Growing Plants without Soil
by
A. N. Binkley

At the present time there is considerable interest in growing plants without soil, which is no doubt due to the wide publicity and spectacular yields reported. It has appealed to the popular fancy of the amateur and the hobbyist, yet it does have possibilities for use by the commercial greenhouse grower. Soilless culture has been used as a technical tool for a long time, but it is only recently that its adaptation to large scale use has become of interest to the greenhouse industry. It is not adapted to outdoor use in the field except in localities, such as islands, where there is not sufficient soil or the soil is not capable of supporting plant life. The backyard gardener could use soilless culture as a hobby but the results as reported from those who have tried it are not very encouraging. Certain types of house plants can be grown without soil with proper equipment.

A brief discussion of soilless culture is given here with the hopes that it will bring about a better understanding of some of the problems involved. In water culture or gravel culture a chemical solution is used to furnish the necessary nutrient elements to the plant. The difference is largely one in the mechanics of supplying the solution to the roots.

**Water Culture**

Water culture refers to the growing of plants in a chemical solution, without a rooting media, such as gravel. The plant is supported by holders and the roots grow in the chemical solution. The term hydroponics has been coined, which means literally water culture. Crop plants, however, will not grow in pure water, but must have the necessary chemical elements in the solution for growth. Roots must have aeration or oxygen for growth so air must be bubbled through the chemical solution for growth.

Plant physiologists have grown plants in liquid nutrient solutions containing the necessary chemical salts for growth for over 75 years. It has been used as a method of determining, under controlled conditions, the factors affecting plant growth. For example, if you were asking information on the effect of phosphate on a particular plant, it would be left out of one series of liquid solutions in which the plants are growing. This would then be compared to treatments with sufficient phosphate for growth and to a series where the phosphate quantity of the solutions varied. The iron, boron, copper and other minor element requirements of plants have been studied by this method. Thus the experimental use of the liquid solution culture is so planned as to be helpful in answering both scientific and practical questions. There are many different types of liquid nutrient solution cultures for different species of plants, and different techniques have been developed for experimental work. The plant foods necessary for growth are obtained from the liquid solution, instead of from soil, which means that the concentration of the solution must be maintained at the proper level. As the plant grows, the nutrients or plant food is taken up and the solution will change. The change may also cause the pH or reaction to change from acid to alkaline side. Water evaporates from the surfaces
of the solution, and the plant loses water through use and loss of leaf surfaces. This means that the water levels and the chemical composition of the solution must be checked at regular intervals and necessary adjustments made. If the solution becomes too acid or alkaline, adjustments need to be made to maintain the reaction at the right level for growth.

Many of these checks must be done for both water culture and gravel culture methods of growing plants. In liquid solutions, air is bubbled through the solution to provide oxygen whereas in gravel culture the gravel media is flooded with the chemical solution at regular intervals during the day, which brings air or oxygen to the roots. Temperature must be maintained at the proper range for crops grown. These points are emphasized to show the importance of having someone familiar and experienced in growing crops without soil.

**Gravel Culture**

The gravel culture method has been found to be more practical to use because it is more adapted to large scale commercial growing of greenhouse crops. The Horticulture Section of the college has been experimenting with gravel culture for over five years to determine (1) the best solution for specific crops; (2) to determine the best medium (gravel, sand, etc.); (3) bench construction; (4) number of floodings of the media per day; (5) adaptation of propagation and transplanting methods to gravel culture; and (6) other new ideas in the operation of the method of growing plants. The results of some of these studies have been published, are in preparation, or not yet completed. A few of the requirements of gravel culture are discussed in a general way, based on the work in the college greenhouses.

**Bench Construction. – Pumps and Tanks**

Gravel culture requires concrete or waterproof benches so constructed that grooves in the bottom will provide drainage of the solution back into the solution tank. The tank, holding the nutrient solution, should be made of waterproof concrete and located so the solution will drain back readily. The size of the tank required should be about the capacity of one-third the cubic content of the bench. The nutrients are pumped from the tank into the bottom of the gravel filled bench until it comes within an inch or two of the top of the gravel surface, then the pump is turned off and the solution allowed to drain back into the tank. The pump can be attached to the tank or be of a portable type. Time switches are available which can be set at time intervals to turn the pump motor on and off.

**Solutions**

The solution which has been found to be satisfactory for our conditions is a modified W.P. solution which contains nitrogen, phosphorous, potassium, calcium, and magnesium, iron and other minor elements added. The solution can be pumped into the gravel two times every 24 hours or as needed, depending on the stage of growth of the plants, the season of the year, weather and other factors.
Here it has been necessary to change the solution every two months for gravel benches of carnations. It is necessary that the solutions be tested twice weekly, and water levels checked daily.

Mr. August Hussenbrock, florist in charge of our college greenhouses, has grown successfully a series of crops over a five year period in benches. He has run the quick chemical tests on the solutions, tried out different practices and new bench construction and other ideas. These crops include carnations, snapdragons, chrysanthemums, stocks, sweet peas, tomatoes, hydrangeas, and other crops. The yields and quality have been outstanding considering the problems of temperature control and growing more than one crop in a small range. While there are still problems of adapting the method to commercial greenhouse ranges, it is only by growing the crops on a commercial scale that the practicability of the methods can be determined. Large greenhouse operators are interested in gravel culture and even if started on a few benches many things of value will be learned about the nutrient requirements of specific crops of which can be applied to growing in the soil. Some of the advantages and disadvantages of growing crops in greenhouses by the use of the gravel culture methods are listed for comparison.

Advantages:

II. Reduction of labor costs.
   (a) Eliminates hand watering.
   (b) No weed control necessary.
   (c) Eliminates cost of changing preparation and fertilization of soil.
   (d) Reduces haphazard methods of watering and fertilization.

II. Better understanding of elements and their balance required for production.

III. Soil borne diseases less of a hazard.

IV. Lowers fertilization cost.

Disadvantages:

I. Higher cost of bench construction, tanks and equipment.
   (Original cost higher but could be charged off over a 10 or 20 year period.)

II. Diseases may be distributed by nutrient solutions.

III. Danger from insecticides running into nutrient solution. The gravel should be flooded with tap water or nutrient solution before spraying.

IV. Requires periodic check on solution balance and reaction.

V. More knowledge required on commercial adaptation and balanced solutions for different crops.

VI. Symptoms of minor element differences may show up on different varieties, especially iron, boron, manganese, and calcium.
Gravel culture is an interesting growing method and undoubtedly will be widely used in the future, particularly where quality and yield are important. In all the experiences in growing crops by the gravel culture methods on a commercial basis at the college, the least difficulty is with the solutions used and their adjustment. More difficulties are encountered in the mechanics of operation. It does, however, require someone trained and experienced in gravel culture methods. It does not require a technically trained chemist, or one with a Ph. D. degree to be successful in growing or in the supervision of the method. Gravel culture will increase in use by greenhouse growers as soon as it can be proven to be more economical and that better yields and quality of crops can be produced.

Visitors are always welcome at the college greenhouses.