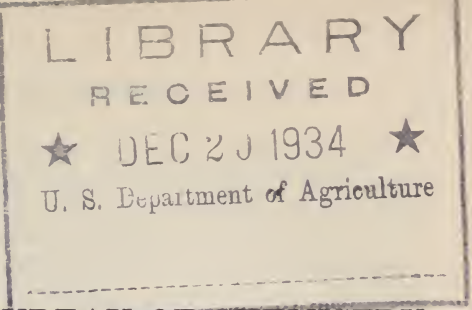


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**REPORT OF THE CHIEF OF THE BUREAU OF CHEMISTRY  
AND SOILS, 1934**

UNITED STATES DEPARTMENT OF AGRICULTURE,  
BUREAU OF CHEMISTRY AND SOILS,  
*Washington, D.C., August 31, 1934.*

SIR: I present herewith the report of the Bureau of Chemistry and Soils for the fiscal year ended June 30, 1934.

HENRY G. KNIGHT, *Chief.*

HON. HENRY A. WALLACE,  
*Secretary of Agriculture.*

**INTRODUCTION**

The practical and scientific value of the activities of the Bureau of Chemistry and Soils has been emphasized during the past fiscal year by important contributions which the Bureau has made to the recovery program when called upon to aid and supplement the work of the Agricultural Adjustment Administration and other recovery agencies of the Government.

The importance of the research and fact finding of the Bureau as they relate to the plant-food researches of the Nation, to the economic utilization of soils, to the development of crop resources, and to the utilization of crop wastes and surpluses by manufacturing industries has been demonstrated by the tying-in of the Bureau's activities and trained personnel at many points with the Department of Agriculture's aggressive program to bring the farmer to economic parity with those engaged in other branches of American industry.

With the object of assisting American farmers to more economical and profitable crop production, the Bureau is engaged in perfecting a Nation-wide inventory of the soil-fertility resources of the United States whereby the Federal Government, the States, and individual farmers will be enabled to develop more efficient and profitable agriculture by the proper adaptation of crops to soils. Another important aid to more economical and profitable crop production is the constant research of the Bureau directed to perfecting and cheapening methods of fertilizer manufacture and fertilizer application. The problem of profitable utilization of farm byproducts and farm refuse is one on which the Bureau is constantly engaged. The object of much of its research work is the widening and improvement of markets for farm byproducts, surpluses, and refuse, by demonstrating their value as sources of raw material for industry, and consequently, as sources of increased income for the farmer.

The Bureau's research work in the past year has included investigations in soil chemistry, soil physics, soil erosion, soil microbiology, soil fertility, nitrogen fixation, potash and phosphate resources, crop chemistry, fruit and vegetable chemistry, fermentation methods for the production of organic acids, the utilization of farm and industrial wastes, food microbiology, food deterioration and spoilage, dust explosions, and farm fires, and improvements in the technic of producing sirups, sugars, vegetable oils, proteins, insecticides, fungicides, tanning materials, and a variety of other products.

For administrative purposes the various activities of the Bureau are organized under three large units—(1) Chemical and Technological Research, (2) Soil Investigations, and (3) Fertilizer Investigations. Probably the most striking development of the past fiscal year has been the demand made upon each of these three units for aid to the various emergency and relief activities of the Government.

The principal activities and objectives of the three units of the Bureau are discussed briefly below with particular reference to those phases of the work which are supplementing the program of the Agricultural Adjustment Administration. A more detailed and comprehensive account of the Bureau's work for the past year is given in the remainder of this report.

#### CHEMICAL AND TECHNOLOGICAL RESEARCH

The chemical and technological research work of the Bureau supplements in many ways the program of the Agricultural Adjustment Administration, as well as the measures which are being taken by other economic and relief agencies.

A very important line of research is the devising of means for more profitable utilization of surplus, cull, and off-grade fruits and vegetables, together with farm waste materials such as straw, stalks, hulls, and other so-called "agricultural wastes." This work supplies the second step in the control of agricultural production which is required to complete the scheme of properly adjusted production and consumption of farm crops. This second step is the complete and intensive utilization of all that is produced on controlled acreage so as to afford the farmer a maximum return for his crops.

Profitable byproducts utilization of surplus, cull, and off-grade fruits and vegetables serves to support the market grades and makes it possible to obtain a greater degree of flexibility in marketing. Thus, in years of relatively large production more of any given crop may be diverted into byproducts, whereas in periods of underproduction it will be profitable to sell a greater proportion through the usual market channels.

Such byproducts industries serve as a balance wheel to control market supplies. This principle is well illustrated by the domestic citrus byproducts industry which was developed as a result of research by this Bureau and which is now the world's largest producer of lemon oil, orange oil, and citrus pectin. More profitable means of utilizing surplus, cull, and off-grade fruits and vegetables, and farm wastes of various types is particularly important because the cost of producing such material has already been incurred, and increase in income derived by the farmer from more effective utilization is clear profit.

A more recent development in this field is the devising of a process for profitable production of high-grade starch from cull sweetpotatoes which constitute a large proportion of the field-run crop and which have heretofore been very poorly and inefficiently utilized. A commercial sweetpotato-starch industry is now being established as a result of this work. In addition, the Federal Emergency Relief Administration is financing a sweetpotato-starch factory as a part of its program for providing employment. The sweetpotato starch so produced is not competitive with cornstarch but will be used to replace imported potato starch.

Other work of a chemical and technological research nature is resulting in new uses for existing crops and in the introduction of new crops to provide products for which uses have been found recently. Thus, for instance, means have been devised for greater utilization of chicory, which is now a minor crop, and certain insecticidal plants which may serve as important crops have been introduced for the purpose of supplying insecticides of new types. Work of this kind is in the interest of greater crop diversification and makes possible increasing flexibility in agricultural-adjustment measures.

Farm income from certain crops can be increased in some cases by better adaptation to market requirements and preferences, particularly in the case of derived products which do not bring the highest market price because of inadequate quality and which thus react against the value of the primary commodity. An illustration of this is the improvement being effected in the production and marketing of turpentine and rosin with increased return to turpentine farmers. An efficient naval-stores industry is essential to successful yellow-pine reforestation which is of great importance to certain sections of the South.

Another illustration of the value of work of this type is the recent improvement in the quality of farm-made sorgo and sugarcane sirups. During recent years there has been a spread of as much as 300 percent in farm price between high- and low-grade sirups, depending on quality. High-grade sirup can be sold direct to the final consumer at maximum price, whereas low-grade sirup is usually sold under distress conditions at an unremunerative price.

The losses to the food industries of the Nation as a result of decay, fermentation, rancidity, staling, discoloration, and other deterioration changes amount to several hundred million dollars annually. Work has been directed to the

study of methods for reducing these losses which are due to the action of micro-organisms, enzymes, oxidation, light, heat, and other causes. This work is of particular value under present conditions because of decrease in some food supplies as a result of the drought.

The "fire tax" resulting from damage by farm fires amounts annually to an average of \$16 per farm for the entire United States. Research is bringing about a material reduction in this tax as well as a reduction in the dust-explosion hazards and losses to which country grain elevators and various industries for processing agricultural products are exposed.

Considerable stress has been placed by the Bureau on insecticide research. Obviously we should not allow the insects to control crop production. Work of this kind is an important factor in any program for agricultural adjustment and production control, since it places this control on a more calculable basis. The research is resulting in the production of new insecticides which are effective against certain insects and yet are harmless to man. The effectiveness of insecticides in general is being increased, and the quantity of toxic residues adhering to sprayed fruit is being further reduced.

### SOIL INVESTIGATIONS

It is hardly necessary at this time to stress the importance of soil-erosion research. The serious character of the soil-erosion situation is now well recognized by the public generally. Millions of acres of our best agricultural lands have been destroyed, even greater areas have been injured in varying degrees, and tremendous damage has been done to our natural and artificial water-storage reservoirs, to stream channels and drainage lines of every type, as well as to lower lying areas of land which are subject to invasion by erosional debris and to flood water released from higher levels.

In view of the serious drought of the present year, it is desirable to stress the water-conservation phase of the soil-erosion research program. The drought has appeared as a largely unpredictable and at present uncontrolled factor in the program of agricultural adjustment. In addition to adjustment measures that are now in force and under consideration for the purpose of effecting economic compensation for inadequate agricultural production in certain areas in drought years, it is important to observe that the effects of drought may be alleviated to an appreciable extent by increasing soil absorption of rainfall and decreasing water run-off through soil-erosion control measures. From this standpoint the program may well be termed a soil-erosion control and water-conservation measure. In other years and under other conditions it may be regarded as a soil-erosion and flood-control measure.

The control of soil and water losses still centers largely in the erosion-experiment stations located in 10 of the most seriously affected type areas of the country. These stations are well distributed and serve an aggregate area of more than 225,000,000 acres. They have contributed much constructive information not only to the public at large but also to various service organizations for direct application in the field and for systematic extension activities for the purpose of placing this information in the hands of farmers as rapidly as possible. Although striking results have been obtained in the control of soil and water losses through the proper use of vegetation and by terracing and other mechanical means in a more or less independent way, it now appears that a combination of these corrective measures may prove more advantageous and effective, particularly since complete dependence is not placed on any one measure over any considerable period.

The importance of soil-survey reports in any scheme of agricultural control is self-apparent. No intelligent action with respect to use of land, the basis of agricultural production, can be made without adequate soil-survey information. An effort has been made to extend the work of the soil survey in directions where it will meet to the greatest possible extent the increased demands made upon it by various recovery and relief organizations.

The maps and reports of the soil survey are being used extensively by those organizations which have such responsibilities as the determination of land use, the zoning of rural lands, appraisal of farm lands, purchase of lands for farms or forests, and the location of reclamation projects. In fact, the published maps and reports of the soil survey, together with special reports, provide the foundation of the majority of the present activities relating to land use.

In the selection of sites for subsistence homesteads, it is of the utmost importance that the land selected be of sufficient productivity to maintain an organization of the type planned. In recognition of this fact the soil maps have been freely used in the selection of such areas, and proposed lands are carefully examined by trained soil scientists familiar with soil-survey methods and with the characteristics and capabilities of the various soil types. Such a procedure assures the home seeker that the land will do its part.

The Division of Program Planning of the Agricultural Adjustment Administration is now developing a series of projects for the planning of land use in sample areas. For such a program the first essential is an accurate inventory of the land resources of the area. Maps showing the distribution of the various soil types and their individual possibilities for the growing of crops, grasses, and forests constitute the essential groundwork for these plans. If poor crop lands are to be abandoned, one must know what soil types are unsuited for crops and where these are located and also what lands unsuited to crop production can be used for grazing or for forestry. Once the soil types of these areas have been determined, sufficient information is available for the initial stage of such undertakings.

It is desirable in an agricultural adjustment program that cultivated land be used for the specific crops for which it is best suited, subject, of course, to required crop rotation and control of total production in relation to consumption demands. Application of this principle is an important factor in reducing unit-production cost. Knowledge of inherent soil fertility and the relative suitability of various soil types to specific crops is indispensable for the purpose of determining whether the use of fertilizer is profitable and, if so, the kind and amount of fertilizer which may be used with profit.

It is also important that soil fertility be kept at a proper level through attention to those factors which make for proper maintenance, adequate drainage, control and adjustment of soil reaction, and the adaptation of acid-tolerant crops to soils of varying acid reaction. We must conserve the humus supply of the soil and extend our knowledge of the use of fertilizers for plant-feeding purposes, including a knowledge of the functions of the less common soil elements which, while present in comparatively small amounts, are of extreme importance in the maintenance of soil fertility. The function of certain less common elements, such as manganese, magnesium, and zinc, in promoting plant growth and in influencing crop quality is an important subject for research. Marketability and crop value have been materially increased by applying information so obtained to various crops, particularly to certain fruits and vegetables.

In addition to the direct influence of fertilizers in reducing production costs and improving quality, it is becoming more evident that the efficient use of fertilizers is an important factor in promoting a more favorable development of soil-improvement crops. In order to obtain effective results in this direction, steps must be taken to coordinate modern fertilizer materials and their mixtures with soil conditions, with special attention to soil and fertilizer reactions.

The Bureau is conducting on important soil types a wide range of soil-fertility investigations dealing with the soil-fertility and fertilizer requirements of leading crops. These studies deal, in the major part, with the usual plant-food requirements and, in addition, with certain less common plant-food elements; also, with organic-matter supplies and with the relation of soil-fertility factors to malnutrition of different crops. All of this work is in the interest of a more efficient agriculture with lower production costs and will result in placing production on a more calculable basis, thus facilitating agricultural planning and adjustment.

#### FERTILIZER INVESTIGATIONS

The fertilizer investigational work of the Bureau embraces those activities which aim at the most economical utilization of this country's resources of the main plant-food elements—nitrogen, potassium, and phosphorus. The conversion of these natural resources into improved fertilizer materials, the preparation of fertilizer mixtures which promote crop growth without increasing soil acidity with resultant injury to crops of subsequent years, the production and study of the properties of new fertilizer compounds with special reference to their use in mixed fertilizers and the need for minor elements are but a few of the lines of research covered.

The importance of fertilizers to the farmer is attested by an increase in consumption of commercial fertilizers in this country from 4,361,795 tons in 1932 to 4,818,811 tons in 1933, whereas the acreages of the four crops to which fertilizers are mainly applied decreased from 35,939,000 to 30,144,000 in the case of cotton, from 108,668,000 to 102,239,000 for corn, from 3,381,000 to 3,184,000 in the case of potatoes, and from 57,204,000 to 47,493,000 for wheat. About 75 percent of the fertilizers consumed in this country are used on these four crops.

The program of fertilizer investigations fostered and carried out by the Bureau for the past 20 years has resulted in a nitrogen industry adequate to meet the country's requirements for peace-time industry and for national defense, a domestic potash industry which guarantees against future shortage and foreign monopoly, improved phosphate and mixed-fertilizer production, and an annual saving to the American farmer of over \$30,000,000.

An idea of the extent to which the farmer has profited as a result of reduced costs of fertilizers, due mainly to improvements in known methods for the production of fertilizer materials as well as to the introduction of new fertilizer materials obtained by cheaper manufacturing processes, and their competition with already established materials, may be gained from a comparison of the costs per unit of 20 pounds of plant food in various materials at producing points in the years 1920, 1925, 1930, and 1933, shown in table 1.

TABLE 1.—*Cost per unit of 20 pounds of plant food in various materials in selected years*

Material	Plant food	1920	1925	1930	1933
Sodium nitrate.....	Nitrogen.....	\$4.44	\$3.28	\$2.49	\$1.53
Ammonium sulphate.....	do.....	4.08	2.65	1.79	1.12
Anhydrous ammonia.....	do.....		<sup>1</sup> 1.75	1.40	1.15
Cyanamid.....	do.....	3.40	2.20	1.65	1.13
Animal tankage.....	do.....	8.38	3.98	3.78	2.02
Fish scrap.....	do.....	8.02	5.33	4.95	2.88
Dried blood.....	do.....	8.97	4.53	4.27	2.63
Cottonseed meal.....	do.....	9.48	5.69	5.01	2.71
Run-of-pile superphosphate.....	Phosphoric acid.....	1.22	.57	.54	.43
Potassium chloride.....	Potash.....	2.41	.68	.69	.70

<sup>1</sup> Cost in 1926.

The steadiness of the price of potash during the past 10 years has been due to the influence of European producers who have heretofore dominated the market. That the American potash industry has become so firmly established as to free this country permanently from foreign monopolistic control, however, has been demonstrated by its initiation this year of a series of price reductions which have brought the cost of muriate of potash to the lowest price at which it has ever been quoted in this country, namely 35.2 cents per unit of potash.

With a realization of the fact that there is a final limit to the economies to be attained by process improvements, the Bureau is giving increased consideration to the economies which accrue from improvements in the physical form of fertilizers, the elimination of fillers, and the production of physiologically neutral fertilizer mixtures.

## ASSISTANCE TO EMERGENCY AGENCIES OF THE GOVERNMENT

An adequate evaluation of the extent to which the Bureau of Chemistry and Soils has aided and supplemented the program of the Agricultural Adjustment Administration and other recovery agencies of the Government can hardly be had from a general discussion. For this reason a brief summary of the specific activities with which the Bureau is aiding the recovery program is given herewith.

### RESEARCH ON NEW INSECTICIDES THAT ARE NONPOISONOUS TO MAN

Under an allotment of \$60,000 from Public Works Administration funds, the Bureau is conducting research both in its Insecticide Division and its Food Research Division in an endeavor to find new insecticidal uses and better

methods of utilizing nicotine, pyrethrins, rotenone, oils, and other insecticides, especially those nonpoisonous to man, including studies to determine the toxicity of insecticidal products.

The allotment for this work was made available for use only this spring, but the staff has been assembled and the work is thoroughly organized and actively under way. Scientists are now actively at work on these problems not only in the laboratories here in Washington and in laboratories of the Bureau in San Francisco, Calif., and in Richmond, Va., but also in the field in the fruit-growing sections of the country.

#### INVESTIGATIONS OF ALKALI-DISEASE PRODUCING AREAS

An allotment of \$35,000 was made available by presidential order dated September 5, 1933, from Emergency Conservation Work funds for investigations by this Bureau in connection with alkali-disease producing areas for the purpose of ascertaining the extent of lands containing sufficient selenium in the soil to render vegetation toxic to animals. Work was begun at once along three lines: (1) Explorations to ascertain the relative selenium content along transects in areas suspected of containing selenium; (2) a soil geological study of the materials presumably the source of the selenium in the soil; and (3) development of adequately accurate and rapid methods of examination of samples of soil, vegetation, and minerals, together with the application of these methods to samples collected in the course of the field studies.

#### DEVELOPMENT OF NEW SWEETPOTATO-STARCH INDUSTRY

Directly as a result of research by the Bureau, which devised and established a method for producing high-grade starch from sweetpotatoes for which an excellent market is indicated, the Federal Emergency Relief Administration has made available to the Mississippi Emergency Relief Administration \$172,000 for the construction and operation of a sweetpotato-starch plant at Laurel, Miss., this project being conducted in association with the Subsistence Homesteads Division. Relatively small factories (to reduce transportation cost of raw materials) of about 2 million pounds annual production of starch are contemplated, and the prospective market for sweetpotato starch would absorb the output of about 25 factories of this size, making possible the direct employment of 6,500 heads of families.

The factory at Laurel is now in the course of establishment under the direction of a scientist from the Bureau, and, under a cooperative arrangement with the Mississippi State Emergency Relief Administration and the Mississippi State College of Agriculture, the Bureau will engage in active research in connection with this problem.

Sweetpotato starch can be produced at a competitive cost and should gradually displace the imported product.

#### SOIL SURVEY OF PUERTO RICO

Under an allotment of \$35,000 from the sugar-processing tax of the A.A.A., the Bureau is to undertake the immediate mapping and classifying of the soils of the interior of the island of Puerto Rico. This work is to be undertaken under a cooperative agreement between the Department of Agriculture and the Puerto Rico Policy Commission. This survey has been urged as an emergency project by that commission in order that the best use may be made of all lands on the island available for crop production, and as a result of these studies it is expected that there can be marked out on the higher lands those areas that can be profitably utilized. Work has not been started on this project, as the funds will not be available until returns are had from the sugar-processing tax which became effective on July 8.

#### SOIL-EROSION SURVEY AND EROSION-CONTROL INVESTIGATIONS IN PUERTO RICO

Under an allotment of \$207,000 from the sugar-processing tax of the A.A.A., the Bureau is to undertake an immediate erosion survey in the island of Puerto Rico for the purpose of establishing a comprehensive program of erosion-control investigations. This work is to be undertaken under a cooperative agreement between the Department of Agriculture, Puerto Rico Policy Commission, and the University of Puerto Rico. The program is a well-defined outgrowth of the present concern that is felt by those in authority over conditions of land denudation that are developing in certain sections of



the island. The work referred to is scheduled to cover a period of 3 years, beginning at such time as funds are actually made available through the sugar-processing tax upon which it has been established.

#### LAND INVENTORY OF THE UNITED STATES

At the request of the National Resources Board, the Bureau is undertaking the immediate preparation of an inventory of the lands of the United States based on the character of the soil and climate, the inherent productivity of the soil, and the relief of the land in the various parts of the country, involving the application of an evaluation in terms of relative productivity of the various soil types to each locality. This work will be carried on through the assignment of a number of experienced scientists in soil survey, and their work will be based upon the data accumulated by the Bureau over the past 30 years in its survey and mapping of the soils of the country. This work is just being inaugurated under an agreement whereby the National Resources Board will undertake to finance this study. As the Board desires to use this material for its report to the President, the studies will be completed within 2 months.

#### SOIL SURVEYS AS A BASIS FOR LAND CLASSIFICATION

At the request of the State Planning Council of Washington, the Bureau has assigned 6 of its experienced soil scientists to make a detailed soil survey of 8 counties in that State, this survey to serve as a basis for land classification and determination of land use. For this project the State planning council has made available a fund of nearly \$100,000, 50 percent of which it is understood is from Federal funds. The scientists of this Bureau will furnish the basic information on the soil types in terms of their inherent fertility, slope, location, etc. The ultimate objective is classification of land according to the use for which it is best adapted—agriculture, forestry, recreation, industrial and urban sites, etc. The Bureau's scientists will be assisted by a number of trained workers assigned by the State.

#### SOIL-EROSION CONTROL

While this is an emergency activity of the Department of the Interior where the Soil Erosion Service has been established as a division under allotment of P.W.A. funds, its work is based on the results of the investigations and experimental work inaugurated in the Department of Agriculture under the Bureau of Chemistry and Soils and the Bureau of Agricultural Engineering. In fact, the Director of the Soil Erosion Service is a member of the staff of the Bureau of Chemistry and Soils under administrative furlough from this Department to the Department of the Interior to organize and direct erosion control of important watersheds. In addition, the Bureau has loaned under administrative furlough to the Soil Erosion Service a number of its soil scientists to take over key positions in this emergency activity. Fundamental research on the problem of soil erosion continues as the function of the Department of Agriculture and is being actively and aggressively carried on.

Also, members of the Bureau's staff are now assigned to Emergency Conservation units to assist with erosion-control problems as they relate to Civilian Conservation Corps camps.

#### SUBSISTENCE HOMESTEADS

In the selection of suitably fertile lands that could be adapted properly to the types of farming required in areas under consideration by the Subsistence Homesteads Division (financed under allotment from the Public Works Administration), the Division has had the active assistance of this Bureau. Several of the leading scientists in soil survey of the Bureau have been assigned to this work on the request of the Division. In this work, the scientists of the soil survey have mapped and reported on a number of sites under consideration by the Division in Alabama, Pennsylvania, West Virginia, Tennessee, North Carolina, Mississippi, and Florida.

#### WORK ON NICOTINE FOR CODLING-MOTH CONTROL

The A.A.A. assigned \$1,200 to the Bureau of Chemistry and Soils for research on nicotine sprays for the purpose of improving the insecticidal power

of nicotine as a means of combating the codling moth, and under this allotment, a chemist was employed for 6 months during the past fiscal year.

As a result of these studies the Bureau has shown that nicotine combines with bentonite so as to permit the preparation of nicotine-bentonite with considerably greater nicotine content than heretofore used. This is an important contribution, as nicotine-bentonite has been shown by entomologists to be a promising insecticide for codling-moth control. In these studies the permanence of deposits from various nicotine sprays was investigated. It was also demonstrated that Florida peat absorbs nicotine to produce an insoluble compound, and the conditions governing the preparation of this material having been worked out, a patent is being applied for.

#### FERTILIZER INVESTIGATIONS OF THE TENNESSEE VALLEY AUTHORITY

The Bureau has assisted the Tennessee Valley Authority in its development of a fertilizer program through assignment to the Authority of several scientists of the Bureau engaged in studies on the development of concentrated phosphoric acid, and in addition, the experimental blast furnace of the Bureau was also made available to the Authority.

#### ASSISTANCE TO THE AGRICULTURAL ADJUSTMENT ADMINISTRATION AND THE FEDERAL EMERGENCY RELIEF ADMINISTRATION IN THE UTILIZATION OF HIDES

The Bureau has been called upon by the A.A.A. for advisory service in the handling of hides from the cattle-killing program of the Government. The hides experts of the Bureau have also supplied the Federal Emergency Relief Administration with tentative working procedures and schedules whereby hides from the cattle-killing program might be handled to provide relief employment and leather for relief and distress purposes.

#### ASSISTANCE TO THE A.A.A. ON NAVAL STORES MATTERS

The Bureau has been called upon by the A.A.A. for assistance and advice in formulating codes for the naval stores industry and supplying statistical information.

#### ASSISTANCE TO THE A.A.A. ON SUGAR-PRODUCTION CONTROL

The Bureau has at the request of the A.A.A. assigned certain of its specialists in sugar to assist in matters concerned with sugar production.

### CONSTRUCTION PROJECTS UNDER ALLOTMENT OF PUBLIC WORKS ADMINISTRATION FUNDS

#### CONSTRUCTION OF AN AGRICULTURAL BYPRODUCTS LABORATORY

For the purpose of effecting better utilization of waste material from farm crops, an allotment of \$70,000 was made to the Bureau from P.W.A. funds for the construction of an agricultural byproducts laboratory at Ames, Iowa. More than 260,000,000 tons of straw and stalks are going to waste annually on American farms. The United States uses more than 11,000,000 tons of paper and paper board annually and imports the raw materials or the finished paper and board for more than half of this amount. This building now under construction will make it possible to adequately carry on investigations in the use of farm byproducts in the making of a large percentage of paper and board now used in this country. This will provide a market not now existing for part of these byproducts, as well as furnish additional employment.

#### CONSTRUCTION OF LABORATORY AND OFFICE BUILDING AT THE NAVAL STORES STATION, OLUSTEE, FLA.

For the purpose of providing needed facilities for the conduct of experimental work on the development and introduction of new and better methods of producing turpentine and rosin, to eliminate waste, make better and more useful products, and increase returns to naval stores producers (which work is provided for in the regular appropriations of the Bureau), an allotment of \$21,000 was made from P.W.A. funds for the construction of a fireproof chemical laboratory and office building at the naval stores station, Olustee, Fla.

**OTHER CONSTRUCTION PROJECTS**

In addition to the two major construction projects being conducted under allotment of P.W.A. funds, the Bureau was allotted \$12,919 for 14 smaller construction projects. These smaller projects have been carried on at Olustee, Fla.; Houma, La.; Columbia, S.C.; Weslaco, Tex.; and Arlington Experiment Farm, Va., and have provided necessary physical improvements to facilitate the research of the Bureau at the several stations. These projects provided considerable employment and have been entirely completed, the last having been finished June 13.

**CIVIL WORKS ADMINISTRATION PROJECT—WORK AT EXPERIMENTAL STATIONS**

An original allotment of \$239,627.60 of C.W.A. funds was made to this Bureau under the title "work at experimental stations." Two major types of work were undertaken: The construction of plane-table base maps of selected counties in 12 southern States; and maintenance and general assistance at the Bureau's several field stations and the Washington laboratories and offices. The plane-table base map work was to provide base maps to be available for later use in making soil surveys in the areas covered, and the work at the field stations consisted principally in the physical repair and improvements to facilitate the research work.

Surveys were conducted in 44 counties, and the maps constructed will be useful for the purpose intended. At the Bureau's field stations the repairs and improvements were carried out as planned, and the research work has been definitely facilitated. Over 800 persons were given employment throughout the country through the C.W.A. project of the Bureau.

**CHEMICAL AND TECHNOLOGICAL RESEARCH****CARBOHYDRATE INVESTIGATIONS****SUGARCANE**

Investigation was continued for the purpose of devising improved and practicable methods of juice clarification, particularly in the case of sugarcane varieties that yield well in cane and sugar per acre, but which yield juice of poor quality or difficult workability in the plantation sugarhouse. Improvements in clarification and handling of cane juice of poor "working quality" are necessary in order to obtain a satisfactory yield of sugar of suitable quality per ton of cane.

During the past season, large quantities of cane juice were treated experimentally by different methods and were made into comparable lots of sugar on a small scale by standard methods. All intermediate and final products were analyzed. The use of various tannins in conjunction with milk of lime and sulphur dioxide and lime was given particular attention during the season's work. Whole mill juice from a large factory was utilized in these experiments. Use of certain tannins yielded clarified juice and evaporator sirup of greatly improved color and clarity and likewise sugar of considerably lower turbidity, although the results were not conclusive with respect to the color of the sugar.

Many samples of cane were handled by the Bureau of Chemistry and Soils mill, which is provided with hydraulics to insure uniform pressure on the rolls, and comparable extraction data were obtained. The samples included the most promising of the newer varieties as follows: C.P. 807, Co. 290, Co. 281, 28/19, and 28/11, and in addition, from the experiment station only, 29/291 and 29/320. The chemical work included the analysis of the juice for sucrose, invert sugar, ash, composition of the ash, and organic nonsugars. The juice samples were clarified by a standard procedure, evaporated to sirup density, again analyzed, boiled to sugar, and the quality of the sugar determined by analytical methods.

The chemical work at the Houma field station is being conducted in such a manner as to supply the necessary advance information regarding the table sirup and sugar-making characteristics of the newer varieties of sugarcane before they are released for commercial cultivation, and the effects of different soil types, until investigation has included a wider range of cultural factors.

## INVESTIGATION OF THE DETERIORATION OF SUGARCANE AT HARVESTING TIME

Lost time in the fields and in plantation sugarhouse operation, due to rains in the continental United States, has been estimated as 15 percent of the total time, or approximately 11 days out of the usual 75-day season required for harvesting and handling the sugarcane crop. It has been estimated that the avoidance of these delays would be worth at least 75 cents per ton of cane handled.

This investigation is being made in cooperation with the Bureau of Plant Industry at the Houma, La., station and has for its purpose the development of methods for storing cane in sufficient quantity, and without appreciable deterioration, to enable the plantation sugarhouse to operate more continuously, thus reducing net costs.

In studying such fundamental factors as temperature and humidity, use was made of a specially constructed storage house consisting of six rooms, individually controlled. All varieties of cane stored under high humidity conditions showed good keeping quality, with temperature playing only a minor part. These findings emphasize the necessity for transferring harvested cane as rapidly as possible, after being cut, to storage piles where it may be sprinkled. That sprinkling is a practical method of preventing evaporation of moisture from cane so as to retard deterioration was proved by many small-scale tests ( $\frac{1}{2}$  ton to 70 tons of cane) and by larger tests, in which piles of 270 tons of cane were kept for 10 days without appreciable deterioration. Since large piles of cane serve as a good insulation against evaporation, only the surface cane needs to be sprinkled after the pile is saturated.

Co. 290 variety was quite resistant to deterioration, but less so than Co. 281, which is the most resistant variety now grown in Louisiana. Preliminary tests showed C.P. 28/19 to be quite resistant, and about equal to Co. 290, whereas C.P. 28/11 showed rapid deterioration under adverse conditions and may possibly be grouped with P.O.J.36M and C.P. 807, which are the least resistant of the present commercial varieties.

A method was developed for determination of invertase in sugarcane and a number of tests were made.

## SUGARCANE SIRUP

The combined use of decolorizing carbon and invertase is a simpler and more practical procedure for farm-scale sirup making than were the older methods originally developed by the Carbohydrate Division. Additional improvements were made for the purpose of adapting these methods to farm sirup-making equipment of various types. Circulars describing this method were widely distributed to meet demands of sirup makers for information on the subject.

The production of "specialties" from sugarcane was studied with particular reference to La Cuite. The methods of juice clarification and treatment of the product to prevent crystallization as developed by this Division were employed in cooperation with a progressive sirup maker. The entire output of this specialty product was readily marketed at a good price and the cooperator plans for a much larger production during next year. It is anticipated that this improved product will afford a profitable market for considerable quantities of sugarcane.

Experimental work was continued for the purpose of studying the sirup-making properties of the newer varieties of sugarcane. The tests of cane varieties are being supplemented by an investigation of methods of clarification which are particularly suitable to different varieties in order to improve the quality of sirup of medium, or poor, quality which is made from canes of otherwise desirable characteristics.

## SORGO SIRUP

Investigation of improvements in methods for making sirup of excellent quality on the farm was continued during the year. Particular attention was given to field work, actually on the farm, in cooperation with small-scale sirup producers. In developing new methods, previously reported, experimental work was planned to yield information regarding the most practicable and efficient details of procedure from a farm-operating standpoint.

The results of this work furnish good comparison of the practical value of the recently developed malt diastase, milk of lime, and decolorizing carbon treatments, not only when used separately, but also when used jointly, and in various combinations during the process of sirup making. Use of milk of lime

and malt diastase, according to the procedure described, gave greater improvement in sirup quality than was obtained by the use of decolorizing carbon alone. Preliminary work of considerable promise was done on a new method of applying malt diastase.

There are many varieties of sorgo (sweet sorghum) which vary greatly in suitability for sirup production. A study of the sirup-making properties of several different varieties of sorgo was conducted during the last season, in cooperation with the Mississippi Agricultural Experiment Station.

#### HONEY

A method of clarifying honey based on flocculation of the colloidal matter with the colloidal clay bentonite, with resulting production of brilliantly clear honey, has been devised. It was found, however, that a certain loss of flavor accompanied this treatment. This loss in flavor is due to adsorption of flavoring compounds by the bentonite, which is of gelatinous consistency, and also to loss during reconcentration of the diluted honey after clarification.

The use of filtration alone for clarification of honey at original density has been investigated, and a method has been developed that does not result in loss of flavor as in the case of the bentonite method. The honey is filtered under pressure at original density with the aid of a rapid filtering diatomaceous earth filter aid, using standard filtration equipment such as a plate and frame filter press.

The filtration process which has been developed by this Division provides a rapid and improved method of processing honey with no loss or change in flavor, in addition to obtaining a degree of clarity never attained heretofore in the honey industry. Better control of granulation is obtained by heating to a relatively high temperature for a short period than by using lower temperatures for longer periods. It is considered probable that the small amount of equipment required for this process will entail little additional cost for its adoption to replace the customary methods of heating and processing. In addition to retarding granulation, the method will yield honey of excellent clarity, with resulting added attractiveness to the consumer and stimulation of market for honey, with resultant benefit to producers.

#### UTILIZATION OF WHEY

The largest present source of loss in the dairy industry is the waste of sweet and sour whey. Approximately 4,000,000,000 pounds of sweet whey and 1,500,000,000 pounds of sour whey are produced annually by the domestic dairy industry. In addition to casein, which is now utilized, the principal valuable constituent of whey is milk sugar. On a basis of 60 percent recovery, approximately 165,000,000 pounds of milk sugar could be produced annually in the United States, as compared with only about 9,000,000 pounds produced in 1930 (principally for use in pharmacy).

Investigation was made of methods of production, manipulation, and properties of various products of a fondantlike nature which were prepared from lactose, derived from whey. Difficulty had been encountered in obtaining the desired consistency of the product under different desired conditions, and particular attention was given to this factor. Since consistency is determined to a great extent by the proportion of crystalline lactose in relation to proportion and density of sirup intimately mixed therewith, a study was made of the solubility of lactose in mixture with other sugars and the influence of various factors on rate of crystallization and size of crystals produced. Products were developed which were satisfactory for certain commercial purposes. This work is being done in cooperation with the Bureau of Dairy Industry.

#### SUGAR BEETS

The results of the analysis of samples of beet sugar selected over a period of several years from factories in all the different areas of the country in which sugar beets are grown show that as a result, in large measure, of the work done by this Division in cooperation with the industry, the quality of beet sugar produced has been steadily improving and is becoming more uniform in character.

Investigation of the location of the nonsugar substances in the sugar crystal has shown that the largest proportion of these substances is in the surface layer and that further improvement in the uniformity of quality of the sugar is

possible, not only by increase in elimination of the detrimental nonsugars from the juice, but also by improved methods of manipulation in the final stages of production. Laboratory results indicate that combined effort in both of these directions may result in production of beet sugar of high and uniform quality. If this can be accomplished, the differential of 15 to 20 cents per 100 pounds in price against beet sugar should gradually be eliminated, and its removal will result in a substantial increase in the income of sugar-beet growers. It should also be possible, as a result of this work, to attain maximum consumption of beet sugar in the areas of production, thus reducing freight charges and thereby also increasing returns to sugar-beet growers.

#### MAPLE PRODUCTS

Particular attention was paid to the possibility of increasing diversification of maple products, especially of lower grades in the marketing of which the producer is at present unduly penalized. In cooperation with a large Vermont producer, investigation was continued on a larger scale of the method mentioned in last year's report for producing a concentrate of strong maple flavor, together with a special grade of sugar. The details of the process for efficient production of these products were studied and developed so that this procedure may be published in workable form and made available for general use by producers.

Sufficient quantities of the maple concentrate and special sugar were produced under these conditions to make possible a survey of the market possibilities for these new products. It is anticipated that the strongly flavored concentrate will find use in the ice-cream industry, for instance, and also that it will find an extensive market for use in the production of cane and maple-sugar sirup blends. The production of blended cane and maple-sugar sirups in this way is expected to afford a better financial return to maple producers than the methods of production and marketing heretofore practiced.

#### UTILIZATION OF CULL SWEETPOTATOES FOR STARCH

The purpose of this investigation is to devise a profitable means of utilizing cull sweetpotatoes. A large proportion of field-run sweetpotatoes (the second largest vegetable crop in the United States and the largest in the South) grown for market is graded out as culls (oversize and undersize) and is largely wasted. A method for production of high-grade starch from these potatoes was developed by this Division. An investigation of some of the properties of sweetpotato starch has been made, and on this basis markets for the starch have been indicated. These markets are as follows:

(1) In cotton mills (for sizing warp yarn, and for finishing). Sweetpotato starch has been tested in several cotton mills which customarily use imported potato starch. The reports from these mills are unanimous in stating that sweetpotato starch gives equally as good results as imported potato starch and that it also has certain advantages, including economy in quantity required. Most of the potato starch imported into the United States is used in cotton mills. Sweetpotato starch can be produced at a competitive cost and should gradually displace the imported product.

(2) As a dextrin for adhesives such as for postage stamps, envelopes, etc. The Bureau of Engraving and Printing has recently tested sweetpotato-starch dextrin prepared by the Carbohydrate Division and, on the basis of both laboratory and machine tests, has pronounced it to be equal to the dextrin made from imported cassava starch, which is now used.

It is estimated that the utilization of all sweetpotato culls at a price commensurate with that which could be obtained for potatoes for starch production would increase the return to growers by some \$4,000,000 annually. A sweetpotato-starch industry is now being established as a result of this work. A factory is being erected at Quitman, Ga., by commercial interests, and the Federal Emergency Relief Administration is financing a factory at Laurel, Miss., for the purpose of providing employment. Relatively small factories (to reduce transportation cost on raw material) of about 2,000,000 to 4,000,000 pounds annual production of starch are contemplated.

#### CARBOHYDRATES IN DOMESTIC PLANTS

The investigation of inulin in domestic crops described in the last annual report shows that while chicory root (dried) has an inulin content of about 50 percent, only 10 to 12 percent could be crystallized from the plant extract.

The inulin remaining in solution was a total loss in the scheme of production, and it was necessary to investigate the utilization of this otherwise waste material in relation to reducing the cost of inulin if it is to be used for medicinal and food purposes or for production of explosives. (See United States Patent No. 1922123.)

Since, apparently, the chicory inulin remaining in solution is of a soluble type similar to that found in a number of other plants, an obvious method of utilization is to hydrolyze it with production of levulose. There is a market for levulose sirup of good color and clarity and a high degree of sweetness. Such a sirup has a number of advantages over the present commercial sirups, particularly with respect to noncrystallization and use in various food products for promoting retention of moisture.

A process was developed for producing a levulose sirup of very light straw-yellow color and high degree of sweetness and with a sugar content of 79 to 80 percent. Due to its high solubility, levulose does not crystallize from the sirup at this concentration.

Cooperative work on inulin was continued. Additional quantities of inulin were prepared and sent to cooperators. Using material prepared in this division, J. C. Krantz, Jr., of the School of Medicine, University of Maryland, conducted research and has recently published an article showing that soluble inulin is assimilated by animals. This has an important bearing on the possible use of inulin by diabetic patients, as mentioned in the report of last year.

### FOOD-RESEARCH INVESTIGATIONS

#### FROZEN PRODUCTS FROM SURPLUS DECIDUOUS FRUITS AND BERRIES

Youngberries were frozen in cartons and cans at 0°, -40°, and -80° F., packed in dry sugar, and in 40-percent sugar sirup. In all cases there was less bleeding in the berries frozen at -40° and -80° than in those frozen at 0°. The sharply frozen berries also held their shape better. There seemed to be little difference between the berries frozen at -40° and those frozen at -80°. Other berries, plums, figs, and melons were also frozen.

#### PRESERVATION OF APPLE JUICE BY STERILIZATION, CONCENTRATION, OR FREEZING

Apple juice was concentrated, 6:1, and the esters were separated from the distillates, refractionated, and added back to the sirup in order to retain the apple flavor. The product was used experimentally in the preparation of a carbonated apple beverage, as a table sirup, or in raising the solids content of apple juice before fermentation.

Three types of fermented apple juice were made: By straight fermentation, by fortifying with sugar, and by fortifying with the apple concentrate. Both dry and sweet products were made by the latter method. Many of these products are brilliantly clear, with a vinous flavor, and should be well received.

#### FERMENTATION FLAVORS IN SIRUPS AND MOLASSES

Taxonomic studies on the yeasts and bacteria responsible for the rum flavor characterizing Barbados molasses have been completed. The sugar-tolerant yeasts were identified as *Zygosaccharomyces nussbaumeri* Lochhead and Heron, and *Z. major* Takahashi and Yukawa. A bacterium, identified as *Clostridium spermoides* (Vinni) Bergey, was found to cause the anaerobic decomposition of organic matter to form higher alcohols, furfural, and aldehydes.

In experiments to determine the possibility of improving the flavors of domestic sirups and molasses by microbial fermentations, particular attention was paid to the flavors that developed in sirups to which organic and inorganic acids and invertase had been added to cause partial inversion of the sucrose. Flavors more nearly resembling those of Barbados molasses were developed in the samples which had been inverted with acetic and phosphoric acids.

#### STUDIES ON WINE MAKING

Studies on the fermentation of youngberry juice have shown that in certain cases the nitrogen content is not high enough to support fermentation or may not be available to the yeasts. By the addition of ammonium chloride and sugar, alcoholic yields were obtained which were high enough to preserve the resulting wine. It is believed that the youngberry can be adapted to wine making by proper control of fermentation.

An experimental bottling of champagne was designed to study the effects of various fermentable substances on the flavor and fermentation of the wine and the role of various stock yeasts in the production of flavor and character in champagne.

#### LOOSENING THE HULLS OF WALNUTS

One of the most critical periods in the growth of the Persian (English) walnut occurs about the time it is ready for harvesting. Continued warm weather at this period results in dark- or amber-colored kernels, only a certain percentage of which is allowed in the first-grade pack of shelled nuts. Experiments during the past season indicate that if the harvesting of the crop could be advanced from a week to 10 days and ethylene used in loosening the hulls, a very large gain would be made in the quantity of first-grade nuts. Since immature nuts tend to shrivel and have an off flavor, it is necessary to determine the stage of maturity at which ethylene treatment will bring the desired results. This phase of the problem is now being studied.

#### SPOILAGE IN SIRUPS AND BEVERAGES FROM WHITE SUGAR

Particular stress has been placed on methods suitable for the removal of yeast stimulants from white sugars. When sugars containing large amounts of yeast stimulants were washed in a nearly saturated sugar solution, made from a high-quality sugar free from stimulants, a reduction was obtained in the yeast stimulant. Since only the outer layer of the crystal was dissolved off, it was concluded that the greater part of the stimulating substance was in the outer portion of the crystal or adsorbed on its surface. Thus inefficient filtration equipment or faulty operation in the factories may account for the presence of excessive amounts of these substances in some sugars.

The methods used to determine the presence of yeast stimulants in sugars were developed and recently submitted in detail to all sugar manufacturers cooperating in this work. The amounts of yeast stimulants present in 55 samples of white sugars obtained during the 1933 campaign have been determined by this standard procedure, and show a distinct improvement in the quality of commercial sugars.

Considerable attention has been given to the numbers of spores of thermophilic bacteria occurring in sugars. Excessive numbers of food-spoilage types were found in 29 percent of the 55 samples of white sugar obtained during the 1933 campaign. From these results it is apparent that some sugars have not yet been improved in quality sufficiently to be acceptable for certification as canning sugars. It is significant that most of the sugars found to be heavily contaminated were from factories situated within a comparatively small area.

An effort was made to determine the probable source of these spoilage thermophiles. Thirteen of the heavily contaminated samples were washed in a heavy sirup free from spoilage thermophiles and dried. A 65-percent reduction in the bacterial content was obtained. Experiments indicate that the thermophilic spores are largely retained on the sugar crystals after crystallization. Some method of eliminating the source of this contamination from the factory should be developed.

#### FROZEN PEAS

As a result of extensive studies on the production of botulinus toxin in frozen and defrosted peas, the following conclusions appear justified:

(1) When vegetables preserved by freezing are properly handled there is no danger of botulism. (2) Containers of frozen vegetables should not be defrosted or held at room temperature for more than 1 day, preferably not at all. (3) Containers of frozen vegetables should not be kept in an ordinary ice box for more than 3 days, preferably not longer than 2 days. (4) The best method to employ in the home is to cook the vegetables immediately, allowing the heating to do the defrosting. (5) Left-over portions should be held under good refrigeration, but not longer than 1 day.

#### FERMENTATION OF HAYS

Chemical analyses to determine the decomposition of the important organic fractions of alfalfa hay under partial anaerobic conditions have been completed. The individual organic fractions showed considerable losses after



fermentation, especially the water-soluble fractions, hemicelluloses, cellulose, protein, and to some extent the lignin. The analyses from this study will be valuable in determining those organic fractions in alfalfa hay that may be significant in the production of unsaturated compounds of a highly oxidizable nature.

For several years efforts have been made to set up laboratory experiments on the fermentation and heating of alfalfa hay under controlled conditions of temperature, aeration, and moisture content. No positive results were obtained from these experiments, due to the small quantities of hay used and the inability to control the fermentations.

Large concrete heating chambers, located at the Bureau of Standards and loaned for use in this work, have enabled the Bureau to repeat these experiments on a larger scale and with better facilities for controlling the conditions necessary for fermentation.

Two bales of freshly cut, undercured, second-crop alfalfa hay, with a moisture content of 31 to 33 percent, were used. Exposed for 32 days under automatically controlled and recorded temperatures, the first bale became light brown in color and had a strong pungent odor, but no charring was evident. The second bale was held for 70 days, the temperature being gradually increased to a maximum of 154° C. Artificial heat was then withdrawn, but the temperature continued to rise for 3 days, showing definitely that spontaneous heating was taking place. When removed from the heating chamber the hay was dark brown or black and extremely brittle, but there were no signs of actual combustion. Within 20 minutes wisps of smoke appeared, and after 45 minutes small areas of red glow were visible. When the bale was broken open large clouds of dense white smoke arose, and in less than a minute the center of the charred area was a mass of glowing embers. This is exactly what happens when a heating haymow or straw stack is opened and the oxygen of the air has ready access to the heated pocket.

#### EFFECT OF GERMINATED WHEAT ON FLOUR

The results show that small amounts of flours from Roman bean and black-eyed pea (cowpea), which legumes had been germinated 1, 2, and 3 days, as well as small amounts of the water extracts from these germinated legumes, had an appreciable effect in bread making; the volume of the loaf was increased and the color improved. Even a small amount of flour from nongerminated seeds of these legumes produced a bleaching effect.

#### THE STALING OF BAKERY PRODUCTS

Experiments to delay or prevent the staling of bread have been carried on with various colloids, all except an extract of carob-bean flour giving negative results. Freezing at a temperature of 20° F. has been found to delay staling to a marked degree.

#### PHYTOCHEMICAL INVESTIGATIONS

Work on the isolation, identification, and quantitative determination of varietal differences in the waxlike coating of apples was brought to conclusion.

An investigation of the waxlike fraction of waste pomace produced in the commercial processing of cranberries for sauce has shown that commercial cranberry pomace yields approximately 10 percent each of petroleum ether and ether-soluble constituents. The ether-soluble fraction consists chiefly of ursolic acid, as was found to be the case with apple pomace. The petroleum-ether-soluble fraction is, however, markedly different from that of the apple, consisting principally of fatty acids with only a small amount of hydrocarbons. Constituents isolated from the petroleum-ether extract include the hydrocarbons, nonacosane,  $C_{29}H_{60}$ , and hentriacontane,  $C_{31}H_{64}$ ; free solid fatty acids of the series  $C_{18}$  to  $C_{26}$ ; liquid fatty acids, linolenic, linoleic, and oleic, the last predominating.

An examination of the ether extract of grape pomace has shown the presence of oleanolic acid, which is similar in properties and closely related chemically to ursolic acid.

#### VEGETABLE-PIGMENT INVESTIGATIONS

Investigations of naturally occurring vegetable pigments were continued. One of the primary purposes of this work is to gain more thorough knowledge of the nature and behavior of the substances responsible for color in fresh

fruits and vegetables and their manufactured products in order to arrive at the best means of preserving these easily destructible pigments. Fruits and vegetables deficient in pigment and discolored canned and preserved goods have a much lower market value. From the standpoint of nutrition, the relation of certain naturally occurring yellow pigments to vitamin activity is another very important phase of color research.

During the past year, particular emphasis was placed on studies of color in tomatoes, sweetpotatoes, corn, and apples.

The yellow pigment of Grimes Golden apples has been isolated and purified to the point where it has been assigned the formula of  $C_{20}H_{21}O_{12}$ . The same substance also occurs in the Jonathan variety. A method has been partly developed for the isolation and crystallization of the red anthocyanin pigment present in Jonathan apples and probably occurring in all red varieties of apples.

#### THE TOXICITY OF FLUORINE COMPOUNDS

The determination of the comparative chronic toxicities of sodium fluoride, sodium fluosilicate, barium fluosilicate, and cryolite has been completed. Using production of mottled teeth in the albino rat as the criterion of toxicity, it has been shown that 14 to 16 parts of fluorine per million parts of food is toxic regardless of which of the above compounds was used, and regardless of the water solubility of the compound.

Rats placed on a balanced basal ration to which barium fluosilicate has been added feel cool to the touch, although the rectal temperatures are normal, due to a condition of vasoconstriction.

By means of a resistance thermometer, numerous observations on skin temperature have been made. It has been found that the skin temperature of a normal rat varies appreciably with the environmental temperature, but that at any given room temperature, the rats given barium fluosilicate range from  $1.5^{\circ}$  to  $2^{\circ}$  C. lower in temperature than the control rats.

Study of this vasoconstrictor action is being continued, control observations being made on rats receiving barium chloride and others receiving sodium fluosilicate. A survey of the literature indicates that this is the first record of a condition of chronic vasoconstriction that has been produced experimentally.

#### FEEDING-STUFFS INVESTIGATIONS

Continued study of the effect of different wave lengths of light upon the development of rancidity in cottonseed oil, corn oil, and lard showed that the blue end of the spectrum develops peroxides and rancidity much faster than the red end and that green light delimited by 4,900 to 5,800 Ångström units has the least effect on the development of rancidity and of peroxides.

Other experiments show that in the presence of moist air green was effective in retarding rancidity.

Investigations show that a high peroxide value in an oil which has been protected from light is not always an indication that the oil is rancid. A protected oil may have the same peroxide value as an unprotected oil which is rancid and yet be free from rancidity. An oil which has been protected from light may give both the Kreis and Von Fellenberg tests and yet be free from rancidity as determined organoleptically.

#### OIL TREATMENT FOR SHELL EGGS

The vacuum-carbon dioxide method of oil-treating shell eggs has been proved to be approximately 30 percent more efficient in maintaining original egg quality in comparison with other commercial methods of oil treatment. Carbon dioxide has a beneficial effect in maintaining the hydrogen-ion concentration of the egg white to a point more nearly comparable with that of fresh eggs. The pH value for the fresh-laid eggs was found to be 7.69; for 36-hour fresh eggs, 8.65; stored unoled eggs, 8.99; stored vacuum oiled (air release), 8.17; stored vacuum oiled ( $CO_2$  release), 7.91; the latter being only 0.22 above that of the fresh-laid eggs. Eggs treated by the vacuum method have less oil on the shell surfaces to be taken up by the paper-pulp packing materials than do eggs treated by other methods.

Broken-out eggs, treated with dry  $CO_2$  gas and quick-frozen, keep better and yield a more uniform product than eggs prepared by the usual commercial treatment.

Carbonation and quick freezing together have a marked effect on keeping down the number of surviving organisms.

## COMPOSITION AND UTILIZATION OF FLORIDA ORANGES

Pleasing alcoholic beverages have been prepared from fermented citrus juices. Among these are tangerine, orange, lime, and lemon cordials, and blended and fortified wines, and brandy.

## COMPOSITION AND UTILIZATION OF FLORIDA GRAPEFRUIT

A very satisfactory carbonated grapefruit beverage, with the characteristic bitter grapefruit taste, has been developed. This beverage may be slightly sweet to be used straight as a beverage or "dry" for mixing with alcoholic drinks. A cocktail was prepared by adding gin and sugar sirup to grapefruit juice followed by flash pasteurization. Grapefruit brandy and cordial and a fortified grapefruit wine, similar to a sherry, have also been prepared.

## COMPOSITION AND UTILIZATION OF TEXAS GRAPEFRUIT

Grapefruit juice and pulp were prepared by knife-peeling the fruit and extracting the juice and pulp in a modified tomato pulper with screen perforations of three-sixteenths inch in diameter. For shipment in barrels, 1,300 p.p.m. of sulphur dioxide was added as sodium bisulphite. This product retained its flavor and color satisfactorily for several months when filled full in 50-gallon white-oak barrels. The amount of sulphur dioxide may be quickly reduced by passing a stream of carbon dioxide through the warmed pulp.

The juice and pulp mixture, without preservative, was heated in a coil pasteurizer to 180° F. and filled in 1- and 5-gallon tin containers. These two methods were applied commercially during the past season, and according to reports furnished by manufacturers, 150,000 to 200,000 gallons of the products were packed for export.

## HEAT PASTEURIZATION OF ORANGE JUICE

Orange juice, deaerated and flash pasteurized, has been in storage at 55° F. for 13 months. Although lacking the aroma of freshly extracted orange juice, the packs in glass and enamel cans had a satisfactory flavor after 13 months storage at 55°. Packs in plain tin cans did not possess such a pleasing flavor. Unfortunately, the enamel of the cans was not stable, and blistering was apparent after 6 months. Storage at temperatures higher than 60° tends to accelerate the development of off flavors, which are pronounced after 4 months if the temperature is consistently as high as 95°. Storage at 45° would add about one-half cent a case per month to storage charges for the canned juice.

## ENZYME STUDIES

One of the fundamental changes noted in shell eggs during storage is the thinning of the thick white and the weakening of the vitelline membrane. This change lowers the egg grade from a quality standpoint and markedly reduces the value of the eggs.

It was found that the proteolytic enzyme of egg white is trypsin. The enzyme was found only in the "thick" fraction of the egg white, which can be separated from the "thin" or watery portion by pouring the whole egg white onto a wire screen. The thin white, instead of containing active trypsin, holds an inhibitor of tryptic activity, so that a mixture of thick and thin white usually shows no tryptic activity whatever.

It was found that the weakening of the yolk membranes and the formation of thin or "watery" whites are both caused by the presence of trypsin, and the chemical mechanism of the formation of watery whites and fragile yolks has been discovered and described.

The change of thick to thin white can be accelerated by the addition of a proteolytic ferment to the egg white. This has an important industrial application in that it forms the basis for a process of rapidly thinning down egg white without allowing it to putrefy. Accordingly, two applications for public-service patents have been filed.

It has been found that inhibitors of peroxidase fall into two classes: (1) reversible inhibitors, which compete with the substrate for the enzyme, and (2) irreversible inhibitors which injure the enzyme itself. In the fruit-darkening problem, the irreversible inhibitors are naturally more important. Comparatively few of these substances were found, most of them powerful poisons. It was discovered, however, that the peptide glutathione, and sub-

stances chemically related to it, are strong inhibitors. These nontoxic substances occur in many food products and were therefore used in experiments on preventing the darkening of fruits on drying.

Treatment of sliced apples with very dilute solutions of cysteine hydrochloride or glutathione by dipping, or better by spraying, prevented discoloration on drying. Apples thus dried show no discoloration, even after several months exposure to ordinary sunlight.

This effect could also be expected by treating the cut fruit with the juice of a plant known to contain a natural activator of a plant protease, such as pineapple, and experiments showed that this deduction was correct. By spraying the cut apples with pineapple juice or fractions isolated therefrom, similar results to those described for glutathione were obtained.

## INDUSTRIAL FARM PRODUCTS DIVISION

### HIDES AND SKINS

Improper and negligent handling is responsible for an annual waste of domestic hides and skins estimated at over \$20,000,000. Several contributions have been made during the past year toward conserving and improving the quality of these raw materials.

United States Department of Agriculture Technical Bulletin No. 383, on the reddening of cured hides, is now available. This bulletin, while dealing primarily with research studies, contains practical information on better curing of hides and skins, especially in showing those salts usually carrying hide-reddening organisms, and those conditions both favorable and unfavorable to the growth of these organisms.

Many commercial salts carry not only reddening organisms, but also other organisms. New and useful observations concerning these salt-tolerant bacteria have been published. They are shown to be capable of growing on a medium containing as much as 25 percent of salt, which means that even thorough salting of hides and skins will not prevent their growth although it will materially retard it. As a group these organisms liquefy gelatin with varying degrees of rapidity, from which it may be generally concluded that they have a similar destructive action on hides and skins.

Damages running into thousands of dollars frequently occur from molds on hides and skins which cause permanent staining of the resulting leather. From a study of molded pickled sheepskin, it was shown that the mildewing resulted from a lowering of the acidity of the skins brought about by absorption of the acid by the wood of the casks in which shipment was made. It was also shown how some molds reduce the acidity of the material upon which they are growing. Damages of this type could be largely eliminated by increasing slightly the original acid content of the pickling liquor, or in this particular instance by the simple expedient of soaking the wooden casks with the pickle liquor prior to packing.

Recently initiated researches on the problem of greasy hides have yielded valuable original data in showing that fat is deposited in large quantities in some cattle hides while on the living animal and that the content of fat runs much higher than has been realized heretofore and varies widely in different portions of the same hide. This work has been summarized in two publications. Greasy hides are apparently on the increase and constitute an economic problem, because leather made from them brings a lower price. These studies are being continued as authentic material becomes available in order to acquire data for correlating life history of the animal with the occurrence of greasy hides.

Economy measures have necessitated abandonment of field work among producers and dealers on eliminating wasteful practices in skinning, curing, and handling of hides and skins. This work was carried on in the South and East and had shown definite accomplishments in improving the quality and increasing returns locally for hides and skins.

### TANNING MATERIALS

The present established domestic supplies of tannin are inadequate. One-half of the \$20,000,000 to \$25,000,000 worth of tanning materials used annually are imported from foreign sources. In other words, there is a yearly volume of business of at least \$10,000,000 in tanning materials that might be diverted to home supplies in the form possibly of a new crop for American farmers.

Studies have been actively continued on the utilization of the waste hemlock bark of the Pacific coast region as a new commercial source of tannin for the purpose of acquiring full economic, technical, and practical information to determine whether or not commercial extract production from this waste bark may be expected to succeed and thus give to farmers, landowners, and labor a new source of income and American tanners a new domestic tanning material. Large-scale sole-leather tanning experiments have been completed using Pacific coast hemlock bark extract blended with other materials. The hemlock leather was rated quite satisfactory. Comparative shoe factory cutting values showed a differential of 0.54 cent per pair for the hemlock crop soles, and 0.37 cent per pair for the belly soles as compared to the regular tannage. Practical tanning tests and laboratory observations show that the amount of red typical of hemlock is much less with the Pacific coast species than with the better-known Eastern bark. Artificial drying experiments on a commercial scale are being made to determine the feasibility and cost of this essential operation. Soles cut from sides of the same hide tanned in part with and without Pacific coast hemlock bark extract are now being tested for comparative wearing quality by cadets of the United States Naval Academy.

#### LEATHER

The frequent failure of leather to render satisfactory service has been shown by pioneer research work by the Bureau of Chemistry and Soils to be due to absorption by the leather of destructive quantities of acid from the open air. This lead is being intensively followed to develop tannages, leathers, and treatments having a high degree of resistance to this natural agency of decay in order to hold and increase the market for leather goods.

A keen interest in the application of this work on leather rot to commercial production of more serviceable leathers of various types is being shown by the tanners. Data are being assembled for publication on the comparative resistance of chrome and vegetable leathers to rot from acids in the air, and also on effective treatments to retard this decay. Chrome leathers show a distinct superiority. Treatment of leather with calcium and sodium salts of certain organic acids, ordinary salt, and the natural nontannins appear to be distinctly helpful. These findings, regarding especially the natural nontannins, may be one of the most valuable contributions yet made to the subject of acid decay of vegetable-tanned leather. Marked changes in many of the present concepts may result and countless leads opened up towards new lines of research for developing longer lasting leathers.

The acid content of leather intended for long service is an important matter to both makers and users of leather. Discrepancies in determining acidity frequently occur. A contribution showing clearly a cause of discrepancies in acidity by the Procter-Searle method was published during the year. Concordant results depend vitally on the manner and rate of making ignitions of the specified mixture of leather and sodium carbonate, especially when sulphited tanning materials are involved. These findings have been acknowledged as valuable to the trade in transactions in which purchase of leather is based on a specified acidity limitation.

#### NAVAL STORES

The chemical and technological research work on naval stores is directed toward saving for producers preventable losses through improvement in process, equipment, and practices, and in enlarging the market for their products by the development of uses and better adaptation of products to uses. Studies on production, processes, and equipment are made at the naval stores station located in the Osceola National Forest near Lake City, Fla. This is a complete producing plant and is operated experimentally on an industrial scale. Fundamental research on composition, properties, and uses of naval stores, and investigations designed to assist the work at the naval stores station are conducted in the Washington laboratories.

#### WORK OF NAVAL STORES STATION

In a study of the operation of the turpentine fire still, 248 charges of gum and mixed gum and scrape were run during the year. A number of these served as demonstrations for the benefit of visiting producers and their stillers, and for forestry and engineering students. From the gum used, all making I

grade or better rosin, the average combined yield of turpentine and rosin was 84.4 percent of the weight of gum received. The ratio of turpentine to rosin was 1 pound of turpentine to 3.46 pounds of rosin. The grades of rosin produced included: WW, 80 charges; WG, 93 charges; N, 33 charges; M, 27 charges; K, 13 charges; and I, 2 charges.

A special device for sampling barrels of turpentine gum was invented by a member of the station staff, and a public service patent (No. 1953886) covering the invention, was granted.

Experiments with the common salt dehydrator, while not completed, have gone far enough to show quite conclusively that it pays the producer to use it. There are fewer "turns", on arrival at market, the turpentine contains but a trace of water, and it is less likely to discolor and thus bring a lower price. Batteries of dehydrators have been installed by some of the more progressive dealers in turpentine.

Advice and information on various stilling problems were given to about 700 persons who visited the plant at Olustee and the office in Lake City, and to the 275 persons requesting information through correspondence, as well as to the forces of 20 turpentine plants visited by members of the station staff.

#### COOPERATIVE NAVAL STORES WORK

The results of investigations on improved practices and equipment for naval stores production were carried to producers in Georgia and Florida through cooperative agents. In Georgia 15 complete naval stores plants were built in accordance with specifications supplied by the Bureau's cooperative agent. In Georgia and Florida there were 50 installations of the Bureau's improved fire still setting, 47 of which were constructed under direct supervision of the cooperative agents or members of the station staff. At the present time 28 counties in Florida and 19 in Georgia have one or more fire stills with the improved setting, which serve as demonstration units for nearby operators. The Bureau's improved method of regulating distillation in fire stills, based on the ratio of spirits to water in periodical samples of the distillate, was introduced at 104 plants. About 20 turpentine dehydrators, designed to remove water from turpentine and thus make it less likely to leak through glued barrels and less liable to deterioration during storage, and more than 40 covered turpentine separators, designed to prevent loss by evaporation, were installed under the supervision of the cooperative agents.

#### CHEMISTRY OF NAVAL STORES

In the laboratory investigations on constants and properties of rosin and rosin acids, pure levo-abietic acid was prepared, together with salts of this acid with organic bases including alkylamines and alkaloids. The diamylamine salts were found to be very useful in the separation of levo-abietic acid from its isomers.

Experiments were made on the preparation from pine gum of resinic acid fractions, some consisting chiefly of pimaric acids, and others chiefly of sapinic acids. These preparations when fused had the appearance of very clear and light-colored rosins. They were, however, much paler than commercial rosins, and differed somewhat in composition and physical properties from ordinary rosin. The methods used in preparing them, or modifications of these methods, may prove of technical value in making rosins especially adapted to specific purposes.

A preliminary study of the composition and properties of rosin as affected by bleaching with oxalic acid indicated that the acid and saponification numbers of rosin are not appreciably changed by such treatment. With vigorous or prolonged treatment, the rosin may become crystalline.

#### FARM FABRICS

One of the most important problems in connection with preservation treatments for fabrics, and one on which little progress has been made industrially, is the development of an inexpensive weather-resistant fireproofing treatment for fabrics used out of doors. Such treatment will be of material service to agriculture as a means of protecting tools and crops and in extending the use of cotton.

During the past year a new glow-proofing chlorinated resin, designed especially for use in the fireproofing of cotton was developed, and its industrial

production is being studied under the direction of the Bureau. It is cheap, effective, and possesses good waterproofing properties. With the well-known Perkin process as a starting point, a largely new and complete fireproofing process was worked out and is now being developed commercially. The new features of this process include the mutual reaction of sodium stannate and heavy metal salts resulting in the precipitation of cheaper metallic oxides with tin oxide, an additional step for increasing the quantity of colored oxide to protect the fabric against deterioration by sunlight, and finally a coating with the new glow-proofing resin, which is, in reality, a flame-proofing agent as well. Three applications were filed for public service patents on the improvements devised.

As a result of collaboration between the Division of Industrial-Farm Products and the Division of Soil Microbiology, a new, rapid, and serviceable test to determine the mildew resistance of fabrics was developed and is now ready for publication. Tests made by this method on untreated duck, samples treated in the laboratory, and samples subjected to commercial treatments, gave consistent results.

#### PAPER AND FIBER BOARD

The work on deterioration of paper dealt with the effect of small quantities of acids which are retained in paper as a result of manufacturing processes, and the effect of sulphur acids which are absorbed by paper from the atmosphere during storage on library shelves. A series of experiments dealing with the effect of known small quantities of aluminum sulphate, sulphuric acid, and hydrochloric acid on the physical properties of a water-leaf sulphite bond paper high in alpha cellulose was completed. The results, now being compiled for publication, showed that small quantities of these chemicals caused rapid deterioration and that hydrochloric acid caused greater and more rapid deterioration than did sulphuric or aluminum sulphate when the active acidities, as measured by the pH value of the water extract, were the same. The results are of great value in pointing out the necessity of washing out excess chemicals which may form free acids and of using only the minimum quantity of alum in sizing.

A study of a large number of samples of paper taken from old books, magazines, and volumes of court records ranging in age from 19 to 169 years was completed. The results, which will be published, show that paper absorbs from the air harmful quantities of sulphur-acid gases which accumulate in the paper and help to cause its early rotting.

The addition to paper at the time of manufacture of a substance that will neutralize or counteract acidic sulphur compounds as they are absorbed by the paper should materially increase the serviceability of valuable books and court record papers.

The work on the collaboration with Government agencies and scientific societies has been continued along the same general line as in previous years. In this connection, considerable work was conducted in collaboration with the Bureau of Plant Industry in preparing tentative specifications and examining Kraft paper bags proposed for use during this season in pollination experiments on corn.

A large volume of general information dealing with the chemistry and chemical technology of paper-making, fibrous materials, and of paper and fiber board was furnished through correspondence.

#### FARM BYPRODUCTS

The work on farm byproducts, carried on in collaboration with Iowa State College at Ames, Iowa, is designed to find and develop large-scale industrial uses for materials which are normally obtained as byproducts in the production of ordinary crops and are now largely wasted. These byproducts include, in the order of available quantities, cereal straws, cornstalks, corncobs, cotton stalks, oat hulls, flax straw, cottonseed hulls, sugarcane bagasse, peanut hulls, and miscellaneous crop wastes.

#### DESTRUCTIVE DISTILLATION OF AGRICULTURAL BYPRODUCTS

In the study of chemical products from wastes by destructive distillation, special attention was given to nut shells as raw material because of their dense structure and the greater possibility of developing immediate industrial utilization of products, particularly carbon. It was found that with the con-

tinuous operating retort and uniform conditions there was practically no fluctuation in yields. The fractionation and composition of the oils obtained in the destructive distillation of various wastes were studied and promising results were obtained on the value of oil from tobacco stems as an insect repellent and for controlling certain animal parasites. Some use has been made of destructive distillation oils in cattle sprays, and work on the tars resulting from the destructive distillation of farm wastes is being done in cooperation with the Color and Farm Waste Division of the Bureau.

Experiments on the possibility of increasing the yields of particular products of destructive distillation by catalysis, pressure, or other means were made in the laboratory to ascertain the factors involved before undertaking trials with the large apparatus. Wastes not previously tested, including Spanish moss, flax shives, and lignin, were investigated on a small scale. Fuel briquettes were made in the laboratory from farm wastes and from the carbon obtained from such wastes. The economic possibilities of such fuel have not yet been determined.

#### FERMENTATION OF FARM BYPRODUCTS

Studies were continued on the production of utilizable gases and residues from farm wastes by fermentation, and on the mechanism of the breakdown which occurs during fermentation. The experimental farm unit gas plant failed to function satisfactorily, thus making further experimentation necessary before this problem is solved. Work is in progress to isolate pure cultures of bacteria which can effect the decomposition of farm wastes in a particular manner. Experiments were started on the aerobic decomposition of farm wastes. The microorganisms and conditions involved in the production of organic acids and other nongaseous compounds were studied in experiments with waste "hydro" sirup from corn-sugar refining, waste gluten, and "steep" water. The results gave promise of obtaining economic yields of products suitable for use as solvents and motor fuel. Some attention was given to the problem of using alcohol-gasoline mixtures as motor fuels. Studies on the possible utilization of lignin and the formation of lignin compounds for industrial uses were continued.

#### OIL, FAT, AND WAX INVESTIGATIONS

##### COMPOSITION OF OILS, FATS, AND WAXES

The seeds and oils from over 70 new varieties of soybeans which were collected in the Orient by the Division of Forage Crops and Diseases of the Bureau of Plant Industry, in order to make a study of their cultivation, properties, etc., have been investigated by the Oil, Fat, and Wax Laboratory with special reference to the oil content of the beans and the character of the oil from the beans of each variety. The principal object of this study is to find soybeans the oils of which have distinctly stronger drying properties than the oils now produced in this country, and which will be of special value to the paint, varnish, and linoleum industries, providing the cultivation of these varieties is adapted to American farming conditions, and meanwhile this is being investigated by the above-mentioned Division. So far three varieties of soybeans have been discovered, the iodine numbers of which, by the Hanus method, range from 137.3 to 138.3, which are notably above those of our domestic soybean oil. Of the oils studied three others were found which gave unusually low iodine numbers (119-123), indicating that they would be especially desirable for edible purposes on account of their weak drying properties and the ease with which they could be suitably refined for such use.

Upon comparing the oil content of the beans from the different varieties of soybeans with the iodine numbers of the respective oils, it was found that the beans giving the highest iodine numbers contained from 15.5 to 17 percent of oil, whereas those giving the lowest iodine numbers contained 20.6 to 22.5 percent of oil. It is interesting to note in this connection that the beans of the wild Manchurian soybean which were examined contained only 7.5 percent of oil, but the iodine number of the oil was 151.7.

Pataua oil, known also as Comou and Batava, which is obtained from a pericarp or pulpy portion of the fruit from the palm *Oenocarpus bataua*, a native of tropical Brazil and Venezuela, is found growing in the marginal forests of the Amazon and Orinoco Rivers. This oil, unlike the well-known African palm oil and many other South American palm oils, is not only liquid at room temperatures but does not solidify until cooled to  $-5^{\circ}$  C., and some-



times even a lower temperature is required. This oil has the appearance of olive oil. Its characteristics are similar, but the iodine number is slightly below that of most olive oil on the market. It is particularly useful as a salad and cooking oil, and from its characteristics and composition it would appear to be suitable for use in certain cosmetic preparations. The possibility of growing this palm in the warmer sections of California and Florida has not yet been investigated, although in the latter State several specimens of related species have recently been introduced which so far appear to be doing very well.

The present investigation was made on a large sample of the oil received from the Instituto de Oleos of the Brazilian Department of Agriculture. The oil which had a saponification value of 190.4 and gave an iodine number of 75.4, was found to contain 14.4 percent of saturated acids and 79.9 percent of unsaturated acids. It should be mentioned that the seeds of this palm fruit contain only about 1 percent of oil and consequently are of no interest to the oil miller.

## PROTEIN AND NUTRITION INVESTIGATIONS

### HUMAN REQUIREMENTS FOR VITAMIN B

There is very little published information that will permit accurate estimation of the quantity of different foods that must be consumed to meet human requirements for vitamin B. In order to obtain some definite information on this point a preparation of tikitiki, which is used in the Philippines for the treatment of beriberi, has been assayed for vitamin B. Beriberi is a disease that occurs most frequently in the Orient, but also in other parts of the world due to an insufficient intake of vitamin B. Tikitiki is a vitamin-B-containing preparation which is made by the Philippine government for treating the disease. The prescribed daily dose of tikitiki contains approximately 200 international units of vitamin B, according to our assays. This quantity of vitamin B is sufficient to cure beriberi where the amount of vitamin B from food sources is very low. From these observations it would seem that 200 units of vitamin B daily should be sufficient to prevent the occurrence of symptoms of vitamin B deficiency in man.

### INTERNATIONAL VITAMIN STANDARDS

A great deal of interest has been shown in the use of the international vitamin standards. The Protein and Nutrition Division has issued the standard for vitamin A to 30 laboratories, the standard for vitamin B to 40 laboratories, and the standard for vitamin D to 21 laboratories.

The use of these standards will greatly enhance our knowledge of the distribution of vitamins in various food material and the vitamin requirements of man and other animals. At the present time the vitamin content is not expressed accurately enough, due largely to limitations in the methods that have been used in measuring them. The international standards make possible the use of the same "yardstick" in different laboratories in different countries and thereby coordinate the efforts of most investigators in the field.

### THE EFFECT ON VITAMIN C CONTENT OF FLORIDA GRAPEFRUIT FROM SPRAYING

Studies on the vitamin C content of oranges made by this Division a few years ago demonstrated that orange trees sprayed with lead arsenate produced fruit low in vitamin C content. Since that time there has been a great deal of interest in the possible effect of spraying grapefruit trees with lead arsenate. As a part of an extensive project, in which the Bureaus of Plant Industry, Entomology, and Chemistry and Soils have cooperated, this Division has made vitamin C studies of grapefruit from trees which have received various spray treatments. While there appears to be some indication that lead or calcium arsenate spraying may reduce vitamin C content the results obtained to date are not consistent. There is no pronounced effect as in the case of oranges or in tangerines. Tangerine trees sprayed with calcium arsenate produced fruit with a vitamin C content only one-half of that of control fruit.

### STUDIES ON THE DIGESTIBILITY OF PROTEINS

Two considerations determine the value of proteins in the nutrition of animals, namely, chemical composition and digestibility. Not only must the protein contain enough of the nutritionally essential amino acids, but it must be suffi-

ciently digestible so that these amino acids will be available for the nutrition of the animal.

Digestibility coefficients of the proteins of many feedstuffs have been calculated and are recorded in books and bulletins. These coefficients, determined by feeding experiments, are very approximate and show nothing of the nature or type of the indigestibility factor. They offer no explanation of the inherent causes of the indigestibility, whereby corrective or preventive methods may be applied to solve problems in nutrition arising from this question.

Certain processes and treatments employed in the preparation and manufacture of foods markedly affect their digestibility and food value.

A method commonly used for the purification and preparation of casein for scientific purposes involves treatment with dilute alkali. Much, if not most, of the casein sold as high-grade casein for scientific work is prepared by this method. Experiments conducted during the last year showed that dilute alkali produced drastic changes in the casein, involving practically complete destruction of the nutritionally essential amino acid cystine. Many discrepancies in the results of scientific work recorded in the literature in which so-called purified casein was used can be explained on the ground that this protein did not represent unchanged casein, but was an altered protein produced by the method used in its preparation. This information is of great importance in experimental feeding tests with small animals. Purified casein is generally used to supply the protein factor in the basal rations. If the casein is prepared by a method that lowers its cystine content, the animals will not grow satisfactorily, and entirely erroneous conclusions may be drawn, ascribing the growth failure to lack of the vitamin or whatever other nutritional factor is being assayed rather than to lack of cystine in the casein.

#### AMINO ACIDS IN WHOLE WHEAT, CORN, AND OTHER FARM PRODUCTS

In our previous studies on soybean proteins it was found that different varieties of soybeans showed variations in the content of the amino acids, cystine and tryptophane, sufficiently great to be significant from the standpoint of nutritional value. These analyses were made on the isolated protein of the soybeans and not on the whole seed. They do not, therefore, give an accurate measure of the amino acids in the whole seed or meal. There are other proteins present in smaller proportions concerning the composition of which no information is available. In order to get a better picture of the content of the amino acids of the whole seed or meal, recently developed methods have been applied for the determination of cystine and tryptophane in soybeans, which give a fairly accurate picture of the amounts present in the whole seed or meal.

Six varieties of Korean and Japanese soybeans showed relatively high percentages of cystine and tryptophane. Although these varieties have not yet been grown in the United States, except on an experimental basis, the values found are of interest in case they prove to be adapted to the soil and climatic conditions in the United States.

#### NUTRITIVE PROPERTIES OF *LESPEDEZA SERICEA* AND OTHER FORAGE GRASS

*Lespedeza sericea* is a new perennial legume which grows readily on the thinner acid soils of the Southeastern States. It provides a dependable hay crop, and is especially adapted for pasture for sheep.

The Bureau is making a study of the proteins of these grasses to see if they can take the place of alfalfa and other grasses which cannot be successfully grown on certain acid-soil areas in the United States.

Preliminary experiments were carried out with the cooperation of the Bureau of Dairy Industry to get information as to where the liberation of protein from hay takes place in the digestive tract. The stomach contents of a cow taken immediately after killing were analyzed for nitrogen distribution. The cow had been on an alfalfa ration. It was found that the nitrogen ratio between the solids and liquids of the stomach contents changes from 10:1 in the rumen to 2:1 in the abomasum, the fourth stomach pouch, showing that a large part of the proteolytic activity occurs in the latter organ. No protein could be separated from the contents of the abomasum, although it gave a slight biuret reaction.

## PROTEINS OF YEAST

The extensive use of dried yeast, particularly in mixed feeds, warrants further studies of its nutritive value. Difficulty has always been encountered in extracting the proteins of yeast to permit accurate determination of its amino acid content. It has been found that the amount of protein that can be extracted from fresh yeast is greatly increased by a preliminary treatment of the yeast with ether. Without this preliminary ether treatment only about 40 to 50 percent of the total nitrogen can be extracted, whereas after 42 hours' contact with ether, 91 percent of the yeast nitrogen was removed by the solvents used. The average crude protein content of dried yeast is about 50 percent. This value is obtained by multiplying the nitrogen content by 6.25. In these studies only one-half of the nitrogen was found to be present as protein nitrogen, so that the dried yeast would contain about 25 percent true protein. The cystine, tryptophane, histidine, and lysine content of this protein places it in a favorable position among proteins considered of good quality.

## COLOR AND FARM-WASTE INVESTIGATIONS

## FAST DYES FOR AGRICULTURAL FIBERS

The Bureau's work on the methods of preparation of the intermediates used in the manufacture of dyes, especially those for use on cotton, has resulted in improvements in these methods which, according to estimates by representatives of the industry, will result in savings of \$750,000 annually. Such savings enable the industry better to meet the competition of imported dyes and, at the same time, so cheapen domestic products as to permit their greater utilization on cotton goods.

Other investigations along this line indicate that iron reactors may be substituted for the usual enamel- or lead-lined apparatus used in many manufacturing processes for vat-dye intermediates. It is estimated that the substitution of cheaper apparatus in the industry, as a result of these discoveries, will lead to marked savings in the cost of manufacture.

## FERMENTATION INVESTIGATIONS

In its work in the field of mold fermentation, the Color and Farm-Waste Division has demonstrated that it is possible to use molds in a submerged condition under pressure and so produce results superior to those actually obtained by the same molds grown on the surface according to the usual method. This discovery is of great importance, because it is hoped by this means to use molds on a large scale in a manner similar to that now employed for yeasts and bacteria, thereby making the former of equal importance as industrial biological agents in the transformation of agricultural products to industrial materials.

## FARM-WASTE INVESTIGATIONS

One of the chemists of this Division has been assigned to work in cooperation with one of the leading sugar manufacturers in Hawaii, on the application of the Bureau's method for the production of high-grade cellulose from sugarcane bagasse by the nitric acid-pulping process. The reports received up to this time are most encouraging, and it is believed that the adoption of this process may lead to the establishment of sugarcane bagasse as an important source for high-grade industrial cellulose.

## LIGNIN INVESTIGATIONS

Experiments on the production of a nitrogenous fertilizer from the lignin sulphonic acids found in the waste sulphite liquor from paper-pulp mills have been continued. Practical tests have demonstrated that the material so formed is equivalent in value to some of the better known industrial fertilizers.

## BIOLOGICAL STAINS

While less spectacular, the work of this Bureau in cooperation with the commission on standardization of biological stains in establishing and maintaining a satisfactory source of stains for the use of the biological scientists of this country has continued. Special attention is being given to the role

played by impurities in many of the difficulties encountered in the application of certain stain technics. In addition, this Bureau has rendered assistance to the Bureau of Plant Industry and the Bureau of Animal Industry by the application of the spectrophotometer to the study of certain of their problems.

### INSECTICIDE INVESTIGATIONS

#### TOXICITY OF INSECTICIDAL PLANT CONSTITUENTS

The study of the toxicity of rotenone derivatives to goldfish was continued and the toxicity: concentration relationships for acetyldihydrotrotone, dihydrotrotone, acetyldihydrotrotolone, and acetyltrotolone established. That data obtained were published in the *Journal of the American Chemical Society*.

Consideration of the means of representing the toxicity of compounds by equations or formulas led to the discovery that the minimum value of the product of concentration and time to kill has certain advantages to recommend it, and may be considered as representing the conditions under which an insecticidal material is most efficient.

All of the derivatives of rotenone are less toxic than rotenone to goldfish with the exception of dihydrotrotone, which is 1.4 times as toxic.

#### USE OF PRODUCTS DERIVED FROM DERRIS AND CUBÉ

The observation made in last year's report that rotenone and extracts of cubé and derris may have value as fly-spray materials was followed during the past year by the completion of an extensive investigation of this subject by the Insecticide Division and the Bureau of Entomology. It was shown that extraction of powdered roots with the type of mineral oil used in fly sprays produces solutions comparing very favorably in insecticidal effect with commercial fly sprays; there is a noticeable difference, however, in the type of action exerted, the derris extracts being less rapid in their action, producing less spectacular paralysis of the flies than is observed with pyrethrum, but permitting fewer recoveries. The supplementary nature of the two reactions suggests the advisability of using mixtures of pyrethrum and derris, the former to paralyze the flies quickly, the latter to ensure their ultimate death.

The demonstration that rotenone undergoes photochemical decomposition when exposed to sunlight was completed last year. This year a beginning was made on the problem of preventing this change by the use of antioxidants. Both chemical and entomological tests were conducted. Tannic acid, hydroquinone, alpha-naphthol, beta-naphthol, and lecithin showed some retarding effect. However, when mixtures of dry rotenone and dry antioxidant were exposed to the arc and then tested insecticidally against mosquito larvae, no definite indication of value was found for any of the compounds tested, which included besides those just mentioned pyrocatechol, p-hydroxybenzoic acid, gum guaiac, phenylhydrazine, maleic acid, anthracene, trioxymethylene, cuprous oxide, and ferrous carbonate. By chemical methods it was also shown that very dilute alkali hastens the rate of decomposition in solution, whereas the equivalent degree of acidity has little or no effect. During the year some samples of cubé and derris that have been stored for a long time were reanalyzed for rotenone and total extract. There was no obvious change in the latter, but there was some indication that the rotenone content had decreased in a few instances. Further work is necessary to prove the point, however.

The approximate solubility of rotenone was determined in safrol, tetrahydronaphthalene, methyl isobutylketone, ethyl benzene, cyclohexanol, and decahydronaphthalene. Of these, safrol is the best solvent, 100 cc dissolving about 10.9 g of rotenone.

#### MISCELLANEOUS FISH-POISONING PLANTS

The investigation of the toxic resin present in the seeds of *Croton tiglium*, mentioned in last year's report, was completed. The exact chemical nature of the resin was not discovered, but much information concerning its characteristics was obtained. It is neither a glycoside nor a glyceride, but most likely a complex ester of a polyhydroxy phenol. Two hydroxyl groups are present and play an important part in its vesicant and toxic behavior. The presence of oleic, linolic, caprylic, capric, lauric, myristic, and palmitic acids was proved after a fractionation of the methyl esters.

A study of the rotenone content of those domestic species of *Cracca* which the Insecticide Division could obtain has been under way through most of the year. All samples have been examined for rotenone, total extract, and methoxyl and some of them investigated insecticidally. No particularly promising samples of *C. virginiana* were found, but one sample of *C. latidens* proved to contain 0.4 percent of rotenone. Near the end of the year the Bureau of Plant Industry began an extensive survey of the occurrence and cultural requirements of *C. virginiana*. The Insecticide Division is cooperating in the chemical examination of the specimens collected.

The miscellaneous plants examined for insecticidal constituents comprised the following: *Aristolochia cymbifera*, *Barringtonia racemosa*, bejuco bravo, bejuco de candelaria, berberra, campalca, *Celastrus rugosus*, colombo, *Cracca candida*, *C. latidens*, *C. lindheimeri*, *C. piscatoria*, *C. toxicaria*, *C. vogelii*, *Derris grandifolia*, emboy, *Euonymus europaeus*, *Fluggea microcarpa*, *F. virosa*, *Galactia elliottii*, *Imperatoria ostruthium*, *Ledum glandulosum*, *Lonchocarpus izabalanus*, *L. peckolti*, *Mundulea suberosa*, *Ocimum sanctum*, *Ocotea bullata*, *Plumeria* sp., *Polygonum* sp., quassia, *Saussurea lappa*, and sourwood. Rotenone was found in berberra, *Cracca piscatoria*, *C. latidens*, and *C. lindheimeri*. Crystalline compounds were obtained from some of the others and are being further investigated. From one sample of *Lonchocarpus* there was obtained about 1 percent of an easily crystallized compound with the empirical formula  $C_{26}H_{26}O_6$ . It is a new compound and was named lonchocarpic acid.

A renewed attempt was made to elucidate the composition of derris resin so far as compounds other than rotenone are concerned. The data obtained indicate that it consists largely of optically active toxicarol and deguelin, with no tephrosin. An investigation was made of the rotenolones which can be prepared from rotenone. Four isomeric compounds, differing probably in the position of the hydrogens on the central asymmetric carbon atoms, have been prepared.

#### PHARMACOLOGICAL TESTS OF INSECTICIDAL PLANTS

Tests were completed during the year of the acute toxicity (by mouth) to guinea pigs of rotenone, dihydrorotenone, dehydrorotenone, rotenonone, deguelin, tephrosin, toxicarol, a derris resin from which the crystallizable constituents had been previously removed, and four samples of derris root of different rotenone and total extract content. A paper describing the results of these tests is being prepared. Long-time feeding tests were begun with white rats and rotenone to determine the chronic toxicity of this insecticide.

#### PHYSICAL PROPERTIES OF ANABASINE

The specific gravity of pure anabasine was found to be 1.0451 at 20°/20°. The vapor pressure of anabasine from 79° C., at which temperature it amounts to 2.5 mm of mercury, to the boiling point at 281.3° was determined. The index of refraction and optical rotatory power were measured, and some evidence of autoracemization obtained.

#### NICOTINE

The entire year was devoted to the study of the compounds which the clay known as bentonite makes with nicotine and other organic bases. These compounds are of great interest as a means of adapting liquid organic bases to use as solid insecticides active against chewing insects.

Various samples of the compounds which bentonite makes with nicotine and with anabasine were prepared for insecticidal testing. Compounds with nicotine and with arecoline were also prepared for the Bureau of Animal Industry to be tested as anthelmintics.

#### SYNTHETIC COMPOUNDS CONTAINING SULPHUR

Past work of the Insecticide Division and cooperating entomologists has shown that diphenylene sulphide has marked toxicity to a variety of insects, and indicates that this compound may become an important substitute for arsenical compounds. Considerable effort was spent on the problem of devising new methods of synthesis which will permit its more economical preparation in quantity.

During the year the three compounds diphenylene disulphide, phenothioxin, and phenothiazine were prepared because of their similarity to the previously

investigated diphenylene sulphide, diphenylene oxide, and carbazole. Tests by cooperating entomologists immediately revealed that phenothiazine is more toxic to mosquito larvae than rotenone, is quite effective against codling-moth larvae, and is also poisonous to several other varieties of insects, all indications pointing to its being primarily a stomach poison, and therefore just the type of material being sought as a substitute for lead arsenate. Phenothiazine is easily prepared by simply melting together diphenylamine and sulphur in the presence of aluminum chloride as a catalyst. Preliminary tests indicated that the compound was not toxic to foliage, and all points considered, this is a very promising insecticidal material.

#### SPRAY RESIDUES

At apple harvesting time, the division cooperated in an extended series of washing tests carried out in conjunction with the Bureau of Plant Industry. These studies included tests of various washing machines and various solutions, and a total of 913 samples were analyzed in duplicate. The most satisfactory procedures were found to be hydrochloric acid plus mineral oil in a brush-flood machine, and sodium silicate followed by hydrochloric acid in a double-process machine. The need for better washing solutions was made plainly evident. A special investigation was made of the solubility of cryolite in chemical solutions. The materials tested included hydrochloric, nitric, sulphuric, chromic, silicic, and boric acids; sodium hydroxide, sodium silicate, the chlorides of sodium, potassium, iron, and aluminum, the sulphates of copper, iron, aluminum, magnesium, zinc, and potassium; borax, sodium bicarbonate, etc. It seems definitely established that aluminum salts, ferric salts, and boric acid in the presence of hydrochloric acid improve the solubility, probably because of the formation of complex fluorine compounds, whereas sodium chloride, and other sodium salts repress the solubility, possibly because of the common ion effect.

#### FLUORINE-CONTAINING INSECTICIDES

Further preparative work was directed toward the making of the complex fluorides of iron and the alkali metals, insecticidal tests with which appear in the literature. White, finely divided powders were obtained whose composition agreed quite well for the formulas  $\text{Na}_3\text{FeF}_6$  and  $\text{K}_3\text{FeF}_6$ . The former proved to be soluble, at 21° C., to the extent of 0.398 g/100 cc, the latter to the extent of 0.784 g/100 cc under the same conditions.

#### GRAIN FUMIGANTS

The Insecticide Division has continued to keep in touch with the fumigation of stored grain, in the development of which it has played a prominent part in the past.

Analyses of 19 commercial grain fumigants showed 7 to be mixtures of ethylene dichloride plus carbon tetrachloride, 3 consisted of propylene dichloride and carbon tetrachloride, 4 of carbon disulphide plus carbon tetrachloride in 2 of which some sulphur dioxide had been dissolved, 2 consisted mainly of chloropicrin, 1 of a mixture of ethylene oxide plus solid carbon dioxide, 1 of calcium cyanide, and 1 of sodium bicarbonate.

During the year information became available concerning the commercial use of methyl formate and ethyl formate, two fumigants which were discovered and initially developed in the Insecticide Division in cooperation with the Bureau of Entomology. Methyl formate is being used in conjunction with carbon dioxide, and according to reliable information one company has made at least one purchase of 50,000 pounds of methyl formate, representing 1,250,000 pounds of its finished fumigant. Ethyl formate has been commercially applied to the fumigation of cartons containing raisins.

#### MUSHROOM FUMIGANTS

The new type of sulphur burner mentioned in last year's report was completed and tested in a mushroom house of standard size at Avondale, Pa. It embodies the use of a fan to supply sufficient air to the sulphur, and proved very successful. Twenty-five pounds of sulphur burned in this new burner produced a higher concentration of sulphur dioxide than could be produced with 100 pounds of sulphur in the old-style burner.

Work was conducted in an experimental fumigatorium at Arlington Experiment Farm to determine the concentrations of sulphur dioxide required to kill

the important mushroom insects and mites at various temperatures in the range occurring during peak heat. It was found that 100-percent mortality of all mushroom insects and mites is produced by the use of a mean concentration of 8 mg per liter for 100 minutes at 100° F., and 4 mg per liter for 75 minutes at 120°. These concentrations may readily be produced by the sulphur burner previously described.

#### FUMIGATION OF SCALE INSECTS

This work has been directed toward finding the fundamental facts connected with the supposed development by citrus red scale in southern California of a resistance to fumigation with hydrocyanic acid that is rendering its control by this means more difficult and even impossible. This year's work has included many seasonal laboratory fumigations under controlled conditions to determine how the resistance of the various stages of scales changes from season to season; small-scale fumigatorium tests as a basis for comparison with other fumigants; tests of special hydrocyanic-acid applicators and of special tents for which superior performance is claimed; analyses of the air under the tents during commercial fumigations; and a special investigation of the phenomenon of protective stupefaction.

During the year, 162 compounds representing almost all classes of organic compounds have been tested in admixture with hydrocyanic acid by a standard procedure, but none proved particularly promising.

Also the efficacy of about 140 fumigants has been compared with that of hydrocyanic acid, special attention being paid to methyl thiocyanate and certain other thiocyanates and isothiocyanates. Methyl thiocyanate proved again this year to be about as toxic, mol for mol, as hydrocyanic acid, and was the only compound to compare at all favorably with that standard fumigant.

#### PREPARATION OF ARSENICAL INSECTICIDES

Until such time as nonpoisonous organic insecticides are developed to the stage at which they can displace arsenic compounds entirely, the latter will continue to be important and hence demand some chemical investigation. Because it contains a second poisonous element, namely, lead, it is particularly desirable to avoid the use of lead arsenate, and this work has for its aim the investigation of other arsenicals which might be used in its stead. The past year's work has dealt with the homologs of paris green, and with a renewed attempt to find the cause for the differing behavior of the various commercial calcium arsenates in their reaction toward plant and insect, an attribute that makes the use of calcium arsenate for many purposes rather uncertain. The particular problem of the relation of basic arsenates of calcium to plant burn and insect toxicity has been under study, but so far only the method of making products of predetermined basicity has been worked out, and experimental batches prepared for testing.

#### CONSULTING AND ANALYTICAL WORK

Two hundred and forty samples of miscellaneous insecticides were received from divisional field stations of the Bureau of Entomology. They consisted largely of arsenicals, fluorine compounds, and samples of derris and cubé which are being used by them in their regular insecticidal testing. There were also conducted for that Bureau a more extended investigation of the composition of a commercial insecticide which has proved to be a valuable attractant for the Mediterranean fruit fly; a study of the corrosion of galvanized-iron bait traps by the tartar emetic used in them; a similar investigation of the corrosive effect of a mixture of lime-sulphur and ferrous sulphate on brass and iron spray containers; and a detailed study of certain commercial mixtures of calcium arsenate and paris green to determine whether they contained, as a product of reaction during mixing, any copper arsenite to which their superiority over ordinary calcium arsenate could be attributed.

The analytical work performed for other units included the analysis of 74 samples of lead arsenate purchased on bid by the Bureau of Plant Quarantine; the examination for arsenic of 40 samples of chemical reagents submitted by another division of the Bureau of Chemistry and Soils; the examination of 2 samples of water and 1 of oil for the Food and Drug Administration; the analysis of 2 fly sprays from the Bureau of Prisons of the Department of Justice, and the determination of arsenic in samples of hair and cigars submitted by an army surgeon in a case of suspected arsenical poisoning.

Thirty-three scientific papers were published and five public-service patents were granted members of the Insecticide Division during the year. The monthly review of patents relating to pest control was issued in mimeographed form and copies sent to Federal and State entomologists and chemical manufacturers interested in insecticides.

#### DUST EXPLOSIONS INVESTIGATIONS

Twenty-four dust explosions were investigated during the year. These explosions resulted in the death of 20 persons, injuries to 46 others, and property damage amounting to \$1,827,200. They covered the following lines of industry: Grain handling, feed and cereal milling, fertilizer manufacture, malting, woodworking, cork grinding, manufacture of celluloid articles, and the handling of molding powder and aluminum dust.

The repeal of prohibition resulted in increased activities at malt houses, breweries, and distilleries. The handling of grain in these industries creates a dust-explosion hazard, and already two serious explosions have occurred. A fire captain was killed and 14 firemen were injured when an explosion occurred while they were fighting a fire in a Buffalo, N.Y., malt house.

#### ARLINGTON TESTS ON VENTING AREA

Research, particularly a study of the effect of location and distribution of vents and the relation of vent area to explosion pressure, was continued during the year. In addition to the regular study to determine the effective ratio of venting area to volume, some work was done with conveyor chokes, and the breaking strength of different types of glass when subjected to explosion pressures was determined.

An inert-gas-producing unit was obtained, set up, and connected during the year. Preliminary tests were made with this equipment to determine the effect of inert gas in preventing or retarding explosions in the experimental chamber.

During the year a number of dust-explosion demonstrations were given at the testing station. A series of tests were made for officials of the Navy Department to demonstrate the method of using vents to release explosion pressures without structural damage and to show the value of inert gas as a means of preventing dust ignitions. A somewhat similar series of tests was made for officials of the Department of Labor.

Tests were made during the year to determine the explosibility of sweet-potato starch and demonstrations given at the testing station for representatives of the Bureau and parties interested in the construction of plants to produce sweetpotato starch.

#### EXPLOSIBILITY OF MALT AND BARLEY ELEVATOR DUSTS

Within the past year the increase in production from malt houses and breweries has created a dust hazard that requires immediate attention. Samples of ground malt and malt and barley elevator dusts have been obtained and explosibility tests have been made to determine the maximum pressure produced, and the average and maximum rates of pressure rise for concentrations of dust in air ranging from 25 mg to 1,000 mg per liter, which is equivalent to 25 to 1,000 ounces of dust per 1,000 cubic feet. This information, together with the ignition temperatures of these dusts, will enable the Chemical Engineering Division to determine their relative fire hazard, and the precautions that must be taken to prevent explosions of these dusts.

The data previously reported on agricultural and other dusts have been arranged in manuscript form, to be submitted for publication as a Department bulletin.

#### OTHER FLAMMABILITY AND FIRE-HAZARD TESTS

The limits of flammability of propylene oxide in air were determined in an apparatus almost cubical in shape and having a capacity of 103.1 cubic feet, which approaches in size some of the apparatus used in fumigation work.

Two weed killers known as Sodium C2 and Calcium C2 were submitted to this laboratory by the White Pine Blister Rust Control Division of the Bureau of Plant Industry, and tests for drying-time and ignition-temperature determinations were made.



A comprehensive bibliography of weed killers has been prepared, with special reference to their chemical composition. The Bureau's interest in this matter pertains to the fire hazard inherent in a great many of these materials.

#### INDUSTRIAL-PLANT STUDIES

An inspection was made of the inert-gas equipment at one of the large feed-grinding plants. This system, installed to provide inert-gas protection against dust ignitions during feed grinding has been changed from time to time to overcome difficulties which have developed. It has served to a certain extent as a test unit for the inert-gas system of explosion protection developed in the Bureau. The present changes are designed to overcome the difficulty caused by corrosion of the piping due to the high sulphur content of the fuel used in the boilers from which the gas is drawn.

At the time this inspection trip was made several grain elevators at Omaha were inspected, and a study was made of the dust-explosion hazard in malt houses and breweries at Milwaukee, Wis.

A special survey of fire and explosion losses in country elevators was made during the year.

#### SCHOOLS OF INSTRUCTION FOR FIREMEN

The Bureau continued its cooperation with the States in presenting the dust-explosion prevention work to the firemen assembled at the instruction schools. The Third Annual Fire Service Extension School of West Virginia University at Morgantown, W.Va., was attended by a representative of the Bureau.

Dust explosions and spontaneous heating were discussed at the First Annual Fire Service Extension School of the Southwestern Pennsylvania Fire Chiefs' Association at the California State Normal School, California, Pa.

Two meetings were held in Buffalo, N.Y., for members of the fire department, and an address accompanied by motion pictures and dust-explosion demonstrations, was given to both officers and men.

#### FARM FIRES

##### EXPERIMENTAL WORK ON SPONTANEOUS IGNITION OF HAY

One large-scale experiment was carried on in the specially-constructed barn at Beltsville, Md., during the summer of 1933, with a total of 50,475 pounds of hay.

Six zones were established, and 32 thermocouples and 6 metal baskets were used. The false bottom used in the June 1933 experiment was again utilized. During the course of the experiment natural admission of air into the mow was varied by manipulation of the ventilator on the roof and of the vents along the alley. The hay was removed from the barn during the second week in October, all of it being weighed out and samples collected for analysis.

A striking observation was the extent to which the hay had dried out during the 4 months it had been in storage. This condition, together with the development of mold, especially at interior points, indicated that the false bottom was effective and a prime factor in aerating the mass.

Another large-scale experiment is in progress which is expected to yield results indicative of the possible efficacy of salt as a retardant or preventive of spontaneous heating.

##### 4-H CLUB ACTIVITIES

The Division, in connection with the Extension Service, has developed programs of activities for 4-H clubs on farm-fire prevention. The State of Oregon undertook the first organized 4-H club work in this field, the campaign being initiated by the State fire marshal in cooperation with the Extension Service of Oregon State College, through the medium of the State 4-H club organization. A 4-H club project on rural fire prevention also has been inaugurated in Nebraska by the Agricultural Extension Service of the University of Nebraska in cooperation with the State fire marshal. The results of this campaign have been so gratifying that it is being continued in Oregon and Nebraska, and plans are under way for such activity in other States. The enrollment in this farm fire-prevention movement of 4-H club members, who usually are the outstanding boys and girls in their farm communities, and the carrying on of well-formulated intensive campaigns centering on farm properties, is bound to result in a greater reduction of farm-fire losses as the movement progresses and spreads.

## VISUAL EDUCATIONAL ACTIVITIES

An exhibit for the State fair work portraying fire prevention was completed by the office of exhibits and shown at the Eastern States Exposition, Springfield, Mass.

Work was continued on the exhibits at the Century of Progress.

A large number of photographs were collected in the Bureau and assembled for dispatching to London, England, for display at the exhibition of the Royal Photographic Society of Great Britain.

An exhibit of hemlock bark for tanning was prepared for the Industrial Farm Products Division.

Plans were made for revision of the Bureau's exhibit at the 1934 Century of Progress. Part of the 1933 exhibit, such as the synthetic-ammonia plant model and converter, was returned to Washington and sent to the new Franklin Institute, Philadelphia, for display at the opening of the institute.

Exhibit material was forwarded to Winter Haven, Fla., for the Bureau's exhibit at the annual Florida Orange Festival.

The soil-erosion exhibits booth was sent to Columbus, Ohio, for display during farmers' week at Ohio State University.

Assistance was given in planning for the development of the soil-erosion train now under consideration by several railroads for exhibition throughout the soil-erosion sections of the United States.

## SOIL INVESTIGATIONS

## SOIL SURVEY

During the past fiscal year 19,399 square miles of rural lands in 26 States and Puerto Rico were mapped by the Soil Survey. This brings the total area covered by the Soil Survey considerably over 1,500,000 square miles. These maps furnish the fundamental groundwork for planning a land policy by the various governmental agencies, both local and national. The soil maps, together with the accompanying reports giving descriptions of the soils and other uses, provide farmers and land appraisers with a practical working handbook for the soil. In many cases these same maps include the only accurate base map showing the location of rivers, lakes, roads, schools, and the other natural and cultural features of the area.

It is well recognized that the maps of the Soil Survey furnish a sound basis for the development of land-use policies. In the State of New York, for example, the Soil Survey has been and is being used directly in connection with the general program of establishing rational policy for the use of land. In North Dakota this Bureau is engaged in making a comprehensive and detailed soil classification used directly as a basis for classification of lands for the purpose of appraisal for taxation. This work has been taken up at the insistence of the local governments in these areas and has extended already to three counties in North Dakota.

For the purpose of carrying out the Department's policy of removing land from the production of surplus crops, especially where these crops are produced only at a low labor income for the operator, the Soil Survey furnishes the necessary information required to readjust the use of these areas for other crops, grazing, or forestry.

In the Western States the soil survey is proving of incalculable value in the extension of the acreage of certain special crops and at the same time serves to point out the areas where the accumulation of salts and the development of alkali would be a menace to irrigation projects. The selection of those soils suitable for the production of cotton and those best adapted to other crops in southern areas infested with the bollweevil has been greatly expedited by the use of the soil maps. Land suitable for the production of high-quality tobacco is selected through the use of soil maps where they are obtainable.

Interpretation of experimental work in the use of lime, fertilizers, and other farm-management practices depends on the soil survey. Experimental results on one soil type may be applied to other areas of that same soil. Because of the exact descriptions and classification of soils contributed by the soil survey, it has become more and more the policy of experiment station workers and county agriculture agents to make their recommendations regarding agricultural practices by soil type.

During the past year the Soil Survey Division has compiled data giving a definite rating of the productive capacity of the principal soil types mapped for several States for the various crops commonly grown. Summary tables for the soils of each area are being prepared for immediate use, for reference, and for future publication. This work is of great value because it furnishes the natural and logical basis for land classification.

The character of the soil is the most important factor determining the appraisal of rural lands for taxation assessment and determining land values. The appraisers of the Federal land bank have made the utmost use of all available soil maps in carrying out the program of the Farm Credit Administration. Many branches of the Government make use of the soil-survey reports and the maps and are constantly calling on the soil-survey experts of the Bureau for detailed surveys of special areas.

Tables 2 and 3 show the details of the work done during the fiscal year 1934, the areas covered, and their distribution.

TABLE 2.—*Individual areas surveyed and mapped during the fiscal year ended June 30, 1934*

State or Territory	Area	Area surveyed	
		Square miles	Acres
Alabama.....	Colbert County.....	<sup>1</sup> 332	212, 480
	Hale County.....	<sup>1</sup> 176	112, 640
	Marion County.....	109	69, 760
	Sumter County.....	<sup>1</sup> 263	168, 320
Arizona.....	Casa Grande area.....	53	33, 920
California.....	Concord area.....	<sup>1</sup> 599	383, 360
	Visalia area.....	222	142, 080
Georgia.....	Toombs County.....	<sup>1</sup> 85	54, 400
Idaho.....	Bonner County.....	<sup>1</sup> 309	197, 760
Indiana.....	La Porte County.....	<sup>1</sup> 316	202, 240
	Steuben County.....	305	195, 200
	Audubon County.....	443	283, 520
Iowa.....	Davis County.....	<sup>1</sup> 84	53, 760
	Decatur County.....	56	35, 840
	Osceola County.....	283	181, 120
	Allen County.....	295	188, 800
Kansas.....	Cheboygan County.....	<sup>1</sup> 237	151, 680
	Ingham County.....	553	353, 920
	Oceana County.....	<sup>1</sup> 194	124, 160
	Saginaw County.....	<sup>1</sup> 137	87, 680
Minnesota.....	Kanabec County.....	<sup>1</sup> 369	236, 160
	Pine County.....	787	503, 680
Montana.....	Middle Yellowstone area.....	<sup>1</sup> 60	38, 400
Nebraska.....	Boyd County.....	<sup>1</sup> 474	303, 360
	Garfield County.....	357	228, 480
	Greeley County.....	571	365, 440
	Keyapaha County.....	<sup>1</sup> 673	430, 720
New York.....	Wheeler County.....	<sup>1</sup> 510	326, 400
	Albany-Schenectady Counties.....	298	190, 720
	Cattaraugus County.....	75	48, 000
	Onondaga County.....	453	289, 920
	Otsego County.....	<sup>1</sup> 587	375, 680
North Carolina.....	Ulster County.....	563	360, 320
	Wyoming County.....	<sup>1</sup> 370	236, 800
	Cartaret County.....	171	109, 440
	Jones County.....	<sup>1</sup> 199	127, 360
	Pamlico County.....	350	224, 000
North Dakota.....	Stokes County.....	300	192, 000
	Billings County.....	566	362, 240
	McKenzie County.....	<sup>1</sup> 35	22, 400
Ohio.....	Morton County.....	656	419, 840
	Logan County.....	<sup>1</sup> 265	169, 600
Oklahoma.....	Alfalfa County.....	<sup>1</sup> 275	176, 000
	Choctaw County.....	88	56, 320
	Garfield County.....	354	226, 560
	Major County.....	122	78, 080
	Murray County.....	153	97, 920
	Pontotoc County.....	315	201, 600
	Tulsa County.....	355	227, 200
	Washita County.....	<sup>1</sup> 153	97, 920
	Umatilla County.....	<sup>1</sup> 199	127, 360
	Bucks County.....	79	50, 560
Huntingdon County.....	629	402, 560	
Puerto Rico.....	Soil Survey of.....	<sup>1</sup> 309	197, 760
Rhode Island.....	Kent and Washington Counties.....	<sup>1</sup> 242	154, 880

<sup>1</sup> These figures do not include portions of these areas surveyed in preceding years.

TABLE 2.—*Individual areas surveyed and mapped during the fiscal year ended June 30, 1934—Continued*

State or Territory	Area	Area surveyed	
		Square miles	Acres
South Carolina.....	Edgefield County.....	1 201	128, 640
	Pickens County.....	186	119, 040
	Sumter County.....	1 199	127, 360
Texas.....	Brown County.....	1 645	412, 800
	Fannin County.....	134	85, 760
	Hunt County.....	1 484	309, 760
	Maverick County.....	57	36, 480
	Williamson County.....	1 310	198, 400
	Zavala County.....	1 528	337, 920
Utah.....	Price area.....	78	49, 920
Virginia.....	Albemarle County.....	311	199, 040
	Halifax County.....	1 504	322, 560
	Southampton County.....	1 21	13, 440
West Virginia.....	Pocahontas County.....	1 186	119, 040
Wyoming.....	Uinta County.....	1 461	295, 040
Total.....		21, 318	13, 643, 520

<sup>1</sup> These figures do not include portions of these areas surveyed in preceding years.

TABLE 3.—*Areas surveyed and mapped in the several States during the fiscal year ended June 30, 1934, and the areas previously reported*

## DETAILED

State or Territory	Work during 1934	Work previously reported	Total	
			Square miles	Acres
Alabama.....	880	58, 006	58, 886	37, 687, 040
Arizona.....	53	4, 083	4, 136	2, 647, 040
Arkansas.....		15, 547	15, 547	9, 950, 080
California.....	821	34, 811	35, 632	22, 804, 480
Colorado.....		5, 865	5, 865	3, 753, 600
Connecticut.....		1, 704	1, 704	1, 090, 560
Delaware.....		2, 276	2, 276	1, 456, 640
Florida.....		15, 160	15, 160	9, 702, 400
Georgia.....	85	35, 862	35, 947	23, 006, 080
Idaho.....	309	12, 003	12, 312	7, 879, 680
Illinois.....		6, 770	6, 770	4, 332, 800
Indiana.....	621	20, 418	21, 039	13, 464, 960
Iowa.....	866	48, 468	49, 334	31, 573, 760
Kansas.....	295	16, 346	16, 641	10, 650, 240
Kentucky.....		5, 542	5, 542	3, 546, 880
Louisiana.....		17, 431	17, 431	11, 155, 840
Maine.....		2, 197	2, 197	1, 406, 080
Maryland.....		13, 959	13, 959	8, 933, 760
Massachusetts.....		8, 811	8, 811	5, 639, 040
Michigan.....	1, 121	30, 948	32, 069	20, 524, 160
Minnesota.....	1, 156	11, 085	12, 241	7, 834, 240
Mississippi.....		30, 740	30, 740	19, 673, 600
Missouri.....		37, 177	37, 177	23, 793, 280
Montana.....	60	3, 227	3, 287	2, 103, 680
Nebraska.....	2, 585	62, 833	65, 418	41, 867, 520
Nevada.....		652	652	417, 280
New Hampshire.....		1, 411	1, 411	903, 040
New Jersey.....		9, 895	9, 895	6, 332, 800
New Mexico.....		2, 565	2, 565	1, 641, 600
New York.....	2, 346	32, 085	34, 431	22, 035, 840
North Carolina.....	1, 020	46, 312	47, 332	30, 292, 480
North Dakota.....	1, 257	19, 690	20, 947	13, 406, 080
Ohio.....	265	18, 142	18, 407	11, 780, 480
Oklahoma.....	1, 815	20, 485	22, 300	14, 272, 000
Oregon.....	199	15, 600	15, 799	10, 111, 360
Pennsylvania.....	708	21, 325	22, 033	14, 101, 120
Puerto Rico.....	309	1, 791	2, 100	1, 344, 000
Rhode Island.....	242	1, 281	1, 523	974, 720
South Carolina.....	586	25, 939	26, 525	16, 976, 000
South Dakota.....		8, 286	8, 286	5, 303, 040
Tennessee.....		11, 198	11, 198	7, 166, 720
Texas.....	2, 158	62, 100	64, 258	41, 125, 120
Utah.....	78	2, 419	2, 497	1, 598, 080
Vermont.....		1, 175	1, 175	752, 000
Virginia.....	836	13, 237	14, 073	9, 006, 720

TABLE 3.—Areas surveyed and mapped in the several States during the fiscal year ended June 30, 1934, and the areas previously reported—Continued

## DETAILED—Continued

State or Territory	Work dur- ing 1934	Work pre- viously reported	Total	
	<i>Square miles</i>	<i>Square miles</i>	<i>Square miles</i>	<i>Acres</i>
Washington.....	10, 752	10, 752	21, 504	6, 881, 280
West Virginia.....	186	23, 497	23, 683	15, 157, 120
Wisconsin.....		26, 659	26, 659	17, 061, 760
Wyoming.....	461	9, 468	9, 929	6, 354, 560
Total.....	21, 318	887, 233	908, 551	581, 472, 640

## RECONNAISSANCE

Alaska.....		31, 915	31, 915	20, 425, 600
Arkansas-Missouri.....		58, 000	58, 000	37, 120, 000
California.....		32, 135	32, 135	20, 566, 400
Kansas.....		39, 960	39, 960	25, 574, 400
Michigan.....		1, 322	1, 322	846, 080
Minnesota.....	994	10, 080	11, 074	7, 087, 360
Montana.....	151	49, 534	49, 685	31, 798, 400
Nebraska.....		53, 064	53, 064	33, 960, 960
North Dakota.....		39, 240	39, 240	25, 113, 600
Ohio.....		41, 420	41, 420	26, 508, 800
Pennsylvania.....		41, 405	41, 405	26, 499, 200
South Dakota.....		41, 400	41, 400	26, 496, 000
Texas.....		152, 855	152, 855	97, 827, 200
Vermont.....		9, 124	9, 124	5, 839, 360
Washington.....		16, 540	16, 540	10, 585, 600
Wisconsin.....		14, 425	14, 425	9, 232, 000
Total.....	1, 145	632, 419	633, 564	405, 480, 960

## WORK FOR SUBSISTENCE HOMESTEADS

Since August 1933, soils have been mapped by this Bureau for the Subsistence Homesteads Division of the Department of the Interior in connection with the following projects: Three projects in the vicinity of Birmingham, Ala.; the Westmoreland project near Greensburg, Pa., and contemplated projects near Irvona and Coalport. In West Virginia the soils on two projects were examined—the Arthurdale Homestead at Reedsville and the Tygart Valley project about 10 miles south of Elkins. In Tennessee, a 10,000-acre tract of land was purchased after examinations had been made on several large tracts. This project is situated on the Cumberland Plateau. In North Carolina a 10,000-acre tract was examined and an appraisal was made of the land. In South Carolina, three tracts were examined. In Mississippi small acreages were examined near Tupelo, Meridian, Hattiesburg, and McComb, and a large acreage near Richton.

From November 1933 to March 1934, eight tracts of land in Florida were examined to determine their suitability for subsistence homesteads. Detailed soil maps were made of the areas in Volusia and Liberty Counties.

## ASSISTANCE TO VARIOUS GOVERNMENT AGENCIES

In addition to the mapping of soils for the subsistence homesteads, a large area in the vicinity of Monticello, Ga., also has been mapped in detail for the Bureau of Agricultural Economics. Another large area was mapped in detail in the vicinity of Beltsville, Md., for the Bureau of Animal Industry and for other bureaus in the Department of Agriculture.

Services of Soil Survey men have been used on the Crow irrigation project in Montana, and Fort Hall irrigation project in Idaho. Another special assignment was to the San Carlos project in Arizona. The War Department and Bureau of Agricultural Economics called on this Bureau to pass on the character and value of the soils in the Fort Peck Reservoir, Mont. The Tennessee Valley Authority used a soil expert for classification and general mapping of the soils on the Norris town site located near the Clinch River. The Public Health Service, Department of Treasury, called on the Bureau to pass on certain lands for proposed hospital sites in Washington and Oregon.

From December 1933, through April 1934, a majority of the Bureau's soil scientists were engaged in the supervision of large parties of Civil Works employees distributed in several States. This work consisted of making of base maps of a number of counties in 10 of the Southern States.

#### PEAT INVESTIGATIONS

The Section of Peat Investigations has continued its research and cooperation with other bureaus and State agencies with the object of locating and developing the vast domestic deposits for use in agriculture and industry. One outstanding objective of this work is to assist the American peat industry, consisting of peat producers in 17 States, to secure and market products of such grade and quality as to replace the imported peat products for which approximately \$800,000 is now expended annually.

During the past year the Section has identified and graded samples of peat and muck submitted for analysis by Federal, State, and private agencies; has advised correspondents and consultants regarding peat products, and the nature of peat deposits; has cooperated with the Soil Survey and the Insular Experiment Station of Puerto Rico in the study of tropical maritime types of peat land, and with the Office of National Parks and the Golf Association in determining the relative merits of different kinds of peat for improving mineral soils.

#### LOCATION OF SELENIZED AREAS

During the summer of 1931 the Soil Survey made a study in parts of South Dakota, Nebraska, and Wyoming to determine what relation, if any, existed between the diseased condition of livestock and the different soils. In the entire area surveyed the trouble occurred on soils of a certain group or could be attributed to hay or grain grown on these soils. These soils were heavy clays derived from dark-colored cretaceous shales.

During the field seasons of 1932 and 1933, the Soil Survey has attempted to determine the distribution of the diseased condition and the extent of the areas of possible occurrence. Exploratory trips have been made to outline the extreme limits of the affected areas and detailed surveys of farms and other areas to learn more of the local distribution of the causal toxic element, selenium. The information in both classes of surveys has been gained by collecting samples of soil, of the underlying shale, and of the plants growing on the soils and sending them to the chemical laboratories for determination of their selenium content.

#### SOIL-EROSION INVESTIGATIONS

The work of the Bureau on soil and water conservation at its 10 soil-erosion experiment stations located in as many of the most seriously affected type areas scattered widely over the country has continued essentially along the lines set forth in earlier reports. As in the past this, of course, has been in close cooperation at all times not only with appropriate State and Federal agencies but with numerous others of a more local nature. During the year these stations have furnished much constructive information not only direct to the public at large but also to various service organizations both for direct application in the field and for systematic extension activities by way of ultimately getting the story across to the farmer in an effective manner.

This information has dealt not only with the relative rates of soil and water losses from various soils under definite conditions of slope, climatic relations, and surface exposure, but also has included well-defined instructions as to procedure in the establishment of proper methods of control under practical working conditions in the field.

The work as a whole has continued to show rather well-defined physical relations between established soil types and erosional behavior and thus, in a very definite way, emphasizes the importance of study and classification of soils from the type standpoint to the accomplishment of most effective and systematic work in this important field of conservation.

#### VEGETATION A DOMINANT FACTOR IN EROSION CONTROL

The dominant role of vegetation as a controlling factor in soil and water losses, whether it be grass, close-growing cover crops, shrub, or forest cover has continued to stand out prominently as in previous years. Control studies at all of the erosion stations involving plots of about one-hundredth acre in

size where all soil and water losses are caught and measured under a variety of surface exposures as to crop and cultivation have continued to provide remarkably interesting and important results during the past year.

Thus at the Temple (Tex.) station a study of the results of the variously treated plots shows that permanent sod not only did not lose either water or soil at any time during the past year with a rainfall of 25.68 inches, but it has not experienced run-off or loss of soil at any time the past 4 years with an average rainfall of 23.78 inches. In contrast with this the plot involving a standard rotation of corn, oats, and cotton suffered water losses under the conditions indicated at an average annual rate of 8.73 percent of the total rainfall and an average annual soil loss of 7.83 tons. These results were obtained in working with the local Houston black clay soil on a slope of 4 percent. Both sheet and gully erosion are locally very severe on slopes of this or even lesser degree under average field conditions in this section, where no control is exercised. Other soils and slopes have shown even more striking comparisons, although in no instance has the grass cover exerted such complete control as is indicated at the Temple station.

At the Guthrie (Okla.) station a similarly established grass plot upon Vernon fine sandy loam with a slope of 7.7 percent gave an average annual loss over a period of 4 years of 1.5 percent of an average annual rainfall of 32.9 inches, while the plot carrying continuous cotton showed a loss of 14.2 percent. Comparing the two plots in a similar way from the standpoint of soil losses, that in continuous grass experienced an average annual loss of 80 pounds per acre as against more than 28 tons for the cultivated plot.

Control plots of a similar nature established under various conditions of forest growth at certain of the erosion stations have also demonstrated the remarkable degree of control this type of cover exerts over soil and water losses especially when undisturbed by burning. Thus, studies at Guthrie on Vernon fine sandy loam with a slope of 5.1 percent have shown that while the average annual loss over a period of 4 years from a rather lightly covered area has been but 0.13 percent of an average rainfall of 33.49 inches, it was increased by nearly 40 times through annual burning over. Likewise the average soil loss for the same period has been increased by 12 times as a result of the exposure under such lightly wooded conditions following burning. The average annual loss of soil for the period from the undisturbed plot was 40 pounds per acre.

Highly effective control measures of this nature are being introduced into many of the emergency-work programs where gully control is the major aim in most instances. In this work extensive use is being made of grass and legume seedings following the building of the check dams and the grading down of the sides of the banks. This work of the Civilian Conservation Corps is under the immediate supervision of the Forest Service with the close cooperation of the Bureau of Chemistry and Soils and of the Bureau of Agricultural Engineering.

#### STRIP CROPPING AND CONTOUR CULTIVATION

Under natural conditions of cultivation strip cropping or the alternation of close-growing crops such as alfalfa or sorghum with cultivated crops such as corn or cotton, in strips of definite width, depending on the degree of slope and other factors, have continued to show highly interesting possibilities for erosion control, wherever carefully studied. The procedure of course falls within the limitation of availability of desirable crops for a given soil, locality, and type of farming, as well as the seasonal exposure involved during periods of seeding.

Substantiating results also have followed those of previous years in the use of improved methods of contour cultivation of various types both with and without terraces. As might be expected, results with terraces in general point toward improvement as the structures settle and cropping relations become better adjusted. Procedure along this line whether it be terracing, contour cultivation, or a combination of the two represents an attempt to build up basin capacity at the surface of the soil to prevent or control run-off of the water and, at the same time, wash-off of the soil.

#### A COMBINATION OF PREVENTIVE MEASURES NEEDED

It is readily seen that a definite knowledge of the sum of the basin capacity in inches of rainfall of the surface conformation of a soil developed by a given

type of cultivation or treatment and the rate of infiltration of water into the soil under those conditions represents a factor of considerable importance in run-off and erosion control, since the difference between this value and the total rainfall must represent the amount that will run off the surface and not only be lost to plant growth, but also cause erosion unless the surface of the soil is properly protected.

While striking results have been obtained in the control of soil and water losses through the proper use of vegetation and by terracing and other mechanical means in a more or less independent way, it is coming to appear that a combination of these facilities may prove more advantageous and effective in the long run, especially in that complete dependence is not placed on either, alone, over any considerable period. It is planned that more and more emphasis will be placed upon combination studies of this type.

#### SOIL-FERTILITY INVESTIGATIONS

The soil-fertility investigations of the Bureau have continued to aid farmers in obtaining more economical production by evaluating the fertility of the principal soil types on which our major crops are produced and by determining their plant-food requirements. This work applies directly to cotton, potatoes, sugarcane, sugar beets, truck crops, citrus fruits, and nut crops, and is carried on in regional field headquarters in cooperation with State agricultural experiment stations.

#### COTTON SOIL-FERTILITY STUDIES

For the benefit of the cotton farmers of North Carolina, South Carolina, Georgia, Alabama, Texas, and Virginia, who desire to make the most effective and economical use of fertilizers, the Bureau has compiled data, following years of cooperative field experiments, which show the amounts and the mixtures of fertilizer that are best suited to the principal cotton-growing soils of these States.

The results obtained by this Division show that nitrogen is the predominant need of the cotton-growing soils of the Southeast and that in this region the yield of cotton may at least be doubled and sometimes trebled through the application of large quantities of commercial nitrogen mixed with mineral fertilizers.

The results of these experiments, which have been carried on for a number of years in North Carolina, South Carolina, and Georgia, are presented in Technical Bulletin No. 452, now in press. Farmers on the most extensive cotton-growing soils of the coastal plain and piedmont sections of those States can now secure additional reliable information relative to the most desirable nitrogen ratios, sources of nitrogen, and time of application on these soils.

Results of previous work showing the ratios of nitrogen, phosphoric acid, and potash which give the largest returns on the principal soil types used for cotton have also been published by the Bureau in Technical Bulletin No. 225.

Changes in the composition of commercial fertilizers are tending to increase their acid-forming property. To study this factor in relationship to cotton production the Bureau has begun a series of experiments to evaluate the effect of acid and neutral fertilizers on some of the most important soil types used for cotton growing.

#### POTATO SOIL-TYPE INVESTIGATIONS

During the past fiscal year cooperative potato-fertilizer studies were conducted on important soils in Maine, New York (Long Island), New Jersey, Pennsylvania, Virginia, Michigan, and Ohio. In these regions the use of commercial plant food is fully recognized as an essential practice in successful potato production, just as much as good soil preparation, good seed, and good cultural care are considered essential. As a matter of fact, proper feeding of the potato crop to obtain increased yields and better quality is a decided economy in that the extra return more than compensates for the cost of the fertilizer applied and results in lower unit cost of production.

The Bureau's cooperative fertilizer studies on potato soils have led to some interesting findings, among which may be mentioned the importance of plant-food elements other than nitrogen, phosphorus, and potassium in the nutrition of the potato. It has been found, for example, that magnesium must be present in sufficient amount in the soil or the potato plants will suffer from lack of green coloring matter or chlorophyll. The results so far secured show



that the addition of suitable magnesium compounds to the fertilizer or direct application of magnesium limestone to the soil overcomes the deficiency trouble, assuring normal growth and yields.

Continued studies to determine the need for uncommon elements, such as copper, manganese, nickel, and zinc, were made on Caribou loam, in Maine, and Sassafras loam, in New Jersey, without any significant response being obtained. The addition of nickel sulphate definitely resulted in injury, particularly so where an application of as much as 50 pounds per acre was made.

#### SUGARCANE SOIL AND FERTILIZER STUDIES

Substantial increase in the yields of different varieties of sugarcane resulted from the Bureau's work in determining and applying the most effective fertilizers for different varieties and different soils in Louisiana in cooperation with the experiment station of that State.

A very high yield resulted from a triangle fertilizer experiment at Jeanerette from an application of a 16-4-0 mixture at the rate of 300 pounds an acre (equivalent to 48 pounds of nitrogen and 12 pounds of phosphoric acid) which produced 42 tons of cane. This experiment on Iberia silt loam resulted in an increase of over 13 tons of cane in comparison with the unfertilized plots.

A yield of 29 tons of cane and 5,288 pounds of sugar per acre was obtained at Raceland with variety P.O.J. 213 first stubble on Yazoo very fine sandy loam. An almost unprecedented increase of 14 tons of cane and 2,431 pounds of sugar per acre was made over the unfertilized plots by applying 60 pounds of nitrogen in the form of sulphate of ammonia. This increase represents an increased return of more than \$50 per acre over the unfertilized plots.

In these and various similar experiments on a variety of soils, the most effective fertilizer was determined by the triangle or fertilizer-ratio system devised by this Bureau and used for many years in connection with Federal and State cooperative projects.

The field studies are being supplemented by laboratory work on the cane juice from the fertilizer plots to determine the composition of the juice as affected by different fertilizers, soil types, and varieties. The composition of the juice affects markedly the clarification methods and the manufacturing costs of sugar.

#### FERTILIZER STUDIES WITH SUGAR BEETS

Experiments with sugar beets carried on by the Bureau near Scottsbluff, Nebr., have shown that a moderate application of phosphatic fertilizer frequently more than doubles yields on certain types of soil with high soluble salt, or alkali, content. These soils in the past were not used for growing beets because of low yields but as the result of studies of the Bureau, can now be brought into profitable production.

During the fiscal year 1934, 3 subprojects were completed in the Red River Valley of North Dakota, 3 in southern Minnesota, and 5 in Nebraska. The work in Nebraska was conducted in cooperation with the Nebraska Agricultural Experiment Station. The information afforded by these experiments is of practical benefit to sugar-beet growers and sugar companies in the several States.

#### STUDIES WITH CONCENTRATED FERTILIZERS

Field experiments comparing single-, double-, and treble-strength fertilizer mixtures in Aroostook County, Maine, have shown that double-strength mixtures in particular rate as efficiently as ordinary mixtures so far as yields are concerned. The treble-strength mixtures, while having proved worth while from a plant-food standpoint, present certain physical difficulties which will have to be overcome before they can be fully recommended to fertilizer consumers. It has been indicated from the work that certain elements other than nitrogen, phosphorus, and potassium may be required, particularly magnesium, which the treble-strength fertilizer fails to carry in sufficient quantity for proper plant development. This can be met by the addition of available magnesium compounds to the fertilizer, or by direct applications of dolomitic limestone to the soil.

Field work comparing methods of applying concentrated fertilizer to potatoes has shown that applying fertilizer on each side of the seed piece in narrow bands at a distance of 2 inches from the seed piece gave best results. It was

found that an increase in yield of 30 to 50 bushels resulted over fertilizer applications under or over the seed piece. A comparison of single- and double-strength fertilizer in Maine, New Jersey, and Virginia has shown that on the lighter soil types in Virginia the chance for injury from concentrated fertilizer is greater. For this reason proper application of concentrated fertilizers has been found important.

Work with concentrated fertilizers in the Southern States includes experiments with truck crops and cotton in North Carolina, cotton in South Carolina and Georgia, and citrus and truck crops in Florida. The year's work confirmed the results of previous years in showing that concentrated fertilizers must be used cautiously and application made so as not to injure seed, which is best done by side placement of the fertilizer in relation to the seed.

Concentrated fertilizers are made more efficient on some soils by blending with the fertilizer small quantities of manganese, copper, nickel, and zinc salts, and by including appreciable quantities of calcium and magnesium compounds.

Valuable information has been secured in the study of concentrated fertilizers blended with minor essential plant foods, as affecting growth and production of sweetpotatoes on Norfolk loamy sand. The results secured confirm those of previous years in showing that the reinforcement of concentrated fertilizers with calcium, magnesium, and other of the less common plant foods, such as manganese, zinc, copper, nickel, etc., has made them more efficient for sweetpotatoes on these sandy soils. The results secured in this experiment, which is made on the same plots year after year, are more accentuated each year.

Experiments with the placement of concentrated fertilizers in relation to the position of the seed are in progress with potatoes on Bladen sandy loam at Aurora, N.C., and on Portsmouth sandy loam, Beaufort, N.C. These fertilizers give best results when the fertilizers are placed to the side of the seed and slightly below the level of the seed. This placement results in better stands and larger yields and renders concentrated fertilizers as efficient as ordinary-strength fertilizers.

Six years' results have been secured in studying effects of concentrated fertilizers on oranges in experiments at Lake Alfred, Fla., in cooperation with the Florida Agricultural Experiment Station. In the experiments where concentrated fertilizers are compounded from pure chemicals and compared with a fertilizer made partly from organic materials, tree condition is better and fruit of a higher quality from base-forming mixtures. These experiments are still in progress.

#### COTTON ROOT-ROT INVESTIGATIONS

Systematic experiments on the relation of soil-fertility factors and the use of fertilizers to the control of cotton root-rot have been continued in the Blackland Prairie area of Texas. These experiments, located on the major soil types in 9 counties of the area, have been conducted in cooperation with 11 representative cotton growers and with Federal and State field stations. Recent results confirm those of preceding seasons in indicating that fertilizers containing suitable ratios of readily available nitrogen and phosphoric acid accelerate growth and fruiting of cotton and increase yields of crop. These effects vary in degree with the soil type and with the season; but they are in general of such magnitude as to be important in the evasion and compensation of losses otherwise caused by the root-rot disease.

Further experimental evidence indicating a direct influence of fertilizer treatment on the rate of plant mortality due to the root-rot fungus has been accumulated. The effect varies with different soils. Consistent and significant reductions in the rate of dying of cotton plants have followed moderate applications of nitrogenous fertilizers on Wilson clay loam; similar effects have followed heavy fertilizer treatments on Wilson clay and Denton clay; and, on Houston soils, reductions in plant mortality have been effected by application of nitrogen fertilizers to cotton following sorghum crops. The effects are in a measure cumulative. Practical application of the results suggest a profitable return in cotton production through appreciable control of the root-rot disease.

Preliminary experiments furnish evidence that the lowered rates of plant mortality, associated with nitrogenous fertilizer treatments on certain root-rot infested soils, are correlated with significant differences in the content and distribution of carbohydrate materials within the plant. Other studies reveal that, in some cases at least, heightened nitrifying power of the soil accompanies treatment with a fertilizer found effective in reducing killing of plants

by root rot, and suggest that enhanced activity of soil organisms, other than the root-rot fungus, is another factor in the suppression of the disease under such conditions.

Experiments with midsummer deep tillage and subsoiling continue to demonstrate their effectiveness in land preparation and reducing root-rot losses the following season to a very low level.

#### FERTILIZER INVESTIGATIONS WITH PECAN SOILS

Soil-fertility studies in pecan orchards of the Southeastern States indicate that commercial production of good-quality pecans cannot be maintained on the soils of this region without making liberal applications of complete fertilizers relatively high in all the essential plant-food elements; without incorporating a large supply of organic matter in these soils regularly; and that due to the rather common occurrence of short periods of drought at critical times in the development of the pecan, it is very essential to conserve soil moisture in every way economically possible.

A cooperative experiment with the Bureaus of Plant Industry and Entomology, in which old, undernourished, and badly rosetted pecan trees were well fertilized, treated with zinc sulphate, sprayed for insects and diseases, and supplied with organic matter through legume cover crops, has resulted in an apparent recovery from the rosette, in renewed growth of the trees and in a heavy set of pecans this year for the first time in several years.

#### SOIL-FERTILITY INVESTIGATIONS WITH PEACHES

The Bureau's fertilizer work with peaches was inaugurated in field experiments at Marshallville, Ga., in 1922, on Greenville sandy loam, a coastal-plain soil, in cooperation with the Georgia Experiment Station.

The results of this experiment, which was continued 5 years, showed a fertilizer mixture containing 4 percent of nitrogen, 8 percent of phosphoric acid, and 8 percent of potash gave best yields of peaches and fruit that remained firm when shipped. Potash was a factor in producing peaches of good shipping qualities.

In 1926 an experiment using a similar plan (triangle fertilizer mixtures) was made on Cecil clay loam, a piedmont soil at Williamson, Ga. This experiment also showed the 4-8-8 fertilizer gave good tree growth and peaches of good quality.

#### CITRUS AND TRUCK-CROP FERTILIZER RESEARCH

The Bureau's investigations of citrus-soil problems comprise a series of experiments to determine the extent of manganese deficiency of citrus soils of Florida, the causes of bronzing of citrus and means of overcoming this destructive nutritional disease, and a series of experiments to study the best means of utilizing new chemical fertilizers. In the last-named studies, fertilizers are compounded to be acid forming and base forming, and these are used on citrus soils of varying degrees of soil reaction.

The results secured contribute to the knowledge of the judicious use of fertilizer and soil amendments in the economical production of citrus fruits in Florida. Orange trees on acid soils when fertilized with acid-forming concentrated fertilizers generally did not give as good yields, nor as heavy and firm fruit as when fertilized with base-forming concentrated fertilizers. While base-forming fertilizers gave larger yields and firmer fruit on acid soils, its superiority was not so marked on alkaline soils. The effect of manganese sulphate added to Florida citrus soils of acid and alkaline reaction were, in general, to increase the manganese content, the firmness and weight of the fruit, and color intensity of the rind of the fruit. The percent of juice in the ripe fruit was in most of the experiments decreased, but the degree of acidity of the fruit was apparently not effected. Manganese sulphate applied to soils of chlorotic groves improved the condition of the trees, and in many experiments chlorosis was reduced as evidenced by the greener leaf color. This effect was most marked on the neutral and alkaline soils, and occasionally noted on acid soils.

In the experiments to determine the cause of bronzing of citrus, a comparatively new nutritional disease, trees to which ground limestone, dolomitic limestone, magnesium sulphate, and ground limestone with manganese sulphate were added, in addition to complete fertilizer, showed earlier indications of improvement.

## GREEN-MANURE CROPS

Since the establishment of the soil-fertility laboratory and the inauguration of green-manure studies at the experiment station at Pontiac, S.C., near Columbia, considerable information has been obtained which has proved helpful in growing crops economically on the light sandy soil at the station. The soil at the station is representative of a typical soil formation occurring extensively in North Carolina, South Carolina, and Georgia, the so-called "sand-hill country."

For maintaining the fertility of sand-hill soils the work of the Bureau shows that the soil should be kept in a crop both winter and summer. It has, moreover, proved more profitable, and soil fertility is maintained at a higher level, to apply periodically a high-nitrogen commercial fertilizer and harvest the crops than to use either no fertilizer or a low-grade nitrogen fertilizer and turn under the green-manure or hay crops.

## STRAWBERRY-SOIL INVESTIGATIONS

Results of fertilizer experiments on the strawberry soils of eastern North Carolina show more vigorous plants, better plant viability, larger yields, and better strawberries from the use of a fertilizer containing 5 percent of nitrogen, 8 percent of phosphoric acid, and 6 percent of potash, when applied semi-annually at the rate of 750 pounds per acre in August and November. Fertilizers with lower or higher percentages of nitrogen and lower or higher percentages of potash than indicated above did not give as favorable results.

The viability of strawberry plants was found to be correlated, in a general way, with the reaction of the soils. Fields where strawberry plants died were found to be more acid than nearby fields with vigorous plants. When the soil was made more acid by the addition of sulphur, the viability of the strawberry plants decreased. On acid soils treated with lime the viability of strawberry plants increased as the soil approached neutrality up to a pH of about 6. The periodic addition of small quantities of lime and the use of physiologically alkaline fertilizers proved to be a means of preventing loss of strawberry plants on the more acid soils.

## MECHANICAL PLACEMENT OF FERTILIZERS

The fertilizer-placement experiments in the South are in cooperation with the agricultural experiment stations of South Carolina, North Carolina, and Florida, and the Bureau of Agricultural Engineering. Work is in progress with cotton on three soil types at Florence, Columbia, and Clemson College, S.C.; with potatoes at Beaufort and Aurora, N.C.; and with beans at Winter Garden and Fort Lauderdale, Fla. The results for the year ended June 30, 1934, confirm those secured in previous years in showing that, in general, the preferred placement of fertilizers for cotton and truck crops is in a narrow band on each side and below the level of the seed.

The results of cooperative fertilizer placement studies on prominent potato soil types in Maine, Michigan, New Jersey, Ohio, and Virginia during the crop season of 1933 are also in harmony with those of other years. In general, best stands and yields were obtained when the fertilizer was applied in narrow bands on each side of the seed piece with approximately 2 inches of fertilizer-free soil intervening. Placement of fertilizer over or under the seed piece failed to give as satisfactory results as the side-placement methods.

## SOIL-TYPE RESPONSES TO MAGNESIUM COMPOUNDS

The magnesium field studies in 1934 were conducted cooperatively in Maine, on Caribou loam; in New York (Long Island), on Sassafras loam; in New Jersey, on Sassafras loam; and in Virginia, on Norfolk sandy loam. In Maine and Virginia striking results were obtained by applying available magnesium compounds with the fertilizer. Normal vine development and yields ensued, in some cases 50 to 75 bushels increase being recorded. The quantity of magnesium to apply varied from 20 to 30 pounds of MgO per acre. It was found that a practical solution lies in applying dolomitic limestone, provided the deficiency is not acute. The relation of soil acidity to the general problem resolves itself again into the use of dolomitic limestone as a correction therefor and to automatically supply some magnesium. Analytical data are being accumulated on foliage and tuber samples from differently treated plots. A

continuation of the magnesium work is in progress to determine comparative value of different sources of magnesium and their effect on growth and yield.

#### BIOCHEMICAL SOIL STUDIES

Additional data on the occurrence of sterols in soil-forming fungi have been obtained.

Further work has been done in an attempt to distinguish between the CO<sub>2</sub> derived from uronic acids and that derived from other organic sources.

It has been found that practically all soils when boiled for some time with water give off CO<sub>2</sub>, and it has been found that this CO<sub>2</sub> arises from some more or less complex carbonate compound or compounds. The presence of such compounds in soils has not been recognized heretofore and a recognition of their presence introduces a new factor of far-reaching importance into the biochemistry of soils.

Data on the carbon-nitrogen ratio have continued to be collected in connection with all routine analyses of soils submitted to the laboratory.

#### SOIL CHEMISTRY AND PHYSICS

During the past year a new line of investigation has been added to the activities of the Division of Soil Chemistry and Physics. It concerns the occurrence and the importance of selenium in soils and vegetation. This investigation is carried on in cooperation with the College of Agriculture of South Dakota. A so-called "alkali disease" of animals in this section was first recognized by an Army surgeon in 1856. For many years it was supposed to be caused by alkali water. It is a matter of scientific interest that a trouble reported in 1856 should find scientific explanation only in 1934. The investigations of the South Dakota institution traced the cause of the animal disease to feed crops grown on certain localized soil areas. This Bureau has shown that the soils and vegetation contain appreciable quantities of the relatively rare element selenium, and that toxicity is associated with the selenium content.

Very delicate and satisfactory methods have been developed for the determination of selenium in soils and in vegetation. By the application of these methods the presence of selenium has been traced from animal to plant, from plant to soil, and from soil to parent shales. An extensive program is now under way which includes chemical analyses of soils and plants and the mapping of soil areas according to their selenium content. It is hoped that in this way the specific areas affected may be differentiated from unaffected areas which in many cases may be located close by.

It is a matter of particular importance that so far as known the affected areas all lie in a region of relatively low rainfall. The occurrence of selenium in soils or shales has been shown to be very wide and to include areas of limited extent in several States. Whether toxic quantities exist in more than four States is not known. Considerable variation in the selenium content of different plants grown on the same areas has been demonstrated.

#### RELATION OF COLLOIDS TO CLAYPANS

A major interest is maintained in a fundamental study of the chemical character of the colloidal material of soils. The importance of soil colloids as influencing soil fertility and soil behavior have previously been emphasized. New chemical and physical data have been obtained, all of which broaden the usefulness of such knowledge in soil classification and in the interpretation of soil problems.

A study of midwestern claypan soils by this division showed that such formations depend on the rainfall and the character of the parent material from which the soil is formed. The results show that in most cases claypans are formed by colloidal material which has been dispersed near the surface, translocated downward without change in chemical composition, and precipitated in a layer which is more alkaline than the soil at the surface.

#### EFFECT OF EROSION ON COLLOIDAL MATERIAL

Further studies in connection with soil erosion show that the total quantity of material eroded is not the sole index of the damage done to the fertility of the soil. When the quantity of erosion is small there is a relatively larger

quantity of colloidal material and organic matter in the run-off and wash-off than when the erosion is rapid.

#### STUDIES OF INFERTILE SOILS

In some agricultural areas there are soils greatly inferior to other soils in the immediate neighborhood. In certain cases the reason is not apparent from such factors as texture, drainage, moisture, etc. A study was made of some of these infertile soils, most of which are derived from basic rocks of high magnesian content. Comparisons of the chemical compositions of the soils, their colloids, and the parent rock show that these soils are unusual in showing a profound influence of the composition of the parent rock on the compositions of soil and colloid. Significant quantities of chromium and nickel are found to be present. The evidence indicates that these elements are definitely toxic to plant growth and in certain cases are the major cause of infertility.

#### MOISTURE RELATIONS OF SOILS

Studies of moisture relations in soils have been carried out with centrifugal forces as high as 300,000 gravity. This force serves to remove moisture to a point much below that available to a plant. Irrigationists, among others, are interested in laboratory methods for determining the field capacity of soils for water. Studies of the moisture distribution in carefully prepared soil columns indicate that the moisture content of wet soil in contact with a dry soil layer will give a satisfactory measure of the field capacity of soils of all textures.

Other lines of investigation being pursued in this division include studies of the constitution of peat, of the acidity of base-free soil acids, and of the rate and character of the hydrolytic effects on parent materials of soils. In addition to the research work, a very large amount of work on the routine examination of soils is being carried on, which includes mechanical and chemical analyses and the determination of physical qualities.

#### SOIL-MICROBIOLOGY INVESTIGATIONS

##### INSPECTION OF LEGUME INOCULANTS

The annual inspection of soil and seed inoculants centers upon two seasons—the fall planting of legumes and those planted in the spring. More than 600 samples have been collected and examined during the year, representing 31 producing establishments. Field tests of inoculants, under the control of the Division of Soil Microbiology, were conducted in Montgomery County, Md. Factory inspections included the plants which manufacture commercial inoculants in Ohio, Indiana, Illinois, Missouri, Iowa, Wisconsin, Michigan, New Jersey, New York, and Pennsylvania. Pressure for improvement in operations and personnel have apparently brought about fairly satisfactory service to the farmers since no complaints of extensive losses due to inoculation have been received during the year.

##### A SPECIAL INOCULANT FOR EVERY CROP

It was formerly believed that a small group of strains of legume organisms could be distributed and insure adequate inoculation for all legume crops. Recent experiments clearly indicate so close adaptation of particular strains of bacteria to particular species of legume, that best field results call for a special culture for each crop. Deterioration of such strains of bacteria in the laboratory and the field also appears, hence the maintenance of highest efficiency in legume growing calls for constant selection and improvement of legume inoculants.

##### CULTURES AVAILABLE

In response to the need of an available supply of such cultures, the Bureau maintains a collection of strains of nodule organisms representing all legume crops commonly raised in the United States, and many rare and special strains for legumes not commonly grown. The constant development of new legume-producing areas and introduction of new legumes to supply particular local needs, is paralleled by the accumulation of the Bureau's stock cultures of the necessary nodule bacteria. Cultures from this collection are widely distributed for experimental purposes.

## MICROBIOLOGICAL TESTS FOR SOIL DEFICIENCIES

Studies of biological methods of determining fertilizer deficiencies in agricultural soils have continued in two lines—that of the *Azotobacter* or Winogradsky plaque method and the Niklas or *Aspergillus niger* method. Aside from very limited success in one group of soils in the United States, the azotobacter plaque test must for the present be discarded. The *Aspergillus niger* test, under rigorous standardization, seems to be adaptable for use with all of the soils tried. The necessity of establishing a basal standard for each soil type, however, introduces a requirement of expense and research skill for each situation studied, which would necessarily limit its use to localities in which development of one-crop farming has been well organized over fairly extensive areas of particular soil types.

So many difficulties were encountered in the handling of the organisms involved in these tests that special study of one of them, *Azotobacter*, was undertaken.

## STRAIN VARIATION IN AZOTOBACTER

A survey of the *Azotobacter* flora of soils collected from various parts of this country and from a few foreign countries has shown that the Ashby mannitol agar in classical use for this organism, is not satisfactory for demonstrating the presence of *Azotobacter*. In nearly all soils, a strain of *Azotobacter* was found by using starch or dextrin in the agar which was not able to utilize mannitol of the Ashby agar medium. In a few soils this was the only strain of *Azotobacter* found. Therefore, in searching for *Azotobacter* in soil, a nitrogen-free medium (Ashby base) with starch or dextrin instead of mannitol, must be used. There are instances in the literature where a fixation of nitrogen has been demonstrated but no *Azotobacter* has been found by the usual methods. The explanation may lie in the fact that the strain of *Azotobacter* in that particular soil could not use mannitol, the source of energy in the orthodox Ashby agar. Variations in the use of other carbon compounds by different strains of *Azotobacter* has also been observed.

## SOIL FUNGI

Study of the groups of fungi from soils varying in type, in origin, and in crop production, have continued. Series of such cultures have been contributed for identification, by widely separated workers, thus furnishing opportunities for comparative studies of the fungous flora of different regions. The proof that certain species which are important as root rots of great destructive capacity, are also free-living members of the soil population, has given added importance to the establishment of sound information as to the normal balance between bacteria, molds, and other organisms necessary to crop growing. A preliminary survey of such a situation in the area of cotton root rot has furnished the basis for further studies in this field.

## ARSENIC AND SELENIUM FUNGI

Numerous problems due to the presence of arsenic in soil have already been reported. Attention has also been given to the activity of molds in producing small quantities of other volatile toxic substances. Recognition of increasing residues of selenium fungicides reaching the soil, together with demonstration of the presence of selenium in large areas of native soil, give importance to the ability of soil organisms to decompose insoluble and nonvolatile selenium combinations with the release of offensive gases. Fungi have already been shown to volatilize arsenicals. These fungi and a still larger group of micro-organisms are found active in decomposing selenium compounds. Quantitative methods are being studied to test the possibilities and limits within which such micro-organisms may be found responsible for toxic conditions in crops grown, or, effective in freeing soil from accumulations of such elements in toxic amounts.

## SOIL FUNGI AS ALLERGIC EXCITANTS

In cooperation with physicians studying asthma and related affections, the exciting cause of disease in particular individuals has been traced to fungi common in soil and decaying vegetation. Certain of these forms, such as *Alternaria*, *Cladosporium*, various species of *Aspergillus*, *Penicillium*, *Mucor*, and *Monilia*, have been implicated so often that many requests for cooperation

have been received. The recognition of other members of these same groups in human and animal diseases have occurred so frequently as largely to obliterate any line between the pathogenic and saprophytic fungi.

Such studies point to a need for better knowledge of the groups present in soil and their distribution in relation to soil type and soil management.

#### CELLULOSE DECOMPOSITION

The identification of common species of *Chaetomium* as rapid destroyers of cellulose has lead to further studies identifying several species of the genus and demonstrating their wide distribution. Mildewed cloth and deteriorating fiber materials of many kinds have been shown to carry the mycelium of *Chaetomium* which goes unrecognized in ordinary culture because other species overgrow and suppress it, whereas it finds optimum conditions in nature for destructive activity.

A method of using one species of *Chaetomium* to test the mildew resistance of textiles has been developed.

### FERTILIZER INVESTIGATIONS

The Bureau is actively engaged in promoting our knowledge of methods of fertilizer production and improvement for the purpose of insuring to the farmer cheaper and more efficient fertilizers. This program involves the development of new processes, the improvement of old methods, the production, examination, and determination of the properties of new products, the investigation of raw materials suitable for conversion into fertilizers and the improvement of the physical form of fertilizers to facilitate their distribution in the field.

#### NITROGEN

##### CATALYSTS IN NITROGEN-FERTILIZER INVESTIGATIONS

The research work under this project is principally concerned with the study of the factors which influence and determine the activities of catalysts such as are used in the conversion of atmospheric nitrogen into nitrogenous fertilizer materials. The work being carried on at present centers upon a study of two types of catalysts involved, the water-gas catalysts used in the preparation and purification of hydrogen, and the synthetic-ammonia catalysts used in converting hydrogen-nitrogen mixtures into ammonia. The results obtained are of industrial and of scientific interest.

Investigation of the nature of the adsorption of hydrogen by iron synthetic-ammonia catalysts, work originally begun for the purpose of ascertaining whether a catalyst must be capable of activating molecular hydrogen in order to serve satisfactorily as an ammonia catalyst, has disclosed that the rate of conversion of ortho-hydrogen into para-hydrogen proceeds readily over an active synthetic-ammonia catalyst at temperatures as low as  $-189^{\circ}$  C. and that, contrary to ideas heretofore current, this conversion is associated with physical rather than activated adsorption of hydrogen.

It was also discovered that the adsorption of hydrogen between temperatures  $-75^{\circ}$  and  $500^{\circ}$  C. caused a marked poisoning of the catalyst for the conversion of ortho- to para-hydrogen at  $-189^{\circ}$ . A study of this poisoning effect revealed definitely for the first time that there are at least three types of adsorption of hydrogen upon iron synthetic-ammonia catalysts, a physical adsorption at liquid-air temperatures, an activated adsorption at  $-78^{\circ}$  to  $0^{\circ}$  C. and a second type of activated adsorption between  $0^{\circ}$  and  $500^{\circ}$ . These discoveries not only enlarge our knowledge of the nature of gas adsorption by solids, but assist in unraveling the mechanism by which hydrogen and nitrogen combine on the surface of iron catalysts to form ammonia.

Further study of the iron-nitrogen system has shown that the rate of nitrogen adsorption by the iron catalysts is apparently the slow step in the catalytic synthesis of ammonia, and that a good catalyst must be capable of bringing about a rapid activated adsorption of nitrogen upon its surface and of permitting this adsorbed nitrogen to react with hydrogen to form ammonia. This discovery is a decisive step toward solution of the question of why iron synthetic-ammonia catalysts differing so little in composition differ so markedly in their catalytic efficiency. Results which have been obtained during the year upon the rate of decomposition and rate of reduction of the various



nitrides of iron with hydrogen have also contributed toward a better understanding of the mechanism of ammonia synthesis and at the same time have yielded data which will be of use to those engaged in the commercial nitriding of steels.

#### PHYSICAL CONSTANTS OF GASES AND FERTILIZER SALTS

The solution of numerous problems confronting scientific investigators depends on a knowledge of the physical constants and the fundamental structure of the elementary substances and compounds involved. Recognizing this the Bureau is provided with efficiently supervised and well-equipped X-ray, crystallographic, spectroanalysis, photochemical, activation, and ionization laboratories which have made many contributions to scientific knowledge during the year.

The determination of the structure of the single molecules of the nitrogen oxides, nitrous oxide, nitrogen dioxide, nitrogen tetroxide, and nitrogen pentoxide, by means of electron refraction has definitely increased our knowledge of such molecules. The adsorption spectrum of nitrogen trioxide, discovered in the Fertilizer Investigation's laboratory, has been studied with respect to its behavior under various conditions of temperature and pressure. The photochemical dissociation of the molecule of nitrous oxide has been determined. The spectrographic study of an oxide of nitrogen which exists in the presence of nitrogen pentoxide and ozone has resulted in the important discovery that oxygen does not exert an influence on the absorption of light by nitrogen dioxide, which is contrary to previous belief. Technic for the absolute determination of the absorption coefficients in the infrared have been developed during the past 2 years and applied to as wide a range of compounds containing the NH group as has been available.

A mass spectrograph has been perfected which is capable of measuring accurately the abundance of isotopes of the substances that can be emitted as positive ions from heated filaments. Application thereof to the measurement of the isotopes of lithium emitted from spodumene and from ammonia catalysts has shown for the first time that the ratio of the isotopes given off from various emitters is in agreement with their abundance as computed from the atomic weight and the packing effect.

A new method has been devised to determine the rate at which neutral alkali atoms are emitted from ammonia catalysts and it has been shown that the ratio of atoms to ions emitted increases with the surface. For low concentrations, where the fraction covered by alkali is less than 0.1, the alkali is emitted almost entirely as ions, but above this fraction the emission of atoms increases very rapidly. The presence of alumina retards the diffusion and decreases the solubility of alkali in iron and hence increases the temperature for equivalent emissions as well as increases the atom emissivity at higher temperatures.

The photoelectric effect has been used to study the condition of adsorbed gases on metal surfaces. The effect of ammonia, hydrogen, methane, and oxygen on various surfaces has been studied and it has been found that, in general, electropositive gases decrease the work function of a metal when selectively adsorbed, while electronegative gases increase the work function.

The entropies of nitrogen, hydrogen, and carbon monoxide have been determined. These are especially valuable for the calculation of heats of reaction involving these gases and are therefore of considerable economic importance. The solubilities of hydrogen in liquid ammonia at 25°, 50°, and 75° up to 1,000 atmospheres pressure have also been determined.

The quantitative formulation of the relations between the pressure, volume, and temperature of compressed gases that has been carried out in previous years has led to the pursuit of methods of curve fitting and to the development of statistical tests for the goodness of fit of empirical formulas and for the detection of constant errors. This statistical work is being applied not only to the fertilizer problems under immediate investigation, but also to the interpretation and planning of experimental work on the yields of crops or the behavior of organisms under various treatments.

The nature of the compounds present in superphosphate has been determined by X-ray diffraction methods combined with chemical analysis. Fundamental work has been done on cholesteryl salicylate, a typical sterol compound related to vitamin D.

Evidence of the extremely valuable character of the physical research facilities at the Bureau's disposal has been demonstrated by the growing

demand for cooperative work between this unit and other units of the Bureau, as well as with other bureaus of the Department of Agriculture and with other departments. As instances of such cooperative work there may be cited the identification of plant waxes and acids for the Chemical and Technological Unit, the treatment of corn, tobacco, chestnuts, and beans by X-rays, in cooperation with the Bureau of Plant Industry, the photographing of the atmospheric absorption bands of ozone, in cooperation with the Smithsonian Institution, and the determination of the infrared spectra of hydrocarbons as a sensitive means of their determination, in cooperation with the Bureau of Standards.

#### PEAT AS A NITROGEN CARRIER

The investigation of the treatment of organic materials with ammonia has been continued during the year with special attention being given to the study of the products obtained by the ammoniation of peat. A detailed examination has been made of the influence of varying conditions on the character of the product. The chemical investigation of the types of nitrogenous materials formed has yielded interesting results. After exhaustive extractions with such solvents as water, alcohol, ether, and 2-percent and 10-percent hydrochloric acid it was found that the insoluble residue represented 58 percent of the original material and contained 47 percent of the original nitrogen. The major portion of the extractable material was found in the water extract, which contained 36 percent of the total nitrogen, 43 percent of which was in the form of urea and 7 percent as combined nitrogen. An analysis of the various extracts for humin, amide, basic, nonbasic, and amino nitrogen has been practically completed.

As an orientating research dextrose, starch, cellulose, and lignin have also been ammoniated and the products studied in order to obtain information concerning the constituents in peat that respond to ammoniation. It was found that cellulose is scarcely affected by ammonia, that starch, when ammoniated, yields a product containing 5 percent of nitrogen, whereas dextrose and lignin are extensively ammoniated. The solid matter obtained in the ammoniation of dextrose was 75 percent of the original weight and contained 16 percent of nitrogen, 46 percent of which was extractable with water. This fraction contained at least 7 percent of urea, as well as ammonium bicarbonate and substituted pyrazine bases. The residue obtained after exhaustive extraction with solvents represented 37 percent of the original solid material and contained 16 percent of nitrogen. In its physical properties it resembled closely the analogous residue from ammoniated peat.

In a number of vegetative pot tests with ammoniated peat the results from those on soils that were responsive to nitrogen gave an average response of 51 percent increase as compared with 100 for sodium nitrate. In pot tests employing the separated water-soluble nitrogen and the water-insoluble nitrogen good results were obtained with the water-soluble nitrogen but widely varying results with the water-insoluble nitrogen.

A series of tests, in which the rates of nitrification of ammoniated peat, the water-soluble and water-insoluble fractions therefrom, ammonium sulphate, cottonseed meal, and dried blood were compared, indicated that the ammoniated peat attains a 35-percent nitrification in an 8-week period as compared with ammonium sulphate and that this value is reached slowly, while the ammonium sulphate nitrifies much more rapidly. The water-soluble nitrogen nitrifies to the same degree as the ammonium sulphate and at almost the same rate, whereas nitrification of the insoluble nitrogen is quite slow, reaching a value of 17 percent only in 6 weeks.

During the year a new product has been produced by treatment of peat with carbon dioxide and ammonia by the same general technic as that used in the manufacture of ammoniated peat. The material thus obtained contains a high percentage of urea mixed with the ammoniated peat. A method is thus presented of producing a urea product which is free from the objectional physical properties of pure urea.

#### BIOCHEMICAL AND ORGANIC NITROGEN INVESTIGATIONS

Studies with *Azotobacter* during the past year have shown that either molybdenum or vanadium is essential in the process of nitrogen fixation by this organism. Although the bacteria will grow in a medium containing fixed

nitrogen without these elements, they are unable to use free nitrogen gas under these conditions. It is of particular interest that only about 10 to 50 parts per trillion of these elements are required, this being of the order of one-thousandth of the usual concentration involved in those cases where traces of elements are considered as needed for the nutrition of higher green plants. Natural soil humates may provide molybdenum and vanadium, as well as iron, to *Azotobacter* growing in a medium deficient in these elements, and it has been found that the rate of nitrogen fixation may be increased twofold to fourfold by such additions. These discoveries have greatly facilitated the study of the process of nitrogen fixation.

Further study of the mineral nutrition of mature cultures of *Azotobacter*, growing in both free and fixed nitrogen, with regard to magnesium, calcium, iron, sulphur, and phosphorus, have confirmed previous views concerning the specific nature of calcium in fixation as distinguished from growth and the nonspecificity of the other elements.

The carbohydrate metabolism of *Azotobacter* has been investigated under carefully controlled conditions and the ability to oxidize a large number of compounds determined. Several enzymes were discovered, including typical dehydrogenases and a carboxylase. The effects of poisons such as cyanide, sulphide, alcohol, and urethanes were determined, and the intermediate compounds formed during oxidation were ascertained.

On the basis of findings concerning the mechanism of fixation, graphical and analytical methods for determining enzyme dissociation constants and other properties of fundamental interest have been developed and the fact that *Azotobacter* cannot fix nitrogen below pH 6, although growth will occur in acid media if combined nitrogen is supplied, has been interpreted in terms of the Gibbs phase rule.

The previously reported discovery that certain species of legume nodule bacteria require an accessory growth factor has been confirmed by further investigations. This factor has been found to be widely distributed in plant and animal products and may be prepared in fairly concentrated form by extracting commercial sucrose, molasses, yeast, and many other materials with absolute alcohol. Only about 2 to 5 parts per million of dry matter, added to culture solutions, is required to give a good growth of nodule bacteria. Although *Azotobacter* synthesizes the factor it does not respond to additions of it.

In studies on the nitrogen "hunger condition" of nodulated legumes, which often occurs in young plants, it has been found that high light intensity tends to aggravate the condition and that the supplying of small amounts of combined nitrogen will not always correct it.

In the preparation and study of organic compounds suitable for high-pressure tests with nitrogen for the synthesis of organic nitrogen fertilizers, organic substances have been sought which are highly active but still sufficiently stable to manipulate under ordinary conditions since most promising results are to be expected from them. A group of unsaturated fluorene hydrocarbons has been found to fulfill these requirements. They react with ease with ammonia and amines to form nitrogen bases. This is the first instance in which such a reaction has been found to occur with hydrocarbons. Moreover, it has been shown that their property of removing hydrogen from certain organic materials not only holds for amines in liquid ammonia but also for alcohols, as well as amines, in alkaline media.

#### POTASH

During the year the development of the American potash industry, inception of which was fostered by the Bureau's researches, advanced to a peak production of 351,250 tons of potash salts, equivalent to 148,150 tons of potash. This is an increase of 245 percent in gross weight and of 238 percent in potash equivalent as compared with the preceding year. Sales were valued at \$5,226,000, a measure of the current value of the results of the efforts made to render the American farmer independent of foreign sources of this fertilizer essential.

The preservation of this domestic industry in a rational state of prosperity is essential if present gains are to be maintained. Accordingly, potash researches are directed toward both improved technology of manufacture and enlarged and more diversified utilization. The greatest handicap now borne

by the domestic industry being high distribution costs, study is being devoted both to the production of concentrated products and the development of new industries to provide potash for the more isolated regions.

A simple method for the production of potassium metaphosphate from potassium chloride and phosphoric acid has been developed. Data of a fundamental nature regarding the reactions involved and the properties of the finished product have been obtained which show the procedure to be not only feasible but the product itself to possess unusual and eminently desirable physical and chemical properties.

A new process for the economical production of potassium sulphate (of which the United States, during the past 10 years has imported \$3,000,000 worth annually) has been developed. In this and the afore-mentioned metaphosphate production hydrochloric acid is yielded, the application of which to the rendering of phosphates by a new process to yield a new, low-cost product has been investigated.

The application of hydrochloric acid to the extraction of potash and alumina from silicates, such as Georgia shale, has been studied. The resulting chlorides are fractionally hydrolyzed to yield potassium chloride and a marketable grade of alumina.

The problem of the utilization of the enormous potash resources represented by Wyoming leucite has been brought a step nearer a solution by completion of a small-scale plant capable of producing high-grade alumina and potassium nitrate. It has been established that nitric acid treatment of Wyomingite therein results in the production of alumina of substantially 100-percent purity and potassium nitrate of 99-percent purity. Both these materials have well established markets, the alumina entering into the manufacture of ceramics and aluminum and the potassium nitrate into the fertilizer trade.

Work on the solubility of Utah alunite has been rounded out by determining the solubility of the roasted material in various solvents. A final summation of the results shows that of all the solvents studied sodium hydroxide was the most effective, 93.44 percent of the potash and 91.17 percent of the alumina being soluble therein at 600° C.

In the production of potassium sulphate from Texas and New Mexico polyhalite by the ammonium-carbonate process developed in this Bureau, it has been found that the yield of the sulphate can be greatly increased by treating the resulting ammonium-potassium sulphate product with potassium chloride, with enhanced economy. The resulting ammonium chloride is employed as a source of ammonia to be recycled. This process provides an increased output and diversification by the existing potash industry of New Mexico.

#### PHOSPHATES

A continuation of the work on the preparation of phosphate fertilizer by the calcination of silica-bearing phosphate rock at about 1,400° C. in the presence of water vapor has shown that the process is applicable to most types and grades of phosphate rock produced in the United States. As compared with the manufacture of ordinary superphosphate, which is the principal phosphate fertilizer in this country, the new process has the advantages that (1) the reagents, silica, water, and fuel (powdered coal or fuel oil), are the most widely distributed and cheapest of all reagents, (2) the final product is free from diluents other than those naturally occurring in the rock (since the usual commercial grades of phosphate rock contain sufficient silica for the reaction) and contains 30 to 35 percent of phosphoric acid as compared with 16 to 20 percent in ordinary superphosphate, (3) the higher phosphoric acid content of the product makes possible the production of higher grade fertilizer mixtures with consequent reduction of transportation and handling costs per unit of plant food, (4) the product contains no free acid or acid salts, is neutral or slightly alkaline in reaction and has no deleterious action on bags and other containers and on fertilizer machinery, (5) the product not only has excellent mechanical properties but improves the mechanical properties of mixtures in which it is contained, (6) unlike superphosphate, the product contains relatively little fluorine and it may therefore be used as a substitute for bone meal in mineral supplements for livestock feeding, and (7) approximately 75 percent of the fluorine in the phosphate rock may be recovered as a byproduct of the new process in comparison with a 20-percent recovery in the manufacture of superphosphate, thus insuring an adequate supply of fluorine compounds for use as insecticides and agricultural poisons. The results of experiments con-

ducted during the past year indicate that the fertilizer value of the phosphoric acid in calcined phosphate is equal to that of an equivalent amount of phosphoric acid in the form of superphosphate.

Further studies made on the treatment of phosphate rock with phosphoric acid have shown that it is possible to produce nonsegregating, complete fertilizers in a single operation by the direct action of phosphoric acid or of phosphoric and sulphuric acids on mixtures of phosphate rock and potash and nitrogen salts. A further improvement in the process comprises the treatment of mixtures of phosphate rock and potash salts with phosphoric acid or mixtures of phosphoric and sulphuric acids, with subsequent direct addition of up to about 10 percent of anhydrous ammonia to the wet mixture, the heat generated eliminating the artificial drying that would otherwise be necessary.

In connection with work done during the year on the composition, chemistry, and properties of ordinary and double or triple superphosphates, an accurate method has been developed for the determination of water in its various states of combination in the commercial materials and in their pure components. Studies were also made on the occurrence and distribution of fluorine compounds and free acids in superphosphates.

As a result of the Bureau's investigations of the production of phosphate fertilizers by the blast-furnace process, carried on during 1928-33, and involving the construction and operation of a number of experimental blast-furnace units, the fundamental principles of phosphate smelting have been determined rather accurately with reference to such factors as blast temperatures, moisture in the blast, character of the phosphate rock and fuel, size and general design of the furnace unit, and methods of charging and blowing the furnaces. The Tennessee Valley Authority became interested in the Bureau's experimental findings early in the last fiscal year, and in the economic possibilities of blast-furnace methods for the production of low-cost fertilizer materials. Being desirous of carrying forward as vigorously as possible further experimental determination of certain engineering details and factors of design, the Authority entered into a cooperative agreement with the Department of Agriculture through this Bureau whereby the blast furnace and all its accessories, together with the Bureau's blast-furnace personnel, were made available to the Authority from October 10, 1933, to June 30, 1934.

#### MIXED-FERTILIZER TECHNOLOGY

An investigation of the fertilizers that have been consumed in the United States since 1880 has disclosed that, whereas the fertilizers used in 1880 had a basicity equivalent to 41 pounds of calcium carbonate per ton, those used in 1932 would require 148 pounds of calcium carbonate per ton to neutralize their acid-forming ingredients. The use of fertilizers of such high acidity has been shown to impair the crop-producing capacity of many soils to which they are applied. In a study of the reactions that take place in fertilizer mixtures to which a sufficient quantity of limestone or dolomite has been added to give a physiologically neutral mixture, it has been found that the addition of limestone to monoammonium phosphate must be limited to 1 mol calcium carbonate per mol of phosphoric acid if loss of ammonia and formation of citrate-insoluble phosphoric acid is to be prevented. Although monoammonium phosphate also reacts with dolomite in the presence of moisture to evolve carbon dioxide, no loss of ammonia or increase in citrate-insoluble phosphoric acid occurs regardless of the proportions of these materials, at ordinary temperatures. The use of dolomite has the further advantage of causing the fixation of part of the ammonia in the mixture in the form of the slightly soluble, but available, compound, magnesium ammonium phosphate. This compound has the advantages of being nonhygroscopic, not burning crops, acting as a conditioner in fertilizer mixtures, and serving as a source of available magnesium. A simple method has been developed for its preparation from monoammonium phosphate and calcined dolomite.

Continuation of work on the ammoniation of double superphosphate has disclosed that the heat developed when double superphosphate is treated with 8 to 10 percent of ammonia is sufficient to bring about an automatic granulation of the product in the usual type of rotary apparatus used, and that the size of the granules produced varies with the original moisture content of the double superphosphate. Heat is also developed in the ammoniation of concentrated mixtures containing double superphosphates but this has to be supplemented by some external heat for a satisfactory granulation of the mixture.

It has been found that dicalcium phosphate will not undergo ammoniation at ordinary temperatures but that at temperatures above 60° C. ammonia is absorbed to form tricalcium phosphate and diammonium phosphate. It follows, therefore, that a double superphosphate which has been ammoniated below 60° will not contain any citrate-insoluble phosphoric acid irrespective of the quantity of ammonia added. More or less citrate-insoluble phosphoric acid will form, however, if the ammonia added exceeds 10.5 percent when the heat of reaction is permitted to raise the temperature of the mass above 60° C.

An analytical method has been developed for the determination of the free acid in superphosphates and, on the recommendation of the Association of Official Agricultural Chemists, a collaborative study of this and other proposed methods is now being made under the auspices of this Bureau with a view to the official adoption of that method found to be most satisfactory.

In a study of the chemical and physical properties of urea-phosphate mixtures it was found that mixtures made from 1 mol or less of urea per mol of monocalcium phosphate are not hygroscopic, whereas those formed with more than this proportion of urea are very hygroscopic. This has been shown to be due to the fact that mixtures of urea and urea phosphate are very hygroscopic whereas mixtures of urea with dicalcium phosphate and of urea phosphate with dicalcium phosphate or monocalcium phosphate are not hygroscopic. When mixtures are made of 1 mol or less of urea per mol of monocalcium phosphate the final mixture contains no excess urea in admixture with the urea phosphate formed by the interaction of the urea and monocalcium phosphate. It has also been shown that the water of crystallization liberated from the monocalcium phosphate in this reaction does not combine with the dicalcium phosphate that is also formed, and that, at relative humidities below 70 percent, this water tends to be evolved from the mixture unless the proportion of urea initially present exceeds 50-mol percent. Dicalcium phosphate dihydrate mixed with urea has been found to lose its water of crystallization more rapidly than the dihydrate alone, and mixtures of the dihydrate with urea phosphate lose their water of crystallization rapidly and quite completely. Urea phosphate, on the other hand, has little effect on the water of crystallization of monocalcium phosphate. A method has been developed for determining monocalcium phosphate by means of its reaction with urea. This method will permit the direct determination of monocalcium phosphate in admixture with dicalcium phosphate or in superphosphates and double superphosphates whereas only indirect methods have been available previously.

A study of the effect of the heat liberated during the ammoniation of superphosphates upon urea present in the mixture or added during the ammoniation has shown that the urea is susceptible to decomposition, the extent of this decomposition being dependent on the amount of water present, the extent of the ammoniation, the hydrogen-ion concentration, and the temperature. It has been found that the urea may in some cases be completely decomposed without loss of nitrogen, the ammonia produced being absorbed by the acidic constituents of the mixture. No appreciable decomposition occurs when the temperature is kept below 55° C. The results obtained will serve as a guide for choosing proper conditions for the treatment of superphosphates with urea-ammonia mixtures and the ammoniation of superphosphate mixtures that contain urea.

In 1900, 91 percent of the nitrogen contained in mixed fertilizers was supplied by organic ammoniates. Since then the supply of such materials at prices that can compete in the fertilizer industry has steadily diminished until in 1931 only 19 percent of the nitrogen in mixed fertilizers was derived from this source. This is largely due to the conversion of such materials into feeding stuffs. At the same time the development of nitrogen fixation has resulted in an ample supply of new materials at lower prices. These new materials contain much higher percentages of plant food than those formerly used. The principal materials used to supply phosphoric acid and potash in mixed fertilizers have also increased in concentration due to changes in the source of supply of raw materials and improvements in processes of manufacture. It has therefore become necessary either to make fertilizers of higher analysis than formerly or to dilute with filler the high-grade materials now available in order to maintain the same low-analysis mixtures. In a study that has been made to determine the nature and the extent of the changes that have actually occurred it was found that the average mixed fertilizer in 1880 contained 2.3 percent of nitrogen, 8.9 percent of available phosphoric acid, and

2.2 percent of potash. In 1931 these plant-food contents had increased to 3.3 percent of nitrogen, 9.6 percent of available phosphoric acid, and 5 percent of potash. The percentage of filler used had increased from none at all in 1880 to 15.2 percent by weight in 1931. If no filler had been used in 1931 the average mixed fertilizer would have contained 21 percent of plant food instead of 18 percent. In some States very little change in concentration has taken place and much filler is used, whereas in others the reverse is true. Filler costs money itself and adds to the cost of bagging, mixing, freight, and other charges on the mixture containing it and, in general, adds nothing of value to the consumer. A part of it could be replaced with basic materials to neutralize physiological acidity with great advantage to the consumer in sections where soils are already acid, as they are throughout most of the section where the bulk of commercial fertilizers is used. To eliminate the balance of the filler will require education of the consumer so that he will cease to demand mixtures of low price per ton which nevertheless are relatively high in cost per pound of plant food.

### INFORMATIONAL AND EDITORIAL SERVICE

During the past fiscal year the Bureau has issued 46 official printed publications, which include 33 soil-survey reports, 6 technical bulletins, 5 circulars, and 2 miscellaneous publications. In addition to these publications, 10 articles from the Bureau appeared in the 1934 Yearbook of Agriculture.

More than 170 articles on various phases of the Bureau's work have been published in outside journals and periodicals in addition to timely information which the Bureau has furnished to newspapers through cooperation with the Press Service of the Department.

Following is a detailed list of the Bureau's official publications printed during the last fiscal year:

### PUBLICATIONS OF THE BUREAU OF CHEMISTRY AND SOILS ISSUED DURING THE YEAR JULY 1, 1933 TO JUNE 30, 1934

#### TECHNICAL BULLETINS

No. 371. The Effect of Different Colloidal Soil Materials on the Efficiency of Superphosphate.

No. 373. Studies of Fluorine Compounds for Controlling the Codling Moth. (Joint publication with Bureau of Entomology.)

No. 377. Character and Behavior of Organic Soil Colloids.

No. 383. Microbiological Studies of Salt in Relation to the Reddening of Salted Hides.

No. 389. The Decomposition of Hydrolytic Peat Products Including Ammoniated Peat.

No. 399. A Study of Claypan Soils.

#### CIRCULARS

No. 273. Effects of Time of Planting and of Fertilizer Mixtures on the Curly-

Top Resistant Sugar-Beet Variety U.S. No. 1 in Idaho. (Joint publication with Bureau of Plant Industry.)

No. 290. Grades of Peat and Muck for Soil Improvement.

No. 303. Soil Profile and Root Penetration as Indicators of Apple Production in the Lake Shore District of Western New York.

No. 304. Windrowing Qualities of Co. 281 and Other Varieties of Sugarcane under Louisiana Conditions. (Joint publication with Bureau of Plant Industry.)

No. 315. Changes in Composition of American Fertilizers, 1880-1932.

#### MISCELLANEOUS PUBLICATIONS

No. 176. Bibliography of Chloropicrin, 1848-1932.

No. 186. Reconnaissance Erosion Survey of the Brazos River Watershed, Texas.

#### SOIL SURVEYS

El Cajon area, Calif.

Crawford County, Iowa.

Eaton County, Mich.

Paso Robles area, Calif.

Hancock County, Iowa.

Hitchcock County, Nebr.

Erie County, N.Y.

Worth County, Ga.

Guthrie County, Iowa.

Delaware County, N.Y.

Midland County, Tex.

Nogales area, Ariz.

Blackford County, Ind.

Van Zandt County, Tex.

Yuma-Wellton area, Ariz.-Calif.

Capistrano area, Calif.

Macon County, N.C.

Brown County, Wis.

Reconnaissance of the Northern Plains of Montana.

Colfax County, Nebr.

Coosa County, Ala.

Harlan County, Nebr.

Craven County, N.C.

Montgomery County, N.C.

Lower Flathead Valley area, Montana.

Washington County, Iowa.

Greenwood County, S.C.

Suisun area, Calif.

Steuben County, N.Y.

Grayson County, Va.

Queen Annes County, Md.

Dundy County, Nebr.

Hardy and Pendleton Counties, W.Va.

YEARBOOK ARTICLES

Eggs Oiled by Vacuum Carbon Dioxide Method Keep Well in Storage.  
Fertilizers May Add to Soil Acidity; Neutral Mixtures Desirable.  
Fertilizer Studies Show Important Possibilities in Ammoniated Peat.  
Fertilizers Without Filler Cost Less and Meet Ordinary Needs.  
Magnesium Deficiency in Certain Soil Types Reduces Potato Yields.  
Rancidity in Foods Delayed by Excluding Certain Wave Lengths of Light.  
Soil Erosion Studies Show Vegetation Has Dominant Role.  
Soil Survey is the Necessary Basis of Land Classification.  
Soybean's Content of Amino Acids Varies Greatly With Variety.  
Vitamin Standards of International Conference Being Adopted in the United States





