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SOME THOUGHTS ON GREENHOUSE SOILS

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There are good reasons for modifying a soil before planting greenhouse crops, otherwise we would have long ago done away with the labor. What do we accomplish by spading or tilling a bed? What do we do in adding peat moss, straw, manure, or leaf mold? Obviously, we must get better growth. Why?

In modifying a soil, we try to provide a root environment suitable for maximum response of the plant, and we reduce chances that a cultural mistake on our part will be disastrous. Almost any plant can be grown in any root medium -- provided the grower doesn't make a mistake. But, all of us at one time or another do make mistakes. If we have not provided a safety factor, one error is enough to ruin a plant.

Modifying soil structure

Let's look at some of the soil factors that may determine plant response. First, compaction. We refer to compaction of the soil in terms of "bulk density." That is, the weight of a volume of undisturbed soil. Under usual field conditions, acceptable bulk densities range from 1.2 grams per cubic centimeter (g/cc) to 1.5 (about 93 pounds per cubic foot). Doubtful bulk densities are encountered if the value approaches 1.7 g/cc. As a general rule, the higher the bulk density (compaction), the less total pore space present, and the more resistance there is to root penetration. To alleviate the possibility of poor root penetration, we dig up the soil and add any number of materials to it to reduce bulk density. Bulk densities in the range of 1.0 to 1.2 g/cc, on the basis of experience, result in acceptable levels of total pore space (about 60 to 70 percent) and negligible resistance to root growth. In reducing bulk density, we make other changes: 1) Since the plant root respires and requires oxygen to function properly, increasing total pore space increases the likelihood of better air supply. 2) We improve drainage characteristics of the soil so that water can both enter and leave more readily. 3) We tend to stabilize soil aggregation so that it is more resistant to breakdown (compaction). 4) Through the action of organic matter, the buffering capacity of the soil is increased, increasing its resistance to radical changes in nutrient composition and acidity. 5) If organic matter is added to mineral soils (most field soils), the water-holding capacity may be, and is usually, reduced. Aeration characteristics are improved. Reduction in water holding capacity is not serious as long as the use of soil additives is not carried to extremes.

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As a rule of thumb, additions of organic matter (peat moss, leaf mold, sawdust, manure, etc.) should comprise 1/3 of the final volume if noteworthy changes are to be made in the soil structure. Sand, particularly fine sand, should be added in amounts exceeding 50 percent of the final volume. Small amounts of sand merely fill up the pore spaces, and tend to "cement" a soil.

By modifying the soil, a number of safety factors against deficient aeration, overwatering, compaction, and fertilizer injury have been incorporated. But the process should not be carried to an extent where the field soil is but a small part of the total. Difficulties may arise in providing sufficient water, sufficient nutrients, and plant support. Materials such as peat are deficient in several important elements. Large amounts of sawdust may lead to nitrogen deficiencies. Ammonia toxicity may result from too much fresh manure. It is best to be moderate.

Factors influencing water content

It was said that modification of the soil may result in reduced water-holding capacity. How much water a soil will hold depends: one, on its physical characteristics, and two, on the conditions to which that soil is subjected in the bed.

Physical characteristics -- We may think of a soil as having a two-phase system. One phase may consist of the pores within the individual soil crumbs (micropores), the other (macropores) consisting of those pores between the crumbs. If the pores are very small, high suctions may be required to drain them. A typical example is a capillary tube. The smaller the tube, the higher water will rise in the tube. More pressure must be exerted to empty a smaller tube. By adding organic matter to a soil, we rearrange the proportions of the two pore systems, changing their size and shape. The desired result is to increase the size of the macropores so that water moves readily into and out of the soil at low suctions, with the micropores retaining sufficient water to satisfy plant requirements. Of course, there are other factors that determine water retention such as surface area of the soil particle. The smaller the particle, the higher the ratio of surface area to size. A cubic centimeter of stone, ground into microscopic bits, may have a total surface area of 1 1/2 acres. Since a film of water adheres to the surface, a clay soil (small particles) may retain considerable amounts of water as contrasted to a sandy soil (large particles).

Factors with the soil in place -- As noted, aside from modifying physical characteristics of the soil, the possibility of whether water holding capacity would be changed was hedged.

Consider the following examples:

Example 1: A deep soil with no water table. During irrigation, water proceeds downward in a "wetting front" that is remarkably uniform if there are no worm holes or cracks present. After watering, the movement of the front becomes slower as excess water from the upper layers drains away. Eventually, 1 to 3 days after irrigation, front movement ceases for all practical purposes. The moisture content of the soil at this point is called "field capacity" -- the maximum water holding capacity of that soil. If the negative pressure of the soil solution is measured (i.e. the affinity of the soil for water -- its retentiveness) we may find suctions ranging from 0.7 to 2.8 psi.

By adding peat moss to that soil, we increase pore size. A lower suction is required to drain an equal amount of water from the soil. At equal suctions, at field capacity, the modified soil will contain less water. The irrigation frequency should be changed to compensate for this (i.e. more often).

Example 2: A soil layer underlain by a layer more permeable to water movement than itself (e.g. coarse sand, gravel, etc.). When the wetting front reaches the interface between A (upper layer) and B (lower layer), the front will cease to move. Water will move across the boundary between A and B only if the pressure in the bottom of A is positive -- greater than zero. When A layer has completed drainage, suction in the bottom will be zero. This is equilibrium. If there is no loss of water, this situation can prevail indefinitely. However, plants remove water and evaporation occurs, so that suction increases and the soil continues to dry out -- just as it would in Example 1. Assume that A layer is 12 inches deep. Suction is zero at the bottom. If we measure suction in the top of A, the value will be equal, but opposite, to the pressure exerted at the bottom of a column of water 12 inches high (about 0.42 psi). If A layer is 2 feet deep, then at drainage completion, suction in the bottom would be zero and at the top 0.84 psi. Compare these suction values with those given in Example 1. Unless pore size is increased radically, or depth of the layer increased, more water may be retained than formerly. Thus depth of the soil layer determines water holding capacity.

Example 3: Assume a constant water table under the soil surface. This is exactly the situation that occurs with Example 2. Instead of placing gravel under the soil, we use a constant water table, thereby maintaining zero suction at the interface between water and soil. Fortunately, in soils with a water table more than 18 inches below the surface, plant water removal is usually in excess of capillary supply from the water surface. But, if the depth of soil is less than 12 inches, wet conditions may be continual -- especially if the soil has been extensively modified. In case of fluctuating water table, irrigation practice should be adjusted accordingly.

Example 4: Assume a soil with a compacted layer under it (hardpan). In this situation, the problem is apparent. Water cannot drain away. The soil remains saturated.

To recapitulate: A modified soil (addition of peat moss, leaf mold, sawdust, manure, etc.) will hold less water than its parent field soil, if when in place, it is deep (in excess of 4 feet), and there is no water table. A modified soil may retain more water if the root medium is underlain by a mixture more permeable than itself. This is the situation that prevails in greenhouse benches. If cracks between boards are large enough, and the boards not too wide, the conditions described in Example 2 will occur.

Given a tight, improperly managed, shallow soil, deficient aeration may be found. Whether the period of poor aeration will be long enough to cause observable reduced growth depends directly on how fast plants remove water. For some florist crops, the amount of water consumed per month per square foot of bench area may vary from 1.9 quarts to 7.1 gallons. Under one extreme (small plants, winter), chlorosis and stunting from poor aeration may be observed. Under the other extreme (large plants, summer), deficient aeration is an impossibility.

Correction of deficient aeration, may be approached from a number of angles: 1) Reduce the total volume of soil, thereby reducing the total amount of water that must be removed. 2) Increase soil depth, thereby reducing the amount of water retained in the upper soil surface. 3) Use large plants. 4) Increase light intensity. 5) Increase temperature. 6) Place heating lines under the bench. 7) Steam pasteurization of the soil. 8) Addition of organic materials and/or synthetic soil conditioners. It is obvious that all these practices tend to decrease the soil water-holding capacity and increase the rapidity of drying. Under high water-loss conditions (large plants, summer), the problem of supplying enough water might become severe.

Fortunately, experience has shown that deficient aeration is very rare in greenhouse benches where a good field soil has been properly modified and handled.