Plant Growth Regulators

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Camp Detrick, Maryland

THE USE OF PLANT GROWTH REGULATORS as herbicides is a subject of great interest to most individuals who deal with plant life. Recently this interest has increased rapidly, if one is to judge by the large number of articles on 2,4-D (2,4-dichlorophenoxyacetic acid) appearing in scientific journals as well as in lay publications.

During the war extensive tests on the use of plant growth regulators were conducted by the Special Projects Division, Chemical Warfare Service, at Camp Detrick, Maryland. Certain phases of this work were performed under contract by members of the Bureau of Plant Industry, U. S. Department of Agriculture, and the Department of Chemistry, Ohio State University. Results of these investigations will be published in part in the June issue of *Botanical Gazette*. Other papers on the subject will appear from time to time in other journals. A brief summary of the results of this work is given here.

Over a thousand compounds were prepared and tested. Since it was impractical to test all potential plant growth regulators on a great number of plants, several screening procedures were devised which permitted the rapid and accurate evaluation of the physiological activity of each compound. The most important screening tests were (a) measurement of inhibition of root elongation of germinating corn seed, (b) measurement of inhibition of tissue production of red kidney beans when a single droplet of the substance, dissolved in water or oil, was placed on the midrib of the primary leaf. The inhibition caused by the chemical was compared with that produced by 2,4-D. Compounds which displayed a high degree of activity in the screening tests were then tested on a number of monocotyledonous and dicotyledonous plants in the greenhouse and in the field. The compounds prepared and tested were functional derivatives of phenoxyacetic, benzoic, naphthoic, phthalic, sulfamic, carbamic, cinchoninic, and picolinic acids and a host of other organic chemicals.

In a study of methods of application it was discovered that the application of like amounts of growth regulator to the soil as a solid and to the aerial portions of plants in the form of aqueous or nonaqueous sprays produced widely differing effects, the herbicide being many times more effective when applied in a spray.

Comparatively low concentrations of growth regulators applied to the soil prevented seed germination, but when the solid chemical was applied to the soil as a contaminant, the dosage required to kill growing plants increased with increasing age of the plants at the time of application. The same age relationship was evident when the regulator was applied to the aerial portions of the plants in the form of a spray.

The persistence of these growth regulators in the soil was also studied. It was found that 2,4-D did not persist in soil for more than 80 days and isopropyl N-phenylcarbamate seemed to disappear within 60 days.

In soil-leaching experiments 2,4-D was recovered in the leachate.

Frequently compounds were encountered which were very difficult to dissolve in the solvent selected, and recourse was made to the use of cosolvents. Tributyl phosphate proved to be the most satisfactory cosolvent and was found to be suitable for preparing high concentrations of herbicides in oil solution. The carbowaxes (polyethylene glycols) were found to be suitable cosolvents for the preparation of aqueous solutions, in which they also acted as wetting agents or spreaders.

Since it had been shown that several hours are required for plants to absorb maximum amounts of 2,4-D sprayed on their leaves, an investigation was undertaken to determine to what extent heavy rainfall would remove this compound and reduce its effectiveness as a herbicide. Results show that when the herbicide was applied in oil solution, an immediate heavy rain caused no diminution in response to the herbicide, as the drops of rain appeared to be shed from the oil-covered leaves without the removal of the oil solution. When aqueous solutions of the herbicide were used, a heavy rainfall within 24 hours reduced the effectiveness of the herbicide to a marked degree. Thus, the value of oil as a solvent in herbicide applications just prior to rain or in regions of high rainfall is indicated. Another advantage of oil solutions as herbicides is the contact injury produced by tributyl phosphate, which is generally used as a cosolvent.

Studies on the mode of entry and translocation of regulators indicate that the stomata may be unimportant as a portal of entry. Young *Nasturtium* and *Coleus* plants were selected for experimentation, since they have stomata only on the lower surfaces of the leaves. Some plants were sprayed in such a manner that only the upper leaf surfaces were exposed, and other plants so that only the lower surfaces were exposed. The resulting degree of inhibition was about the same, regardless of the particular leaf surface

sprayed. However, when plants are exposed to volatile growth regulators or aerosols, stomata probably play a more important role.

Often 2,4-D enters the leaf with great rapidity. On warm, sunny days young broadleaf plants sprayed with this compound may exhibit epinasty and stem curvature within one hour after treatment.

It was originally believed that there might be a high degree of compound-crop specificity. This was found to be true to a limited extent. In general, the compounds were more toxic to broadleaf plants than to grasses. One group of compounds, however—the carbamic acid derivatives and, in particular, isopropylphenylcarbamate—was more toxic to cereals than to broadleaf plants. This confirms the results of British investigators (*1*). Among the broadleaf plants only one instance of compound-crop specificity was noted. The compound, 2,4,5-trichlorophenoxyacetic acid, and its derivatives were highly inhibitory to Irish potatoes, while all the other phenoxyacetic acids and derivatives tested on this crop had little effect.

Reference

1. TEMPLEMAN, W. G., and SEXTON, W. A. *Nature, Lond.*, 1945, **156**, 630.

Obituary

John Campbell Merriam

1869-1945

Dr. John Campbell Merriam, distinguished paleontologist, died in Oakland, California, on 30 October 1945. He had just passed his seventy-sixth birthday. Since his retirement from the presidency of the Carnegie Institution of Washington, which office he held for 18 years, Dr. Merriam had continued his writing and scientific study on the Pacific Coast, spending much of his time at the California Institute of Technology. In 1943 he became consultant and lecturer at the University of Oregon, where he was associated with the Departments of Geology and Anthropology. These were his last scientific interests before his health failed.

Born in Hopkinson, Iowa, Merriam received his early education at home and in the schools of that state. It was here that he saw his first fossils—the Paleozoic invertebrates he collected not far from his father's home. After taking a bachelor's degree at Lenox College, Iowa, he came to the University of California to study geology under Joseph Le Conte and botany under E. L. Greene. During this period he was an assistant in mineralogy. As was customary in those days, Merriam went to Munich for advanced study, receiving his doctorate at the University under Karl von Zittel. His dissertation related to mosasaurs from the Kansas chalk. On his return to the University of California in 1894 he taught and conducted research in invertebrate paleontology.

However, vertebrate paleontology claimed his major interest, and there followed published accounts by him and by his students on cave explorations and early man in California, Triassic ichthyosaurs and thalattosaurs, and on the geology of the John Day basin. He later enlisted the aid of Miss Annie M. Alexander in his research, and the generous response of this fine and steadfast patroness of paleontology and zoology was an important factor in permitting him to achieve success. Even before completion of the work on fossil reptiles his interest turned more strongly toward fossil mammals and early human history. Among his many papers, those which relate to western Tertiary faunas, correlation studies, and to the deposits and faunas of Rancho La Brea may be cited as among his most significant contributions. They were published for the most part in his productive period of research at the University from about 1900 to 1919. These were the years when a number of students came under his influence, and many men receiving instruction from him were subsequently to find responsible posts in science and industry.

During this time he became increasingly active in the affairs of the University and of the community. He was particularly interested in promoting research and in furthering the publication of original investigations. In 1912 President Benjamin Ide Wheeler appointed him chairman of a newly formed Department of Paleontology. At the time of World War I he saw the urgency of a national defense program. He became chairman of the Research Committee, California State Council of Defense, which office he held from 1917 to 1920. In 1919 he was chairman of the National Research Council. Later, in 1920, he became dean of the faculties at the University.

Although considered a candidate for the presidency of the University of California during the period which followed the retirement of Dr. Wheeler, Merriam accepted the presidency of the Carnegie Insti-