm hybrids proving most satisfactory. Finally yields and sucrose content of the beets were for all practical purposes the same as the 10 year averages for beets produced commercially in established beet producing areas of the nation.

Cooperation: Departments of Entomology and Soils

(Project 492)

FORESTRY

R. H. Westveld, Chairman

FOREST SITE EVALUATION. (A. J. Nash). The productive capacity of forest land is of primary economic importance in a state which has as high a percentage of total land area in forest cover as has Missouri. Income derived from forest land can be a large source of revenue within Missouri. Some forest lands are not capable of producing merchantable timber. These should be left for water shed protection purposes. Other lands have produced a large quantity of high value wood products because of the nature of the soil topography and other factors making up the "Site".

A preliminary statistical analysis of the effect of five independent variables: aspect, degree of slope, slope position, soil texture, and permeability was completed in relation to the site index for 309 site areas. The independent variables have been revised to conform to a more sound approach based on the effect of each on soil moisture or soil aeration. The five variables used in the final analysis were: slope and aspect combined, soil texture of the B horizon, stone content of the B horizon, soil position, and soil constituency. It has been shown that these variables were correlated with the site index but in varying degrees according to the area in question. A pilot test of the system of estimating site index by photo interpretation will be conducted in Oregon County.

Publications: Nash, A. J. Forest Site Evaluation. A thesis submitted in partial fulfillment of the requirements for the degree, Doctor of Philosophy, Graduate School, State University, College of Forestry, Syracuse, New York.

Cooperation: Department of Soils; Columbia Forest Research Center, U. S. Forest Service

(Project 346).

SITE PREPARATION FOR FORESTATION. (R. B. Polk, D. J. Janes). In recent years forestation work in Missouri has approximately doubled. In 1960 approximately six million trees were planted. Tree planting will become increasingly important in the production of timber crops; in the maintenance of desirable forest species; and in the protection of water sheds and attendant stream flow regulation; in maintaining a wildlife habitat; and in meeting the growing needs of outdoor recreation. Changing land use patterns continue to add large acreages to the need for reforestation. Information is needed as to how good stands of timber can best be established.

A site preparation study was established at Ashland in 1950 and another at Weldon Springs in 1956. Both of these experiments were on heavy soils and both show full and deep plowing advantageous over row plowing; and row plowing over the old scalp and plant method; or no preparation. At the Southeast Missouri Research Center sixteen 100 tree plots of *Populus deltoides* Bartr. were planted. Cuttings were compared with seedlings and two local races, Southeast Missouri and Missouri River lowlands at Boonville, were compared. A total of 1,936 trees were planted. The wildling Boonville seedlings had large root systems and it was necessary to dig the planting holes for them. Despite the fact that the Boonville source was represented by a much harder planting stock there is evidence that the Southeastern race has made the better development. Preliminary trials have been started on three other species: *Taxodium distichum* (L.), one plot of 100 trees, 94% survival; *Liquidambar styraciflua* L., 2 plots of 100 trees each, 93 and 63% survival; *Plantanus occidentalis* L., 2 plots of 100 trees each, 76 and 82% survival. Studies have been made of the propagation from cuttings of the apparently difficult to root *Populus alba* crossed with *P grandidentata* hybrid. Of the planting methods used, one was far superior: setting cuttings vertically with one inch supporting a bud above ground. The use of a hormone was not effective. Cuttings above one-half inch in diameter were better than those under this diameter.

Publications: Quaynor, Solomon Opar-Addo. Site Preparation as a Cultural Measure in Establishing Pine Plantations on Old Fields in Central Missouri. A thesis submitted in partial fulfillment of the requirements for the degree, Master of Science, Graduate School, University of Missouri, 1961.

Cooperation: Forestry Division, Missouri Conservation Commission; Columbia Research Center, Central States Forest Experiment Station, U. S. Forest Service

(Project 157).

OAK REPRODUCTION IN MISSOURI. (L. M. Nichols, L. K. Paulsell, D. J. Janes, R. A. Musbach). Missouri's second growth forests are mainly of sprout origin. More and more attention is being directed to the oak reproduction problem. Trees of sprout origin tend to be more defective and of lower quality than trees developing from seed. Oak stands in Missouri produce large seed crops yet the proportion of seedlings is low.

The initial block of reproduction plots at Weldon Springs has now been through three growing seasons. Originally about 81% of the plants were seedlings; 15% single seedling sprouts; 3% multiple seedling sprouts; 1% sprouts. A sample of 176 original true seedlings were microscopically examined for age. They averaged 1.29 feet tall and 7.5 years old. During the three year period about 10% of the true seedlings became single seedling sprouts. On stems-cut and burn plots many multiple seedling sprouts resulted. Average height growth of plants surviving the three year period was least under heavy canopy and greatest on clearcut plots. Fire completely killed many plants in cases where the root collar was above ground. These results need further testing. A new block of plots at the University forest will be established. (Project 394).

SPROUTING VIGOR IN OAKS. (G. S. Cox, A. R. Vogt). The second growth hardwood forests of Missouri are primarily of sprout origin. These sprouts arise from dormant basal buds which do not develop unless the physiological balance of the trees is disturbed. Normally they do not begin growth unless the crown of the tree is killed by cutting or girdling the trunk. In many cases sprout forests of Missouri are of poor quality. This has resulted from repeated high-grading, fire, and over grazing. Sprouting capacities of desirable species may have increasing importance in the regeneration of certain types of stands. From the standpoint of managing forests for the highest short term production of wood volume, sprouting may prove the most satisfactory means of reproducing stands. This should prove to be of particular importance in the event of pulp mill development which would use hard woods. The improvement of the quality of hardwood forests in Missouri is necessary.

Beginning studies have indicated that auxins were the controlling factor in the sprouting of dormant basal buds in oaks. Control trees produced 97 sprouts while trees treated with a 1% indole-3-acetic acid paste had a total of 16. A study of the effect of double cutting of the stem on sprouting showed that stems cut once produced 165 sprouts while 146 sprouts appeared on the twice cut stems. Studies of methods of extracting and identifying growth controlling substances which influence sprouting have been started. Efforts will be made to determine the source of auxin which controls basal sprouting.

Cooperation: Columbia Forest Research Center, U. S. Forest Service; National Science Foundation

(Project 443).

IMPROVEMENT OF HARDWOOD STANDS. (L. K. Paulsell, R. A. Musbach, G. S. Cox, C. D. Settergren). Much of Missouri's timber has been depleted and rehabilitation of these stands will require a long time. Studies may help in the re-establishment of these hardwood stands.

Fire Studies. Plots were burned in accordance to a predetermined schedule. All reproduction plots were examined, inventoried, and maps brought up to date. Analysis has not been completed.

Pruning of Oak. Routine maintenance of the plots assigned to this study has been made. Several more years will be required to evaluate the results of pruning.

Conversion of Low Value Hardwood Stands to Conifers. Survival of height measurements have been taken and considerable bending and breaking has occurred in the plots because of a severe ice storm. Many large trees failed to straighten. Large loblolly was especially hard hit. Eastern Red cedar continued to show the best survival. Loblolly exhibited the best growth. Survival and growth continued to be best on the chemically treated plots as compared to the "dozed" plots. (Project 75).

FOREST STAND IMPROVEMENT CUTTINGS. (L. K. Paulsell, R. A. Musbach, J. M. Nichols, D. J. Janes, C. A. Settergren, G. S. Cox). Missouri's forests have been cut largely on the basis of demand with little or no consideration for future wood production. Information is needed on hardwood management in order to be of help to owners desiring to adopt better cutting practices.

Stand Improvement Cutting. In addition to regular maintenance with the immature oak study, four soil pits have been installed, one each on plots involving four different treatments, and sampling procedures have been devised for study of soil moisture.

Regeneration Cutting. At the University forest the first five year periodic measurements were made for the six one acre plots Block No. 2. At Weldon Springs, reproduction quadrants were reinventoried for 18 one-acre plots of Blocks 1, 2, and 3. Timber sales involving the Weldon Springs timber management phase totaled \$2,436.30. Ten percent of the sales income was reallocated to timber stand improvement work. This project requires data collected over a number of years before substantial differences can be determined.

(Project 122).

EFFECT OF STAND TREATMENT ON GROWTH, SEED PRODUCTION, AND REGENERATION OF BOTTOM LAND HARDWOODS. (L. K. Paulsell, R. A. Musbach, J. M. Nichols). The production of bottom land hardwoods has not received much attention. A number of industries are developing which make use of bottom land hardwoods and several of these industries have extensive holdings under management. The outstanding potential of bottom land production of hardwoods is now being recognized.

Regular sampling of acorn production from 36 one-half acre plots has been continued and the acorns produced have been classified. The total production of sound acorns was intermediate in relation to past years. The flooded areas continued to produce a heavier crop than the unflooded areas. The sampling of mast production will be continued and will be summarized after a sufficient number of years have been recorded.

Publications: Paulsell, L. K., R. A. Musbach, J. M. Nichols. Pin Oak Acorn Production and Regeneration as Affected by Stand Density, Structure, and Flooding. Missouri Agricultural Experiment Station Research Bulletin No. 750, 1961.

Cooperation: U. S. Fish and Wildlife Service; the Missouri Conservation Commission; U. S. Forest Service (Project 287).

ACORN PRODUCTION IN MISSOURI. (J. M. Nichols, D. J. Janes, R. A. Musbach, C. D. Settergren). Data on acorn production has been collected at Weldon Springs, the University Forest, Sinken Experimental Forest, and Mingo Wildlife Area. No detailed analysis has been made since a number of years of records will be necessary before the data will have meaning.

Cooperation: U. S. Fish and Wildlife Service; U. S. Forest Service; Missouri Conservation Commission (Project 123).

SAWMILL EFFICIENCY. (R. C. Smith). A high percentage of the land in Southern Missouri is forested and the timber resource is being restored to a productive condition. Increasing supplies of wood have encouraged the expansion of wood using industries. They contribute substantially to the economy of the region. Jobs have been provided for more than 10,000 workers in logging and in processing plants in the Eastern Ozark region. Sawmilling is one of the more important industries in terms of total value in products and payrolls. Information on the efficiency of sawmill operation is of great value to this industry.

Four mills that differed in the investment in equipment and whose work consisted of sawing one inch lumber and dimension stock from oak logs were used in a time study to determine the number of minutes to saw 1,000 board feet of lumber. The data were adjusted to account for unproductive periods that were necessary in sawing lumber (such as tool care and rest periods.) The mean time to saw 1,000 board feet ranged from 60.94 minutes to 195.47 minutes. A regression analysis was made for each of the four mills to relate time required to saw 1,000 feet over log diameter and length. A similar analysis was made using lumber output per log as the independent variable. In both cases equation of the second degree, sloping to the right, resulted. An analysis of cost and net returns and relating them to sawing time remains to be completed.

Cooperation: Central States Forest Experiment Station, U. S. Forest Service (Project 450).

FENCE POSTS. (W. J. O'Neil). Millions of fence posts are used annually by Missouri farmers. The replacement costs of the fences on Missouri farms is much greater than the initial cost of installation. Untreated wood seldom lasts over three years. Treated posts will last from 10 to 30 years.

The posts at Weldon Springs were tested in 1961. Forty-six posts failed or disappeared during the year. A pull of 40 pounds as measured with a spring balance was made on each post. Insects that caused damage have been identified in most cases. The posts on the plot near the Stadium in Columbia were tested and no further posts had failed; 42 posts remained servicable. These posts were of the following species: black locust, catalpa, white oak, Chinkapin oak, black oak, slippery elm, eastern red cedar, and shortleaf pine. Most all of these have had treatment.

Cooperation: Departments of Agricultural Chemistry and Entomology (Project 345).

THE GROWING OF CHRISTMAS TREES. (R. B. Polk, D. J. Janes). Many Missouri landowners are planting comparatively small tracts of idle land to Christmas tree species. A ready market within the State awaits the local grower of Christmas trees. Fine quality trees command premium prices.

Controlled pollination techniques for the genus Pinus have been continued and a total of over 1,100 cones have been collected from previous pollinations. The effects of temperature, humidity, gas relations, and light have been studied. Outplantings have been made at various points in the State. These plantings have included several Rocky Mountain and Southwestern species. F₁ progeny of selected Pinus banksiana Lamb have been transplanted. A geographical race test of Pinus sylvestris L. including 93 origins has been established. These plantings were located on five experimental areas well distributed over Missouri.

Cooperation: Forestry Division, Missouri Conservation Commission (Project 9).

THE UTILIZATION OF NATIVE TIMBERS. (E. A. McGinnes, Jr., J. P. Pastoret). The forests of Missouri contain a large quantity of low grade wood and wood residues for which there is little market. In the hope of developing commercial uses for this quality of wood and in order to better understand the limitations in the use of wood, basic studies on the physical and chemical properties of wood are needed. Also,

there is a need to evaluate wood quality and silvicultural-treatment relationships for Missouri's tree species in order to form a basis for future management practices.

Thirty wood using industries within Missouri were contacted to obtain data on the following subjects: details of operations, amount and kinds of wood processed, raw material sources, market for finished products, description of kind and quality of wood waste. Techniques for measuring dimensional changes in oak wood samples as a result of controlled temperature-humidity variations have been developed. Data have been recorded on 100 trees of shortleaf pine in order to evaluate growth and quality. Records have been made for the following items: specific gravity, growth rate, percentage summerwood, extractables, holocellulose, lignin, fibril angle, and fiber dimensions. The work will be continued. (Project 159).

MARKETING TIMBER PRODUCTS. (R. C. Smith, T. H. Meredith, R. J. Reaver, R. J. Laacke). The timber products marketing situation is unsatisfactory for many land owners, producers of rough products and lumber dealers. An opportunity to sell some products does not exist, or often is very unstable. Wood using industries are concerned with problems of obtaining an adequate supply of raw material of suitable quality. Most of them recognized that improvements can be made in marketing efficiency and promoting good working relationships with producers of rough products.

In 1960, owners and managers of all wood using industries (except lumber) in a 14 county area were interviewed to determine industry characteristics, output, employment, sales, and marketing practices. Sawmill owners and producers of saw logs in the same region were interviewed and the data correlated. Mills that produced from 100,000 to 5 million board feet were included (88 mills). Sixty producers of saw logs who supplied these sawmills were interviewed. This study is a part of North Central Regional Project (NC-27) and the data from this study will be combined with that of the other North Central States.

Cooperation: States of the North Central Region (NCM-27); Columbia Forestry Research Center, Central States Forest Experiment Station (Project 406).

MARKETING CHRISTMAS TREES. (R. B. Polk, D. J. Janes). Christmas tree production is a young and growing industry in Missouri. Information is needed on consumer preferences in terms of species, varieties, sizes, grades, and color. Also, data is needed on the markets available and the best methods of transportation and retailing.

A total of 771 Christmas trees, almost all Scotch pine, were marketed in the greater St. Louis and Columbia areas. These sales showed: (1) a continued preference for Scotch pine in the general market and (2) the importance of quality. Data on species, tree grades, and prices were obtained in the St. Louis, Columbia, and Kansas City areas. Information was secured from local growers in each of these areas relative to marketing practices and problems. The problems usually related back to poor plantation cultural practices. This study will be continued in terms of local production. Records will be maintained on species, tree grades, and prices in the Missouri market. (Project 245).

ECONOMICS OF TIMBER PRODUCTION. (A. J. Nash, R. C. Smith). An important problem in American forest management concerns improvement of the poor forestry practices of small forest owners. Before forest owners can be expected to adopt sound forestry practices the economic limitations of forest production must be established. This involves a study of location, species composition, and markets.

In 1951, 150 growth plots were established in 21 counties in Missouri. Plots were remeasured in 1956 and the final measurement was made in 1961 on 111 plots. The other plots were eliminated because they had had timber cut from them, or because the original plots could not be accurately located. Trees were measured on 53 plots on land under government control and 58 plots on privately owned land. The average annual growth rate on government land was 70 board feet per acre and on privately owned land, 56 board feet per acre. Assessed value and taxes per acre data were collected on 756 tracts of forest land and 271 tracts of cleared farm land for four years: 1954, 1956, 1958, 1960. The mean assessed value for forest land was \$5.28 per acre and taxes were .186 dollars per acre. For farm land the mean assessed value was \$16.74 per acre and taxes were .614 dollars per acre. Complete taxation records for sample properties in 26 counties for the period 1944 - 1966 have been recorded. During this period, taxes on both classes of land increased substantially. Forest land was assessed at 100% of market value but other classes of property were assessed at substantially less. Analysis of the data collected will be completed and publications prepared. This project will then be closed. (Project 124).

THE EFFECT OF FOREST COVER ON SOIL AND WATER RESOURCES. (L. K. Paulsell, D. J. Janes, R. A. Musbach). Water is becoming increasingly important in Missouri. Periodically extreme flooding occurs along many streams. Also, drouth is a common occurrence. Good forest management may prolong moisture enough to insure maximum growth during a comparatively dry season. Any system of management

whereby peak stream flows can be reduced resulting in a more prolonged stabilized flow in dryer seasons would be most helpful.

Daily weather records have been maintained at Weldon Springs and at the University Forest. Monthly reports were furnished to the United States Weather Bureau. Observations on interception by a hardwood canopy have been continued, as well as observations on a shallow well on the University Forest. A small water shed gaging recorder has been operated throughout the year. Improvements have been made in the equipment and methodology for measuring water movement. The present installation appears to be extremely sensitive. It is planned to begin analysis of data collected; particularly the records of the effects of storms.

Publications: Semago, W. T., A. J. Nash. A manuscript has been prepared for publication as a Missouri Agricultural Experiment Station Research Bulletin.

Lull, H. W., P. W. Fletcher. Comparative Influence of Hardwood Trees, Litter, and a Bare Area on Soil Moisture Regimen. A manuscript has been prepared for publication as a Missouri Agricultural Experiment Station Research Bulletin.

Fletcher, P. W., H. W. Lull. Soil Moisture Depletion by a Hardwood Forest During Drouth Years. A manuscript has been prepared for submission to the Soil Science Society of American for publication.

(Project 158).

OAK WILT IN MISSOURI. (O. J. Dooling, T. W. Bretz). Missouri's forests occupy approximately 1/3 of the land area of the State. Oak species are dominant on more than 80% of this forested area and these forests support a large forest products industry. Oak wilt is a lethal fungus disease to which no species of oak is known to be immune. Also, this disease is known to occur in scattered locations in Missouri.

Inoculations made in 1957 and repeated in 1961 on the surviving individuals resulted in 80% mortality in *Q. rubra*, none in *Q. macrocarpa*, and *Q. alba*. The oak wilt fungus was found to be exceedingly variable in its cultural characteristics but it is uncertain whether heterocaryosis accounts for the variation. Under controlled laboratory conditions, the cultural characteristics of individual isolates remained relative stable through at least five generations of single spore origin. Oak wilt was found for the first time in Texas in 1961 some 200 miles Southwest of its previously known most southerly occurrence. Additional studies on variation among isolates of fungus; ability of fungus to grow and survive as saprophyte; and possible means of fungus dissemination and modes of infection will be continued.

Publications: Bretz, T. W. Oak Wilt: Present Status and Future Needs. Recent Advances in Botany, Lectures and Symposia, presented at the Ninth IX International Botanical Congress. University of Toronto Press.

Dooling, O. J. Oak Wilt Identified in Texas. U. S. Plant Disease Reporter, 45:749.

Cooperation: Forest Service, U. S. D. A.

(Project 52).

FOREST AND SHADE TREE DISEASES IN MISSOURI. (T. W. Bretz). This project is designed to identify the diseases of forest and shade trees in Missouri. It is based on the receipt of specimens sent for diagnosis and on limited surveys. During 1961, 366 diseased specimens were received for identification. Of these 64 were for Dutch Elm disease and 36% of which yielded the Dutch Elm disease fungus in culture. The presence of this disease was confirmed for the first time in 14 additional Missouri counties. It has become a state wide problem of serious proportions. Diseased specimens of 19 other tree species were received. The greatest number of specimens were of foliage diseases and anthracnose infections on hardwood species, and various needle case infections on the conifers.

Publications: Dooling, O. Cedar Rusts. The Green Leaf, Volume II, No. 3 Missouri Cooperative Extension Service, 1961.

Dooling, O. Verticillium Wilt. The Green Leaf, Volume II, No. 11. Missouri Cooperative Extension Service.

Berry, F. H., Dooling, O. J. *Fomes annosus* on Shortleaf Pine in Missouri. Manuscript prepared for publication.

(Project 401).

HOME ECONOMICS

Margaret Mangel, Chairman

IMPROVING THE QUALITY OF MEAT. (M. Mangel, R. Baldwin, H. D. Naumann, M. Bailey, V. J. Rhodes, C. Rodgers, D. Christy, B. Korschgen, P. F. Gould, J. Hendrix). Production of cattle and hogs is a major source of income for Missouri farmers. The improvement of a product has proved to be an effective tool to enlarge the market for this product. Improvement, to be effective, must be buyer oriented. This project has been designed to study methods of improving the final acceptability of beef and pork.

A study has been made of the effectiveness of dry heat cooking methods (broil versus oven at 500°F) for round steak. Cooking losses were much greater and tenderness and flavor and juiciness were less desirable with the broiling method. The effect of heredity upon consumer acceptance of pork loins from six sire groups has been tested by a consumer panel of 210 families. Results are being summarized. The retail yield of beef has become of major importance to retailers. Trim retail yields were obtained on 56 cattle in a super market of a major chain. Yields of salable meat ranged from 61.3% of carcass to 74.4% with a mean of 69.0%. Yields of porter house steak ranged from 5.4% to 8.1%. Cooperation of four major packers, six commission firms, a stockyard company, and several cattle feeders has been secured for a study of the effects of heredity and feeding upon consumer acceptance and retail yield. It is hoped that as many as 40 lots of cattle can be used in this study if the cooperation of retailers can be secured. It is highly important that information be secured as to how retail yield may be recognized on the hoof and that pricing practices be improved at wholesale and live levels. The effects of heredity and feeding upon retail yields and eating acceptance of both pork and beef will be continued. This is an Agricultural Marketing Act Project.

Publications: Rogers, C., M. Mangel. Meat Preparation Practices. Manuscript in preparation.

Rhodes, V. J. Acceptance and Yield of Choice and Good Beef: Research results and implications. Journal of Farm Economics, May 1961.

Cooperation: Departments of Animal Husbandry and Agricultural Economics, American Meat Institute, U. S. D. A., A. M. S. (Projects 348, 349, 350).

USE OF MEATS IN THE RESTAURANT INDUSTRY. (H. D. Naumann, H. Hedrick, M. Mangel, C. Pudelkewicz, R. Baldwin, C. Rodgers, J. Clifford, B. Christy, B. Korschgen, V. J. Rhodes, H. Leach, H. C. Little, J. W. McKinsey, G. Nance, J. West, C. Braschler, D. Alexander). A detailed report will be found in the Agricultural Economics section. (Projects 385, 386, 387).

THE RELATION BETWEEN PROCESSING AND PREPARATION FACTORS AND THE UTILIZATION OF FOOD. (G. M. Amick, B. M. Christy, B. A. Bisbey, R. E. Baldwin, D. D. Merrill, M. W. Mangel, C. Rodgers). Both low heat and high heat dry milk solids are produced in Missouri. Both of these products are issued on surplus commodities to school lunch and welfare programs. Much interest continues on the freezing of pastries. Present methods for freezing cream and fruit pastries are not completely satisfactory.

Dry Milk Study. Seven brands of dry milk have been reconstituted and evaluated. No outstanding flavor differences were noted. There was a marked difference in ease of reconstitution between the powdered and the granular forms; the powdered being the more difficult to handle. The use of dried milk solids in present formulas and procedures has been studied using both types of dry milk solids. The dry milk issued on school lunch commodities and to welfare clients is the low heat spray dried type. Most of the dry milk available in markets is of the "instant" type. The solubility differs between these two types.

Frozen Pastries Study. Laboratory studies have been completed in which formulas and procedures for preparation of frozen cream pies and fruit pies were developed and evaluated. Variations of the cream pie formula were developed for chocolate, lemon flavored, and raisin fillings. Extensive taste studies have been conducted. The products have been tested immediately after preparation and after storage periods of one day, one week, one month, and two months. The underneath portion of a standard meringue remained uncooked when baked on a frozen pie at a high temperature. Therefore, longer baking at a medium temperature was required. Various vegetable gums have been incorporated in the standard meringues in an effort to improve characteristics of meringues baked on frozen pies. However, the palatability of such products was lessened. Best results were obtained when a small amount of hot (165°F) cooked corn starch paste (4 gms. corn starch to 53 gms. of water) was beaten into the finished meringue before placing it on a frozen

pie which had been held two minutes under the broiler. Special equipment was constructed to facilitate the testing of temperatures in the meringues and at the interface. Mean temperatures obtained in the meringue and at the interface of the meringue and pie filling were found to be respectively 127°F and 85°F. With the frequent occurrence of food poisoning attributed to uncooked egg white it is essential to develop procedures for handling meringues which are safe. Various crumb and frozen fruit toppings also were tested. These were found to be highly acceptable by the judging panel. These toppings included: (1) fruit sauces, and (2) mixtures to be toasted by exposure to the broiler for a short time after spreading them over the surface of frozen cream fillings. Studies were continued on the qualities of frozen apple pies. Of special concern in this series of tests were the changes occurring in the flavor of the spices in the pies. (Project 463).

PROTEIN REQUIREMENTS OF HUMAN SUBJECTS. (C. Pudelkewicz, H. Gordon, J. Clifford). One of the most serious nutritional problems which confronts man today is protein malnutrition. This problem is especially serious among peoples who rely primarily on grains for their food supply. In practice, cereal proteins are supplemented with other proteins of either plant or animal origin. However, concern is with the total mixture of proteins as consumed rather than with individual proteins in this diet. Therefore, information is needed on the best possible combinations and most effective means of utilizing the various proteins in feeding the human race.

Replacement values of white bread and of lysine-supplemented bread for one or two eggs when compared with the same basal diet plus three eggs per day were determined by nitrogen balance. Total protein intake was 47 to 50 grams per day. Little or no difference was observed between the two bread periods when they replaced egg protein. All six subjects excreted slightly less nitrogen when supplemented bread was fed. There appeared to be a decrease in packed redblood cell volume for all six subjects and a lower concentration of hemoglobin for three of the subjects after 45 days on the experiment. Replacement values of 5% toasted soy protein bread or 6% nonfat dry milk bread for two eggs when compared with the same basal diet plus three eggs per day is being evaluated by nitrogen balance. Seven day dietaries of food intake and food habit questionnaires are being collected from 100 senior citizens in Columbia. A number of persons on high and on low intakes of protein will be studied further to determine the accuracy of a four-hour urinary nitrogen excretion as a means of predicting nitrogen intake. The supplementation of a low protein diet with white bread containing fish flower will be studied.

Publications: Pudelkewicz, C. Human Metabolic Studies with Lysine-Supplemented Bread. A manuscript prepared for publication in the Journal of Nutrition.

Cooperation: States of the North Central Region (NC-49); University of Missouri Student Health Center; Station Chemical Laboratory (Project 318).

ADOLESCENT GIRLS CLOTHING. (A. E. Ginter, M. L. Rosencranz, K. Alexander, D. Sawyers, D. Swall, F. Rourke). Clothing requirements change as a girl reaches adolescence. At this age larger sizes, higher stylings, and a wider variety of needs increase clothing costs for the family. Selection problems become more acute because of the varied fabric choices and more importance given to style. The states of the North Central Region considered it worthwhile to know what satisfactions were important to the consumer.

In studies of the effects of repeated laundering and dry cleaning on skirting fabrics of wool, and wool blends of 75% wool with 25% polyester, 60% acrylic with 40% wool, and 85% wool with 15% nylon, higher tearing strengths were frequently found for the laundered rather than the dry cleaned fabrics. Repeated laundering and dry cleanings of rayons and blends of rayon flannels indicated that suiting fabrics of rayon and blends of rayon and acetate did not give a full measure of satisfaction when the method of cleaning employed was laundering. Greater satisfaction was indicated for blends of rayon with acrylic fibers. Such blends using 50% or more of acrylic showed few changes in appearance after repeated launderings. Tearing strengths were higher for dry cleaning than laundered fabrics. A questionnaire was given to 9th grade girls in four different cities in Missouri concerning their clothing practices in relation to winter school skirts. The number of winter school skirts owned by the girls ranged from 2 to 40. The mean number was 8.9. The fibers in order of preference were: (1) wool, (2) wool blend with synthetics, and (3) cotton. The prices paid for the last school skirts purchased ranged from one to thirty dollars. The mean price was \$7.53. The skirts were purchased in chain stores, clothing specialty shops, and large department stores in the order named. The occupation of the father appeared to have more influence on clothing practices than did any other background characteristic. The employment status of the mother was found to be significantly related to stores patronized and the care of skirts by washing and ironing.

Publications: Rosencranz, M. L. Criteria Related to the Selection and Use of Winter Skirts for Ninth Grade Girls. Manuscript has been prepared for publication.

Alexander, K. The Effects of Repeated Laundering and Dry Cleaning on Skirting Fabrics of Wool and Wool Blends. A thesis submitted in partial fulfillment of the requirements for the degree Master of Science, Graduate School, University of Missouri, 1961.

Sawyers, D. The Effects of Repeated Launderings and Dry Cleanings on Rayon and Blends of Rayon Flannels. A thesis submitted in partial fulfillment of the requirements for the degree Master of Science, Graduate School, University of Missouri, 1961.

Rourke, F. The Study of Winter School Skirts from Missouri Ninth Grade Girls. A thesis submitted in partial fulfillment for the degree Master of Science, Graduate School, University of Missouri, 1961.

Cooperation: States of the North Central Region (NC-24) (Project 162).

THE USE OF COTTONS OF SELECTED FIBER PROPERTIES. (A. E. Ginter, M. L. Rosencranz, L. Costigan). The cotton crop is of major economic importance to Missouri and improvement in the quality of the cotton produced in this State should be reflected in greater economic return to producers. This project is a part of a Southern regional project designed to develop a more scientific means for the selection of fiber in relation to end use performance. Bales of cotton selected for various lengths and strengths were spun and woven according to specifications established by the Southern Regional Technical Committee. These fabrics were made into sheets and distributed to several state experimental stations for testing. The sheets assigned to the Missouri station have been worn and laundered 60 times. Some, withdrawn after 45 periods of wear and laundering, have been sampled, measured for changes in dimensions, count, weight, and tearing strength.

Cooperation: States of the Southern Region (SM-18) (Project 319).

THE STABILITY OF ANTHOCYANIN PIGMENTS IN FRUITS. (M. Mangel, M. Glidden). Highly colored fruit products undergo deterioration in color during processing and storage. This color deterioration is minor in frozen products but of major importance in jams, jellies, and canned products. There is a lack of understanding of the discoloration products.

The infra-red visible and ultra-violet spectrum of the juices and pigment systems which have been treated with various additives and stored for specified periods of time have been graphed. The Munsell color notations for the juice and pigment systems have been calculated for each solution for each storage period. These changes are being compared with the changes which occur in the visible spectrum.

Cooperation: Spectrographic Laboratory (Project 352).

ELECTRONIC COOKING. (B. M. Christy, M. F. Crawley, I. Delaney, R. E. Baldwin, M. W. Mangel, C. Rogers, D. Korschgen). Although the electronic range has been available for several years it has not been widely accepted. This has been due partly to price and partly to problems of adapting receipts to institutional and home use. The latter problem appears to be the more important.

The program this year has been concerned with: (1) testing the performance of an electronic range; (2) developing methods for studying the behavior of protein test systems subjected to micro-waves. Literature of the electronic cookery of foods has been reviewed in order to focus on areas of needed investigation.

(Project 464).

FAMILY FINANCIAL SECURITY. (F. Miller, P. Benson, H. Bohling). Farm families need to understand how an intelligent use of credit can increase farming efficiency, raise levels of living, and contribute to family financial security. Little is known about the factors which influence farm families in their decisions to use mortgage credit for purchase of their farms, production credit for farm operations, and consumption credit for family living. Such information would be most helpful to rural families and credit agencies who serve these families.

The field schedules for Missouri have been taken, edited, and coded for entry on IBM cards. An outline has been prepared for determining the provisions that families make to achieve financial security. Separate determinations have been planned for occupation, income, age, education, and family composition groups. The financial resources as well as the institutional provisions (such as health, accident, unemployment, life insurance and social security coverage) of each of these family groups are being examined to determine how long they can maintain normal or essential expenditures in case of emergencies. The extent of desire to use credit also is being examined. During the coming year the analysis of this data will be completed.

Cooperation: Department of Agricultural Economics; States of the North Central Region (NC-32)

(Project 311).

THE EFFECTIVENESS OF MASS MEDIA IN HOME ECONOMICS. M. L. Rosencranz, O. Gregory). There is an increased demand for Home Economics information from a wider and more diverse audience. This has

made it necessary to develop relatively inexpensive effective methods of making information available to large numbers of homemakers. This has increased emphasis upon mass media. A plan has been designed for Audrain County Missouri. This plan includes both rural and urban homemakers. A systematic series of programs and news releases have been designed and simultaneously questionnaires have been prepared to measure the exposure and response to the home information series.

Cooperation: Department of Rural Sociology

(Project 430).

HORTICULTURE

R. A. Schroeder, Chairman

IRRIGATION FOR HORTICULTURAL CROPS. (A. D. Hibbard). More than half of the fruit producing acreage in Missouri is under supplemental irrigation. The use of water has become essential for the profitable production for many specialized crops. Most of the present systems of irrigation were installed in recent years. Many were purchased after crop failures or near crop failures during the drouth years of the 1950's. At that time irrigation was looked upon as drouth insurance to be used only during an emergency.

It now has been shown that a bearing orchard in Missouri will utilize up to 45 inches of water during the growing season. This is above the average amount of rainfall for the entire year.

The season in 1961 was characterized by frequent and heavy precipitation. Irrigation was not required to any substantial extent. The moisture utilization pattern was studied in both peach and apple orchards. The pattern of moisture extraction was followed to a depth of 9 feet and across the interval between trees. The roots at the end of the 7th year extended beyond the 9 foot depth and reached to the center of the tree row or 17.5 feet. The rate of moisture utilization was most rapid for the upper soil layers. The first crop was harvested from 7 year trees which had been under differential irrigation treatment during the early life of the orchard. Irrigated trees averaged 5.3 boxes of fruit while non-irrigated averaged 3.6 boxes. Peach seedlings were grown in pot cultures from transplanting in March until August under uniform moisture conditions. One-third of the young trees were subjected to moisture stress (minimum 15% of field capacity) until normal leaf fall November 26. Another lot was subjected to the same stress from May 2 to June 2 the following growing season. The control lot was held at a minimum moisture content of 70% of field capacity. The spring drouth was more detrimental to plant growth than the fall drouth. (Project 1).

THE NUTRITION OF FRUIT CROPS. (A. D. Hibbard, D. D. Hemphill, H. G. Swartwout). The yields and quality of fruit produced in some areas of the State are low. Symptoms of nutrient deficiency have become evident. Satisfactory information for recommendation of nutrients other than nitrogen is not available. The usual recommendations based on chemical soil tests which apply well to many field and annual vegetable crops apparently are not applicable to perennial fruit crops. Efforts are being directed toward establishing more effective means of determining these nutrient needs.

Leaf analysis of apple orchards indicated that for a season with excessive rainfall all orchards were apparently well supplied with phosphorus. About one-fourth of the older orchards have potassium levels below optimum. Most of the young orchards with trees of bearing size but under 12 years of age showed excessive nitrogen fertilization. Phosphorus fertilization of new set on apple trees gave increased growth and root development. This effect was accentuated by mulching and by irrigation. Post harvest sprays of nitrogen and potassium gave increased leaf contents of these elements in samples taken in June of the following year. (Project 4).

GROWTH AND REPRODUCTION IN HORTICULTURAL PLANTS. (D. D. Hemphill). There is considerable variation in the effects of chilling as noted by different workers using the same variety of plant. There is some evidence of correlation between geographical locations and the amount of cold required to break rest (dormancy). Induction of flowering is determined by photoperiod and temperature and the regional adaptation of plants is of primary importance.

Studies with Tomatoes. The yield of marketable tomatoes was increased by cluster sprays of p-chlorophenoxyacetic acid, 2,4-Dichlorophenylacetyl-d, l-methionine, and N-meta tolylphthalamic acid. Cluster sprays of gibberellic acid and foliage sprays of N-meta tolylphthalamic acid resulted in large numbers of small (less than 3 oz) unmarketable fruit. N-dimethyl amino succinamic acid decreased internode length of tomatoes, beans, and strawberries when applied as a foliar spray and when incorporated in the

potting soil. Fruit yields of treated plants were reduced.

Studies with Strawberries. Dixieland and Surecrop varieties of strawberries grown in climatic chambers under conditions of 16 hours light and 8 hours dark at 70°F during light periods and 55°F during dark periods produced one major flush of flowers and fruit and very little thereafter. Only one plant of 20 produced runners. Plants grown in 8 hours light and 16 hours dark at 70°F continuously produced four major flushes of flowers and fruits. The petioles were normal appearing throughout the experiment.

Cooperation: Departments of Botany, and Biochemistry

(Project 129).

THE CONTROL OF PRE-HARVEST DROPPING OF FRUITS BY PLANT GROWTH REGULATORS. (D. D. Hemphill). In order to produce quality apples and peaches, it is necessary to thin most varieties. Without this thinning the fruit fails to develop the most desirable size, color, and some varieties of apples tend to bear biennially. Hand thinning of fruits is expensive. Chemical methods of thinning are used. More effective chemicals in preventing pre-harvesting dropping of apples without reducing storage are needed.

The Jonathan variety of apples is readily thinned by naphthylacetamide; and the use of surfactants offers no advantage. The Golden Delicious variety is difficult to thin by use of this chemical even with the addition of the surfactant Tween 20. Most satisfactory thinning was obtained by the use of naphthylacetamide at petal fall followed by an application of naphthaleneacetic acid seven to ten days later. N-1 naphthylphthalamic acid (NPA) at concentration of 100 to 300 ppm applied four to six days after full bloom gave satisfactory thinning of most varieties of peaches. Sevin was used at rates of 1 to 3 pounds 50W with and without Tween 20 (one pint per 100 gallons) on Jonathan, Delicious, Golden Delicious, Redgold, and Lady apple varieties and applications were made at 5, 12, 19, and 26 days after full bloom. These varieties were most susceptible to thinning at 12 to 19 days after full bloom, but fruit set was still affected 26 days after bloom. Jonathan and Delicious were thinned satisfactorily with the two pound rate whereas Golden Delicious was not thinned adequately even with three pounds plus Tween 20. Trials will be continued with Sevin and other growth regulator combinations.

Publications: Hemphill, D. D. Suggestions for Thinning Apples and Peaches. Missouri Horticultural News, 1961.

Hemphill, D. D. Stop-Drop Sprays for Apples. Missouri Horticultural News, 1961.

(Project 195).

NEW VEGETABLE VARIETIES. (V. N. Lambeth, A. D. Hibbard). The improvement of vegetable varieties through breeding, selection, and testing for adaptability to this area must be continuous to meet the constantly changing demands of production and marketing. Local variations of climate, soils, diseases, insect problems, and cultural practices present problems which are often best solved by improved varieties.

The cooperative testing and evaluation studies of irish potatoes, sweet potatoes, tomatoes, and watermelons have been completed as planned. Of the 19 entries in the North Central potato trials the five highest ratings were Norland, Wisconsin Ag. 233, Louisiana 42-45, Nebraska 27.55-2, and North Dakota 3815-IR. Centennial rated highest of 17 sweet potato varieties and lines and only L-8-92 was recommended to promotion to the Advanced Trials test. New hybrid combinations of both red and pink fruited forcing type tomatoes compared favorably with the best commercial stock. In early market tomatoes, selection was continued for resistance to radial cracking and several new hybrids showed promise, notably 21-St-11 and 21-St-14. Kl35 was rated best of the processing tomatoes and STEP 341 for the second consecutive year proved best of the STEP lines. Most productive watermelons were Blackstone, Seedless X317 with 11 tons +/A L5, W5 + 59-7 were most promising new lines. PI 271132 was used as parent to introduce downy mildew resistance. Breeding for disease resistance in bush-ice box type melons was continued.

Publications: Missouri results were included in the following publications:

Steinbauer, C. E. U. S. D. A., ARS. Replicated and Observational Sweet Potato Trial Summary.

Lana, E. P. Summary North Central Irish Potato Trials 1961. American Potato Journal, 1961.

Nettles, Victor. Summary of 1961 Watermelon Trials.

Twenty years of cooperative sweet potato research 1939 to 1959. National Sweet Potato Collaborator's Report. Now in press as a Southern Regional Bulletin.

Cooperation: Southern Tomato Evaluation Program (STEP); Southern Regional Cooperators-Watermelons;

Sweet Potato Collaborator's Group; Cooperators North Central Irish Potato Trials (Project 128).

NEW PLANTS FOR FRUIT AND NUT PRODUCTION. (A. D. Hibbard). Fruit and nut crops may be very profitable enterprises on Missouri farms. The production of these crops is exacting and requires highly technical information and a substantial investment.

An inventory of the fruit and nut varieties at the Missouri Station has been prepared for the Agricultural Research Service, U. S. D. A. new crops section. Data were secured on the orchard performance of 47 peach varieties and on the relative resistance of these peach varieties to bacterial leaf spot. First

crop year yield records were secured for apples worked on Clark dwarfing and Hiberna framework stocks. Clark dwarf induced earlier fruiting while fruiting was delayed by frameworking on Hiberna. The U. S. D. A. peach varieties, Ranger and Keystone, were outstanding in disease resistance and quality of fruit produced this season. This work will be continued.

Publications: Hibbard, A. D. Peach Varieties for Missouri, 1962. A mimeographed leaflet distributed by the Department of Horticulture. (Project 468).

SMALL FRUIT PROBLEMS. (D. D. Hemphill). The small fruit industry is in an unfavorable economic position due to its requirement for hand labor. Efficiency in production must be improved. More desirable varieties of strawberries are needed. These varieties must have high resistance to foliage diseases and Red Stele. Many new varieties of strawberries are being introduced each year by the United States Department of Agriculture and by various state experiment stations. Some of these varieties may well be adapted to Missouri conditions. These varieties must be tested. New virus free varieties and strains of blackberries and raspberries are needed. Sterility is a major problem in blackberry production. Previous work at this station has indicated that this condition is produced by a graft transmissible entity. Further studies are needed.

Strawberries. First year yield data have been collected on 27 varieties and selections, and second year yield data were collected on 40 varieties and advanced selections. Pocahontas, Sparkle, Midland, Armore, and Sure Crop were the best performing varieties. Missouri selections No. 20 and 8 continue to show promise. Approximately 2,000 seedlings have been evaluated. Fourteen selections were made from these seedlings and approximately 7,000 seedlings were set this year for evaluation during the coming year.

Raspberries. A new raspberry planting included red, purple, and black varieties. The recently introduced varieties were included. Virus free strains of several raspberry varieties were obtained for comparison with commercial strains.

Blackberries. Studies have been continued with the sterility problem of blackberries (and raspberries). Numerous experiments have shown the sterility condition to be graft transmissible within blackberry varieties, and limited results have indicated that it is transmissible between blackberries and raspberries. Heat treatments have not been effective in inactivating the sterility producing entity. Work in this area will be continued.

Publications: Hemphill, D. D. Success with Strawberries. Missouri Agricultural Experiment Station Bulletin (in press).

Hemphill, D. D. The Sterility Problem in Rubus. The Green Leaf. Missouri Cooperative Extensive Service, 1962. (Project 291).

STUDIES WITH VEGETABLE ROOTS. (V. N. Lambeth, R. C. Das). The significance of root properties in the nutrition of plants has not been fully investigated. Studies on specific root properties of each vegetable when combined with soil data will serve as a basis for improved fertilizer practices.

Growth stimulating and growth retarding chemicals were tested on two varieties of plants. They affected the cation exchange capacity (C. E. C.) and growth of roots. Gibberellic acid (G. A.) significantly increased the C. E. C. of sweet corn roots but significantly reduced the root growth on a dry weight basis. On the other hand, Phosfon significantly reduced both the C. E. C. and growth of sweet corn roots when used at 100 ppm. At 5 ppm it did not significantly affect either C. E. C. or dry weight. The lowering of C. E. C. by Phosfon at 100 ppm could be partially overcome by adding G. A. in the same solution at a final concentration of 100 ppm. However, the C. E. C. remained significantly lower than the control. Indolacetic acid in Hoagland's solution at 10 ppm concentration affected neither C. E. C. nor root growth. However, at 50 ppm it significantly reduced the C. E. C. Studies with these chemicals on bean roots were more erratic due to complicating root rots. Studies in this area will be continued.

Publications: Biswas, P. K., V. N. Lambeth. Studies in the Cation Exchange Capacity of Vegetable Roots. Indian Journal of Horticultural Science, (in press).

Cooperation: Station Spectrographic Laboratory; Station Chemical Laboratory (Project 196).

GREENHOUSE FLOWER CROPS. (M. N. Rogers, R. R. Rothenberger, R. J. Shaw, J. E. Smith, C. G. Costley, P. K. Biswas). The commercial floricultural industry in Missouri produces plants and flowers each year having a wholesale value of several million dollars. Methods of producing more and better flowers with longer lasting qualities would be of great help.

This year more efficient methods were developed for propagating and producing geraniums. Several of the principal factors affecting uptake of gibberellic acid by plants were determined. Additional information was secured about the application methods, timing, and concentrations used to replace the cold requirement for hydrangeas and to cause enlarged flowers on geraniums. Studies have been continued with the

use of chemical growth retardants for commercial application to poinsettias and potted chrysanthemums. Time of panning poinsettias after treatment with the chemical did not have any appreciable effect on results. Six factors which might affect carnation stem strength were studied. Varietal selection seemed to be the most important. A chemical antitranspirant added to the water was found to increase vase life of snapdragons by several days under the best conditions. Studies will be continued with carnation stem strength and the use of growth retardants. Also, enrichment of carbon dioxide in the green house atmosphere will be studied.

- Publications: Rogers, M. N. Geranium Culture in the 1960's. Flor. Rev. 128 (3305): 17-18, 59-62, 1961.
Rogers, M. N. Increasing Geranium Yield. Flor. Rev. 128 (3325): 21-22, 79-82, 1961.
Rogers, M. N. Factors Affecting Carnation Stem Strength. Missouri State Florists News 22(4): 7-11, 1961.
Biswas, P. K. M. N. Rogers. The Effects of Different Light Intensities Applied During the Night on Growth and Development of *Mathiola incana*. Fifty-eighth Annual Meeting ASHS, p. 32, 1961.
Biswas, P. K., M. N. Rogers. Passage of Gibberellic Acid Through the Separated Cuticles of Two Varieties of Column Stock, *Mathiola incana*. Fifty-eighth Annual Meeting ASHS, p. 77, 1961.
Rothenberger, R. R., M. N. Rogers. Effects of (2-chloroethyl) Trimethylammonium Chloride on Poinsettias. Fifty-eighth Annual Meeting, ASHS, p. 78, 1961.
Rothenberger, R. R., M. N. Rogers. Effect of Several Methods of Application of 2,4-dichlorobenzyltributyl Phosphonium Chloride on Different Varieties of Chrysanthemums. Fifty-eighth Annual Meeting ASHS, p. 78, 1961. (Project 466).

CONTROL OF WEEDS IN HORTICULTURAL CROPS. (D. D. Hemphill, R. V. Nevins). Weed control in many horticultural crops if done by hand may cost up to \$150 per acre. Many of these weeds can be controlled better and at much lower costs by use of chemicals.

In an experiment started in 1956, Diuron and Simazine have continued to give satisfactory weed control without evidence of serious injury or reduction in quality or yield of fruit when compared to mechanically hoed plots. In establishing strawberry plantings diphenamid was the most effective of several herbicides used in early April for the control of perennial grasses, annual grasses, and broad leaf weeds. Dacthal compared favorably with Sesone, Falone, and grandular 2,4-D in new plantings. Granular and/or liquid formulations of several herbicides were evaluated on snap beans, sweet corn, cantaloupes, okra, sweet potatoes, and tomatoes. The most promising chemicals were Eptan, CDAA, and Casaron for snap beans; NPA and ethyl di-n-butylthiolcarbanate for cantaloupes; CDEC for okra; Atrazine, Simazine, 3(3,4-dichlorophenyl)-1-methoxy-1-methylurea for sweet corn; Amiben for sweet potatoes; and Amiben for tomatoes. Dacthal and Zytron were the most satisfactory of ten chemicals evaluated for pre-emergence control of crab grass. DMA and related arsenates and mixtures of other chemicals with DMA gave most satisfactory post-emergence control of crab grass. No chemical gave satisfactory selective control of Nimblewill. Dacthal, Simazine, and Sesone plus CIPC gave satisfactory weed control in six species of ground covers.

- Publications: Hemphill, D. D. How Weed Killers Act. Proc. Second Annual Lawn and Turf Conference, University of Missouri, 1961.
Hemphill, D. D. Weed Control in Nurseries and Christmas Tree Plantings. Proc. Second Annual Agricultural Chemicals Short Course, U. of Mo., 1962.
Hemphill, D. D. The Use of Herbicides Around the Home. Proc. Second Annual Agricultural Chemicals Short Course, U. of Mo., 1962.
Hemphill, D. D. Lawn and Turf Weed Control. Folder 95, Missouri Agricultural Experiment Station, 1961.
Hemphill, D. D. Suggested Weed Control Chemicals for Truck Crops. Vegetables News, U. of Mo, 1961.
Hemphill, D. D. Pre-emergence Control of Crab Grass. Research Report, North Central Weed Control Conference 18:85, 1961.
Hemphill, D. D. Performance of Pre-emergence Herbicides in Green Beans. Research Report, North Central Weed Control Conference 18:85, 1961.
Hemphill, D. D. Weed Control and Horticultural Crops. Research Report, North Central Weed Control Conference 18:119-120, 1961.

Cooperation: Departments of Field Crops, Forestry, Agricultural Engineering ARS, U. S. D. A.; Amchem Products Inc.; Diamond Alkali Co.; Ansul Chemical Co. (Project 146).

THE HORTICULTURAL FARM. (R. A. Schroeder). This project is to provide for the continued development and maintenance of the Horticultural Research Farm located near New Franklin, Missouri. In addition to the usual maintenance of the several research projects in operation, the gravel and dirt roads have been improved; additional boundary fencing has been completed; and some creek banks have been cleared.

(Project 116).

PROMOTION OF HORTICULTURE. (R. A. Schroeder). For many years Missouri has had a great interest in horticulture. It has been making substantial efforts: to enlarge and better existing horticultural enterprises; to develop new horticultural enterprises; to improve grower and processor organizations; to disseminate current horticultural information; to further cooperation within the industry; and to see that Missouri is represented at major horticultural meetings.

A substantial effort has been made to improve apple merchandizing. This has consisted of informing commercial apple buyers of the location and availability of Missouri apples. From time to time members of the staff of the Department of Horticulture have attended State and National Horticultural meetings to present the findings of their research programs and to learn first hand of progress being made in other areas.

Publications: During the year, the following publications have been written and distributed: Horticultural News, Floricultural News, Vegetable News, Weekly Spray Letters, and The Green Leaf. These publications have provided a rapid means of keeping growers informed as to current production and marketing problems.

Cooperation: Stark Bros. Nursery

(Project 169).

SYSTEMIC ANTIMICROBIAL AGENTS FOR CONTROLLING HORTICULTURAL CROP DISEASES. (R. N. Goodman, H. S. Goldberg, W. H. Schaffer, S. K. Addy, S. Lewis, C. H. Baldwin). It has been difficult, with few exceptions (these being the antibiotics), to eradicate established infections in plants. It also has been difficult to affect an internal protection of the plant against disease (confer immunity). Systemic compounds offer a way to both eradicate, and confer an internal immunity against infections.

The passage of C^{14} labeled compounds through excised apple leaf cuticles has demonstrated that this membrane is relatively impermeable. Hence, the permeability of intact apple leaves to these substances suggested foliar absorption to be an active process. Homologous smooth and rough forms of Erwinia amylovora revealed the smooth virulent form to remain streptomycin susceptible, whereas the rough avirulent type was quickly made resistant to 1,000 ppm. of the drug after 3-4 serial transfers. The morphological effect of 20 ppm of the toxin colletotol was a rapid (2 hours) disintegration of spongy parenchyma. Erwinia amylovora phage were isolated and increased in titer to 10^{10} . These have been successfully used to type Erwinia amylovora isolates.

Publications: Goodman, R. N. Recent Advances in the Control of Bacterial Phytopathogens. In press, Madras Agricultural Journal (Golden Jubilee Issue). An invitational manuscript which reviews the scientific advances of the past 50 years in bacterial phytopathology.

Goodman, R. N., S. K. Addy. Penetration of Excise Apple Cuticles by Radioactive Organic and Inorganic Compounds. Phytopathology (in press).

Lewis, S., R. N. Goodman. Morphological Effects of the Toxin Colletotol on Tomato and Digitalis Foliage. Phytopathology (in press).

Schaffer, W. H., Jr., R. N. Goodman. Progression In Vivo, Rate of Growth In Vitro, and Resistance to Streptomycin as Indices of Virulence of Erwinia Amylovora (fireblight). Phytopathology (in press).

Goldberg, H. S., R. N. Goodman, J. T. Logue, S. P. Handler. Long Term, Low Level Antibiotics and the Emergence of Antibiotic Resistant Bacteria in Human Volunteers. Proc. Conf. Antimicrobial Agents (in press).

Cooperation: Department of Entomology; Department of Microbiology, School of Medicine (Project 27).

CHEMICAL INHIBITION OF PLANT VIRUS DISEASES. (D. F. Milikan, D. Zawadzka, R. P. Honeycutt, W. G. Godbey). Missouri annually produces millions of cherry, peach, plum, and apricot nursery trees for sale to growers throughout the Nation. Presently, eradication is the only means of controlling virus infections, and many promising varieties possessing superior horticultural merit have had to be discarded. There is need for new approaches to virus therapy so that elimination of valuable varieties because of virus infection will not be necessary.

Emphasis has been placed on development of methods for extracting and identifying the nucleic acid constituents of plant tissues. A colorimetric method for identifying the DNA constituents of leaf tissues has been developed. This involves several extractions which increase the chances for error; and therefore, this test was compared with two other tests. Data indicated that the new test was about five times as sensitive as diphenylamine but that the latter test could be used provided that at least twelve micrograms of DNA were present in each milliliter of test solution. In RNA experiments, an attempt has been made to perfect two wave length methods which will simplify analyses. Comparisons are being made between this method and one involving phenyl extraction as well as column purification. Since the methodology involved have been fairly well developed, it is planned to close this phase of the work.

Publications: Zawadzka, B., W. G. Godbey, D. F. Millikan. Comparison of Three Colorimetric Methods for Determining DNA in Prunus and Malus Leaf Tissues. *Phytopathology* 52:34. 1962.

Zawadzka, B., D. F. Millikan, W. G. Godbey. Estimation of RNA in Healthy and Virus Infected Leaf Tissue. *Phytopathology* 52-34, 1962.

Zawadzka, B., D. F. Millikan, W. G. Godbey. Preliminary Investigations on the DNA Content of Leaf Tissue of Several Prunus Species. In press, Polish Academy of Sciences.

Cooperation: Station Chemical Laboratories; Herman Frasch Foundation. (Project 285).

STONE AND POME FRUIT VIRUS DISEASES. (D. F. Millikan, C. M. Wright, G. M. Hall). Stone fruits have been found to be infected with over 40 different virus diseases. Few of these diseases cause death but most cause serious reduction in productivity. The widespread occurrence of virus diseases has caused many states to invoke rigid quarantines on interregional shipping. Missouri has large nursery interests and sizable commercial production areas that would be greatly benefited by control of these diseases.

During the past year several interesting things have been observed. Complications arising from flowering cherry indexing resulted in isolating bacteria from cankers typical of those incited by virus infections. This suggested that flowering cherry readings must take into account the possibility of bacteria whenever this host is used. A new previously unreported virus infection has been found in one of our cherry varieties. This clone is to be heat treated in an effort to eliminate this infection. Another study gave proof that two varieties differed only in their virus content. Forty years ago there was considerable controversy as to whether Black Twig and Paragon were the same varieties. Since Paragon was compatible with Virginia Crab it was considered different. Inoculation studies have shown that Paragon is free from the Stem Pitting Virus while Black Twig is infected.

Publications: Millikan, D. F. Virus Diseases of Orchard Trees. A paper presented at the annual meeting of the Illinois State Nurserymen's Association, Chicago, Illinois, 1961.

Millikan, D. F., H. W. Gengerich. Field Observations and Transmission Studies of the Stem Pitting and Scar-Skin Disorders in Apple. Paper presented at a conference on apple tree disorders of multiple stock plants, Monticello, Illinois, 1961.

Cooperation: Missouri State Department of Agriculture; Stark Brothers Nursery (Project 68).

HORTICULTURAL PATHOGENS. (D. F. Millikan, M. N. Rogers). Diseases incited by bacteria, viruses, fungi, and nematodes continually harass horticultural crops. The causative organisms must be identified and control measures developed.

A flower rot disease causing as much as 50% loss of flowers in one of the larger commercial carnation growing establishments in the State has been found and studied. Isolations have resulted in what appears to be a previously unreported pathogen. Samples of the diseased plant material have been submitted to three other plant pathologists, one of whom had apparently found similar infections. The other two isolated Fusarium tricinctum a previously reported flower rotting organism from the diseased flowers. Approximately 75 letters concerning plant diseases have been written during the year. One new virus disease was found in stone fruit crops. This apparently was necrotic rusty mottle. An increasing amount of root rots incited by the pathogen Rhizoctonia solani has been noted. The work carried on under this project will be combined with another project (466) beginning with the next year and this project will be closed. (Project 258).

THE EFFECT OF PESTICIDES ON FRUIT FINISH IN APPLES. (H. G. Swartwout). There is a continuous need for more effective and safe fungicides; particularly those with a very broad spectrum; those that possess both eradicated and protective activity; and those that might have systemic qualities. More information is needed on materials and programs on the control of the summer diseases which recently have become of economic importance such as Botryospheria rot and Alternaria fruit spotting.

This year reduced dosage rates of Dodine in combination with sulfur and in combination with Captan plus Zineb were used on Golden Delicious to obtain further information on effectiveness against scab and on fruit finish. Earlier studies had shown that these materials induced extensive russetting of Golden Delicious apples under certain conditions. This year scab incidence was so low that no readings on control were made; however, good readings were obtained on russet intensity. The following percentages of essentially russet free fruit were obtained with the sprays indicated: (1) Captan 1 1/2 + Zineb 3/4 + lead arsenate 2-90.5%; (2) Captan 1 1/2 + Zineb 3/4 - 87.2%; (3) Magnetic 70 sulfur at 4 + Zineb 1 - 83.3%; (4) Dodine 1/8 + Captan 1 + Zineb 3/4 - 82.0%; (5) Dodine 1/4 + Captan 3/4 + Zineb 1/2 - 78.2%; (6) Dodine 1/8 + Magnetic 70 sulfur 2 + Zineb 1-74.6%; (7) Dodine 1/4 + Magnetic 70 sulfur 2 + Zineb 3/4 - 71.5%.

Dodine at 1/4 pound and 1/2 pound beginning after the fruit lost its pubescence caused no russetting.

Publications: Swartwout, H. G. Suggestions for Spraying Commercial Apple Orchards. Missouri Agricultural Experiment Station Circular No. 756, 1962. (Project 232).

GRAPE DISEASES. (H. G. Swartwout, B. Jones). The commercial grape growing areas of Missouri are located in sections of the State where wild grapes are found in wooded areas adjacent to or near the vineyard plantings. These are a continuing source of disease infection and harmful insects. A number of different treatments have been applied during the year and of these the most effective was G. C. No. 2466 at 2-100 all season. Two other treatments were almost as effective: Ferbam 2 through the bloom period, Ferbam 1 plus Zineb 1 the remainder of the season; and Captan 1 1/2 plus Maneb 1/2 all season. The unsprayed control showed 56.6% black rot. Ferbam-Phaltan combinations have consistently given excellent control of black rot for three years. The weakness of Phaltan has been phytotoxicity when used in after bloom sprays. No mildew (downy) developed in the test plots this year. (Project 194).

THERMAL ACTIVATION OF SPORES IN PROCESSED FOODS. (M. Fields, N. Finley, A. Garrett, M. Johnson). The canning industry is one of the major food preserving industries in the United States. Canned foods are available at any place and at any time for consumption in homes, hospitals, institutions, and public eating places. One of the spoilage problems in canned food over the years has been "flat-sour spoilage". This type of spoilage is extremely important to the canner and the consumer because neither the canner nor the consumer can detect the spoilage until the can is opened. The bacteria produce acid without gas so the can does not swell. This problem must be solved during the production of canned foods.

Heat induced dormancy was observed when spores of two strains of Bacillus stearothermophilus were heated in distilled water at 80, 90, and 100°C, while maximum heat activation was accomplished at 110°C. Heat activation studies using phosphate, glucose, maltose, dextrin, starch, fructose, sucrose, and food extracts as suspending media were completed. Spore suspensions had a greater effect than individual carbohydrate on spore activation. Phosphate had a very definite inhibitory effect upon spore germination. Spores heat shocked in corn extract were activated the least and in green beans the most with pea and spinach intermediate. The age of the bacterial spores heat shocked in tomato juice and oidium tomato juice had a greater effect than did pH on temperature of heating. The young spores were heat activatable while the old spores were not. It was also shown that Bacillus coagulans could produce spores while growing with the mold, oidium lactis in simulated plant conditions produced in the laboratory. These studies will be continued on spore formation, activation, and thermal death of B. stearothermophilus in extracts of corn, peas, spinach, and green beans.

Publications: Finley, N., M. L. Fields. Heat Activation and Heat Induced Dormancy of Bacillus Stearothermophilus Spores. Applied Entomology, 1961.

Fields, M. L., R. C. Jenne. The Effect of Oidium Lactis on Thermal Activation and Recovery of Bacillus Coagulans Spores. Missouri Agricultural Experiment Station Research Bulletin No. 802, 1962.

Fields, M. L., R. C. Jenne. Effects of Heating Menstrua, Spore Age, and Suspension Preparation on the Heat Activation of Bacillus Coagulans Spores. Missouri Agricultural Experiment Station Research Bulletin No. 805, 1962. (Project 434).

MICROBIAL DECOMPOSITION IN PROCESSED HORTICULTURAL PRODUCTS. (M. Fields, N. Finley, A. Garrett, R. C. Jenne, M. C. Johnson). The American people expect clean, wholesome foods and beverages from markets. In order to supply the highest quality products it is necessary to have a full understanding of the various stages of decomposition caused by specific food spoilage micro-organisms. Early recognition of the beginning of decomposition will result in improved food quality at time of delivery. The acetylmethylcarbinol method proved satisfactory for evaluating microbial quality of apple juice. Laboratory studies showed that two principal spoilage rot producing organisms - Penicillium expansum and Alternaria sp. - produced acetylmethylcarbinol (AMC). Studies on naturally fermenting apple juice showed that AMC content increased with increased plate counts. Pilot plant studies showed that increased proportions of decay as determined on a weight basis in the manufacturing of apple juice can be detected by the Voges-Proskauer test. These studies also indicated that apple juice could be manufactured with AMC values of 1.6 ppm or less. Of the 39 samples of commercial apple juice evaluated, the Voges-Proskauer reactants ranged from 0.74 to 10.0 ppm expressed as AMC. Pure culture studies on food spoilage fungi were conducted to determine the amount of AMC produced and the interaction of one fungus on another in terms of AMC content. This work will be continued and tomatoes and strawberries will be included.

Publications: Fields, M. L. Voges-Proskauer Test as a Chemical Index to the Microbial Quality of Apple Juice. Food Technology.

Fields, M. L. A Survey of Selected Filamentous Fungi for Voges-Proskauer Reactions. Applied Microbiology. (Project 433).

POULTRY

E. M. Funk, Chairman

PRODUCING TURKEYS ON FORAGE. (H. V. Biellier, E. M. Funk). Most of the market turkeys reared in Missouri are grown on range. The lack of satisfactory feeding programs and proper range management has limited the returns derived from pasture and forage crops. The good use of range grown pasture and grain will result in more economical production.

This year forage feeding trials were conducted on 837 Broad Breasted Bronze poults grown for 14 weeks on the regular starter and grower rations. At this age they were moved into the milo fields and the daily amount of 28% protein concentrate fed was restricted in order to encourage the poults to consume the standing milo. After a four week restricted feeding training period the poults were divided into four groups: Group A, restricted pellet concentrate on milo range; Group B, free choice pelleted concentrate on milo range; Group C, free choice mash concentrate on milo range; and Group D, free choice pelleted concentrate and whole yellow corn on sod range. The feed cost per pound of gain from 0 to 24 weeks of age was respectively 9, 12.5, 12, and 12 cents; from 24 to 28 weeks, for toms only, 7, 22, 10, and 17 cents. A hatch of 409 toms were reared successfully on milo range with concentrate restricted mechanically in the drinking water. Trials will be continued.

Publications: Jackson, D., H. V. Biellier. Milo Forage Studies Again Show Reduced Feeding Cost for B. B. Bronze Turkeys. M. P. I. A. Yearbook, 1962.

Biellier, H. V. Use of Milo to Reduce Cost of Growing Turkeys. Missouri Turkey News, Vol. 3:17-18, 1962.

Biellier, H. V., R. Paschang, E. M. Funk. Effect of Depth of Artificial Insemination on Fertility of Broad Breasted Bronze Turkey Hens. Poul. Sci. 40:1379, 1961 (abstract).

Biellier, H. V., W. Russell. Missouri Plan of Turkey Breeder Management. Missouri Cooperative Extension Division Circular No. 742, 1961. (Project 344).

BREEDING CHICKENS FOR EGG PRODUCTION. (A. B. Stephenson, E. M. Funk, Q. B. Kinder). Poultry is one of the major sources of agricultural income in the United States and eggs have a greater value than all other poultry products combined. Poultry breeding offers a good method for increasing the efficiency of egg production. This study is an effort to evaluate the different methods of poultry breeding.

This year's work represented the third generation of selection in the recurrent selection and segregating types of breeding. Differences among types were not significant in either fertility or hatchability except for the inbred lines. Fertility values within the crosses and within inbred were not significantly different. The crosses as a type had only half as many families with blood spots as the other types. Within the crosses the Rhode Island Red progeny had 7 times as many blood spots as the progeny from white Leghorn or white Plymouth Rock males. Meat spots were significantly more frequent in the Rhode Island Red progeny. Broodiness was more frequent among the cross bred progeny of the Rhode Island Red males. The differences in annual egg production within the crosses were not significant for the birds laying over 15%. There were 3, 2, and 1% of the progeny of white Leghorn, Rhode Island Red, and white Plymouth Rock males respectively which have less than 15% production. Each of these values is significantly different from the other. The eggs of the Rhode Island Red progeny were the smallest size and had the lower specific gravity.

Publications: Stephenson, A. B. Selection for Egg Production Within Cross Bred Chickens. Manuscript submitted to Poultry Science.

Cooperation: States of the North Central Region (NC-47) (Project 164).

FLOCK REPLACEMENT, FEEDING, AND LAYING HOUSE MANAGEMENT. (Q. B. Kinder, E. M. Funk, A. B. Stephenson). Poultry producers in an effort to achieve more uniform production and to make maximum use of capital investments and labor are resorting to multibrooding replacement systems, new housing systems, controlled feeding, and confinement growing. This work is an effort to evaluate these changes as to their effect upon performance of the birds and economic returns.

The Effect of Season of Hatch on Second Year Production. The season of hatch had an influence on both the weight and pattern of second year production. At present values it would not be profitable to keep layers for a second year unless the pullet replacement cost exceeded \$2.00.

Floor Space. Birds that have been in production for 10 months were moved to laying shelters. They were given 1 1/2, 2 1/4, and 3 square feet of floor space (earth). They laid at rates of 54.8, 59.6, and 58.6% respectively. A similar crowding experiment with pullets gave 6% fewer eggs when housed at 1 1/2 square feet per bird than when given 3 square feet.

Feeding Systems. Rations with 945 and 878 calories per pound did not show a significant effect on production. The antibiotic treatments were significantly different at the 5% level. The interaction between antibiotic and energy level was significant at the 1/2% level. In another trial with 400 birds antibiotic fed birds laid at 68.7% and the controls at 66.2 and 67.5%. A third trial showed birds with nf-180 layed at 70% and their controls at 69.5%. Limestone gave 1% higher production than oyster shell. The pens with granite grit layed 0.7% more eggs than pens without grit.

Publications: Kinder, Q. B. Floor Space Studies with Laying Hens. A manuscript submitted to Poultry Science.

Cooperation: Ford Motor Company

(Project 244).

THE NUTRITIONAL REQUIREMENT OF THE CHICK FOR AMINO ACIDS AND UNRECOGNIZED GROWTH FACTORS. (J. E. Savage, E. M. Funk, A. B. Stephenson, D. A. Ross, D. Bird, J. Yohe). Much progress has been made in improving efficiency of poultry production but feed costs still make up well over half of the cost of production of poultry meat. As increased knowledge of the nutrient requirements of poultry becomes available further increases in efficiency may be expected. The costs of production may also be decreased by use of by-products or surplus materials to supply either unrecognized growth factors or to serve as an economical source of amino acids or other nutrients.

Chicks fed high levels of iodinated casein showed growth depression and increased mortality. Addition of liver fractions to the diet partially counteracted the detrimental effects. The addition of L-thyroxine produced symptoms similar to iodinated casein, and liver was effective in reducing these toxic symptoms. Chicks and poults consuming copper deficient diets showed growth depression, developed leg deformities, subcutaneous hemorrhage, and defects in major blood vessels. A high mortality, due to massive internal hemorrhage, occurred in chicks fed the deficient diets but this symptom was not observed in poults. The poults showed a marked lack of pigmentation. Copper supplements increased growth, no hemorrhage or mortality occurred, and incidence of leg abnormalities was reduced greatly. In broiler feeding trials .8% dietary calcium was found to support gains equal to those obtained with 1.3% calcium. Maximum growth and feed efficiency was obtained with a ration composed of 50% protein soybean oil meal and 3% fish meal as the major protein ingredient source but various other ingredient combinations were shown to give almost equal results. This work will be continued, especially the work with copper and manganese.

Publications: Savage, J. E., D. A. Ross, B. L. O'Dell. Antithyrototoxic Studies with Chicks. Poul. Sci. 40: 1452, 1961, (abstract).

Ross, D. A., B. L. O'Dell, J. E. Savage. The Growth Stimulant Present in Swine Intestinal Mucosa. Poul. Sci. 40:1451, 1961 (abstract).

O'Dell, B. L., J. M. Yohe, J. E. Savage. Interaction of Calcium and Phytic Acid on Zinc Availability. Poul. Sci. 40:1438, 1961 (abstract).

O'Dell, B. L., B. C. Hardwick, G. Reynolds, J. E. Savage. Connective Tissue Defect in the Chick Resulting from Copper Deficiency. Proc. Soc. Exp. Biol. Med. 108:402-405, 1961. (Project 277).

UNIDENTIFIED FACTORS IN DIETS FOR HENS AND THEIR EFFECT ON PROGENY. (J. E. Savage, E. M. Funk, A. B. Stephenson, D. A. Ross). Information which will improve the efficiency of production of market eggs and the sale of hatching eggs is of major importance to Missouri poultrymen.

Eggs from hens reared on purified diets and fed similar purified diets in reproduction studies showed low hatchability. Dietary supplements of corn, casein, alfalfa, whey, liver, corn distillers solubles, and corn fermentation solubles increased hatchability but did not improve egg production, egg weights, or body weight. Casein and corn also improved feed efficiency. In three growth trials with chicks from hens fed the various supplements no evidence was obtained that the factors responsible for the increased hatchability were transferred to the egg and influenced growth of the progeny.

Publications: Savage, J. E. Minerals in Poultry Nutrition. Midwest Centennial Nutrition Conference Proc. 71-84, 1961.

Cooperation: Department of Agricultural Chemistry

(Project 255).

THE EFFECT OF LIGHT ON POULTRY. (H. V. Biellier, E. M. Funk, A. B. Stephenson). The effect of varying day lengths on the time of ovaposition in poultry is of primary importance in developing higher annual egg production.

The restriction of artificial light to 6 hours per day on growing pullets from 8, 10, 12, and 14 weeks until housed at 18 weeks of age was not effective in conditioning them for early sexual maturity under progressive light stimulus. Eight hours of artificial light with increased intensity of one foot-candle per week was not satisfactory for laying hens. Hatchability studies on 58 hens classified into three groups as to average interval between ovipositions of 24.0, 25.0 and 26.7 hours respectively were compared to control hens. Light

cycles of dark plus light totaling 23, 25, and 27 hours along with intravenous injections of 3 units of mammalian oxytocin forced ovipositions at time desired. Hatchability, blastoderm diameter and shell thickness measured as deviation from controls increased when interval between ovipositions was increased in three hatches. The utilization of reduced day-length (23 hours) in the selection of breeding hens has developed over 10% which lay at intervals less than 24 hours apart. Genetic family selection of strains with long and short sequence lengths will be continued.

Publications: Biellier, H. V., O. W. Ostmann. Effect of Varying Day-Length on Time of Oviposition in Domestic Fowl. Missouri Agricultural Experiment Station Bulletin, No. 747, 1960.

Harrison, P. C., H. V. Biellier, E. M. Funk. Effect of Light Restriction During Growing Period on Reproductive Performance of Chickens Subjected to Various Light Regimes. Submitted for publication. (Project 292).

THYROID ACTIVITY IN LAYING HENS. (H. V. Biellier, E. M. Funk, A. Rosales, A. B. Stephenson, P. C. Harrison). Egg production is subject to wide variation and is greatly affected by seasonal fluctuations in temperature and light. Basic knowledge of environmental effects of the physiology of the laying hen will help in providing optimum environmental conditions. It has long been known that the thyroid gland plays an important roll in the metabolic processes which regulate and augment biological phenomena of the body.

Meat-type strains and a laying strain were utilized to determine the thyroid hormone secretion rate throughout the laying period, July to June. The level of daily thyroid secretion rate varied from 0.4 to 1.2 micrograms of L-thyroxine per 100 grams body weight. In a separate trial it was demonstrated that a minimum of 48 hours were required for each individual *in vivo* thyroid count to stabilize, following either low or high levels of injected thyroxine. This project has been a part of a regional project which has been terminated. Therefore, this project will be closed at the end of this year.

Cooperation: States of the North Central Region (NC-43) (Project 296).

QUALITY OF EGGS IN MARKET CHANNELS. (O. J. Cotterill, F. Cunningham, E. M. Funk, M. Sebring, W. E. Seideman, A. B. Stephenson). Basic research on the chemical composition of eggs must be expanded to increase utilization of these commodities. More complete information offers a sound basis for developing new poultry and egg products and processes. There are 23 egg breaking plants and 9 egg drying plants operating in Missouri. Many eggs from other states are processed in this State. The development of new uses, or improvement in existing products, will help stabilize prices and consumption trends.

This year observations have been made on several factors affecting the filming and coagulative properties of egg white and whole eggs. Special attention has been given to methods of improving the foaming properties of yolk contaminated white. Pancreatic lipase as well as heat treatment improved angel cake volume. Higher temperatures and shorter holding periods have been studied. Centrifuging yolk contaminated white improved functional performance and concentrated the yolk lipid in the precipitate. Contamination of egg white with small amounts of yolk decreased the amount of protein insolubilized air-liquid interface of the foam. Heating yolk-free egg white at high pH levels electrophoretically immobilized the lysozyme fraction while heating at lower pH immobilized the conalbumin fraction. Insolubilization, coagulation, and color of whole egg varied greatly according to the pH of the system. High pH levels (10 to 12) increased the electrophoretic mobility of ovomucoid and decreased the mobility of both conalbumin and lysozyme. Egg white gelatin occurred at about 12.5. These studies will be continued during the coming year.

Publications: Cunningham, F. E., O. J. Cotterill. Factors Affecting Alkaline Coagulation of Egg White. Poul. Sci. 41.

Cooperation: States of the North Central Region (NCM-7); Refrigeration Research Foundation; Monarch Egg Corporation; F. M. Stamper Company; W. S. Horvath; Henderson Produce Co; Armour and Company (Project 17).

RURAL SOCIOLOGY

Robert McNamara, Chairman

SOCIAL CHANGES OCCURRING IN MISSOURI TRADE-CENTER COMMUNITIES. (J. S. Holik, C. E. Lasley, W. Wagner, R. B. Meinershagen, V. W. Lane). Community adjustment to rapidly increasing industrialization and urbanization has created a need for knowledge relating to the processes of social changes occurring in Missouri trade-center communities. Many Missouri trade-centers are undergoing great adjustments. Expanded knowledge will help direct these changes. Population figures for all Missouri trade-center communities having a population of less than 2,500 have been assembled. The population changes by decades from 1890 to 1960 have been computed and 603 communities are now being classified into population trend categories. The relationship between population changes and geographic location have been noted. Analysis of changes in communities in the Planned Progress program has resulted in: (1) development of a theoretical social action model; (2) a description of pattern of leadership employed; and (3) a description of changes in organization structure to meet local situations. Sample towns will be selected for intensive comparative analysis during the coming year.

Publications: Holik, J. S. *Small Community Development Process: An Action Model*. Presented to the committee on Community Research and Development of the Society for the Study of Social Problems, St. Louis, Missouri, 1961.

Holik, J. S. *Social Action*. Paper presented at the North Central Rural Sociology committee meeting, Chicago, 1961.

Holik, J. S. *Patterns of Leadership in Small Community Development*. A paper presented to the Central Missouri Chapter of the American Society of Public Administration, 1961. (Project 306)

PROBLEMS IN RURAL AREAS DUE TO CHANGES IN POPULATION. (R. L. McNamara, R. R. Campbell, J. J. Hartman). There is a continued heavy out-migration from rural areas and a related in-migration to the larger metropolitan areas. These changes have created problems in both areas. Agricultural agencies, health and welfare agencies, and urban-industrial organizations need information that can be of help in the adjustments that are necessary on account of these changes. Studies have been started to show the extent and direction of growth of metropolitan areas; to show the long time change patterns of small towns; and to show change of residence anticipated by open country people as they approach retirement.

Publications: McNamara, R. L. *The Impact of Rural Migration on the City*. Chapter XII in "Labor Mobility and Population in Agriculture", a book published by Iowa State University Press, Ames, Iowa, 1962.
New, Peter Kong-Ming. *Aging in Missouri: Some Aspects of Growing Old as Reported by a Sample of Elderly Persons*. Prepared for the Missouri Committee of the White House Conference on Aging. A mimeographed statement, 1960.

Campbell, R. R., R. L. McNamara. *Patterns for Emerging Population Density*. Prepared for journal publication, 1962.

Cooperation: States of the North Central Region (NC-18) (Project 325)

THE DISSEMINATION AND USE OF SCIENTIFIC FARM INFORMATION. (H. F. Lionberger, R. R. Campbell). Information which will increase the efficiency of farming becomes more valuable if it can be put into use with less "time lag". This study is to determine how new information becomes available to those who will benefit from its use. A previously reported manuscript has been reviewed and is in process of being rewritten.

Social Stratification. A comparison of factors which are involved in the accordence of status and the actual correlates of prestige have been made in two communities. The factors upon which status was accorded were much the same in both the communities. However, significant differences existed with regard to the importance accorded participation in church activities, level of living, and number of times mentioned as an innovator. Preliminary analysis showed discrepancies between prior statements and actual correlates; particularly in regard to the importance attached to farm ownership as a status factor.

Organizational Status and Membership. Coding and analysis of data regarding farm operator membership and participation in a variety of several organizations have continued. Tables are now available which permit comparison of characteristics of people who participate in different kinds of farm organizations; those who participate in a variety of organizations; and those who participate in none.

Values and Attitudes. A short scale has been devised for measuring farmer attitudes toward farming as a way of life, as compared with farming as a business. This scale helps explain the adoption of new farm practices. It is a refinement of a longer one developed and reported previously.

Diffusion Patterns. Preliminary work regarding the relationship of the use of improved practices to various social structures in the community has been undertaken.

Publications: Campbell, R., J. Bennett. Your Audience: What's It Like? Missouri Agricultural Experiment Station Bulletin No. 771, 1961.

Lionberger, H. F. Adoption of New Ideas and Practices. A book published by Iowa State University Press, 1960.

Lionberger, H. F. How Farmers Adopt New Ideas. Farm Store, 1962, pages 16-18.

Cooperation: The Foundation for Research of Human Behavior: the National Project on Agricultural Communications. (Project 29).

ILLNESS IN RURAL AREAS OF MISSOURI. (R. L. McNamara, M. Gadallah, C. E. Lively, E. W. Hassinger, R. P. Montaba, H. E. Plyler, J. L. Bennett, R. M. Keith). As rural farm and rural non-farm people develop closer relationships with urban institutions for health services, it is important to have knowledge of urban concentrations of doctors, dentists, nurses, and hospitals; to maintain a continuous inventory of physician supply; and to delineate emerging health service areas for rural people.

A field study of the background and community participation of physicians in 20 rural counties has been conducted. Interviews were completed with 151 physicians and preliminary analysis of the results has been made. A study of health insurance in a small town was conducted with interviews in 183 households. The first phase of the accident study has been completed and a manuscript prepared. Interviews were conducted with matched groups of accident repeaters and non-repeaters. It is planned to complete the analysis of physician's background and community participation in 20 rural counties.

Publications: Hassinger, E. W., R. L. McNamara. Health in Two Counties, A Summary and the Comparison. Missouri Agricultural Experiment Station Research Bulletin No. 779, 1961.

Hassinger, E. W. Health Insurance in a Small Missouri Town. Missouri Agricultural Experiment Station Bulletin No. 780, 1962.

McNamara, R. L. The Dentist and the Community. Journal of the Missouri Dental Association, 1962.

Gadallah, S. M. Environmental Factors Associated with Farm Accidents in Missouri. Missouri Agricultural Experiment Station Research Bulletin No. 790, 1962.

Cooperation: Departments of Home Economics, Agricultural Economics, Dairy Husbandry, Agricultural Education, Agricultural Engineering; Missouri State Division of Health; U. S. P. H. (Project 201).

HUMAN FACTORS AFFECTING FOOD SELECTION AND CONSUMPTION. (C. L. Gregory, M. B. Brown). There is an inherent relationship between agricultural production and food consumption. An effort is being made to show basic sociological and psychological factors which influence food selection. A general methodology has been developed. Studies have been made with the relationships of characteristics of families to their concern for economy in food purchases.

It was discovered that high interest in economy did not decrease consistently as one moved up the scale of husband's occupational level. Full time homemakers and working wives at clerical, small business, and sales levels were less concerned over economy than were working wives at the professional, skilled, semi-skilled, and unskilled levels. No consistent relationship was discovered between educational attainment of household head and economic score. There was a meaningful relationship between the wife's educational attainment and economic score. Those with 8 years of schooling considered economy with greater frequency than those with more education. Homemakers with high school training were slightly less interested in economy than the college group. There was no consistent relationship between age of homemaker and economic score. There was no apparent connection between club membership and economic score. Concern over economy was not noticeably related to the size of community in which the shopper had lived most of her life.

Publications: Gregory, C. L., M. Brown A Methodological Approach to the Study of Sociological Factors Associated with the Purchase of Food. Prepared for publication.

Gregory, C. L., M. Brown. The Consumers Consideration of Economy in the Purchase of Foods. Manuscript prepared for publication. (Project 266).

THE LOCAL PUBLIC HEALTH NURSE. (E. W. Hassinger, V. W. Lane, H. A. Chandari, C. E. Grubb). The local public health nurse is important in implementing programs developed by State Division of Health and is the principle public health resource person at the local level.

Interviews have been conducted with the local public health nurses, members of county court, members of health department boards of trustees, local physicians, personnel of the Missouri Division of Health, and with a sample of the general population. Work this year has been devoted primarily to elaborating the design,

preparing interview schedules, and laying the ground work for interviews. Preliminary interview schedules have been prepared and, while the schedules for each area under study differs in some respects, a common set of 30 nursing activities have been included in each schedule. These items were developed on the basis of open-end interviews with 35 local public health nurses, 15 county court members, and a survey of 20 lay families. The work will move into field studies during the coming year.

Cooperation: U. S. P. H.

(Project 456).

SOILS

George Smith, Chairman

SOIL FERTILITY AND CORN PRODUCTION. (C. M. Woodruff, E. Kroth, T. R. Fisher, P. M. Smith, R. J. Crabtree). Corn is the most widely cultivated plant and contributes more to agricultural income than any other crop in Missouri. The wide differences in climatic conditions and natural soil productivity make corn production research a complex undertaking.

Nutrient requirements of corn were studied at all research centers in 1961 excepting the Southwest Missouri Research Center where a study of continuous sorghum for silage was started. Rainfall was adequate to excessive in most locations. Nitrogen at the rate of 100-120 pounds per acre was indicated for optimum yields. One hundred fifty pound applications proved profitable in Southeast Missouri. Crop yields above 100 bushels per acre were produced at all sites. Some experiments produced lower yields due to difficulty with stand and soil conditions. Phosphorus and potash were indicated on the sandy soils of Southeast Missouri and phosphorus on the soils of the other stations. The need for lime was indicated on the acid soils of Central Missouri. When optimum yields were expected, plant populations in excess of 14,000 per acre were necessary for Southeast Missouri where irrigation was possible. A study of the soil treatments for continuous corn and sorghum silage was started at Columbia. Work next year will be continued along the same lines. (Project 268)

THE ECONOMICS OF FERTILIZER ON CORN. (J. P. Doll, J. T. Sanderson). A detailed report will be found in the Agricultural Economics section. (Project 455).

SOIL FERTILITY AND COTTON PRODUCTION. (G. E. Smith, J. A. Roth, E. F. Kroth). Previous research has shown the seasonal conditions affecting the release of nutrients for soils growing cotton. Few soils without fertilization can deliver the quantity of essential elements required for the most efficient production. On many soils fertilization is required for profitable yields.

Soil fertility experiments were conducted at Sikeston and Portageville and with eight cooperators located on the various soil types of Southeast Missouri. Long time experiments were initiated at the Southeast Missouri Research Center at Portageville on the "gumbo" or heavy soil type. These experiments included basic soil treatments, crop rotation, continuous cotton, the use of limestone, and the use of winter cover crops. With a late season such as 1961, the application of a complete fertilizer as a starter was very essential. Nitrogen appeared to regulate the production of cotton and may, if applied at too high a rate in a year such as 1961, delay maturity. The application of phosphate and potash was necessary where nitrogen was used. The elimination of the various trace elements from the trace element mixtures have practically no effect on lint yields. Fertilizer treatments, if properly applied, can off-set the bad effects of deep cuts on a field graded to a uniform slope. Work will be continued through the coming year.

Publications: Smith, G. E., J. A. Roth, E. M. Kroth. Soil Research in Southeast Missouri for 1961.

Missouri Agricultural Experiment Station Special Report No. 9.

(Project 267).

RESPONSE TO FERTILIZERS. (T. R. Fisher, J. A. Roth, E. M. Kroth, P. M. Smith, R. J. Crabtree, L. E. Barnes, T. M. Dean). The application of information obtained from soil tests has been a major influence on the progress of soil fertility improvement and of crop production in Missouri. Almost all of the counties in Missouri now have soil testing laboratories. The application of soil testing consists of two essential features: (1) the laboratory chemical procedure in which the amount of the plant nutrient in a particular soil is determined and (2) the interpretation of these laboratory findings expressed in terms of the degree of deficiency of a given plant nutrient. These two features must be well correlated for the soil testing program to provide its greatest usefulness. Response to fertilizers, therefore, is important.

Northwest Research Center. Five year averages showed that yields from plots receiving no phosphate as compared with plots receiving adequate phosphate were 80% for corn, 75% for oats, and 75% for hay. Almost no response was obtained for any of the crops from potash treatments.

Southwest Research Center. Grain sorghum yields showed that the plots receiving no phosphate yielded 70% as much as those receiving adequate phosphate. Plots having no potash yielded as low as 33% of those receiving potash. This was due largely to difficulty in harvesting because of increased incidence of disease and lodging in the no-potash treated plots. Wheat yields on plots receiving no phosphate were 65% of those receiving phosphate. No response from potash was observed.

Weldon Springs. The wheat plots receiving no phosphate yielded 74% of those receiving phosphate and those receiving no potash yielded 85% of the potash treated plots. Little response was obtained on corn from either phosphate or potash.

McCredie. Corn yields on phosphate untreated plots were generally 80% of the phosphate treated plots. No responses were observed from potash treatments on corn or phosphate or potash treatment on wheat and soybean. The established plots at all Stations will be continued. (Project 229).

THE APPLICATION OF FERTILIZER TO FARM CROPS. (G. E. Smith, J. R. Crabtree, J. A. Roth, P. M. Smith, L. S. Murphy, C. M. Woodruff, S. A. Sanders). The manufacture of fertilizers is now the largest chemical industry in the country. Chemical fertilizers probably account for more than one-fourth total crop production. Most crop lands in Missouri now receive some type of soil treatment and the use of fertilizers has become a standard practice in soil and crop management. Many new chemical processes in fertilizer manufacture are being developed. Experimental work is required to determine the most efficient fertilizers and methods of using them.

This year studies have been made on crop response to different fertilizer materials using small grains as test crops. Many of the comparisons made have been the result of questions raised by farmers. The results have furnished information concerning the best rate, time, and method of application of different fertilizer materials. There was a hazard in using urea in fertilizer blends when the material was used as a starter on small grains. Analyses have been completed for nitrogen compounds in plants (including nitrates in forages) as influenced by nitrogen fertilization. Nitrate content of pastures has been found much higher than in hays. The residual acidity from nitrification of anhydrous ammonia appeared to be sufficient to influence a breakdown of rock phosphate. Small amounts of fine lime have not been as effective as large quantities that supply coarse particles in addition to the same quantity of finer materials. Blended fertilizers are being used to a greater extent. These are being spread with a fan type distributor and it has been shown that much of this material is giving an uneven spread. More work needs to be done on the mechanics of spreading fertilizers from trucks. The part of this work dealing with nitrate in forages will be transferred to another project (99) on pasture fertilization. This project (178) will be closed as a federal grant project but will be continued as a state project.

Publications: Smith, G. E., J. A. Roth, C. M. Woodruff. Soil Fertility Research in Southeast Missouri.

Missouri Agricultural Experiment Station Special Report No. 9, 1961.

Cooperation: Phillips Petroleum Company

(Project 178).

SOIL FERTILITY AND SOYBEAN PRODUCTION. (E. M. Kroth, J. A. Roth, P. M. Smith, J. H. Wagner, R. J. Crabtree). Missouri is one of the principal soybean producing states and soybeans are one of the main cash crops of the State. Missouri is at the western edge of the principle soybean growing area and frequently the combination of high summer temperatures and low rainfall limit response to soil treatments.

Field studies have been continued with the exception of the nitrogen study which has been completed and reported in a research bulletin. New studies were established involving calcium, phosphorus, and potassium fertilization. Also, the influence of barley as a green manure crop for soybeans has been under investigation. Further studies are being made with the influence of row spacing for soybeans. Of the various inorganic fertilizers used only lime has shown significantly increased yields. Row spacing, rate of seeding, and the extent of weed growth influenced soybean yields. In comparing rows spaced 20 inches with those spaced 40 inches apart, it was found that when the plant population per acre was kept constant the yields for the two spacings were essentially the same. Wheel track planted soybeans in 20 inch and 40 inch rows yielded as well as those planted in a conventionally prepared seedbed provided the plots were kept free of weeds. Studies with the fertilization of soybeans will be continued.

Publications: Wagner, G. H. Nitrogen Fertilization of Soybeans. Missouri Agricultural Experiment Station Research Bulletin No. 797.

Cooperation: Agricultural Engineering Laboratory, ARS, U.S.D.A.

(Project 357).

THE USE OF FERTILIZERS ON PASTURES. (E. M. Kroth, P. M. Smith, R. J. Crabtree). Missouri has extensive areas of land that are best adapted to grazing or forage production. Recent census figures show over 11,000,000 acres of permanent pasture. Additional areas of cultivated land are utilized for grazing. Forages grown in sequence with cultivated crops are harvested annually with livestock. The sale of livestock or livestock products is one of the principal sources of farm income. Improved quality of pastures means more efficient livestock production.

Excessive rains in 1961 reduced the responses to applied nutrients below those of 1960. Plots receiving nitrogen produced improved yields with less weeds. The use of lime and phosphorus increased yields over nitrogen alone. Seedings made in the fall of 1960 at the Bradford farm and at the Southwest Research Center failed and were replanted in the spring of 1961. These were successful excepting those on the Gerald soil which were again reseeded in the fall of 1961. Studies are being made with a top dressing of P_2O_5 and K_2O at the Southwest Missouri Research Center. Work with the fertilization of pastures will be continued.

(Project 99)

SOIL TREATMENTS FOR ALFALFA AND BIRDSFOOT TREFOIL. (E. M. Kroth, R. J. Crabtree, T. M. Dean, E. Barnes). Alfalfa is the most nutritious forage produced in Missouri. It has the highest mineral requirement of any crop produced. It can fix its own nitrogen for optimum growth but a 4-ton yield removes nearly 50 pounds of phosphate and 180 pounds of potash. Birdsfoot trefoil has been successfully grown in adjoining states but it has been difficult to secure stands on most Missouri soils and the influence of soil treatments has been erratic. There is much interest in this crop since it is a legume with deep rooting habits and chemical composition similar to alfalfa.

Superphosphate had a slight advantage over rock phosphate as a phosphorus carrier for alfalfa at the North Missouri Research Center. It was evident that potash must be applied for optimum yields of alfalfa on this soil type (Edina silt loam). Plots receiving no potash produced 2.4 tons per the acre in contrast to 3.4 tons for plots receiving potash. Topdressing phosphorus and potash was a satisfactory method of applying these nutrients to alfalfa. At Weldon Springs use of lime showed no increase in yield. Phosphorus applied as superphosphate or good quality rock phosphate gave yields of 6.5 tons per acre. Experiments will be continued at Columbia, Weldon Springs, Southwest Missouri Research Center, Southeast Missouri Research Center, and North Missouri Research Center.

(Project 358)

THE FATE OF FERTILIZER NITROGEN IN DIFFERENT SOILS. (G. H. Wagner). The availability of abundant supplies of low cost chemical nitrogen has changed soil management systems in the United States. There has been a wide variation in the response of farm crops to fertilizer nitrogen applied to the different soils of Missouri. Evidence has accumulated to correlate this variation with loss of nitrogen in a gaseous form and also in drainage waters. There are indications of the development of unfavorable effects on plant growth of some intermediate products of nitrogen transformations in the soil.

Plots of sudan grass were established on four different soil types in Missouri. Two levels of nitrogen were applied. The yield of forages produced; the nitrogen content of this forage; and the total nitrogen in the harvested forage were determined for each plot. The recovery of fertilizer nitrogen was small in comparison with the total amount applied. The excessive treatment was to provide residual nitrogen for subsequent crops. The fate of this residual nitrogen with regard to plant uptake and loss by leaching was studied. Porous ceramic cup assemblies were constructed and installed at various depths in the profiles of soils under study. These cups permitted sampling of soil water. The moisture content of the soil also was obtained with a neutron meter. From this date the total content of nitrogen in the drainage waters of the profile was calculated. Limited results indicated the movement of a large amount of nitrate nitrogen through the profile to at least a depth of 3 feet. Plots will be again planted to sudan grass and the nitrogen recovery by the sudan grass measured.

Publications: Wagner, G. H. The Use of Porous Ceramic Cups to Sample Soil Water within the Profile.

Paper prepared for publication in Soil Science.

Cooperation: States of the North Central Region (NC-16); Station Chemical Laboratories. (Project 457)

SOIL IMPROVEMENT THROUGH HEAVY APPLICATIONS OF NITROGEN AND CARBONACEOUS ORGANIC MATTER. (E. M. Kroth, G. H. Wagner). Most Missouri soils are declining in organic matter. Legumes in rotations have been considered a practical means of restoration. However, where livestock is a principal source of farm income the forage is harvested for hay and the efficiency of return of manure is low. Chemical nitrogen has become available in large quantities and at a reduced cost in recent years.

The increased use of nitrogen has permitted the production of higher yields of non-legumes. The amount of residues returned from these crops can add more organic matter than was possible when legumes furnished the nitrogen and were harvested for hay. However, the expectant beneficial effect on soil productivity due to heavy applications of organic residues has not been realized. Increased yields have not resulted

from these treatments. In general the reverse has been true. Apparently it is difficult to increase soil organic matter content or to increase ordinary farm crop yields with heavy applications of carbonaceous material. A good fertilizer program plus good management of crop residues appears to be the best method for Missouri farmers. This project will be closed at the end of this year. (Project 231).

ORGANIC MATTER AND PLANT GROWTH. (G. H. Wagner, V. E. Renner). Increased application of inorganic salts as fertilizer has resulted in changes in the quantities and quality of crop residues which are returned to the soil each year. These residues are digested by the microbial population of the soil to form soil organic matter. In turn soil organic matter influences the nutrition of subsequent crops. Therefore, there is need to understand fully the role of organic compounds in the nutrition of farm crops.

The soil polysaccharide fraction of organic matter (warm water extract precipitated with acetone) was obtained from Putnam, Weldon, and Sharkey soils. The amount of ash in this fraction was found to be high and to vary with the type of soil. The major portion of this ash was calcium and magnesium sulfate, precipitated along with the polysaccharide by the acetone. Spectrographic analysis of the ash revealed an array of trace metals. Possibly many of these were held as chelates by the complex molecules of soil organic matter. The influence of electric desalting of the polysaccharide on the ash content and the trace metal content was determined. Preliminary tests have been made on the influence of this crude polysaccharide fraction on plant growth. Significant effects were observed.

Publications: Wagner, G. H., V. E. Renner. Growth Responses of Sudan Grass Seedlings to Organic Substances. I. A Manuscript submitted for publication in Plant and Soil.

Cooperation: States of the North Central Region (NC-17). (Project 208)

RECLAMATION OF ERODED SOILS. (C. M. Woodruff). Appreciable areas of subsoils exposed by erosion and by terracing exist throughout Missouri. The fertilization, management, and cropping of these subsoils presents problems that are different from those associated with the more desirably textured surface soils. It is essential to know the best management methods for the use of subsoils in the production of crops. The crops used during the past year have been alfalfa, lespedeza, fescue, and corn at four plant populations on the desurfaced soils of 7 plots.

Yields for 1961 and Averages for the Past Six Years

	<u>1961</u>	<u>6 Yr. Average</u>
Plot 1 - Alfalfa-lime and fertilized	6.03T/A	4.5 T/A
Plot 2 - Lespedeza - unit treated	Unharvested	Unharvested
Plot 3 - Fescue-lime and fertilized	3.7T/A	3.1T/A
Plot 4 - Corn-fertilized-4000 stalks/A	47 bu./A	47 bu./A
Plot 5 - Corn-fertilized-8000 stalks/A	42 bu./A	58 Bu./A
Plot 6 - Corn-fertilized-12,000 stalks/A	45 bu./A	52 bu./A
Plot 7 - Corn-fertilized-16,000 stalks/A	39 bu./A	48 bu./A

For forages on eroded glacial soils, alfalfa has proved to be an excellent crop. Grass, because of its high nitrogen requirements, must be considered unsuitable without fertilization. At this stage it is apparent that corn yields are limited and that lower than normal rates of planting were desirable if corn was grown. The low water storage capacity of the soil (insufficient through the months of July and August when corn must have ample moisture to produce satisfactorily) was responsible. (Project 209)

THE EFFECT OF FERTILITY ON RUNOFF AND EROSION. (E. M. Kroth, P. M. Smith). Most erosion and runoff measurements have been made on soils with inadequate nutrient supplies for optimum crop growth. Full fertility treatments have resulted in deeper plant rooting, the use of larger amounts of soil moisture, a more dense canopy of vegetation, and the return of larger amounts of plant residues. All of these factors aid in reducing runoff and erosion. The purpose of these studies is to determine the effects of full treatments of plant food in reduction of runoff and erosion.

Continuous corn with full treatment and plowed seedbed produced 150 bushels per acre with a runoff of 2.11 inches of water and 1.84 tons soil loss; continuous corn with full treatment, subtilled seedbed, a yield of 150 bushels per acre, 1.39 inches of runoff, and 1.56 tons soil loss; corn in rotation (C, W, M, M) with full treatment produced 142 bushels per acre, 1.26 inches of runoff and 1.29 tons of soil; continuous corn with starter only produced 24 bushels per acre, 5.74 inches runoff, and 5.27 tons of soil; and rotation corn with starter only 55.7 bushels per acre, 3.45 inches runoff and 2.43 tons of soil. Rainfall was 3 inches above nor-

mal with 4.44 inches occurring on June 30 and July 1. This storm gave 1.7 inches runoff and 3.4 tons soil loss from the rotated corn plot with starter; 1.1 inches of runoff and 1.5 tons soil loss from continuous corn with full treatment; 1.6 inches runoff and 1.7 tons soil loss from rotation corn with starter; and .9 inches runoff and 1.2 tons soil loss from the full treated rotation crop. High fertility helped conserve water and soil in both continuous corn plots and rotated plots. The results from these studies indicated that fertilizer would not replace terraces and that it would be hazardous not to use terraces on 3% slopes of much over 90 feet length even when farmed on the contour.

(Project 77)

THE EFFECT OF LEGUMES AND FERTILITY OF THE SOIL ON CROP SEQUENCES AND ON CONTINUOUS CROPPING. (E. M. Kroth, P. M. Smith, J. A. Roth, T. M. Dean, M. H. Brown, E. M. Barnes, E. Calvin) Missouri has a wide variety of soil and climatic conditions and therefore, has a wide variety of crops adaptable to the State. Recent research has indicated that rotations have been exploitive of soil fertility. Changes in soil management practices with the addition of adequate plant food have made it possible to increase the percentage of time that land can be devoted to high value crops.

During the past year a cold wet spring delayed planting and in a number of cases made replanting of corn necessary. On Sanborn field, continuous corn plots with full fertility treatments yielded about 10 bushels less than corn in rotation with wheat and clover. However, the continuous corn plots had to be replanted. At the North Missouri Research Center continuous corn outyielded the best producing rotated plots by about 5 bushels to the acre. New rotation studies have been established at Columbia and at the North Missouri Research Center using corn as the indicator crop and at the Southeast Missouri Research Center using cotton as the indicator crop. This work will be continued during the coming year.

(Project 117)

RAPID ROUTINE METHODS FOR SOIL ANALYSIS. (T. R. Fisher) Recent methods of soil management have been based on some type of soil testing. Some of these systems of soil testing are more elaborate than others. Many farmers now rely to a great extent upon the results of soil test to guide their fertilizer and lime programs. The speed and accuracy with which soil tests can be made, therefore, is very important.

Participation in the North Central Regional Soil Testing Program has been continued. Soil samples were collected, prepared, and sent to neighboring states in a cooperative exchange of soil samples to correlate better the soil testing programs among the states. The hydrochloric acid extract for flame photometer analysis in soil testing was investigated further by using a radioactive isotope to determine the completeness of extraction of exchangeable calcium, magnesium, sodium, and potassium. The 0.1 N hydrochloric acid in most instances did not extract as large a quantity of these exchangeable ions as did 1 N ammonium acetate or 25% sodium nitrate. This, however, did not preclude its use as an extraction agent since suitable corrections could be made. Chemicals, reagents, standard solutions, check samples, and equipment were prepared and supplied to county soil testing laboratories in sufficient quantities to test approximately 90,000 soil samples. Tissue testing supplies including potash testing papers, phosphate and nitrate reagents were prepared and supplied to county agents to supplement their soil testing programs. Approximately 2,000 soil samples from field research areas were tested in the soil testing laboratory at Columbia. The furnishing of reagents, supplies, and equipment to county soil testing laboratories will be continued and further studies will be made of soil sampling methods and techniques of analysis.

(Project 170)

THE EFFECT OF CLIMATE ON MISSOURI AGRICULTURE. (W. L. Decker, J. D. McQuigg). For 15 years work has been progressing on the analysis of weather information important to the agriculture of Missouri. Weather records from 57 locations have been placed on IBM cards for ease in preparation of summaries. This number of locations provides a density of weather stations of one for each 1,200 square miles of area. Intelligent use of this information will enable producers to alter operations to fit the most likely climatic events.

Studies have been made on the relation of humidity to the time for cotton harvest in Southeast Missouri. The quality of cotton was improved by delaying picking until the humidity had fallen to 60%. This condition occurred prior to 9 a. m. on only two out of ten days but picking conditions were favorable on 7 out of 10 days, by noon. Clear skies at 7 a. m. was a good indication that favorable picking conditions would occur during the day. A mathematical model has been developed for estimating the probability of the completion of an outdoor activity without interruption by rain. This model utilized a beginning date for an activity, the amount of precipitation which will interrupt the activity, the length of time required to "dry out" prior to the resumption of work and the number of days required to complete the activity. A summary is being prepared for all of the North Central States of the frequency of runs of days with critically high or low temperatures. The data for all of the contiguous states of the region are now being assembled in Missouri. A manuscript for regional publication will be prepared during the coming year.

Publications: McQuigg, J. D., W. L. Decker. Humidity and Cotton Harvesting in the Missouri Delta.

Missouri Agricultural Experiment Station Bulletin No. 776, 1962.

McQuigg, J. D., W. L. Decker. The probability of Completion of Outdoor Work. Journal of Applied Meteorology 1; May, 1962.

Cooperation: States of the North Central Region (NC-26); the United States Weather Bureau (Project 281)

THE DETERMINATION OF THE GEOGRAPHIC DISTRIBUTION OF PRECIPITATION CLOUDS BY USE OF RADAR. (W. L. Decker). Rainfall measurements are at present point estimates. This makes it impossible to obtain an actual measure of variation of rain. By radar a space measurement of rainfall is possible. It may be practical to locate areas favorable for storm genesis and dissipation. This would make it possible to answer many questions about the distribution of Missouri's rainfall. Such questions as the frequency of raining in river bottoms as compared with upland areas can be intelligently answered. This work has been aided greatly by the data supplied by the "White Cloud" project of the Cloud Physics laboratory of the University of Chicago. Under the "White Cloud" project a cloud seeding program has been carried out in Southcentral Missouri. A test area has been defined as the region through which silver iodide spreads. This defines a region averaging about 400 square miles in size. Using hourly rainfall records and a graphical technique for averaging the amount of precipitation, the average rain is calculated for each day with rain which was tested. Based on incomplete data, the test area is covered to the extent of 10 to 75% with rainfall on a day with rain. The median value is 50% of the area covered with rain. On the day with rain, the average rainfall with each hour ranged from .001 to .018 inch with the median value of .008. It is too early to use these results for the benefit of agriculture and records for additional years will be necessary. During the next year work will continue with the analysis of present and newly accumulated records.

Cooperation: University of Chicago; NSF

(Project 324)

THE EFFECTS OF METEOROLOGICAL AND CLIMATOLOGICAL VARIATIONS ON AGRICULTURAL PRODUCTION IN MISSOURI. (W. L. Decker, G. L. Darkow, J. R. Eagleman). This work is to provide a method for determining the environmental factors associated with heat, cold, and drouth injuries to crops. Methods may be developed for reducing the hazard of environmental induced plant injury.

Detailed measurements of evapotranspiration were obtained from a corn field and the concurrent environmental factors were recorded in order to evaluate the energy budget of the corn field. The analysis of the data has not been completed but preliminary information indicated that evapotranspiration ranged from .10 to .33 inches per day. Covering the soil surface under the corn with a plastic reduced the amount of evapotranspiration by about 5%. Net radiation measurements were compared for the uncovered and plastic covered corn. The amount of reduction in the net radiation by the black plastic was also about 5%. A preliminary study has been made to determine the effect of dry periods on yield of corn. In this study a portion of the experimental area was shielded from rain for a three week period just after silking. The average yield in the area not shielded was 124 bushels per acre while the yield in the area subjected to a dry period was 110 bushels per acre. The work during the coming year will be with soybeans instead of corn.

Publications: Decker, W. L. The Precision of Estimates of Evapotranspiration in Missouri's Climate. A paper submitted to the Agron. Journ.

Decker, W. L. The Role of Environmental Factors in Evaporation Transpiration in a Corn Field. Proc. Amer. Seed Trade Assn.

Ewalt, R., J. Dole, W. L. Decker. The Correlation of Drouth Indices with Corn Yields. Missouri Agricultural Experiment Station Research Bulletin No. 788, 1962.

Cooperation: U. S. Weather Bureau; ARS; NSF; U. S. D. A.

(Project 210)

MISSOURI SOIL SURVEY CLASSIFICATION. (C. L. Scrivner, J. C. Baker, K. D. Vogt, B. J. Miller). For many years work has been progressing on a comprehensive survey of the soils of Missouri. An accurate soil classification is basic to the agriculture of the State as measured by farm management, soil management, watershed studies, irrigation possibilities, or simply an inventory of a basic resource. Approximately one-half of the counties of Missouri have been surveyed. However, many of the earlier surveys are useful only for regional consideration. The more recent surveys have been much improved. The soil survey of Missouri should be completed as rapidly as possible in order to have complete information on this most basic resource of the State.

During the year, the detailed soil map of Henry County has been completed to such an extent that only 90 square miles remain to be mapped. Detailed sampling has been continued and was greatly aided by a newly acquired truck-mounted hydraulic probe. Analyses of samples include particle size distribution as well as complete chemical characterization. The results have been summarized for use in the descriptive legend.

Publications: Soils of Howard County. Missouri Agricultural Experiment Station Bulletin No. 749, 1961.

Soils of Blackwater and Lamine Townships, Cooper County. Missouri Agricultural Experiment Station
Bulletin No. 772, 1961.

The completion of the survey of Henry County, both field mapping and laboratory analyses will be the primary goal for the coming year.

Cooperation: Soil Conservation Service, U.S.D.A.

(Project 206)

THE BRADFORD FARM. (G. E. Smith, E. M. Kroth, M. H. Brown). This project was started to provide for the development and maintenance of a portion of the Bradford farm devoted to soils research. During the past year, it has been concerned primarily with moving field experimental work from the Beasley to the Bradford farm. Approximately 60 acres have been developed for experimental plots. The land has been smoothed and roadways constructed. Preliminary construction for a new metal building has been completed including the installation of water and sewage facilities. A farm office, washroom, and shop have been built. Equipment for drying samples has been constructed and a weather station established. This project will be closed at the end of the present fiscal year and the responsibility for the development of the farm taken over by the Central Farm Organization.

Cooperation: Central Farm Operations

(Project 436).

SUGAR BEET PRODUCTION IN MISSOURI. (D. Green, C. M. Woodruff, L. Jenkins). See report under Department of Field Crops.

Cooperation: Departments of Field Crops and Entomology.

(Project 492)

ENERGETICS OF IONIC RELATIONSHIPS IN SOILS AND PLANTS. (C. M. Woodruff, J. D. Mikulcik, R. J. Crabtree). Previous research has established the fact that band applications of phosphorus were much more effective than broad cast applications for growing corn. Conventional soil tests do not indicate whether or not a band treatment of phosphorus is necessary nor, when necessary the proper rate of fertilization in the band.

The energy approach toward the evaluation of the nutritional state of the soil with respect to phosphorus may provide a better type of test, the results of which will correlate with the response of corn to the banding of phosphate fertilizers. Rates of banding ammonium phosphate for corn were studied at two locations. It appeared that 25 to 30 pounds of P_2O_5 was adequate for corn. Depressions in corn yields were associated with the banding of large amounts of P_2O_5 and were not overcome by the use of trace elements. Silty textured soils of the Missouri uplands developed suitable phosphate potentials with additions of 200 to 300 pounds of P_2O_5 per acre, whereas soil containing admixed subsoil required as much as 800 to 1000 pounds of P_2O_5 to develop satisfactory potentials. A method of testing soil for potassium designed on the basis of energy of replacement proved much superior to methods based upon measuring exchangeable potassium. The work will be continued during the coming year.

Publications: McIntosh, J. L. Chemical Characteristics of Potassium in Soils. A thesis submitted in partial fulfillment of the requirements for the degree, Doctor of Philosophy, Graduate School, University of Missouri, 1961.

Woodruff, C. M., J. L. McIntosh. Testing Soil for Potassium. 7th International Congress of Soil Science, Vol. III, 1960.

Sinha, H. Potassium-Boron Interactions and Plant Growth. A thesis submitted in partial fulfillment of the requirements for the degree, Doctor of Philosophy, Graduate School, University of Missouri.

Cooperation: American Potash Institute, Inc.

(Project 263).

MOISTURE STORAGE CAPACITY OF MAJOR MISSOURI SOILS. (E. M. Kroth, P. M. Smith). Increased rates of nutrient additions to soils for summer crops have now made moisture a limiting factor in crop production in many seasons. Information is needed on specific soils for the best design of irrigation systems. This same information will be of value in developing drainage and water management programs. This was a year of adequate rainfall and therefore, no water determinations or infiltration rate calculations were made. A study of the barrier effects to water movements between coarse and fine aggregates in the same soil was made. There was no great barrier effect found. Water movement from loose plowed soil into a former packed seed bed was not greatly hindered by the coarser aggregates in the loose layer. Loose plowed areas were settled down during the first rain so that good capillary contact was made with the packed area of a wheel track or the plow sole. Soil volume in a profile was slower to regain than moisture percentages after being reduced by drouth conditions. Alfalfa removed water to a greater depth than corn and corn to a greater depth than blue grass. This work will be continued in the same manner.

Cooperation: States of the North Central Region (NC-40)

(Project 211)

THE RELATION OF SOIL FERTILITY TO THE EXCHANGE COMPLEX. (C. E. Marshall, E. M. Kroth). There is no knowledge of the losses of the exchange cations from our soil in the drainage water nor the rate

of movement downward in the soil. The work this year has centered on choice of site at the Bradford Farm for small plots, the planning of the locations of the lysimeters; and the development of the proposed treatments. A minimum of 24 plots and corresponding lysimeters have been planned and during the coming year installation and analytical work will start. (Project 416)

ISOTOPES OF THE BIOSPHERE. (E. R. Graham, B. J. Wells, D. D. Killion) Recent studies in Missouri have indicated a higher Sr-90 content in milk than the national average. This is an effort to determine the reason for this condition.

The results of 1961 showed a greater removal of radioactive Sr than was obtained during the fall of 1960. This was explained by the fact that soils were very wet in the fall of 1961 and dry in the fall of 1960. The removal of Sr from the fallow plot was .98% as compared to .04% for the fescue meadow. Cover effect was observed with I-131. In this case the fallow plot revealed .44% and the meadow was .0003% removal. The activity removed was related to the amount of runoff and the cover of the plot. Runoff of the meadow for the November 3 rain was .41 liters. The activity was 6,000 disintegrations per minute per plot. In the case of the corn plot the runoff was 38.76 liters and the activity 107,000 disintegrations per minute. For the fallow crop plot the runoff was 680.96 liters and the activity 290,000 disintegrations per minute. The runoff expressed as inches showed for the meadow a trace; the corn plot, .02; the fallow plot, .33 inches. The activity and the runoff of water of I-131 in relation to crop cover in the fall of 1961 revealed that when the inches of runoff were less than .01 the accompanying activity was very low being less than 10,000 disintegrations per minute per plot. Runoff of .05 inches from the fallow crop resulted in a removal of 3,863,000 disintegrations per minute per plot per activity. Activity in the runoff water was easily measured and was more quantitative than measurements of runoff. Runoff which reaches hundredths of an inch in magnitude will result in runoff and activity measurements of value. Runoff erosion experiments will be rerun for I-131 and Cerium 144. Studies will be initiated on the effect of the growth of forages as influenced by the additions of nitrogen and other fertilizers on the concentrations of plant strontium, carbon, and cesium.

Publications: Graham, E. R., M. W. Clar, V. E. Renner. Removal of Radioactive Fission Products from Surface Water Supplies. Missouri Agricultural Experiment Station Research Bulletin No. 787, 1961.

Cooperation: AEC

(Project 418)

ISOTOPE STUDIES ON SOILS AND SOIL PLANT RELATIONSHIPS. (E. R. Graham, T. R. Fisher, V. E. Renner, P. M. Smith). The maintenance and improvement of the soil fertility level of Missouri is a continuing problem. Knowledge of the effect of soil water on the distribution of specific elements will be a great help on this problem.

The Rate of Isotopic Exchange. Isotopic exchange phosphorus rate studies have shown that soils containing a high level of phosphorus and high sand content have a relatively slow rate of isotopic exchange. Soils of medium texture and medium phosphorus level have a medium rate and soils which have a high clay content and a low phosphorus content have revealed a very rapid rate. When available phosphorus was harvested by growing a rye crop and correlated against chemical tests for extractable phosphorus or isotopic exchangeable phosphorus the resulting correlation was excellent.

The Distribution Coefficient of Trace Elements. Studies have been made to determine the most suitable way of handling the distribution co-efficient or selectivity number of trace elements. A concentration factor influenced results obtained with the soil colloid, illite, montmorillonite, and Putnam, probably due to the effect of CaCl_2 . This was not a factor for colloids, kaolin, and organic materials.

The Completeness of Exchange and the Exchange Capacity of Soils. Isotopic exchange studies on soils of Missouri to determine the completeness of exchange and the exchange capacity have shown the following: An isotope exchange performed with Ca-45 resulted in an excellent reproductability and a correlation with the values for exchange Ca and exchange capacity determined with ammonium acetate. When isotope exchange determinations were made with Na-22, Mg-28, and K-42, and equilibration carried out at room temperature results were adequate for the amount of exchange ions and low for exchange capacity. Exchange studies with phosphorus will be continued.

Publications: Graham, E. R., D. D. Killion. Soil Colloids as a Factor of the Uptake of Cobalt, Cesium, and Strontium by Plants. Soil Sci. Soc. Amer. Proc. (in press). (Project 417)

HEAVY CLAYS IN THE SOILS OF MISSOURI. (C. E. Marshall). Missouri has many soils of heavy clay content. These studies are to develop a better understanding of the behavior of heavy clays in chemical mineralogical terms. The effects of lime and of fertilizers on soils can be understood only with reference to such basic knowledge. Much experimental material on the electrochemistry of bentonite suspensions was accumulated during the summer of 1960. During 1961 extensive calculations have been made on the potentiometric and conductometric data obtained previously. It was found that a consistent description of the electri-

cal double layer resulted when all the data were combined. The values for conductivity agreed reasonably well with those calculated, using a theory of O'Konski as applied to platy particles. During the coming year it is planned to use these methods with a variety of clay materials and exchange cations.

Publications: Deshpande, K. B., C. E. Marshall. The Electrical Double Layer and Surface Conductivity in Sodium Montmorillonite Suspensions. Journal of Physical Chemistry (in press). (Project 6)

WEATHERING OF SOIL MINERALS. (C. E. Marshall, C. L. Scrivner). The weathering processes in soils and rocks are fundamental to soil formation. These studies will provide information on the way in which locked up mineral nutrients slowly become available to plants. Extensive material on surface reactions of micas has been prepared for publication. The polyfunctional character of mica surfaces in exchange reactions has been well shown by these data. The dioctahedral and trioctahedral micas formed two groups with distinctly different exchange characteristics and the calcium mica margarite was entirely different from all other mica studies. The sensitive nature of the surface properties in relation to the detail of crystal structure was well illustrated by the micas. The selectivity curves so successful in the case of the micas will be applied as far as possible to other minerals. A new phase of the project will be the preparation of synthetic minerals of known composition on which studies of surface reactions can be performed.

Publications: McDowell, L. L., C. E. Marshall. Ionic Properties of Mica Surfaces. Soils Sci. Soc. Amer. Proc. (in press).

Marshall, C. E. Reactions of Feldspars and Micas with Aqueous Solutions. Economic Geology (in press).

Cooperation: NSF (Project 414)

VETERINARY MEDICINE

A. H. Groth, Chairman

HOG CHOLERA IMMUNIZATION. (C. Elder, A. H. Groth, D. E. Rodabaugh, H. Wright). Difficulty has been experienced in developing a strong immunity against hog cholera. In many cases for some reason the animals were not protected against field exposure although the vaccination apparently was performed properly. Autopsy of these animals showed characteristic hog cholera lesions.

This year 24 pigs were given virulent cholera virus, 24 were fed Salmonella choleraesuis, 24 were injected with hog cholera virus and fed Salmonella. With virus alone three developed temperatures but no other signs of illness. Twenty-four pigs receiving Salmonella cultures developed temperatures above 105°F. All were back to normal in 3 to 4 days. Pigs exposed to virus and Salmonella had the same type of reaction as those exposed to Salmonella alone. In another experiment 56 pigs vaccinated with SWIVAX previously, were exposed to virus and to Salmonella. In the pen receiving cholera virus alone 9 pigs developed temperatures, 3 died with symptoms and lesions of hog cholera. In another pen 22 hogs developed temperatures, 3 died. Pigs raised under optimum conditions of pasture and balanced diet withstood the challenge of hog cholera virus and Salmonella infection. Pigs on concrete had less immunity, or increased time between vaccination and challenge caused lower antibody level. Salmonella choleraesuis and hog cholera had no synergistic relationship. Work will be continued with the possible role of Salmonella infection interfering with production of immunity to hog cholera. (Project 140)

SWINE ENTERITIS. (C. Elder, H. B. Wright, A. H. Groth). Enteritis in swine is wide spread throughout the central states. Many swine producers in Missouri have had heavy losses from the various forms of this disease.

Swine enteritis has been consistently produced with Salmonella Choleraesuis. When pigs went off feed and their temperature rose, water consumption went down. This indicated that the administering of drugs to sick animals in drinking water was not practical. Symptoms, effects, and death rate were most severe with swine that were raised on concrete. Least affected were those maintained on pasture from farrowing until age of exposure. Environment of the host prior to exposure was important in the pathogenesis of swine enteritis. This project is Missouri's contributing project to NC-13 which is being closed and therefore, this project also is being closed. Work with swine enteritis will continue under project 326.

Cooperation: States of the North Central Region (NC-13) (Project 448)

SALMONELLA CHOLERAESUIS. (C. Elder, H. B. Wright, A. H. Groth). The Salmonella choleraesuis organism has been for many years associated with enteric disease in swine. In many cases the role of this

agent has been that of a primary pathogen. Salmonella choleraesuis has been isolated from the intestinal tract of swine which were without clinical evidence of disease.

A nitrofurantoin product was used in an effort to obliterate the effects of vaccination stress and super imposed Salmonella choleraesuis infection. The results were encouraging. The treatment appeared to suppress the effect of infection when fed either at the time of exposure and continued for 6 weeks or when fed one week prior to infection and continued for a like period. These results were based on a limited number of animals. Infected pigs were less affected when raised on pasture from farrowing until exposure. Those raised on concrete were the most affected. The pathology found in those dying was essentially the same as that commonly associated with field cases of necrotic enteritis. This project along with project 448 was a contributing project to NC-13. Since the regional project is being terminated this project is being rewritten with new objectives and will be continued.

Cooperation: States of the North Central Region (NC-13)

(Project 326)

LEPTOSPIROSIS. (D. C. Blenden, A. H. Groth, V. Patel, H. S. Goldberg, P. Kuppaswamy). Leptospirosis in a few short years has become a very important infectious disease of domestic animals. Missouri suffers in the economic loss caused by this disease. In addition to the cost to farmers, humans can contract this disease from livestock and pests.

During the year the battery of leptospiral antigens to which serums are reacted has been increased to 12, insuring complete testing. Titers to unusual antigens have been detected. Fluorescent antibody staining has been incorporated into the laboratory regime with a high degree of success. The results of the leptospirosis tests made by the Missouri Department of Agriculture have been analyzed and showed that 1,402 samples out of 20,700 (6.1%) were positive for L. pomona. Metabolic tests conducted on virulent and non-virulent leptospire show a marked difference between the two. The work next year will be continued with emphasis on the effects of experimental leptospirosis. Also, the skin test antigen will be used with experimentally infected animals.

Publications: Mishra, A. Studies on Leptospirosis. A thesis presented in partial fulfillment for the degree, Master of Science, Graduate School, University of Missouri.

Blenden, D. C., H. S. Goldberg, P. Kuppaswamy. Studies on the Skin Tests for Leptospirosis. American Journal of Veterinary Research, 22, 91, 1081-1084, 1961.

Cooperation: School of Medicine, USPH

(Project 375).

PNEUMONIA ENTERITIS IN CALVES. (C. Elder, A. H. Groth, D. E. Rodabaugh, H. B. Wright). The pneumonia enteritis syndrome of calves has been a serious detriment to the production of sturdy, fully developed animals for many years, especially among the dairy breeds. Each year there are serious outbreaks resulting in heavy losses in weight gains and even death of many individuals.

Efforts were made to produce pneumonia enteritis syndrome with para-influenza 3 virus, *Pasteurella multocida* and *Pasteurella hemolytica*, or combination of the two. Para-influenza 3 virus alone produced fever, anorexia, and slight nasal discharge. In three days the calves recovered. *Pasteurella* species alone produced no illness. In those exposed to virus and *Pasteurella* there were more severe reactions including elevated temperature, scouring, anorexia, copious nasal discharge, and a soft non-productive cough. All were normal in 7 days. Nasal material from these calves introduced into the nose of three beef calves running with dams produced no effects. Twenty-eight days after the original exposure all calves were given para-influenza 3 virus by nasal installation. Calves previously exposed to virus showed no reaction, calves exposed to *Pasteurella* developed slight temperature, refused to feed, had a mild cough, but recovered promptly. Difficulty was experienced in standardizing antigen in hemagglutination-inhibition tests. Virus isolation was successful in one calf. Further work will be continued and attempts made to produce artificial cases of the syndrome.

(Project 412)

INTERNAL PARASITES OF RUMINANTS. (G. C. Shelton, A. H. Groth). The livestock industry in Missouri ranks foremost among all of our agricultural industries. However, the climate of Missouri is such as to encourage the development of internal parasites as a major disease problem in ruminant animals. Lambs were infected with pure strains of certain internal parasites. This year 12 lambs were on the experiment and were weighed each week over a period of 16 weeks. Weights did not vary more than 7 pounds between the three controls and the 9 inoculated lambs. Hemoglobin was determined once each week throughout the 16 weeks and varied only from 11.5 to 13.5 to which significance is not attached. The total white blood cells was counted once each week. Three lambs received 20,000 eggs developed to their larvae stage. When these parasites developed to patency, the lambs were then dosed with 100,000 larvae of the same species. The second dose caused an increase of 15,000 white blood cells in the total counts. Otherwise, in the remaining two inoculated groups there was no particular response as determined by total white cell counts. The egg counts of the arti-

ficially parasitized lambs were of interest in that three lambs receiving 20,000 larvae at the end of 16 weeks had an egg count of 25,000. In lambs receiving the first 20,000 larvae and later 100,000 at the end of 16 weeks only 1,507 were noted. In the third group where the lambs received 100,000 larvae as an initial dose the average count at the end of 16 weeks was 5,539. The group which received 2 doses of larvae was most interesting in that *T. axei* developed from this group were exceedingly small compared with those developed from the first group of larvae. (Project 108)

THE CEREBAL CIRCULATION OF SHEEP. (H. E. Dale). In dealing with sick animals, it is apparent that mental changes accompany diseases. These changes are manifested by depression, anxiety, inappetence, etc., and are employed as criteria for the fact that the animal is sick. A study of the physiology of the adnexa of the central nervous system may add to the knowledge of mental disease. The intracranial vasculature was studied in 18 animals, most of which were obtained from the necropsy room. Ten heads were studied by corrosion methods, six were dissected, and one live animal was studied by serial and cine angiographic techniques and the histological structure of the rete mirabile was obtained from one animal studied. Apparently arterial blood was supplied to the brain from the internal maxillary artery by way of the rete mirabile, and the superior sagittal sinus was the only place from which to collect pure cerebral venous blood. This made further investigation of the function of the carotid rete mirabile necessary. Progress was made in the adaptation of the nitrous oxide method for use in sheep. (Project 443)

SALMONELLOSIS IN TURKEYS. (H. C. McDougale, A. H. Groth, C. L. McCune). Salmonellosis is a problem in poults and adults wherever turkeys are produced and grown. Testing records for Missouri indicate a low amount of *S. pullorum* infection. However, only the 4+ birds are indicated as reactors. Many lessor reactors are removed from flocks and are not indicated as reactors. Three toms were each conditioned with 300 milligrams of cortisone acetate intramuscularly over a period of 6 consecutive days. On the sixth day they were injected intramuscularly with one ml of a 24 hour broth culture of *S. pullorum*. All three birds had a titer of 1 to 200 or higher on the seventh day following the injection. *S. pullorum* was not isolated from the blood or feces throughout the entire titer period which was only 32 days. Later the same birds were re-injected intramuscularly using 0.5 ml of a 24 hour broth culture of *S. pullorum*. Seven days post injection all had a titer of 1 to 100 or over. Titers from this second injection were over 1 to 200 at only one bleeding date, nine days post injection. Titers from the first injections of this group were over 1 to 12,800 for seven consecutive days. One of the turkeys died later and still retained a titer of 1 to 100. *S. pullorum* was not isolated. Another tom developed a titer from the second injection which has persisted for 9 months. The third tom carried a titer for 5 months and 15 days but now is negative. Three other turkeys were each conditioned for a total of 300 mg. of cortisone acetate, 100 mg. being given intramuscularly on three consecutive days. On the last day of cortisone injection 0.5 ml of the 24 hour broth culture of *S. pullorum* was injected intramuscularly into their right shoulders. Six days post injection all turkeys had a titer of 1 to 200 or over. All titers for a consecutive period of 20 days were over 1 to 1600. One turkey carried a titer of 1 to 800 or higher for almost 10 months. For comparison three other turkeys were injected intramuscularly with one ml. of the seven hour broth culture of *S. pullorum*. *S.* was isolated from a fecal sample of a poult hatched from one of these turkeys. These turkeys retained their injection titer for 34 days. Six turkeys served as uninoculated controls. All remained healthy. (Project 176)

INFECTIOUS SYNOVITIS. (E. L. McCune, A. H. Groth). Joint and tendon sheath infections are the most frequent diseases observed in turkeys in the Diagnostic Laboratory.

Transmission of an infectious arthritic condition was successful in four of thirteen attempts with material from field cases. Partial maintenance of agents in storage was indicated by the successful reproduction of synovitis in one of six attempts. This was with one suspension of pooled tendon sheath exudate and liver tissue stored 9 months at -70°C. Studies were made from data contained in the records of the Poultry Diagnostic Laboratory. Synovitis was classified as a transmissible disease incubating in 7 to 12 days producing symptoms and lesions commonly described as infectious synovitis without demonstrable bacteria or concurrent lesions of other disease. Staphylococcus was recorded when purulent arthritis and synovitis were found with or without general systemic lesions and from which bacteria of the genus Staphylococcus were isolated. Arthritis was recorded when transmissibility and cultures for bacteria were negative in the presence of arthritis as the major lesion. (Project 308)

PULLORUM TESTING. (H. C. McDougale, A. H. Groth, E. L. McCune). Missouri is a poultry exporting state and poultry produced in Missouri must meet or surpass standards established by importing states. The purpose of this work is to provide the tube agglutination test materials for the detection of pullorum disease in turkeys and to type Salmonellas that are isolated. During the year 27,109 samples were tested to detect carriers of *S. pullorum*, and 26,260 tests were conducted to determine carriers of *S. typhimurium*. S.

pullorum antigen was produced and distributed to test 159,000 samples and in addition to that used in this laboratory there is on hand enough to test 40,000 additional samples. Of the *S. typhimurium* antigen enough was produced to test 200,000 samples and in addition to that used in this laboratory there is on hand enough to test 270,000 additional samples. Thirteen species of *Salmonella* were isolated from 51 Missouri flocks. Serological typing was used to determine the species. Chemical typing was used for variations in *S. pullorum*. Diagnosis was made on 2,748 specimens, brought or sent to the Poultry Diagnostic Laboratory. This work will be continued. (Project 145)

DISEASES OF GOATS. (H. C. McDougle, A. H. Groth). Dairy goat owners have requested experimental work on caseous lymphadenitis. Efforts are underway to isolate and classify agents causing this disease. A series of biochemical tests were made on isolations from goat abscesses. These were all dextrose positive acid in TSI and failed to utilize other carbohydrates. They were also SIM and urease negative. Inoculation of guinea pigs with *C. ovis* caused them to lose weight within three days. Upon being killed, four days post inoculation, peritoneal abscesses and abscesses throughout various organs were present. The organism was readily reisolated. Mice inoculated on the same date remained healthy. Investigations of goat management practices have been made with special emphasis centered on predisposing factors. Four goats, as indicated in last year's report, were injected on the left side. The disease did not spread to their right side. This year two other goats were injected on their right sides with a different strain of *C. ovis*. One of the goats injected on the left side the previous year was exposed to the same strain as were the latter two goats on the other side of the body. This strain of *C. ovis* appeared to be as pathogenic as the first strain since all animals injected developed abscesses. (Project 414)

ENDOCRINE MODIFICATION OF THE CANINE ESTRUS CYCLE. (H. E. Dale). The combined periods of proestrus and estrus in the bitch may last as long as thirty days. During this time, because of the attraction of male dogs, a house dog loses much of her attraction as a pet and a working dog may have to be confined to the kennel during a time when the owner needs her services the most. A total of 117 bitches have been studied to date, 35 during the past year. These dogs have been assigned to various treatment groups. The duration of proestrus and estrus has been estimated by cytological changes in the vaginal smear. An analysis of the data is being made to determine whether the various treatments have had an effect on the length of proestrus and estrus. The work will be continued next year. (Project 368)

Publications of the Agricultural Experiment Station

JULY 1, 1961 - JUNE 30, 1962

RESEARCH BULLETINS

- 763 Studies on Calcium Requirements of Ewes, by Stanley F. Erwin, G. B. Thompson, and W. H. Pfander, 36 pp.
- 764 Dwarfism in Beef Cattle and the Influence of Dwarfism Genes on Physiological Response to Hormone Induced Stress, by S. E. Curl, J. E. Comfort, and J. F. Lasley, 64 pp.
- 765 The Soil, Its Broader Implications, by William A. Albrecht, 88 pp.
- 766 Carcass Evaluation in Live Hogs, by C. J. Heidenreich, L. F. Tribble, S. E. Zobrisky, and J. F. Lasley, 60 pp.
- 767 Metabolic Rate and Food Utilization as a Function of Body Size, by Max Kleiber, 44 pp.
- 768 Meat Buying and Storage Practices of 61 Columbia, Missouri, Homemakers by Patricia L. Benson and Mahla Ivey, 20 pp.
- 769 Root Development and Lodging Resistance in Oats, by Dale T. Sechler, 40 pp.
- 770 Environmental Physiology and Shelter Engineering, LVII, by H. D. Johnson, A. C. Ragsdale, John D. Sikes, James I. Kennedy, E. B. O'Bannon, Jr., and D. Hartman, 26 pp.
- 771 Weather Variability and Economic Analysis, by James D. McQuigg, and John P. Doll, 40 pp.
- 772 Creep Feeding Studies With Lambs, by C. V. Ross, M. L. Karr, and R. L. Payey, 16 pp.
- 773 Practical Tests With Anthelmintics for Grazing Lambs, by C. V. Ross, and G. C. Shelton, 16 pp.
- 774 Reproductive Performance of Swine Fed Different Planes of Energy During Gestation, by B. T. Dean, and L. F. Tribble, 44 pp.
- 775 The Leucocytic Response of Swine to Stilbestrol and a Progesterone-Estradiol Combination, by B. N. Day, J. L. Lasley, H. E. Addleman, and L. F. Tribble, 16 pp.
- 776 Populations of European Corn Borer *Ostrinia nubilalis* (Hbn.) in Field Corn, *Zea mays* (L.), 96 pp.
- 777 Consumer and Laboratory Panel Evaluation of Good and Choice Beef Loins, by H. D. Naumann, Curtis Braschler, Margaret Mangel, and V. James Rhodes, 48 pp.
- 778 Terrace Channel Design Using the Spatially Varied Flow and Tractive Force Theories, by D. K. McCool, and R. P. Beasley, 32 pp.
- 779 Health in Two Missouri Counties: A Comparison and Summary, by Edward W. Hassinger, and Robert L. McNamara, 24 pp.
- 780 Determining Maximum Net Returns For Cropping Systems on Marshall Soil Using Linear Programming, by Howard D. Utter, and Fred E. Justus, Jr., 48 pp.
- 781 Characteristics of Missouri Livestock Auction Markets, by Durward Brewer, 44 pp.
- 782 A Comparative Study of Laws Relating to Low-Equity Transfers of Farm Real Estate in the North Central Region, by Fred L. Mann, 64 pp.
- 783 Effect of Female Sex Hormones, Thyroxine, and Vitamin B₁₂ on Embryonic Mortality in Rats by Mostafa S. Fahim, D. T. Mayer, and J. F. Lasley, 36 pp.
- 784 The Influence of Soil Textural Stratification and Compaction on Moisture Flow, by J. R. Eagleman, and V. C. Jamison, 16 pp.
- 785 Environmental Physiology and Shelter Engineering, LVIII., by T. H. Kamal, H. D. Johnson, and A. C. Ragsdale, 116 pp.
- 786 Environmental Physiology and Shelter Engineering, LIX., by H. D. Johnson, A. C. Ragsdale, and R. G. Yeck with Assistance of Joan F. Jones, 40 pp.
- 787 Removal of Radioactive Fission Products From Surface Water Supplies, by E. R. Graham, Marion W. Clark, and Vernon E. Renner, 12 pp.
- 788 Correlation of Drouth Indices with Corn Yields, by Roy L. Ewalt, John P. Doll, and Wayne L. Decker, 32 pp.
- 789 The Biology of the Red-Banded Leaf Roller, (*Argyrotaenia Velutinana*) (Wlkr.), In Missouri, With Notes On Its Natural Control, by Earl R. Oatman, and Lee Jenkins, 16 pp.
- 790 Selected Environmental Factors Associated With Farm and Farm Home Accidents in Missouri, by Saad M. Gadalla, 116 pp.

- 791 Environmental Physiology and Shelter Engineering, LXII, by H. D. Johnson, A. C. Ragsdale, I. L. Berry, and M. D. Shanklin, with Technical Assistance of Sandra McLarney, 40 pp.
- 792 Environmental Physiology and Shelter Engineering, LX, by H. H. Kibler, R. G. Yeck, and I. L. Berry, 28 pp.
- 793 Environmental Physiology and Shelter Engineering, LXI, by H. H. Kibler, 32 pp.
- 794 Environmental Physiology and Shelter Engineering, LXIII, by B. F. Cargill, R. E. Stewart, and H. D. Johnson, 32 pp.
- 795 Irrigation Practices and Costs in Southeastern Missouri--1960, by Ted L. Jones, and Frank Miller, 44 pp.
- 797 Nitrogen Fertilization of Soybeans, by G. H. Wagner, 24 pp.
- 798 Where Ozark Tourists Come from and Their Impact on Local Economy, by Ronald Bird, and Frank Miller, 48 pp.
- 799 Contributions of Tourist Trade to Incomes of People In Missouri Ozarks, by Ronald Bird, and Frank Miller, 72 pp.
- 800 Comparative Influence of Hardwood Trees, Litter, and Bare Area on Soil-Moisture Regimen, by Howard W. Lull, and Peter W. Fletcher, 16 pp.
- 801 Environmental Physiology and Shelter Engineering With Special Reference to Domestic Animals, LXIV, by I. L. Berry, and Milton D. Shanklin, 80 pp.
- 802 Environmental Physiology and Shelter Engineering, LXIV, by I. L. Berry, and Milton D. Shanklin, 32 pp.
- 803 Soybean Insects, and Related Arthropods in Missouri, by C. C. Bickenstaff and J. L. Huggans, 52 pp.
- 804 A Study of the Circulating Leucocytes in Swine, by F. E. Romack, J. F. Lasley, and B. N. Day, 12 pp.

Station Bulletins

- 769 Missouri College of Agriculture Through A Half Century in Retrospect, by M. F. Miller, 68 pp.
- 770 Annual Report for 1959-1960, by J. H. Longwell, and S. B. Shirky, 188 pp.
- 771 Your Audience--What's It Like, by Rex Campbell, and John Bennett, 20 pp.
- 772 The Soils of Lamine and Blackwater Townships of Cooper County, by C. L. Scrivner, J. C. Baker, 20 pp.
- 773 Changes in Missouri Farming, (Taken from Census Report) 8 pp.
- 774 Farm Machinery, Investment and Use, Based on a Study in Northeast Missouri, by Donald C. Huffman and Fred E. Justus, Jr., 20 pp.
- 775 Improvement of Swine Through Breeding, by J. F. Lasley, B. N. Day, and L. F. Tribble, 20 pp.
- 776 Humidity and Cotton Harvesting in the Missouri Delta, by J. D. McQuigg, and Wayne L. Decker, 16 pp.
- 777 The Weather and Hay Making in Missouri by Earl Borgman, and D. B. Brooker, 8 pp.
- 778 Missouri Commercial Fertilizer Inspection and Analysis 1960-61, by Elmer R. Kiehl, 36 pp.
- 779 Timber Resources of the Eastern Ozarks, by Joseph J. Mendel, 76 pp.
- 780 Health Insurance in a Small Missouri Town: Rural Health Series, Publication 18, by Edward Hassinger, 8 pp.
- 782 Missouri Cattle Markets, by Durward Brewer, 48 pp.
- 786 The "Joiners"...What Are They Like? by Rex Campbell, 12 pp.
- 787 Agricultural Production Trends, In Missouri Counties 1939-1959, by Elias N. Saig, and John P. Doll, 76 pp.

SUMMARY OF PUBLICATIONS

	<u>Number of Publications</u>	<u>Number of Pages</u>	<u>Number of Copies</u>
Research Bulletins	41	1762	65,700
Station Bulletins	<u>15</u>	<u>624</u>	<u>52,500</u>
TOTAL	56	2386	118,200

GRANTS, GIFTS, CONTRACTS, AND COOPERATIVE ALLOTMENTS

For the Year July 1, 1961 to June 30, 1962

Agricultural Chemistry

<u>Project</u>	<u>Donor</u>	<u>Purpose</u>
56	Dept. of Health, Education and Welfare, U. S. P. H.	Therapeutic Factors in a Hemophilia-Like Disease
81	Dept. of Health, Education and Welfare, U. S. P. H.	Basic Biochemical Investigation of Germ Cells
81	Dept. of Health, Education and Welfare, U. S. P. H.	Chemistry and Physiology of Spermatozoa and Ova
132	National Science Foundation	Determination of Amino Acids by Gas Chromatography
132	Dept. of Health, Education and Welfare, U. S. P. H.	Study size, shape, and structure of Proteins
137	Monsanto Chemical Company	Amino Acid requirements of the Chick
149	National Science Foundation	Nutrients required by Guinea Pigs
151	Dept. of Health, Education and Welfare, U. S. P. H.	Determine effect of Maternal Nutrition on Developing Embryo
151	Dept. of Health, Education and Welfare, U. S. P. H.	Vitamin B ₁₂ in Embryonic Development and Aging
152	Feed Service Corporation	Urea and Nitrate Nitrogen in Ruminant Rations
212	Dept. of Health, Education and Welfare, U. S. P. H.	Folic Acid and Biotin, Extraction and Assay; Methodology
247	Dept. of Health, Education and Welfare, U. S. P. H.	Biochemical Lesions in Nutritional Muscular Dystrophy
247	Moorman Mfg. Company	Effects of Nitrate on Lactating Cows

Agricultural Economics

<u>Project</u>	<u>Donor</u>	<u>Purpose</u>
386	Myron Green Cafeterias	Aid to Food Service Industry

Agricultural Engineering

<u>Project</u>	<u>Donor</u>	<u>Purpose</u>
43 & 227	United States Dept. of Agriculture	Soil and Water Conservation Management
282	Farm Electric Council	Use of Electricity on Missouri Farms

Animal Husbandry

<u>Project</u>	<u>Donor</u>	<u>Purpose</u>
3	United States Dept. of Agriculture	Breeding of Swine
142	William Cooper & Nephews, Inc.	Controlling Stomach Worms in Fattening Lambs
168	Dept. of Health, Education and Welfare, U. S. P. H.	Role of Stilbenes in Growth & Nitrogen Storage of Lambs
168	American Dehydrators Assn.	Utilization of Energy in Ruminant Rations
168	American Dehydrators Assn.	Can Alfalfa Enhance the Utilization of Energy in Ruminant Rations
222	Dept. of Health, Education and Welfare, U. S. P. H.	Maintenance of the Corpus Luteum in Gilts
248	U. S. Atomic Energy Commission	Phosphorous Metabolism in Ruminants - Radioactive
355	Sethness Products Co.	Effect of Flavors & Odors in Rations for Swine

356	Swift & Co.	Varied Protein & Energy Rations for Fattening Lambs
397	Eli Lilly & Company	Evaluating Red Meat Animal Carcass
398	Kansas City Stockyards Co.	Partial Purchase of Ultrasonic Device
398	St. Joe Stockyards Co.	Partial Purchase of Ultrasonic Device
398	Missouri Bus and Truck Assn.	Partial Purchase of Ultrasonic Device
398	Missouri Production Credit Assn.	Partial Purchase of Ultrasonic Device
447	Dept. of Health, Education, and Welfare, U. S. P. H.	Rations that Cause Metabolic Disorders
465	U. S. Atomic Energy Comm.	Radioactive Studies of Body Composition

Dairy Husbandry

<u>Project</u>	<u>Donor</u>	<u>Purpose</u>
28	Dept. of Health, Education and Welfare, U. S. P. H.	Supply Grant for Dr. W. R. Miller, Steriod Hormones of Bovine
28	Dept. of Health, Education and Welfare, U. S. P. H.	Endocrinology of Mammary Gland Growth & Lactation
28	Dept. of Health, Education and Welfare, U. S. P. H.	Estimation of Parathyroid Hormone Secretion Rate
28	American Cancer Society	Hormones & Enzymes involved in Mammary Gland Cancer
80	U. S. Atomic Energy Comm.	Radio-Active Isotopes in Productive Processes
125	Dept. of Health, Education and Welfare, U. S. P. H.	Study Ambient Temperature on Rate of Aging in Rats
200	J. C. Penny	Purchase of Guernsey Cattle
453	Missouri Butter & Cheese Institute, Inc.	Mild Quality as it Influences Milk Products'

Entomology

<u>Project</u>	<u>Donor</u>	<u>Purpose</u>
30	Shell Chemical Co.	Control of Insects in Crops Using Aldrin, Diedrin and Endrin
30	American Cyanamid Company	Evaluation of Organic Phosphates for Control of Field Crop Insects
30	Missouri Pest Control Assn.	Research in Entomology
36	Entomology Research Division U. S. D. A.	Taxonomic Research
269	Hercules Powder Company	Toxaphene for Crop Insect Control
269	Velsicol Chemical Corporation	Evaluation of Insecticides
269	Shell Chemical Company	Reasearch in Entomology
312	Shell Chemical Corporation	Chemicals in Soil for Control of Nematodes

Field Crops

<u>Project</u>	<u>Donor</u>	<u>Purpose</u>
48	National Science Foundation	Study of Genes
48	National Science Foundation	Analysis of Unorthodox Genetic System in Maize
49	Dannen Mills, Inc.	Soybean Quality Improvement
85	Missouri Farmers Assn.	Hybrid Corn
85	Quaker Oats Company	Improving White Corn Hybrids
85	Hercules Powder Company	Effects of Seed Treatments on Stored Seed
85	Corn Industries Research Foundation	Development of High Amylose Corn
90	Anheuser Busch, Inc.	Breeding and Genetics of Winter Barley
127	Dept. of Health, Education and Welfare, U. S. P. H.	Host-Parasite Relations in Papilionoideae Legumimosae
156	Missouri Farmers Assn. Oil Co.	More Efficient, Effective and Safer Weed Controls
156	Missouri State Highway Comm.	Control and Eradication of Johnson Grass

156	Dow Chemical Company	Chemical Methods of Control of Johnson Grass
156	Am. Chem. Products, Inc.	Weed Control Research in Soybeans
156	Am. Chem. Products, Inc.	Use of 2; 4-D Formulations on Corn
156	Geigy Chemical Corporation	The Fate of Herbicides in the Soil
160	Bucoda Gin Company	Cotton Improvement
202	Regional Plant Intr. Station	Seed Increase for Approximately 30 Crop Species for Industry
261	National Science Foundation	Cytogenetic Study of Polyploid Species of Wheat
322	Hercules Powder Company	Fungicides for Cotton Seedling Diseases
322	Ansul Chemical Company	Cotton Defoliation
331	National Science Foundation	Physiological Genetics of Mutation in Aribidopsis
332	Union Carbide Chemical Company	Cotton Weed Control and Defoliation
332	Ansul Chemical Company	More Effective and Efficient Cotton Defoliation

Forestry

<u>Project</u>	<u>Donor</u>	<u>Purpose</u>
443	Forest Service U. S. D. A.	The Distribution of Auxin and the Influence of Light upon this Distribution in Black Oak
443	National Science Foundation	Factors Influencing Basal Sprouting in Oaks
450	Forest Service U. S. D. A.	Sawmill Efficiency

Horticulture

<u>Project</u>	<u>Donor</u>	<u>Purpose</u>
27	Dept. of Health Education and Welfare, U. S. P. H.	Interactions Plant Hormones and Antimicrobial Agents
68	Stark Bros. Nursery	Joint Discussions on Horticulture Crop Virus Diseases-Mr. Roy Cropley, East Malling Research Station, England.
68	State Dept. of Agriculture	Indexing of Fruit Trees for Virus Diseases
146	Am. Chemical Products, Inc.	Research in Weed Control
146	Diamond Alkali Company	Use of Chemicals to Control Weeds
146	Ansul Chemical Co.	Evaluation of Chemicals for Control of Crabgrass
146	Velsicol Chemical Co.	Evaluation of Certain Chemicals for Use in Controlling Lawn and Turf Weeds
169	Stark Bros. Nursery	Discussion of Dwarf Fruit Trees-Dr. A. P. Preston of England
194	Upjohn Company	Studies with Spraying Materials
194	Rohn & Haas Company	Research on Fruit Fungicides
194	National Grape Coop. Assn., Inc.	Concord Grape Nutrition and Disease Control
195	Union Carbide Chemical Co.	Use of Chemicals to Control Flowering
285	Herman Frasch Foundation	Philosophy and Inactivation of Plant Virus Diseases
293	Floral Industries Assn., Inc.	Research in Floriculture
466	Missouri Valley Carnation Growers, Assn.	Research on Carnations

Poultry

<u>Project</u>	<u>Donor</u>	<u>Purpose</u>
17	F. M. Stamper Company	Help Purchase Egg Dryer
17	William S. Harvath	Help Purchase Egg Dryer
17	Henderson Produce Company	Help Purchase Egg Dryer
17	Armour & Company	Help Purchase Egg Dryer
17	Monarch Egg Corp.	Help Purchase Egg Dryer
17	Refrigeration Research Foundation	Studies on Heat Transfers on Poultry Meat
164	United States Dept. of Agriculture	Breeding of Poultry

244 Ford Motor Company Housing of Layers and Efficiency of Egg Production

Rural Sociology

<u>Project</u>	<u>Donor</u>	<u>Purpose</u>
201	Dept. of Health, Education and Welfare, U. S. P. H.	Farm Accidents in Missouri
201	Dept. of Health, Education and Welfare, U. S. P. H.	Local Public Health Nurse in Non-metropolitan Areas
201	Missouri Dept. of Public Health & Wel- fare	Information about Meaning of Heart Disease Held by the Public
306	Union Electric Company	Small Community Development

Soils

<u>Project</u>	<u>Donor</u>	<u>Purpose</u>
178	National Plant Food Institute	Utilization of Nitrogen by Forages
178	Phillips Petroleum Company	Retention of Anhydrous Ammonia in Different Soils
178	Plant Nutrition Council	Publication of Soil Fertility Conference Paper
178	Phillips Petroleum Company	Residual Acidity of Anhydrous Ammonia on Solubility of Phosphate Rock
210	U. S. Dept. of Commerce Weather Bureau	Rate of Evapotranspiration of a Growing Crop
210	National Science Foundation	Remodeling Laboratory Facilities for Research in Atmospheric Sciences
263	International Minerals & Chemical Corporation	The Chemistry of Phosphate Fertilizers in Soils
263	American Potash Inst., Inc.	Chemical Characteristics of Potassium in Soils that Reflect Composition of Plants with Respect to Potassium
324	National Science Foundation	Cloud Research
414	National Science Foundation	Weathering and Surface Reactions of Soil Minerals
418	Atomic Energy Commission	Colloid Type Soil and Radio Nuclides

Veterinary Medicine

<u>Project</u>	<u>Donor</u>	<u>Purpose</u>
326	Hess & Clark	Therapeutic Value of Various Drugs on <u>S. Cholerasuis</u>
368	M. L. Morris Animal Foundation	Duration of Proestrus and Estrus- Hormones
375	Dept. of Health, Education and Welfare, U. S. P. H.	Epidemiologic Studies on Leptospirosis

FINANCIAL STATEMENT

UNIVERSITY OF MISSOURI
COLUMBIA

Divisions Exclusive of Medical Center and State Crippled Children Service

STATEMENT OF AGRICULTURAL EXPERIMENT STATION FOR THE YEAR ENDED JUNE 30, 1962

	Federal Appropriations							Working Capital	Total
	Hatch Act as Amended	Regional Research Fund	Agricultural Marketing Act	State Appropriations	Fertilizer Fees	Station Sales	Station Grants		
<u>INCOME</u>	\$726,339.00	\$134,800.00	\$53,000.00	\$1,216,040.00	\$260,678.24	\$654,977.02	\$454,481.12		\$3,500,315.38
<u>EXPENDITURES</u>									
Salaries and Wages	\$643,264.72	\$103,261.56	\$51,055.42	\$ 847,114.00	\$112,921.01	\$149,093.89	\$273,066.60		\$2,179,777.20
Traveling Expense	7,284.58	7,850.72	162.09	29,726.25	26,221.14	24,546.63	18,635.10		114,426.51
Repairs and Replacements	7,506.94	481.75	.03	61,209.63	9,596.40	27,980.99	14,613.97		121,389.71
Land, Buildings and Equipment	25,103.77	3,607.78	60.00	47,519.01	8,831.75	64,698.49	36,962.19		186,782.99
Other	43,178.99	19,598.19	1,722.46	230,471.11	89,400.58	460,333.44	73,490.50		918,195.27
	\$726,339.00	\$134,800.00	\$53,000.00	\$1,216,040.00	\$246,970.88	\$726,653.44	\$416,768.36		\$3,520,571.68
Excess of Expenditures over Income	\$ -	\$ -	\$ -	\$ -	\$ 13,707.36	\$ 71,676.42-	\$ 37,712.76	\$ -	\$ 20,256.30-
Transfer between funds							8,684.85		8,684.85
Balance, July 1, 1961					17,019.78	124,186.89	140,775.28	150,000.00	431,981.95
Balance, June 30, 1962	\$ -	\$ -	\$ -	\$ -	\$ 30,727.14	\$ 52,510.47	\$187,172.89	\$150,000.00	\$ 420,410.50

CHANGES IN STAFF For the Year Ending June 30, 1962

APPOINTMENTS

<u>Department</u>	<u>Beginning Date</u>	<u>Rank</u>
Agricultural Chemistry		
William R. Carroll	6-1-61	Instructor
Creighton N. Cornell	6-1-62	Instructor
Donald M. Henricks	9-1-61	Assistant
Krishna D. Singh	9-1-61	Assistant
Agricultural Economics		
Mildred S. Bradsher	2-1-62	Assistant
Fred Dopson	9-1-61	Assistant
William J. Free	7-1-61	Assistant
Jay F. Goold	9-1-61	Assistant
James Hendrix	7-1-61	Assistant
Nolan D. Heseman	7-1-61	Assistant
James C. Martin	9-1-61	Assistant
Edwin Pfuehler	2-1-62	Assistant
William N. Ross	2-1-61	Assistant
James N. Shoemaker	2-1-62	Assistant
Donald H. Silva	7-1-61	Assistant
John Squibb	9-15-61	Assistant
Gary Van Winkle	9-1-61	Assistant
Dorwin L. Williams	5-1-62	Instructor
Agricultural Editor		
Robert J. Hodgson	5-1-62	Assistant
Donald M. Springer	1-1-62	Assistant Agr. Editor

Agricultural Engineering		
Leroy G. Hahn	8-1-61	Research Associate
John P. H. Mason	5-1-62	Instructor
Neal E. Minshall	2-1-62	Research Associate
Byron H. Nolte	2-1-62	Assistant
Harold V. Walton	1-1-62	Professor
David A. Woolhiser	2-1-62	Research Associate
Animal Husbandry		
William J. Eaton, Jr.	9-1-61	Assistant
Richard C. Gray	9-1-61	Assistant
Paul F. Gould	9-1-61	Assistant
Wayne E. Loch	9-15-61	Assistant
Andrew J. Monson	9-1-61	Assistant
Marvin G. Moosé	9-1-61	Assistant
Jimmy D. Neill	9-1-61	Assistant
Stanley L. Oxenreider	6-10-62	Assistant
Lowell Schake	7-1-61	Assistant
Neal H. A. Scharre	9-15-61	Assistant
Dairy Husbandry		
Donald Grogan	7-1-61	Assistant
Chester E. Hendrich	10-16-61	Assistant
<u>Department</u>	<u>Beginning Date</u>	<u>Rank</u>
Frederic A. Martz	9-11-61	Assistant Professor
Director's Office Services		
John H. Letcher	10-1-61	Assistant, Chem. Lab.
Rahul K. Nandi	2-19-62	Assistant, Chem. Lab.
James Ussary	9-1-61	Assistant
John A. Waller	7-1-61	Assistant
Melvin Williams	7-1-61	Assistant, Chem. Lab.
Palamand S. Rao	5-1-61	Instructor, Agr. Chem.
Theodore S. Hermann	7-1-61	Asst. Spectrographic Lab.
Lewis B. Peggs	7-6-61	Technical Leader
Extension Education		
Robert M. Dimit	6-11-62	Visiting Professor
Entomology		
David M. Daugherty	7-27-61	Research Associate
Edwin C. Houser	5-14-62	Assistant
John W. Neal, Jr.	6-1-61	Assistant
Fertilizer Control		
Roger Q. Brown	2-20-62	Fertilizer Inspector
Noel A. Fischer	8-14-61	Fertilizer Inspector
Field Crops		
William D. Aycock	6-15-61	Assistant
E. M. Brown	3-17-61	Professor Emeritus
Paul Hoskins	8-1-61	Assistant
Arthur G. Matches	5-29-61	Research Associate
Robert E. Pettit	6-1-61	Instructor
Jimmy F. Stritzke	6-5-61	Research Associate

Forestry		
Hewlette S. Crawford	6-7-62	Research Associate
James P. Pastoret	2-1-61	Assistant Professor
Albert R. Vogt	6-5-61	Assistant
Home Economics		
Ruth E. Baldwin	9-1-61	Associate Professor
Uriel W. Carlton	6-7-62	Assistant
Lenora M. Costigan	9-1-61	Assistant
Diana D. Merrill	9-1-61	Assistant
Virgil A. Metcalf	2-1-62	Instructor
Mary L. Rosencranz	9-1-61	Associate Professor
Horticulture		
Richard P. Honeycutt	6-6-61	Assistant
Robert C. Jenne	6-7-61	Assistant
Maynard Johnson	9-1-61	Assistant
Shoji Kamimura	9-1-61	Assistant
Richard J. Shaw	7-10-61	Assistant
Barbara Zawadzka	4-24-61	Assistant
Poultry Husbandry		
Donal W. Bird	9-1-61	Assistant
Paul C. Harrison	9-1-61	Assistant
Donald D. Jackson	9-1-61	Assistant
Rural Sociology		
Thomas M. Anderson	1-8-62	Assistant
John L. Bennett	7-24-61	Assistant
Howard R. Delaney	2-22-62	Assistant
Charles E. Grubb	10-1-61	Assistant
John J. Hartman	9-1-61	Assistant
Paul Hopwood	6-1-62	Assistant
Patsy M. Keith	9-1-61	Assistant
Norman Knight	6-1-62	Assistant
Brian Meharg	6-4-62	Assistant
Perry G. Thompson	6-1-62	Assistant
Willard Wagner	10-15-61	Assistant
Soils		
Grant L. Darkow	9-1-61	Assistant Professor
Donald D. Killion	7-1-61	Assistant
Lynne C. Kratzer	2-1-62	Assistant
Bobby Joe Miller	6-1-61	Assistant
Sherrell A. Sanders	4-1-61	Assistant
Owen E. Thompson	6-1-62	Assistant
Veterinary Medicine		
P. K. Sinha	2-1-62	Assistant

RESIGNATIONS OR COMPLETION OF TERM

<u>Department</u>	<u>Effective Date</u>	<u>Rank</u>
Agricultural Chemistry		
Billy A. Erickson	8-31-61	Instructor
Ben C. Hardwick	3-31-61	Assistant
Eugene Morris	5-20-62	Instructor
Agricultural Economics		
Ronald D. Alexander	5-20-62	Assistant
Warren D. Alexander	1-31-62	Assistant
Harold Bohling	3-31-62	Assistant
William S. Byrd	9-30-61	Assistant
Roy Lee Ewalt	6-30-61	Assistant
Robert D. Finley	6-30-61	Assistant
Jay F. Goold	9-10-61	Assistant
Mahendra P. Gupta	6-30-61	Assistant
John H. Hildebrand, Jr.	6-30-61	Assistant
William H. Hutcherson	3-14-61	Assistant
Ted Lee Jones	8-31-61	Research Associate
Kumud Karnik	3-15-61	Assistant
Brij B. Khare	6-30-62	Assistant
Eugene A. Leonard	9-30-61	Instructor
Gordon Nance	7-1-62	Professor
Edwin Pfuehler	4-10-62	Assistant
William N. Ross	8-31-61	Assistant
John Squibb	5-31-61	Assistant
Martin S. Stauber	6-30-62	Research Associate
William R. Summitt	12-31-61	Assistant
Dorwin L. Williams	2-8-62	Instructor
Agricultural Editor		
Donald N. Collins	12-31-61	Assistant Agr. Editor
Agricultural Engineering		
Robert L. Bedwell	6-30-62	Instructor
Ivan L. Berry	6-30-61	Research Assistant
Joe P. Gentry	2-12-62	Assistant
John P. H. Mason	6-30-62	Instructor
Donald K. McCool	4-23-61	Assistant
William N. Reynolds	3-31-61	Assistant
Robert E. Stewart	6-30-61	Professor
Milton Shute	6-30-62	Instructor
Glen A. Thompson	6-30-61	Research Associate
Animal Husbandry		
Marion F. Brink	8-31-61	Assistant
Jerry F. Brooks	10-16-61	Assistant
Robert E. Cooper	8-10-61	Assistant
John W. Cowan	8-31-61	Assistant
Benjamin T. Dean	6-30-61	Assistant
Earl W. Gibson	6-30-62	Assistant
Byron J. Greiman	6-30-61	Assistant
William A. Hargus	6-30-62	Instructor
Andrew J. Monson	6-30-62	Assistant

Jimmy D. Neill	6-30-62	Assistant	lambs
John C. Rea	8-31-61	Assistant	
Neal H. A. Scharre	6-30-62	Assistant	
William H. Sellers	1-31-62	Assistant	
Neil A. Worker	7-24-61	Assistant	
Keith O. Zoellner	6-30-62	Assistant	
Dairy Husbandry			
Ralph R. Anderson	6-30-62	Instructor	
Methodius Bartek	6-30-61	Assistant	
Henry C. Damm	6-30-61	Research Associate	
David R. Griffith	6-30-62	Research Associate	
Kentaro Himeno	6-30-61	Research Associate	
Bill F. Kelso	6-30-61	Assistant	mones
William R. Miller	6-30-62	Research Associate	
A. C. Ragsdale	8-31-61	Professor and Chairman	tation
Kashi P. Sinha	6-30-61	Research Associate	
Eugene C. Viets	6-30-61	Research Assistant	ate
Oliver Wayman	6-30-61	Research Associate	
Ralph Williams	6-30-62	Research Associate	nd
Director's Office - Services			
John H. Letcher	6-2-62	Assistant	Rats
Rahul K. Nandi	6-30-62	Assistant, Chem. Lab.	
John M. McMillan	6-30-62	Assistant, Chem. Lab.	
John A. Waller	9-10-61	Assistant	
James C. Williams	9-1-61	Asst. Spectrographic Lab.	
Billy M. Beal	3-10-61	Assistant	
Donald F. Goerlitz	7-1-61	Assistant Chem. Lab.	
Frank Johnson	6-30-62	Instructor, Agr. Chem.	in and
Palamand S. Rao	8-31-61	Instructor, Agr. Chem.	
Robert A. Tempel	6-30-61	Assistant, Chem. Lab.	
Robert S. Clough	12-5-61	Technical Leader	Field
Theodore S. Hermann	9-1-61	Asst., Spectrographic Lab.	
Lewis B. Peggs	9-30-61	Technical Leader	
Eugene W. Peiter	4-13-62	Asst., Spectrographic Lab.	
Phil M. Smith	2-28-62	Foreman, McCredie Expt. Farm	
Director's Office			
Abner Beck	6-30-61	Assistant	
Earl S. Webb	10-15-61	Assistant Professor	
Entomology			
Dean Barry	9-11-61	Assistant	
Oscar L. Benson	1-31-62	Assistant	
John D. Davis	6-1-62	Assistant	e
Maurice A. Pickard	9-15-61	Assistant	
Donald E. Short	2-15-62	Assistant	
Fertilizer Control			
Roger Q. Brown	5-31-62	Fertilizer Inspector	
Noel A. Fischer	12-31-61	Fertilizer Inspector	
Ogle D. Hopkins	6-5-61	Fertilizer Inspector	mimosae
			ols

Field Crops		
Aristeo Acosta	6-30-62	Instructor
E. M. Brown	3-16-61	Research Associate
George E. Brown	7-31-61	Assistant
Frank S. Davis	6-30-61	Research Associate
James A. Hooks	6-30-62	Assistant
Takeo Maruyama	8-31-61	Assistant
Alexander C. McBride	6-30-62	Instructor
Masasuke Okamoto	6-10-61	Instructor
Gurgal M. Reddy	6-30-62	Assistant
John P. Thomas	6-30-62	Instructor
Forestry		
Gilbert F. Begeman	6-30-61	Instructor
Roy S. Brundage	5-2-61	Instructor
Oscar J. Dooling	9-15-61	Instructor
Theodore H. Meredith	9-30-61	Instructor
Kenneth W. Seidel	2-28-62	Research Associate
Home Economics		
Kay Alexander	6-30-61	Assistant
Patricia L. Benson	1-31-62	Instructor
Jean E. Clifford	6-30-61	Instructor
Mina Glidden	6-30-61	Instructor
Beverly A. Kluge	7-1-61	Assistant
Edna F. Mathieson	8-31-62	Associate Professor
Virgil A. Metcalf	6-30-62	Instructor
Roma J. Ropp	6-30-62	Instructor
Betty Sawyers	6-30-61	Assistant
Donna S. Swall	6-30-61	Instructor
Maxine Teetsel	6-30-62	Assistant Professor
Horticulture		
Neil Finley	6-30-62	Assistant
James F. Fontenot	6-30-61	Assistant
Anthony Garrett	6-30-61	Assistant
Robert C. Jenne	6-30-62	Assistant
Maynard Johnson	1-25-62	Assistant
Brian Jones	9-1-61	Assistant
Sally Lewis	6-30-62	Assistant
Robert B. Nevins	8-31-61	Assistant
Barbara Zawadzka	4-30-62	Assistant
Poultry Husbandry		
Dale A. Ross	5-1-62	Assistant
John M. Yohe	6-30-62	Assistant
Rural Sociology		
John L. Bennett	9-30-61	Assistant
Haider A. Chaudhari	7-31-61	Assistant
Howard R. Delaney	6-30-62	Assistant
M. S. S. Gadalla	12-31-61	Assistant Professor
Virgil W. Lane	9-30-61	Assistant
Rebecca Meinershagan	6-30-62	Assistant
Robert P. Montaba	8-31-61	Assistant
Henry Plyler	8-7-61	Instructor

Soils

Homer A. Brady	1-31-62	Assistant
Robert J. Crabtree	12-31-61	Assistant
Lynne C. Kratzer	1-31-62	Assistant
Jerry L. McIntosh	6-30-61	Assistant
Sherrell A. Sanders	6-30-62	Assistant
Kenneth D. Vogt	2-14-62	Assistant