are now being made to continue it. The chemical work is under the direction of Dr. S. D. Wilson and the biological and parasitological phases are being conducted by Dr. G. F. Winfield, of Cheeloo University.

AT the University of Oxford a statute has been promulgated amending the provisions of the statutes governing the study of forestry. The object of the proposed statute is to simplify and to render more coherent the organization of the study of forestry by merging the School of Forestry and the Imperial Forestry Institute under a single control, and thereby to enable the university to make a more valuable contribution to forestry work throughout the empire. Under the new statute the department of forestry will be under the direction of the professor of forestry, and one central committee will provide for the instruction and supervision of four classes of students. These will be (*a*) forest service probationers; (*b*) forest officers taking refresher courses; (*c*) undergraduates who have taken honors in honor moderations in natural science and graduates or undergraduates who have taken honors in a final honor school; and (*d*) candidates working for the diploma in forestry. This same committee will also provide for the higher training of forest officers and for the conduct of research into the formation, tending and protection of forests.

THE boundary of Hawaii National Park, Hawaii, has been authorized to be extended eighty-six square miles, as the result of an act at the last session of Congress. Besides authorizing the addition of lands in the so-called Kalapana and Footprint area to the park, the act also authorizes the acquisition of additional lands adjacent or contiguous to the existing park for the purpose of rounding out its boundaries. The act permits the United States to accept title by donation or gift, but prohibits the expenditure of Federal money for the purchase of land. Included in the 86 square miles of land authorized to be made part of the park are 12 miles of ocean shore line and areas of historic, archeological and scenic interest. Hawaii National Park was created in order to preserve the volcanic exhibit existing on the twelve islands that comprise the Hawaiian group.

DISCUSSION

WHAT IS SOIL?

RECENT references to the culture of plants in sand, cinders or gravel to which solutions of nutrient salts are added as "soilless crop production" have caused confusion as to the differences between hydroponics and non-hydroponic culture. This raises the question, "What is soil?" While soil scientists are not agreed as to all the physical, chemical and biological characteristics of the earth's surface that are to be included in the term, nevertheless they and the farmers are agreed that soil is ground or foundation in and on which plants grow if water and plant food are available. This foundation is a more or less porous solid that holds water as thin films around various-sized particles. This distinguishes soil, ground or foundation from that part of the earth's surface in which water is not so held. Thus to use the term "soilless" in any connection that ignores this fundamental difference between porous solids and liquids has no justification.

To contend that when sand, cinders or gravel have been treated and all plant nutrients removed they are therefore "soilless" and that the subsequent additions of nutrients thereto still retain these materials in such state ignores basic differences of properties that must be considered in classification. One would not contend, that when the soil solution of a fertile field has become virtually depleted of available nutrients by the growing of a crop, consequently could not sustain another crop until nutrients have been restored by whatever way this may be accomplished, the nutrient-depleted field is in a "soilless" state. The presence or absence of one or all nutrients held in solution or otherwise in a porous solid does not differentiate categorically between the soil and soilless state of culture media.

The quantity of nutrients in a culture medium reflects fertility or crop-producing potentiality. However, as other conditions are essential to growth of crops, therefore fertility of any culture medium must be considered in a relative sense whenever comparison is made. The insoluble particles of soil are not involved in its fertility. This is a function of the character of the soil solution. The insoluble character of a part of the soil certainly is not a basis for defining such material as "soilless." Insoluble material is an essential part of soil.

Soil is a means of providing vegetation with nutrients and as long as they are incorporated therein are part of the soil. The elimination of available nutrients therefrom, however, does not alter the basic physical and geologic character of the earth's crust described as soil. But soils are not studied as a geophysical science. Soils have a biologic meaning. It is the relation of the earth's crust to vegetation that determines the scope of the concept implied in the term.

The basic difference beween the soil and soilless types of culture media is in the mobility of the solutions they hold and retain. In the one case the solution

is held as surface film, in the other, which contains no solid particles, the liquid manifests full hydrostatic properties.

Cinders and gravel, which can not provide the properties required of soilless culture media, are large-sized particles, hence their water-holding capacity is low. The pores are of good size, hence drainage is rapid. Frequent application of nutrient solution is necessary, which is usually obtained by flooding the beds in which the plants are set. For convenience and economy the drained solution is used over and over. Basins are necessary to hold these low water-retaining materials so as to check the too rapid drainage of the frequently added nutrient solution. But the imperative need for drainage to open the pore spaces to air necessary for growth of crops in this type of culture media emphasizes the soil characteristics of the material. The removal of the excess solution completes the picture of the true characters of a soil—water held as films by solid particles, also some water held in the free state and its flow retarded by friction, with air space between the particles arising from drainage, following saturation by rain or irrigation.

Another basic difference between the soil and the soilless types of culture media is in the amounts of water and nutrients a given volume of each provides vegetation and in the consequent effect thereof in the magnitude of production. A unit volume of culture media that contains no solids provides more water and nutrients than does one in which space is occupied by solids. In these premises are found the explanations for the markedly greater productive potentiality of hydroponics, which is obviously soilless, than that of agriculture. Those who contend that if ample amounts of nutrients were supplied to a good soil the productive potentiality per unit area thereof would equal that of hydroponics have failed to provide evidence. Because hydroponics permits denser stands of vegetation than is possible with soils, therefore larger yields are obtained. For example, a basin—1/220 acre—carrying three crops at once for part of their growth periods, the stand of each denser than that of agriculture, yielded 8.6 bushels (60 pounds per bushel) of potatoes, more than 1,000 pounds of tomatoes and celery not yet matured. Another basin of the same size planted to potatoes and corn yielded 6.8 bushels of potatoes, and although the corn is not yet mature for harvest, nevertheless the indicated yield predicts production far in excess of that known to agriculture. Experimental evidence is also at hand showing that two crops of potatoes can be so grown as to be harvested together with yield markedly exceeding the above-mentioned large yield of a single crop. The second crop is planted at such a growth stage of the first crop that when the latter has passed the period of full light requirement the former enters therein. Also evidence is at hand that the two and three crops grown together as mentioned do not constitute the full productive potentiality of hydroponics in regions having long seasons of favorable climate.

Terminology of languages does not convey the same meaning and distinctions. "Soil" in English has a synonym, "dirt—something that pollutes, such as loose earth, dust, muck, manure." These, however, are materials that enrich land—that is, build soil. The absence of these in land could in a sense be construed to mean soilless. But is it becoming to the dignity of land to call dirtless soil "soilless"? In other languages, the concept of ground and foundation has not been taken away in the terminology commonly applied to the earth's crust which supports vegetation. Earth materials like sand or gravel, if used for the culture of plants, are not classed as "soilless."

W. F. GERICKE

UNIVERSITY OF CALIFORNIA,
BERKELEY

ARE THERE DIFFERENT CRITICAL OXYGEN CONCENTRATIONS FOR THE DIFFERENT PHASES OF ROOT ACTIVITY?

RECENT investigations with apple tree roots under field and greenhouse conditions have indicated that there may be different critical oxygen concentrations for different phases of root activity.

(1) *Subsistence.* Evidence from field studies now in progress indicates that apple tree roots larger than 1 mm in diameter are able to subsist in soil atmospheres containing less than 0.1 per cent. to 3.0 per cent. oxygen for considerable periods of time when the tree as a whole is in active growth. Controlled greenhouse experiments with apple seedlings[1] point to the probability that when the oxygen in the soil atmosphere is maintained at 3 per cent., the roots are at a "subsistence level" with respect to oxygen, that is, they continue to live but grow slowly if at all. At oxygen pressures below 1 per cent. they seem actually to lose weight. This "subsistence level" probably coincides with the lower critical concentration as defined by Cannon.[2]

(2) *Initiation of new roots.* Recently Tukey and Brase[3] have found that during wet years newly planted apple trees have produced larger root systems and tops when German granulated peat moss has been incorporated with the soil in the tree hole than when topsoil alone was used. During dry years there was little or no beneficial effect from the peat. Through the cour-

[1] J. DeVilliers. Unpublished data.

[2] William Austin Cannon, *Carnegie Inst. Wash. Pub.* 368, 1925.

[3] H. B. Tukey and K. D. Brase, *N. Y. State (Geneva) Agr. Exp. Sta. Bull.* 682, 1938.