mide) performed nearly as well. Today, if methyl bromide is to be used, chloropicrin is generally added to give disease control as a bonus. If chloropicrin is to be used, methyl bromide is added to give weed and nematode control as a bonus. The added cost by these additions is not excessive because the qualities of each fumigant are enhanced by the action of the other. Aeration of soil for two days is sufficient following methyl bromide fumigation. Ten to 14 days are required for methyl bromide-chloropicrin combinations.

Generally the end result of a fumigation is failure when the principals are not thoroughly familiar with the fumigants they are using, or if they are unaware of the susceptibility of the weed seed or pathogen to be controlled. Failure can and most likely will occur, irrespective of the fumigant used, if improper application techniques are used, or if soil condition requirements are not met, or if an incorrect dosage is applied.

MODERATOR TICKNOR: Thank you, Jerry. Our next speaker is one whom I think most of you know, Mr. O. A. Matkin. He will speak to us on recent developments in soil mixes. Mr. Matkin:

SOIL MIXES

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The term "soil mix" is rapidly becoming a misnomer. In recent years there have been millions of plants sold which never saw "soil" as such. In the past two decades we have seen a radical departure from the old "green thumb" approach to plant production. The beginning of a new philosophy probably had its start with the John Innes approach in England. With the publication by the University of California of Manual 23, titled "The UC System For Producing Healthy Container-Grown Plants", an overall philosophy was outlined which has become an accepted approach throughout the world. In any final analysis of events which have occurred and will occur, economics must be accepted as the dominating factor.

Since the number of potential soil mix preparations is infinite, we should look first at the underlying economic factors which must influence our choice of formulation.

1. Cost of raw materials is an obvious consideration. Why pay $5 for something which can be obtained in equal quality for $2.50? The term "quality" is not always easily defined, but must inevitably show up in some phase of economic evaluation.
2. Cost of mixing can be a substantial factor. Equipment, man-power, and storage areas all have values which can be assigned. Materials which are difficult

to blend may be very costly to use for that reason. The time is coming when specialists will prepare custom mixes to save the grower and the landscaper time and money. There are already a few instances of this type of activity.

3. Cost of transportation is becoming an increasingly important factor. Not only does the soil and the container have to be transported within the confines of the production area, but long-distance shipping may also be involved. It is no longer unusual for California-grown container plants to be sold in Eastern United States. Some are even shipped overseas.
4. Cost of cultural care can also be influenced by soil mixes. The more porous mixes usually require more frequent application of both water and fertilizer. Usually the cost of these items is not considered a major investment, but cost of application of fertilizer and water can be very important. With the modern mixes and the need for more precisely controlled cultural conditions, it is not surprising to find automatic irrigation and constant liquid-feed injection becoming common place.
5. Cost due to overhead during the period of growth is commonly figured in terms of cents per square foot per month. Since this type of overhead is inescapable, it follows that the more rapid the growth and development of plant material to point of sale, the lower the overhead investment in the product. Both uniformity of growth and speed of growth become important, since growing areas involved often can not be replanted until the last plant has been removed. Numerous growers have reported as much as a 50% reduction in growing time by converting to more modern methods.
6. Cost of producing "quality" plants might well be considered as an additional factor. Although growing media are frequently held responsible for this vague property, it is more often the result of cultural care and environment. Such simple tasks as trimming and and spacing at appropriate stages of growth often make the difference between a saleable and an unsaleable product. Fast production methods require alert growers and constant attention.

With full appreciation of the foregoing underlying influences, one should be prepared to attack the task of soil mix formulation from available materials and get the desired results.

DESIRABLE CHEMICAL PROPERTIES

1. Low salinity is normally required and desirable, though in some instances slightly elevated salinity may produce a better quality product at the expense of speed of growth. This

has been evident in such crops as pot mums where height control is important and in the production of certain vegetable plants such as celery and tomato seedlings for transplant into the field.

2. "Optimum" fertility is another desirable feature under most circumstances, but again, there are some conditions where this may not be the case. For instance, there is the bedding plant grower who wishes to hold back an early planting of petunias so that it will be in saleable state at the peak of the season. He may omit nitrogen and allow the plants to become quite yellow and stunted, knowing they can be quickly greened up when the time is ripe. Excessive fertilizer may be employed to provide the semi-stunting effect of slightly high salinity.

3. Freedom from toxic minerals or compounds which may accidentally be present or may be evolved through such treatment as steaming or fumigation is of primary importance.

4. Maximum practical nutrient retention is desirable. Although clays impart this property in the form of high cation exchange capacity, the many shortcomings of clay usually prevent its use. Few artificial or specialty products provide this property in appreciable degree. Peat moss is among the best.

PHYSICAL PROPERTIES

1. High water infiltration rates virtually assure high porosity and adequate air space after drainage. For very shallow soil columns, it may be necessary and desirable to obtain *unusually* high rates for assured aeration.

2. Maximum practical water retention commensurate with aeration is desirable under most circumstances. Certain exceptions are noted, as for instance, in propagating media where mist is to be applied, or, in container glasshouse growing in the northern states during winter months when rate of drying is extremely slow.

3. Resistance to loss by decomposition might be considered important in many uses such as landscape installations or permanent beds for cut flowers growing. Decomposed organic materials can attain some of the undesirable features of clay.

4. Low density is often desirable in containers and in modern landscape on rooftops or similar locations. Usually the low density products impart unusually high porosity. However, mixing of unlike materials can frequently defeat the purpose. For instance, consider mixing equal volumes of course perlite with sand. The resulting mixture tends to have properties more like sand than like perlite, since the fine particles infiltrate the voids between the larger perlite particles. To the extent possible, uniform particle sizes should be employed for all additives.

CURRENT TRENDS

1. Peat moss has long been a basic standard amendment and is commonly used as part or even 100% of the growing medium. Besides cost, a major shortcoming has been lack of standardization of grades. As a result, many growers have been anxious to obtain reliable *substitutes*.

2. Wood residuals such as sawdust and bark, have come into widespread use, particularly on the West Coast. This approach has become feasible and economic, as we have learned how to provide necessary nitrogen additives to compensate for their primary limiting factor. Emphasis in use has been placed primarily on those materials resistant to decomposition. The demand often exceeds the supply in California. A new approach is the preparation of the amendment in such a manner that only a little sand, soil, or other mineral need be added to provide a complete planter or growing mix. All fertilizers have been incorporated in the amendment.

3. Minerals of various types have been successfully employed including the original fine sand recommendation of the UC System. Currently many container mixes include, as a substitute for all or part of the sand, such materials as pumice, haydite, calcined clay, perlite, and vermiculite. Except for vermiculite, these materials provide little except physical stability and low density. They actually reduce the water holding capacity of the medium in which they are mixed. Vermiculite is less stable physically, but does have a unique property of providing substantial potassium in an exchangeable form. As a result, where it is used in high proportion (20% by volume or larger), it becomes unnecessary to add potassium fertilizer to the mix.

Since propagation is foremost in the minds of many, it should be pointed out that the desirable physical conditions of a growing medium are commonly employed in the preparation of propagating media. The only difference might be the elimination of chemical additives, since fertility is not an essential factor in propagation and can sometimes be inhibitory. It might be mentioned, however, that the addition of certain amendments such as lime to peat/perlite mixes often improves rooting response. The effect of pH on root initiation is, we believe, worthy of additional academic research. Two crops showing marked response in our experience have been peperonia and poinsettia.

SOIL MIX FORMULATION BY FACT AND LOGIC

1. The first step is that of selection of bulk ingredients. Materials which satisfy the practical and economic requirements should be prepared in various ratios until properties of infiltration rate and water holding capacity appear satisfactory.

2. The chemical properties of each bulk ingredient should be thoroughly reviewed and an estimate made of chemicals

most likely to be required to attain optimum fertility. This may require analysis of each component or an analysis of the final physical mix.

3. Since missing or low elements must be supplemented, it will be helpful to have in mind normal rates of addition which will result in good nutrient supply without excess. Both form and quantity of additive must be considered. For instance, it is undesirable to add materials which will contribute to high ammonium nitrogen availability for sensitive crops such as bedding plants, carnations, and numerous bare-root cutting crops. Also, it must be kept in mind that maximum tolerable quantities to avoid salinity effects will vary with the buffer capacities of the physical components. For instance, one pound of potassium nitrate per cubic yard of sand is high, but the same amount per cubic yard of clay or peat moss is low. Following is a list of commonly used chemical fertilizers and amendments and an average rate for an hypothetical container mix:

Chemical Fertilizer	Typical Addition Rate (Am't /cu yd)	Elements Supplied Primary	Elements Supplied Secondary
Blood meal or other high N organic	2 - 5 lbs.	N	
Calcium nitrate	1 lb.	N	Ca
Calcium sulfate (gypsum)	2 - 5 lbs.	Ca, S	
Iron sulfate (ferric or ferrous)	1 lb.	Fe	S
Lime - calcium carbonate	0 - 20 lbs.	Ca (rise in pH)	
Lime - dolomite	0 - 20 lbs.	Ca, Mg (rise in pH)	
Magnesium sulfate (Epsom Salts)	2 lbs.	Mg	S
Potassium nitrate	1 lb.	N, K	
Potassium sulfate	1 lb.	K	S
Potassium chloride (muriate)	1 lb.	K	Cl, B (?)
Sodium borate (Borax)	¼ oz.	B	
Sulfur	½ lb.	S (lowers pH)	
Superphosphate, 0-20-0	2½ lbs.	P	Ca, S
Superphosphate, 0-45-0	1 lb.	P	Ca
Synthetic slow release	Mfrs. instructions	N, etc.	

Considerations should include elements supplied or not supplied in the irrigation water. If the planted crop is to be placed on constant liquid feed, no reserve nutrient (e.g. blood meal) will be required. This will allow young plantings to be placed on the same program as old. Phosphate will normally be added in sufficient quantity to last for the full crop life or at least one season.

4. After the best estimate of formula has been tabulated, a trial mix should be prepared for test growing and for laboratory analysis. Following this, some minor modifications may be required. Once a good mix has been developed, any

changes should be made only after careful comparison of growth results.

One very important consideration for any growing medium is freedom from disease. Ideally, the mix will be steamed or fumigated prior to use. This is a necessary part of soil mix preparation.

MODERATOR TICKNOR: Our next speaker, Mr. Fred Petersen, is from the same firm. He is going to talk on the subject of aerated-steam. Fred:

COMMERCIAL APPLICATIONS OF AERATED STEAM

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STEAM-AIR OR AERATED-STEAM. These terms are used to describe a system or method of soil treatment in which treatment is obtained by exposing soil to a mixture of steam and air. The temperature of the resulting mixture is controlled below 212°F. by adjusting the ratio of steam to air according to established physics. While any treatment temperature between that of ambient air and 212°F. is possible, the temperature range between 140°F. and 160°F. appears most ideal.

PROGRESS. If measured by the number of successful installations now operating at high efficiency, and yielding daily benefits to nurserymen, such progress in my opinion can be summarized as:

California — Disappointing to a point of concern.
England — Encouraging as expected, since the concept is British.
Australia — Enthusiastic, as evidenced by the manner in which Australian growers installed systems after a brief, but complete, introduction to the benefits aerated-steam offers.
Eastern United States — Encouraging, as indicated from fragmentary reports.

However, if progress is measured by the quantity and quality of words already spoken or written, such progress would in my opinion, place California in a paramount position. Paramount, I maintain, because of the excellent papers and speeches which have been presented to California growers by many experts, foremost of which is Dr. K. F. Baker of the University of California at Berkeley.

Nurserymen the world over have been literally blessed with much of Dr. Baker's early work, the most familar of which is his editing of University of California MANUAL 23, the *UC SYSTEM FOR PRODUCING HEALTHY CONTAINER*