THE correspondent at Ottawa of *The Times*, London, reports that the Commonwealth and Empire Conference on Radio for Civil Aviation has recommended the establishment of a permanent central office in London for the remainder of the war. The conference has been examining war-time radio developments such as radar and their application to civil flying. At the closing session Sir R. Watson-Watt, head of the British delegation, said that projects that have been studied at Ottawa will be further examined and tested by radio and aviation authorities in the countries of the Commonwealth during the next few months and that the data made available would finally become the subject of international consideration.

THE information *Bulletin* of the Embassy of the U.S.S.R. states that five miles from Tashkent the Uzbec Scientific Research Institute of Forestry is laying out a park. On an area of about a hundred acres a protected zone has been planted with lanes of oaks and sycamores, poplars, walnut trees, chestnuts, limes, fruit trees and roses. There is a nursery containing a hundred and forty different types of trees and bushes. A meteorological station has been established to study prevailing winds. It is hoped to grow about a thousand, five hundred different kinds of trees and bushes. The park will be the largest nursery in the Republic, from which state farms, collective farms and towns will be able to obtain specimens of new types of plants.

DISCUSSION

THE MEANING OF HYDROPONICS

CORRECT terminology is requisite to scientific progress. The incorrect terms which were used in attempts to describe soilless crop production before its scientific basis could be clarified have caused wide misconceptions of its principles and have markedly delayed the establishment of this method to wide use.

Soilless crop production consists of growing crops in water, containing chemicals. Large shallow basins for the water, and wood shavings, sawdust, straw or other waste vegetable litter for seedbeds which support the plants in the water are essential equipment. Water causes the architecture of the roots of plants to become different from those growing in the soil. These differences in architecture are reflected in the functions of the roots. For this reason some crops can be grown more economically without soil than with soil, and by the same tokens others can not.

The revolutionary feature of soilless crop production consists in the substitution of the dynamics of fluids for the dynamics of a porous solid in the universe of growth of land plants. Fluids can not provide anchorage for the roots, hence their architectures become different from those growing in the soil. This change is according to a fundamental biologic law—an organ atrophies or changes in form and function in an environment in which some of its functions can not operate. In the differences of root growth of plants in water from those of the soil is a universe of new phenomena whose interpretation can be formulated into a distinctive category of knowledge.

Because plants grow according to the activities of their roots, and as the dynamics of water changes these from their soil types according to a pattern that can be described and formulated, hydroponics[1] meaning *water working* was chosen as the name for the art and the science of crop production without soil.

Terms as chemical farming, chemiculture, nutrient solution culture and kindred expressions not only were inappropriate but did great harm to this development in its crucial formative period, as they created a wrong perspective concerning the scientific basis of soilless crop production. These terms projected the functions of the nutrients into the foreground and thereby distorted their relative position of importance to other essential factors. This distortion obscured the perspective of the outstanding determinants of the system—the dynamics of water and the physical influences of the seedbed. Likewise, the term soilless agriculture is misapplied, as it is contradictory in meaning and implication—agriculture infers land, that is, solid matter as the home of the roots of plants.

The creation of soilless crop production depended on the solution of three scientific problems. They were:

(1) Establishment of the use of economic materials and the development of simple practical procedures in place of the costly refined materials and the complicated techniques employed in the growing of plants in small glass containers filled with nutrient solutions, in scientific laboratories for experimental studies on the mineral nutrition.

(2) The complete divestment of the water culture method of crop production from the laboratory concepts of water culture which were designed to study the mineral nutrition, in order that hydroponics be provided with its own distinctive basis—the dynamics of fluids substituted for that of porous solids on the root growth of plants. The divestment was necessary in order that the right approach to the practical use of the method could be established.

[1] W. F. Gericke, SCIENCE, 85: 177–8, 1937.

(3) The formulation of the dynamics of water. This involved, (*a*) explaining why the roots of plants when grown in nutrient solutions become different from those grown in the soil; (*b*) formulating the pattern as to how they become different; (*c*) describing how the hydroponic technique is arranged for various species in various climates to meet the requirements of a changed root system; (*d*) interpreting the significance of differences in roots in other characters in plants, and (*e*) integrating these phenomena in the evolutionary history of vegetation.

The functions of water in hydroponics are dynamic and physiologic, in agriculture they are physiologic only as the solid matter of the soil provides the dynamic functions. In soil water exists largely as a film around solid particles, hence has little or no hydrodynamic properties. Its dynamics is that of the solid matter to which it adheres. Water in the free state in hydroponics precludes or markedly restricts (*a*) anchorage for roots, (*b*) fixity of position for roots, (*c*) resistance to penetration with its induced stimulus of roots, (*d*) temperature differentials with their induced effects, (*e*) moisture saturated atmosphere affecting production of root hairs, (*f*) and other physical conditions which affect the tectonics of roots.

The mass of the nutrients required by plants is too small to be an appreciable part of the dynamics of the medium that supplies them, hence their functions are physiologic only. The non-nutritive materials create the dynamics, control the physical influences and determine physical conditions which affect the growth of vegetation. Water is the chief non-nutrient material used in hydroponics. Its dynamics is the foundation on which the art and the science of hydroponics is formulated.

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VITAL RESEARCH OF AGRICULTURE

EXPERIMENTAL study of plants and animals for the purpose of feeding, clothing and sheltering the human race should be called "vital research." Webster defines "vital" as "essential to the continuance of life" and "necessary to life." Thus, the word accurately describes research that will aid the producer to supply food, clothes and shelter, as well as raw materials for industrial uses. The benefits are commonplace in times of abundance, but are likely to be dramatic when there is a scarcity of the daily essentials. The responsibility of the agricultural industry to provide ample food is heavy now and will be tremendous in the postwar period.

Much agricultural investigation is of the vital type, since it attempts to solve some producer's or consumer's problem that is impairing production, quality, food value or return for the consumer's dollar. Farmers, farm advisers (county agricultural agents) and scientists at the agricultural colleges are daily pointing out and working to solve such problems. The broad objective is not only to furnish plenty, thus eliminating the specter of starvation, but also to provide the particular kinds of food that are essential for human vigor. These general characteristics apply also to studies outside the field of agriculture—for example, medical research.

It is essential for a group of research people to have a goal; a definite, simple objective is necessary to the industry served, both for training young people to solve problems and for guiding mature workers. Naturally vital research, with its broad problems, its fixed goals and often its limited time for accomplishment, demands scientists of wide training. Frequently it requires the cooperation of several workers in related fields, since the practical production of plants and animals involves wider extremes of heredity and environment than some other types of research. The investigator must keep abreast of agricultural, industrial and economic trends if he is to assist the producers in applying scientific principles intelligently to their problems.

A recent statement in the *A.A.A.S. Bulletin* is of interest in this connection: "There appear to be two principal important functions of the Association in the near future, as there have been in the recent past. One is to keep ever before scientists the fact that science as a whole is much greater and richer than any of its parts, and that extreme specialization and isolation will in time lead to sterility and decline. The other is to emphasize the obligations of scientists to society and, reciprocally, to make clear to the intelligent public how greatly society depends upon science.[1] It is hoped that these two simple goals and the results of vital research will enrich science, besides insuring the essentials of life. Considering the frequent occurrence of new problems and the ever-changing trends of agriculture, it is difficult to see how "sterility and decline" will take place in vital science if the vital-research worker keeps firmly in mind his role of service to industry.

There are numerous examples of work that will fulfil the qualifications for vital research. The use of proper environment and non-bolting strains has prevented the premature seeding of celery and other biennials; a change in plant composition has led to increased fruitfulness; yield and sometimes quality have been improved through the use of hybrid seed corn or onions; the deficiency effects of essential ele-

[1] "Democracy in Science," *A. A. A. S. Bulletin*, 3: 50–51, 1944.