organisms can be splashed on the foliage, but rather takes cuttings from the tops of the plants. We adopt methods of sterilization from beginning to end. The cutting, the rooting medium, the containers, and the container-medium are sterilized. Growers who suffer severe losses soon learn the value of sterilizing everything.

Another aspect of growing in the West, which I believe is highly important, is that of mechanization. The introduction of the "Plantainer" type of container has made it possible to handle the material in such a way that rapid planting can be carried out. We do have an excellent example in certain nurseries in Century, California, where a machine has been developed which has allowed eight men to plant 120,000 one-gallon containers in two weeks.

Now, getting into what I feel is the substance of what I want to offer for your consideration, I would like to say that much of the folklore of plant growing is being replaced by new information and the ability to control plant growth more completely.

Mr. Matkin presented his paper, entitled: "Prepared Soils for Container Growing." (Applause)

PREPARED SOILS FOR CONTAINER GROWING

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The nursery business has been highly traditional and resistant to change until the past few years. With the introduction of large scale container production and modern sales techniques by a few, the industry has been forced to reconsider the efficiency of its methods and procedures.

To those steeped in tradition the changes occurring must seem radical and, perhaps, discouraging. The "Art" of growing is fast giving way to the "science" of growing. Plants are being made to perform to the utmost of their abilities. The procedures employed by the most successful are those of the factory assembly line.

It is recognized that all plants have similar basic requirements, that they can and do lend themselves to mass production techniques. It is the purpose of this discussion to take up those basic requirements and explain their use in container culture.

Factors influencing plant response may be placed in two general categories—(1) Those *required* for normal response, and, (2) those *retarding* normal response.

In this discussion we are primarily interested in the root zone requirements which are:

1. Available moisture.
2. Adequate aeration.
3. Sufficient mineral nutrient.

In outdoor growing the above ground requirements are not too easily controlled. They may be summarized as consisting of:

1. Light of favorable intensity and duration.
2. Favorable temperatures:
3. Sufficient carbon dioxide for photosynthesis.

Factors retarding normal development might be listed in general as:

1. Competition from weeds or other plants.
2. Damage by parasites and insects.
3. Physiological damage from toxic materials in soil or atmosphere or from applied materials such as insecticides, fungicides and weedicides.
4. Mechanical damage.
5. Unfavorable hereditary characteristics.
6. Unfavorable status of *any of the basic requirements* listed above.

It is often difficult to clearly separate these influencing factors in appraising actual situations. Much of this difficulty stems from a tendency to use some vague or meaningless term to cover a whole range of symptoms. How often have you heard the phrase, "too much water!," as a diagnosis of plant failure? We are all aware that plants can be grown in a water solution, which is certainly the maximum in supply of water. If we try to use reason in breaking down the true meaning of the term, "too much water," we must assume it doesn't mean exactly what it says. It may mean (1) moisture application was at a high enough rate that the soil, presumably of poor structure, contained an inadequate supply of oxygen for normal root function, or (2) disease of some type was present in the soil or plant and a high moisture level allowed this disease to develop at a rate which overcame plant development, or (3) excessive use of moisture caused leaching to the extent that severe mineral nutrient deficiencies occurred, or some combination of any or all three of the foregoing resulted in plant failure. On the other hand, it is possible that none of these was causal. Perhaps the plant was injured mechanically by animal or insect or physiologically by spray material or air pollutant such that conducting tissue could no longer supply the leaves with water. The result would be an accumulation of moisture in the container simply because it was not removed by the plant.

One of the common causes of plant failure in container or field is disease. Many growers feel they are experts when they have learned to "live with disease" so that the plant remains alive. The *real* expert is the man who realizes the true nature of the problem and takes steps to eliminate it rather than live with it. As the retailer and consumer become more educated to the potential of container grown plants, it is going to be more and more difficult to sell them rhizoctonia, pythium and phytophthora root rots, fusarium and verticilium wilts as an acceptable part of plant material.

Very often the problems encountered in plant failure are complex. For instance, plants may be lost because a light infection of rhizoctonia root rot is emphasized by slightly high salinity in the growing medium. Either retardant by itself may not have been lethal, but the two in combination frequently are. A similar illustration might be drawn for water mold root rots and soil structure. Poor areation of the root zone will greatly enhance the activity of the organisms and materially reduce the activity of the plants, resulting in plant failure.

The experienced grower recognizes that it is frequently impossible to "cure" plant ills. Control lies in the realm of "prevention."

With the above in mind, we might first consider the selection of a satisfactory growing site and, second, a specific procedure of container growing as practiced by a number of nurseries on the west coast.

Since artificial irrigation is almost certain to be necessary in container growing, good water quality is a first prerequisite in determining the suitability of a growing site. Light and temperature requirements must be satisfied for the crops to be grown. Trees, hills. or buildings may interfere with light relations and correction is not always practical. Small variations in elevation can make the difference between frost damage and none. The nature of the terrain is certainly important if mechanization is to be used and if flooding is to be avoided. In certain areas of California we have become conscious of the importance of air pollution and its effect upon plant response. This is not an unknown problem in other highly populated areas and should, therefore, not be disregarded.

Once the above conditions have been found satisfactory, the next step is that of selecting a growing medium. Then follows the program of preparing the medium, planting into it, and caring for the plant growing in it.

A discussion of criteria for the growing medium is, perhaps, best carried out by use of a specific illustration. The soil mixes known as the "U.C. system of soil mixes." It is a development from work carried out in the Department of Plant Pathology, University of California at Los Angeles.

By way of background, it might be pointed out that the ultimate sources of disease organisms are (A) soil or (B) plants and plant materials. The former is taken care of by soil treatment, the latter by clean stock and sanitation. In the effort to aid growers in California to control disease in the production of ornamental plants, it was found that soil treatment for this control was often ineffectual because of soil-mix problems. Salinity, poor drainage, poor aeration, toxic reactions to soil treatment, and poor nutritional balance frequently overshadowed the attempts to control disease. What started out as a simple effort to establish some standard mix which would not be subject to these problems became a major project. A comprehensive treatise on the subject is in the hands of the University editors and should be available as a manual in the near future. It is titled, "Diseases in Relation to Prepared Soils for Container Grown Plants," and will be available from Agricultural Publications, University of California, Berkeley 4, Calif.

The following is one of any number of possible combinations of mixes and is selected as a good formulation for general purposes.

½ yard fine sand
½ yard peat moss, sphagnum type
10 lb. dolomite lime
5 lb. gypsum
3 lb. organic nitrogen (hoof & horn, blood meal, urea-formaldehyde resin)

1 lb. potassium nitrate
1 lb. treble superphosphate

This formulation gives consideration to nine important criteria. They can now be taken up specifically.

1. *The ingredients are available in most areas.* Peat moss is a common standard used throughout the world. Fine sands are found as wind-blown deposits, river and beach wash, and as by-products of the sand and gravel industry. The particle size limitations are quite definite as this component is of extreme importance in determining the physical characteristics of the medium. The material used should contain at least 85% of the particle sizes in the range of 0.5 to 0.05 millimeters in diameter. This includes medium sand, fine sand, and very fine sand according to U.S. Department of Agricultural standards. It coincides with sieve sizes of 30 to 270 mesh.

2. The raw material ingredients, fine sand and peat moss, are reliable as to *uniformity of physical and chemical properties.* Peat moss is accepted as being acid in reaction, low in salinity and low in nutritional properties. Fine sands are generally low in salinity and nutritional properties and are usually near neutral in reaction. A fine sand deposit will normally be found quite uniform in its chemical properties, though one source may vary some from another. The peat moss is quite uniform physically and the particle size specifications on the fine sand insure its physical uniformity.

3. The *practice of disease, weed, and insect control will require stability* of the medium *to steam* or *chemicals.* Both the fine sand and the peat moss satisfy this requirement. The chemical additions to them also satisfy these requirements with the possible exception of the organic nitrogen source, urea-formaldehyde. It has been shown to release a little urea nitrogen upon being steamed, but in many cases this is unimportant.

4. The physical components should be capable of being *easily blended* with one another. Fine sand and peat moss are easily mixed together. The same cannot be said of clays or cloddy materials. They may require expensive grinding apparatus to prepare them for mixing and this process of grinding may destroy physical structure desired.

5. *Good areation* of the physical mix must be assured if the best root development is to be attained. Clays and some organic materials "may" provide good aeration, particularly at first, but it is not assured. The fine sand-peat moss combinations do assure excellent aeration from the first. No amount of fertilizer will overcome poor soil structure.

6. *Nutritional characteristics* of each component and the final mix should be *known.* Components of high fertility are not necessary to a successful mix. Sometimes this characteristic can be undesirable as such materials are apt to be non-uniform. In this illustration both components are known to be of low fertility. Therefore it is a simple matter to add the desired fertilizer elements in the quantity required to raise the fertility to any appropriate level.

7. Moisture retention and the availability of the moisture retained in the medium should be reasonably high. The cost and labor of irrigation can become unreasonable when the soil dries out too rapidly. The

peat moss in this combination is a major factor in retention of moisture. Fine sand, as opposed to coarse sand, is also remarkably efficient in retaining moisture in a container. What is even more important is the fact that most of the moisture retained by these components is available to plant use. Clay mixes do not offer the same high degree of availability of moisture retained.

8. An important feature when handling and shipping container grown plants is that of weight. A low bulk density is generally desirable. There are practical limitations, however, as too light a mix may result in containers being easily blown over in the field during windy periods. Where important, the ratio of fine sand to peat may be altered to suit a particular circumstance. The maximum wet bulk density of the fine sand is approximately 115 lb/cu.ft., while that of peat moss is about 40 lb/cu.ft.

9. A final deciding factor in any soil mix preparation is that of cost. The cost of peat moss in a given area is usually fairly constant. The cost of the fine sand will be primarily dependent upon hauling charges. It is not highly valued as are many of the "top soils." It is unimportant whether the fine sand comes from the surface or from far below the surface. At the present time three to four dollars per yard for the final mix is often considered reasonable. A number of growers on the West Coast have managed to use substitute organic materials which satisfy all the foregoing criteria and have brought the cost down to a figure between one and two dollars per yard. Among the materials used are rice hulls and redwood sawdust.

The foregoing discussion of the nine criteria deal to a large extent with the physical attributes of the illustrated soil mix. Some discussion of the fertility additions is necessary.

Potassium nitrate is added to supply available nitrogen plus potash. If the immediately available nitrogen is not desired, sulfate or muriate of potash may be added. In this illustration nitrogen is also supplied as organic for purposes of extending the period of supply of the element. Where soils are to be stacked for a period of time before use, the organic nitrogen should be omitted as it will begin to release available nitrogen from the time it is mixed with the soil components. Storage might result in toxic build-up of available nitrogen.

Phosphate may be added as single superphosphate, using three times as much in order to match the supplying power of the treble superphosphate.

The dolomite lime is added to supply calcium and magnesium and to counteract the rather strong acidity of the peat moss. Gypsum is sometimes added to boost the calcium level a little higher without changing the reaction.

Variation from the assumed norm in basic physical components will call for variation in fertilizer additions. In some cases a grower may wish to alter the nutritional characteristics quite drastically. In a system of soil mixes such as this it is simple to make the desired alterations.

No single mix, such as that used in illustration, is or ever will be, a soil mix to end all soil mixes. It is for that reason that it is designated as a system. It should be fairly obvious, too, that this system offers an excellent tool for research to produce information in standard and specific detail. Such findings could be applied directly to practical growing since duplication of soil mix properties is entirely feasable.

The final consideration is that of fertilizing the growing plants. Experience to date indicates that nitrogen is the element most rapidly lost. Potassium is next and phosphate is least rapidly reduced. Fertilizer formulae which seem best suited to the system generally follow a nitrogen, phosphate, potash ratio of about 3—1—2. Both liquid and dry materials are currently being used. A detailed discussion of this phase seems unwarranted here as the variations due to conditions of growing and materials in use are too numerous. Frequent, light feeding is desirable.

This is not the only system of soil mix preparation and handling which can be used to produce quality plants and such is not meant to be inferred. However, it is one of the few systems which offers simplicity and reliability. It is the result of careful consideration of basic scientific principles coupled with practical trial in the field. The take home lesson is not the example formulation, but, rather, the principles upon which it is based. Finally, it offers features which lend it to use in assembly line type production.

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MODERATOR MATKIN: Our roundtable this morning is to encompass, in addition to this discussion about West Coast production, other parts of the country. You will find that much of the fundamental information that we enjoy in learning how to grow comes from our universities. The universities are doing basic things that we, as growers, are unable to do.

We have with us a gentleman from Ohio State University, Mr. Phillip Barker, who will discuss the research that they are doing on container production at that institution.

Mr. Barker presented his paper entitled "The Production of Nursery Stock in Containers." (Applause)

THE PRODUCTION OF NURSERY STOCK IN CONTAINERS

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The production of nursery stock in metal containers was begun at Ohio State University in 1953. The project was expanded in 1954 to include a total of 1500 plans of 17 different species and varieties. During the winter of 1954-55 protection tests were conducted with these plants and those that survived, with 3000 additional plants, were included in the 1955 study. Since its beginning the project has been primarily one of determining the adaptability of various ornamental plants to production in containers under Ohio climatic conditions. It is proposed that these plants will be used further in a marketing study to determine customer acceptance of container nursery stock.