The Story of

Soils Research

T. F. Buehrer

Scientific soil management in Arizona had its beginning with establishment of the Agricultural Experiment Station in 1891. Up to that time information on the nature, behavior and management of arid soils of Arizona was very limited. Hence it was necessary to accumulate a body of reliable information through research on both the irrigated and non-irrigated soils of Arizona before intelligent recommendations concerning their management could be made.

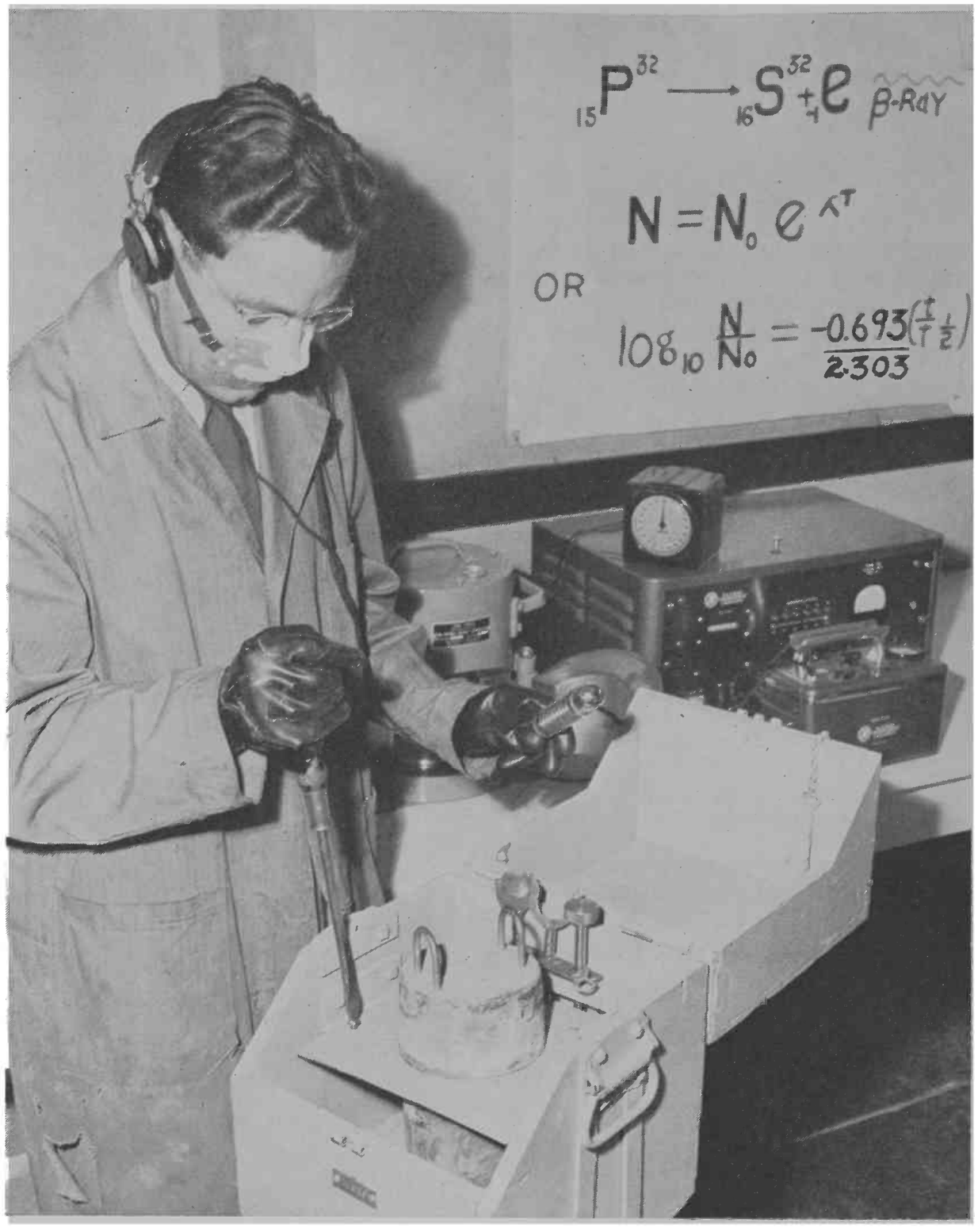
Much of the research necessarily was of a "basic" nature, aiming to establish the principles or laws underlying soil behavior, and to learn the reasons for crop responses to soil treatment in the field. Many field studies were made, and are still being made, to demonstrate the practical application of these principles.

Impressive Publication Record

Between 1891 and 1960 the Department of Agricultural Chemistry and Soils published 71 technical bulletins, mostly on soils, 28 "general" bulletins, 10 mimeographed reports, a number of extension circulars, and about 160 articles in scientific journals, most of which dealt with problems peculiar to soil management in Arizona.

The first work in agricultural chemistry and soils was started in 1895 by R. H. Forbes, the first chemist in the Agricultural Experiment Station. It was a soil survey of the Salt River Valley area, published in 1898, in response to numerous requests from farmers and immigrants in the State.

Research was next conducted on the damaging effects of copper mine flotation tailings, being discharged into the upper Gila River, upon crops in the Duncan, Solomonville, Safford and other areas in the valley. Forbes showed that these sediments caused the otherwise productive soils to become impervious to water. This condition, together with the presence of soluble copper and alkali salts in the water, seriously reduced the yield of alfalfa and other crops. The results obtained in these studies provided evidence for court settlement of a controversy of long standing between the farmers and mining companies. It resulted in settling basins being installed to remove the sediments prior to discharge of the water into the river.



OPENING the first container of radioactive elements shipped into Arizona for research purposes is Dr. W. H. Fuller, head of the Department of Agricultural Chemistry and Soils. This event, in 1949, marked the first use of atomic energy as a research tool in Arizona.

Reclaiming Alkaline and Saline Soil

Reclamation of highly alkaline and saline sodium soils received early attention by Vinson and Catlin who found that adding sulfuric acid to irrigation water, as well as the ancient practice of applying gypsum directly to the land followed by heavy leaching, was effective. It is now standard practice to apply gypsum to the land if the exchangeable sodium percentage is high.

Previous studies on the use of gypsum in soil reclamation had shown the necessity of understanding the cation exchange relationships of desert soils. Research in this field demonstrated that sodium-clay,

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Dr. Buehrer will soon complete 40 years of teaching and research in the university's Department of Agricultural Chemistry and Soils. Known as an outstanding classroom teacher in soils, Dr. Buehrer has also directed cooperative activities with agricultural students in other lands.

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rather than sodium carbonate, was the primary cause of high alkalinity and breakdown of the aggregated condition through dispersion. Conversion of sodium-clay to calcium clay reduces alkalinity and dispersion and favors aggregation. McGeorge developed a procedure for determining the "gypsum requirement" of a soil similar to the "line requirement" of acid soils.

McGeorge also studied the cation exchange properties of soil organic matter, showing that the addition of organic matter, especially to sandy soils, increased the cation exchange capacity, thus holding plant nutrients against leaching during irrigation.

Soil Fertility Studies

Extensive studies have been made on the levels of nitrogen, available phosphorus and potassium in Arizona soils, and the factors that affect their availability. Nitrogen was found to be the most deficient element.

Phosphorus is usually present in fairly large amounts, even in virgin soils. Because of the fact that most cultivated soils under irrigation are calcareous, the phosphate may be of a low degree of availability. The conditions affecting soil phosphate availability have been studied in great detail by chemical, greenhouse, and controlled pot methods and radiotracer techniques. Considerable amounts of organic phosphate were found in desert soils by Fuller.

Since high alkalinity and soil calcium are the primary factors causing reversion to less available forms, McGeorge recommended the use of acidulated fertilizers to keep the phosphate available. As a result, some mixed fertilizers are formulated to contain both sulfur and organic wastes such as animal manures, sawdust or sewage sludge, which decompose under microbial action to form acidic substances.

McGeorge in extensive studies on soil potassium, found that the majority of Arizona soils cultivated under irrigation contain unusually high amounts of available (exchangeable) potassium, in most cases sufficient for many years of cropping. As a result, potassium fertilizer is not ordinarily necessary except on soils of long cropping history or for crops of high potassium requirement where exceptionally high yields or quality are desired. Most mixed fertilizers sold in Arizona are not formulated to contain potash.

Numerous field investigations have been made on the fertilization of lettuce, alfalfa, cotton, grain crops and citrus to determine the effects of kind of fertilizer, rate of application, placement and time of application upon yield and composition of the crop. The results have been published as station bulletins.

Designed Standard Lettuce Bed

One investigation of far-reaching interest related to the design of the most favorable bed for lettuce production to reduce damage resulting from high concentrations of soluble salts rising to the top of the bed by capillarity, as well as to increase the efficiency of irrigation and the fertilizer applied. The result was a flat bed with two rows of lettuce planted along the side, about 22 inches apart. This type of bed is standard practice in lettuce production in Arizona today.

In a study of chlorosis in citrus and deciduous fruit trees, McGeorge found that it was lime-induced, as in calcareous soils both iron and manganese are of low availability. Factors contributing to it were found to be poor drainage and soil aeration, calcium carbonate alkalinity, and high pH value of the soils.

McGeorge recommended (a) the use of acid soil correctives, (b) injecting ferric citrate into the trunks of the trees, or (c) spraying the leaves with iron or manganese solutions. For the soil, use of cover crops and mulching was recommended to improve drainage. The technique of using iron citrate solutions as a spray was also successfully used on sorghums and other field crops where iron, due to high calcium carbonate content in the soil, becomes insoluble.

Radioactive Tracer Research

The first use of atomic energy in Arizona as a research tool was begun in 1949 by W. H. Fuller. Grants from the agricultural chemicals industry and contracts from the U. S. Atomic Energy Commission made possible, in our Department of Agricultural Chemistry and Soils, of one of the finest atomic energy laboratories in the west. Here were tools for evaluating the utilization of nutrients in crop residues by succeeding crops, when the residues are incorporated in field soils. Now research has developed basic principles regarding the competitive uptake of calcium from its various forms in the soil.

Problems involved in the evaluation of phosphate fertilizers, such as kind of phosphate applied, particle size, placement, time of application and dosage, have been studied with radiophosphorus as a tracer. Other basic studies on radioactive iron, calcium and iodine have been initiated.

Soil Structure and Aggregation

The micro-aggregated condition of arid soils, dispersion of colloidal clay, compaction, existence of hardpans, and low organic matter content, are responsible for poor aeration and water movement in many of our cultivated soils. McGeorge studied this problem from the standpoint of what happens to the aggregates when the soil is mechanically worked at different moisture contents.

He recommended that in field practice the land should not be cultivated nor mechanically worked, nor should cattle be allowed to graze while the soil is at or near its "sticky" point. That is, while it is most plastic. When this precaution is observed, and the soil treated with gypsum and/or organic matter, the aggregated condition of the soil can be maintained. Studies by Buehrer indicated that puddling reduces the amount of available moisture in such soils.

Soil Surveys Made

The department has for many years cooperated in carrying out soil surveys in the cultivated areas of the state. The first such survey in 1895-98 by Forbes has been followed by others, so that to date 18 areas in different parts of the state have been mapped and reports describing the soil types, crop adaptations, chemical and mechanical composition, and other factors affecting the productivity of the land have been published. In all, 186 soil series have been identified and correlated, and 3,046,000 acres of land have been mapped.

Evaluating Water Quality

This department has made thousands of analyses of water from numerous wells and surface water supplies throughout the state. The first bulletin on the "Ground Water Resources of Arizona" appeared in 1926 and a later one in 1949 by Smith, et al. These bulletins have been in great demand.

The department has also cooperated in research on a problem of health, the cause of "mottled enamel", a defect of human teeth. The cause of the defect was discovered in 1934 by Dr. M. C. Smith, and found to be due to fluorides in drinking water. A concentration as low as 1.0 ppm will cause this defect if drinking water or milk containing it is given to children during early childhood while their teeth are erupting. Areas of occurrence of this defect were found chiefly in the valleys of the Gila, Salt, and Little Colorado Rivers.

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