

The Sand Culture of Seedlings and Mature Plants

A. A. DUNLAP



Connecticut
Agricultural Experiment Station
New Haven

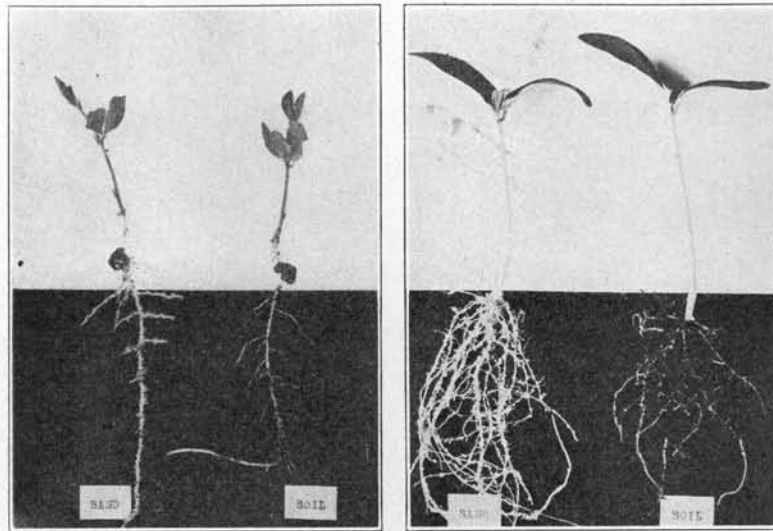


Figure 2. Root development of seedlings in sand and soil; sweet pea at left and cucumber at right.

DIRECTIONS FOR PRACTICAL USE OF THE SAND CULTURE METHOD

1. Secure sand (as clean as possible) from a deep pit, seashore, or dealer in builders' supplies. If fresh, clean sand cannot be found, treat according to one of the methods listed on page 4.
2. Place the sand in clean containers, such as tin cans with holes in the bottom, flower pots, wooden flats or benches.
3. Wet the sand thoroughly, level off the surface and sow seeds. Cover the seed with clean sand.
4. After seedlings emerge, keep cultures in sunlight as much as possible. Feed occasionally with nutrient solution as described on page 4 and keep sand constantly moist with plain water.
5. When seedlings are large enough to handle, they may be transplanted to flats of soil. By continued feeding, larger plants may be grown for setting directly into the garden.

The Sand Culture of Seedlings¹ and Mature Plants

A. A. DUNLAP*

THE USE of sand for starting plants from seed is becoming popular with amateur and professional growers. This method largely eliminates the danger of damping-off and enables the grower to regulate the development and size of the seedlings. He may suspend the growth of young plants and keep them in sand for extended periods in a healthy condition before transplanting. Sand-grown seedlings, furthermore, have large, strong root systems that make transplanting easier and insure a high percentage of survival.

The present circular supersedes Station Bulletin 380 and Circular 117 which are now out of print. It includes the practical information that has been obtained in our experiments up to the present time and new features in watering and feeding the sand cultures. In addition, it outlines the method followed at the Station for growing certain plants to maturity in sand. This work is still in the experimental stage.

The large variety of plants that have been grown successfully as seedlings in our experiments with sand would indicate that this method is useful for practically all kinds of seeds. Seedlings of species that require a period of several months to attain any appreciable size are usually the most difficult to grow. Also a few others may require special handling or treatment. Owing to the fact that sand culture is somewhat different from soil culture, a little practice and experience on the part of the grower may be necessary before the best possible results may be obtained with sand.

MATERIALS AND PROCEDURE

Sand

Success in growing seedlings by this method depends to a large extent upon the cleanliness of the sand. Suitable grades can usually be obtained from dealers in building supplies. White quartz or fresh sand from such sources as the seashore or a deep inland pit is usually favorable, without washing or sterilizing, for raising seedlings. Colored sand of natural yellow, red or brown color are even more desirable than pure quartz. Slightly coarse grades are preferable to those that are very fine. Excellent growth of both seedlings and mature plants has been obtained with sands having the following particle sizes:

Particles retained by a 20-mesh sieve.....	10—20%
Particles passing through a 20-mesh sieve but retained by a 40-mesh sieve.....	50—70%
Particles passing through a 40-mesh sieve.....	20—30%

¹ A revision of Circular 117 with certain additions.

* Doctor Dunlap was Assistant Mycologist at the New Haven Station until July 1, 1938. He is now Chief of the Division of Plant Pathology and Physiology, College Station, Texas.

Partial Sterilization of the Sand

One of the following methods of sterilizing the sand may be used in case it is suspected of containing damping-off fungi:

- (a) Wash the sand in several changes of hot water, 160° F. or higher, until the water remains relatively clear after stirring.
- (b) Pour boiling water over the sand and allow it to stand for half an hour.
- (c) Drench the sand with formaldehyde solution, 1 part commercial formalin to 50 parts of water, and allow it to stand for one day or longer. The formaldehyde must then be thoroughly flushed out of the sand with plain water before planting.
- (d) Heat the sand for two or three hours in a hot oven.
- (e) Flame the sand with a blowtorch or weed burner.

While the above measures are necessary in some cases, most *new* sand that is free from loam and organic matter can be used without any special treatment.

Containers

Seedlings may be grown in various kinds of containers when sand is used. Tin cans with a few small holes punched in the bottom, flower-pots, wooden flats, greenhouse benches, and even entire cold-frames are suitable. It is imperative, however, that the containers be clean. If wooden flats or benches have previously been used with soil, they should be thoroughly washed with the formaldehyde solution described above. Containers with waterproof walls are preferable, although there should always be some sort of an opening in the bottom for the passage of water. When clay flower pots are used, they should be given one or two coats of varnish or paint to prevent excessive evaporation from the walls, and the hole in the bottom should be partially closed to keep the sand from washing out. The size of the container depends upon the size and the number of seedlings to be grown. A tin can four or five inches in diameter is large enough for starting several hundred small seedlings, such as those of snapdragon or petunia. Similar numbers of larger seedlings require more growing space.

Fertilizers for Seedlings in Sand

Because most kinds of sand contain little readily available plant food, it is usually necessary to supplement the food supply within the seed by adding a solution of fertilizer chemicals. Some of the larger seeds contain enough stored food to produce seedlings of a sufficient size for easy removal and transplanting. Larger and more rapidly growing seedlings will, of course, be obtained when nutrients are added to the sand.

A solution made up of one level teaspoonful each of saltpeter (potassium nitrate, KNO_3), and superphosphate [containing soluble monocalcium phosphate, $Ca(H_2PO_4)_2$], in one gallon of water makes a suitable fertilizer for nearly all kinds of seedlings in sand. Both of these materials may be purchased in commercial grades from dealers in agricultural supplies. It makes no material difference whether the superphosphate is of high or low phosphorus content. At most drug stores, one can obtain pure grades of saltpeter and sodium phosphate. The latter material may be used in place of superphosphate.

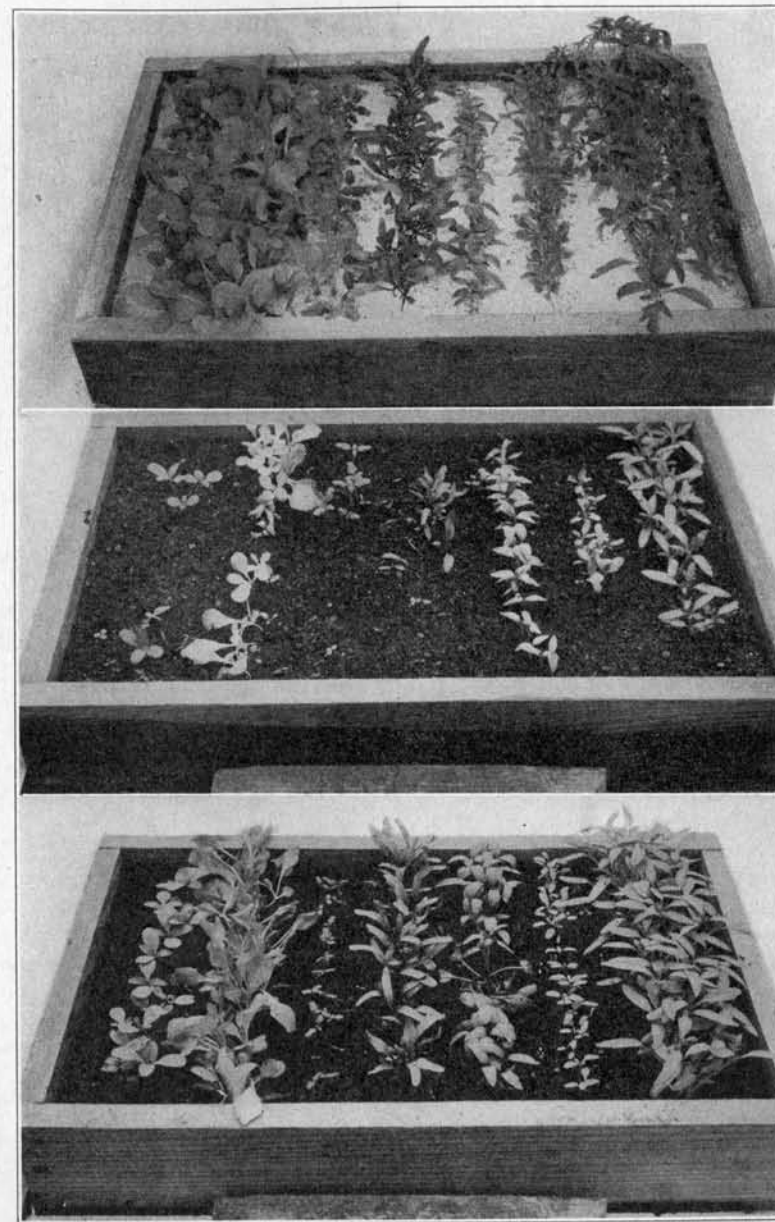


Figure 3. Results of seedling culture in sand and in soil. Each of these flats was planted with the same number of seeds of the following species and in the following order: Zinnia, lettuce, clarkia, beet, eggplant, gypsophila and tomato. Above, sand culture. Center, untreated soil. Bottom, formaldehyde-treated soil.

Another satisfactory feeding solution for seedlings and older plants may be made by adding 6 level teaspoonfuls of any standard grade of a complete chemical fertilizer (the 5-8-7, 5-10-10 or 4-12-4 and similar grades) to one gallon of water. As in the case of superphosphate, there is much insoluble material in fertilizer mixtures, but after stirring for a moment enough of the essential plant nutrients will be dissolved and the insoluble residue may be added to the sand or discarded. If one uses a concentrated fertilizer which is almost entirely soluble in water (such as the 8-16-16 or similar grade), only 2 level teaspoonfuls need be added to a gallon of water.

Seed Treatment

Since sand culture is in itself a control measure against damping-off, it is usually unnecessary to treat the seed with protective materials when they are to be planted in sand. Sometimes copper-containing seed treatment materials have been found injurious to certain seedlings in sand culture. On the other hand, seeds may be treated with hot water or mercurial compounds when it is thought necessary to destroy seed-borne diseases before sowing.

Planting and Covering the Seeds

After the container is filled to the top with wet sand that has been firmed down, the seeds may be planted. If dry sand is used it should be thoroughly saturated with water beforehand, and the nutrient solution may or may not be sprinkled over the surface of the wet sand at this time. The seeds may be broadcast or sowed in drills. Small seedlings can be grown in close masses in sand. If larger seedlings are desired, or if the species, like cabbage or cucumber, has a tendency to develop long stems, it is better to allow more space between the plants.

It is easier to cover the seeds with clean, *dry* sand, although wet sand can be used over large seeds. Small seeds, such as petunia, require only a light sifting of sand, whereas most vegetable, tree, and large flower seeds should be covered deeply enough to enable the seedling roots to obtain a foothold. A light watering follows the covering of sand.

Cultures that are to receive surface watering may be protected from too rapid drying out after planting by placing over them some such material as cardboard, glass or paper. These covers should be removed as soon as the plants start to come up and the cultures should then be given as much sunlight as possible.

Watering and Feeding

Because the fertilizing of plants growing in sand is so closely associated with watering, the two processes may be outlined together.

If seeds are planted in sand in boxes, benches, or other containers in which considerable surface watering will be necessary before the seedlings emerge, it is of little use to add nutrients to the sand before the plants come up. If tin cans, flower pots, or containers with holes in the bottom are used, the cultures may be watered from beneath. Using this method, the fertilizer remains near the plants, and one cup of any of the above solutions may be added to each quart of wet sand in the container, just before planting the seeds. In most cases, it is best to wait until the seedlings have started

to grow, when they may be given a thorough watering with the nutrient solution once or twice a week. One of the most satisfactory methods of feeding consists in watering the culture with a dilute nutrient solution. However, appropriate treatment depends largely upon the type of container in which the plants are being grown.

Containers that are from four to seven inches tall, such as tin cans or pails with holes in the bottom and flower-pots, may be most easily watered by keeping them standing in a shallow pan or trough of water. It is not necessary to have water in the pan all of the time, since the sand takes up enough moisture to last, under most conditions, for several days. As mentioned earlier, this plan of watering permits the application of some fertilizer to the sand at the time of planting because it does not wash the nutrients away before the seedling roots can absorb them.

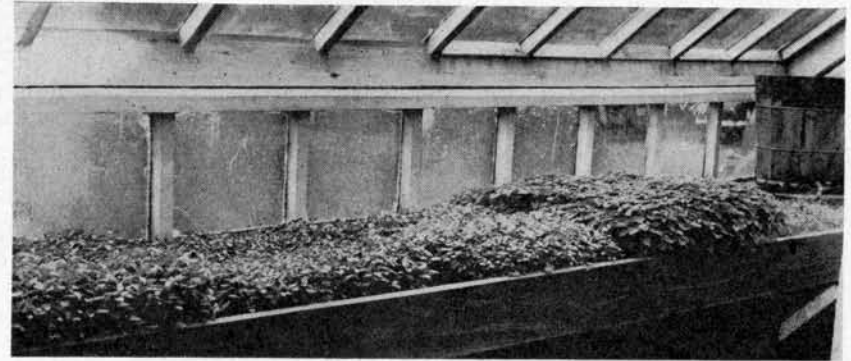


Figure 4. Seedlings growing in a greenhouse bench in sand. Left to right: pepper, snapdragon, celery and salvia.

Regardless of whether the cultures were fertilized at planting, and regardless of the type of container or method of watering, feedings may be made after the seedlings have come up by sprinkling the plants and sand with nutrient solution. It is not necessary to use exact amounts, and a thorough watering with a feeding solution is the most that can be added at a time. Satisfactory growth will result from lighter applications, but for steady growth these must be somewhat more frequent than the applications with larger amounts. Solutions of the strength indicated on Page 6 can be sprinkled over the seedlings without danger of serious chemical injury to the foliage. A light sprinkling with plain water after the feeding will wash any nutrient solution from the leaves. This is most important with cultures in bright sunlight where the solution would tend to evaporate quickly.

Seedlings and young plants in shallow boxes or ordinary flats of sand are usually watered by sprinkling from above with a watering can or hose. After the seedlings have emerged, even such shallow containers as flats, holding sand to a depth of from two and one-half to three inches, may be watered conveniently by occasional sub-irrigation. With certain kinds of

seeds, however, germination is inhibited by too high a water content in the sand. For small cultures, a bottle provided with a clothes sprinkler is useful for both feeding and watering.

Benches of sand may be watered from above with a can or hose. If there is a considerable area to be watered, one can arrange a useful watering device with a tub or barrel and garden hose. In setting up an irrigation system of this sort, the tub is placed at the end of the bench and elevated somewhat so that its bottom is just above the top of the sand. A piece of garden hose, connected at one end to the bottom of the tub or barrel, is then placed along the center of the bench. Small holes, one-eighth of an inch or less in diameter, are punched about 10 or 12 inches apart along the top of the hose, which is later buried just beneath the surface of the sand. A small stick or piece of wire long enough to project a few inches above the sand is placed in each hole to prevent excessive flow of water and to enable the grower to start the flow again in case the hole becomes clogged. A pinchcock is located between the hose and the reservoir so that the latter may be kept full of water when not in use. When the pinchcock is opened, the pressure causes a gradual leaking at the holes. The escaping water is taken up by the sand and distributed to all parts of the bench. A device of this sort saves considerable time for the grower and insures a thorough watering of the sand. When watered thoroughly until they drip, benches containing four inches or more of sand will remain sufficiently wet for a few days under most greenhouse conditions.

The feeding of flats and benches is best accomplished just after a thorough watering. A satisfactory way of applying the fertilizer is by sprinkling the seedlings with nutrient solution, using about one pint to every square foot of sand surface. By feeding after watering, in this manner, the fertilizer remains in the region of the absorbing roots for a considerable period.

Delayed Feeding to Prevent Long Stems

Some kinds of seedlings, notably cabbage and cucumbers, tend to have exceedingly long stems when grown in too dense stands. Withholding of the nutrient solution for such seedlings, until 10 days or more after their emergence from sand that has not been fertilized, has resulted in the growth of normal stocky seedlings. When the seedlings are fed following this starting period, growth seems to take place as leaf and shoot expansion rather than as stem elongation.

Conditions of Light, Temperature, and Humidity

In general, conditions which favor growth of plants in soil are equally favorable for sand culture. Ordinary greenhouse conditions are usually suitable because an abundance of light is essential for the development of sturdy plants. For this reason, cultures maintained in the home should be given as much direct sunlight as possible after the seedlings come up. Cultures of seedlings that are being started in the spring, while freezing temperatures still occur at night, may be placed outdoors in some sheltered location during the day and returned to the house at sundown. When kept outdoors, containers of sand, especially shallow flats, should be provided with sufficient water to keep them moist despite the increase in evaporation.

It is well known that many kinds of seeds germinate and plants grow more rapidly under warm, than under cool, conditions, provided other factors are kept the same. One is able, therefore, to regulate the rate of emergence and growth of some seedlings by changing the temperature at which the cultures are kept. As to humidity, it is easier to maintain sand cultures in relatively moist air because the sand dries out more slowly when the humidity is high. With continuous sub-irrigation, however, the moisture content of the air is of minor importance.

Transplanting Seedlings from Sand

For the present, probably one of the most practical uses of sand culture lies in the production of healthy seedlings of a suitable size to be transplanted into soil. For this purpose cultures must be maintained for a period of from two to six weeks after planting for most of the common flower and vegetable species, depending to a major degree upon the temperature. Some slower-growing seedlings require a longer period for development. In transplanting, it is convenient to transfer a group of plants together with the sand around them to a shallow vessel of water. The sand readily washes away from the roots and the individual seedlings may be easily lifted out.

Sand-grown seedlings may be transplanted into soil in a flat, cold-frame, or hotbed, outdoor garden, or into the field. Strong root systems are formed early in sand and the seedlings are ready for transplanting as soon as they are large enough to be handled, provided they can be protected from the sun. In greenhouse flats and coldframes such protection is simple, but in the garden it may be more difficult. Therefore, it is advisable to allow the plants to attain a larger size before transplanting them directly outdoors. For this purpose superior seedlings will be obtained if the seeds have not been sown too thickly. Unless the soil is very moist, plants set outdoors directly from sand should be watered at the time of transplanting. In addition to the watering, tender seedlings, such as those of certain flowering plants, should be protected from the sun for a few days after being set in the garden.

In cases where suitable soil for transplanting is not readily available, seedlings may be transplanted from the sand in which they were started into a larger container of fresh sand. By feeding with a nutrient solution, as described on page 10, larger plants may be raised for outdoor setting.

Continued Use of the Sand

During the course of our experiments, certain types of sand frequently have been used for three or four consecutive crops of seedlings without any treatment at any time and without being contaminated with damping-off fungi. If the sand is to be used over again, probably the safest procedure would be to sterilize it by one of the methods listed on page 4. After the same sand has been used for a few crops of seedlings, it usually contains a considerable amount of decaying roots, seeds, or other plant material and should be thoroughly washed before using again, or else discarded. Either new or used sand, when thoroughly dry, may be stored in a clean place indefinitely without danger of contamination from damping-off organisms.

Sand Culture in Coldframes or Hotbed

Damping-off frequently becomes a serious problem under coldframe conditions. Standard formaldehyde treatments are dangerous because the disinfectant disperses slowly at the low temperature and seed treatments are often inadequate. Therefore, some fungus-free medium, such as sterilized soil or clean sand, is especially desirable for the coldframes.

In a limited amount of experimental work, we have been successful in avoiding damping-off in the coldframe by using sand culture. Germination and emergence were much better in sand than in plain soil in different sections of the same coldframe. Although the growth of the young plants was somewhat more rapid in the soil, the plants in the sand were much stockier and they formed a better stand of seedlings than was obtained from the same quantity of seeds in the soil plots. Some of the growth differences in this case may have been due to the fact that the nutrients were not supplied to the sand in the coldframes until after the seedlings had emerged.

Under coldframe conditions, we found that there was a distinct advantage in lining the bottom of the frame with roofing paper before putting in the sand. This tends to prevent both water and nutrients from draining out of the sand. The paper may be so arranged that a shallow watertight container is formed, or it may be merely placed flat on the ground within the frame. Sand is used to a depth of about six or eight inches. The same principles apply to the general culture under coldframe or hotbed conditions as were stated for indoor culture in the preceding pages. Because the plants are usually allowed to remain in the coldframe until considerable size has been attained, it is better to use a three- or four-salt solution such as is described under the next topic.

GROWING LARGER PLANTS FOR FIELD SETTING

Frequently, sand-grown plants considerably larger than seedlings may be desired for transplanting outdoors. In such cases one may continue to feed the culture of seedlings and promote the growth of fair-sized plants even in the original container. It is well, under these circumstances, to thin out the stand of seedlings so as to allow room for each plant to develop, or else to sow the seeds more thinly at the start. As stated previously, seedlings may be transplanted to fresh moist sand and, after allowing three or four days for the roots to become reestablished, nutrient solution may be added. Such plants need feeding about once a week provided excessive watering from above is not practiced between feedings. Since these young plants are to make considerable vegetative growth, it is preferable to use a somewhat more complete nutrient than is employed in the case of seedlings. Epsom salts (magnesium sulfate) should be added to the solution mentioned previously, making a nutrient solution of the following composition:

Salt peter.....	1 level teaspoonful
Superphosphate.....	1 level teaspoonful
Epsom salts.....	1 level teaspoonful
Water.....	1 gallon

Water extracts of high grade, complete commercial fertilizers may also be used in growing larger plants for transplanting. About a level half teaspoonful of Epsom salts should be added per gallon. Their use is the same as described earlier in this circular for seedlings.

GROWING PLANTS TO MATURITY IN SAND

At the present time much popular interest is being shown in the artificial culture of plants for the production of blooms, fruit, or green vegetables. In addition to the freedom from damping-off among sand-grown seedlings, plants grown to maturity in sand usually escape the common root and soil-borne diseases that attack greenhouse crops in soil. These diseases necessitate sterilization and frequent change of soil in the greenhouse. Another advantage of sand culture for mature greenhouse plants lies in the uniformity of growing conditions, such as soil fertility, which the grower can provide for the crop from year to year. With soil, on the other hand, it is difficult to provide even similar types or degrees of fertility each season.



Figure 5. Mature tomato plants raised in four inches of sand in a greenhouse bench, with the nutrient solution described.

Although our experiments along these lines have been somewhat limited in number, and only a few different kinds of plants have been tried, considerable success has been attained under greenhouse conditions. With slight modifications, the method has consisted chiefly in continuing the sand

culture method used for seedlings throughout the growing period of the plant. In this manner, mature plants of chrysanthemum, coleus, begonia, petunia, and zinnia have been easily grown in sand and excellent blooms have been produced. Tomato plants have also grown to unusual size by this method and produced good yields of high-quality fruits. In all cases, the plants in sand have been especially free from soil-borne diseases.

In our experiments, numbers of mature plants were raised entirely in sand, in benches, or reared individually in flower pots or large cans. Containers of the latter types were kept standing more or less continuously in shallow water for sub-irrigation, as described earlier for seedlings. The majority of our plants, however, grew most rapidly in benches of sand which were fed twice a week with nutrient solution. Enough solution was applied at each feeding to wet the sand thoroughly and to cause considerable dripping from the bench. Surface watering was applied between feedings as required to keep the sand moist. In a few cases both the water and nutrient were successfully supplied through the tub-and-hose device.

The nutrient solution employed here in the culture of full-grown plants contained four ingredients:

Saltpeter.....	1 level teaspoonful	Sulfate of ammonia..	$\frac{1}{2}$ level teaspoonful
Superphosphate..	1 level teaspoonful	Water	1 gallon
Epsom salts.....	1 level teaspoonful		

While this solution is not to be considered the most satisfactory in any sense,* it produced excellent growth of many different kinds of plants in sand, and the ingredients may easily be obtained in inexpensive form. In our experiments, certain essential minor elements probably have been supplied as impurities in the commercial grades of fertilizer salts, in the water, or in the sand.

The approximate amounts and frequency of application of the nutrient solution for best results will vary with the size of the plants, amount of sunlight, watering, temperature and other conditions. Since this sort of plant culture is still in the experimental stage, no definite directions can be given that would be suitable for all conditions or for any large number of plant species. For these reasons, each grower should be alert to modify the method to suit his particular needs in order to obtain better results wherever possible. The opportunity for individual accomplishment along these lines makes such culture of plants exceedingly interesting to both amateur and professional gardeners.

* In more recent trials, the following solution has been used with very favorable results:

Monopotassium phosphate...	6 grams	} per 5 gallons of solution
Calcium nitrate.....	20 grams	
Epsom salts.....	10.5 grams	
Ammonium sulfate.....	1.8 grams	

- Dunlap, A. A. Sand Culture of Seedlings. Conn. Agr. Expt. Sta. Bul. 380: 137-159. 1936.
- . Growing Seedlings in Sand. Conn. Agr. Expt. Sta. Circ. 117: 1936.
- . Sand Culture Prevents Damping-off. Market Growers Journal 62: 138-140. 1938.
- . Starting Seedlings in Sand with Chemicals. Horticulture. 16: 87-88. 1938.
- . Sand Culture for Seedlings. Florists Exchange & Horticultural Trade World 90 No. 12:21. 1938.