Colorado Flower Growers Association, Inc.

IN COOPERATION WITH COLORADO STATE UNIVERSITY
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Soil Porosity
as a factor in
Irrigation of Greenhouse Soils

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The texture of a soil, the fineness of its particles and the percentage of sand, silt, clay and organic matter, determines the relative ease with which it gives up its water to plants. A sandy soil gives up water freely while a clay soil holds water rather tenaciously. The arrangement of these particles in aggregates or crumbs determines the porosity or air space of a soil. The wetter a soil the less air available to the plant roots. Good soil structure and porosity allow the greatest margin for error in watering greenhouse soils.

Butterfield (1) and Odom (4) have shown that as porosity of a propagating medium increases the quality and size of roots increases and the time of rooting decreases. This same effect of porosity on root growth occurs in soil or other growing media. Healthy root growth must have oxygen, even when the soil is wet. Non capillary pores in a soil of good structure remain full of air even during or immediately following irrigation. Soils of low porosity cause most of the watering problems. They are difficult to wet and slow to dry out. The air supply to the plant roots is too often limited.

The porosity of a soil is easily measured by the rate it will take water and the amount this rate decreases after five or six applications of water. A soil which will continue to take water freely is a good soil for greenhouse and container use. If the percolation rate through a soil decreases considerably with repeated applications of water (such as 5 or 6 waterings in succession) the structure of this soil is unstable and the soil will give trouble in the greenhouse.

Good structure is difficult to build into some soils, while others are rather easily improved. Percolation tests on virgin soil should be made to help a grower select the best native structure obtainable. Addition of sphagnum peat helps percolation rate, and porosity, but no rule can be used as to amount of peat required by all soils. The accompanying results of additions of both peat and sand to Littleton clay loam shows some of the problems one encounters in trying to improve porosity of a tight soil.

One standard method of measuring percolation rates is through a column of soil or soil mixture approximately 10 inches deep. The soil is air dried and weighed samples are put in a number of percolation tubes. Water is then supplied to these tubes constantly at very low pressure and the percolation rate in milliliters per hour can be measured.

Lyle Akey, while a grower for Crowley Bros. at Littleton, Colorado, made the following tests for possible means of improving the porosity of Littleton clay loam.

Effects of Modifying Littleton Clay Loam on Percolation Rate of Water

	Hourly periods - Percolation in ml					
First test	1	2	3	4	5	Total
Virgin soil	50	12	12	11	11	96
5% peat added	34	32	31	31	30	158
10% peat added	50	33	31	30	31	175
15% peat added	33	32	32	30	28	155
20% peat added	74	70	71	70	57	342
Same soil cropped 2 yrs. - steamed once	134	117	94	71	70	486
2nd sample same as above but following better crop	213	192	155	131	116	807
Second test						
5% peat added	18	14	16	14	14	76
10% peat added	36	32	32	32	34	166
20% peat added	90	120	98	94	96	498
5% peat + 5% sand	18	14	14	13	14	73
10% peat + 5% sand	16	14	10	18	12	70
20% peat + 5% sand	18	20	10	12	12	72
20% peat + 10% sand	26	48	32	32	32	170

The virgin soil had a very slow but steady percolation rate except for the first hour. This soil is quite difficult to use in a greenhouse bench because it has such tight structure. With its high clay content, most growers do not water it often enough hence their plants would be stunted to a certain degree.

The addition of 5% sphagnum peat by volume more than doubled the percolation rate in the first test while 10% peat doubled the 5% rate in the second test. Twenty percent peat increased the percolation rate by 3½ times in the first test and even more in the second test, although the cost of this much peat might well be prohibitive.

A third point of note from the table is the good effects on structure of growing a crop of carnations. Littleton clay loam which had grown carnations two years was approximately 5 times as porous as virgin soil. The soil from another section was 8 times as porous, although it is difficult to say whether the better crop increased the porosity of the soil, or a more porous soil to start with caused the better crop. The two go hand in hand.

It should be noted that the addition of 5% or 10% sand in the second test either failed to help or actually decreased porosity. The addition of sand to most tight soils does not improve structure or porosity. The colloidal material in the soil melts around the sand and fills the pore spaces just as well as it did before the sand was added.

Improving structure of greenhouse soils

We have seen that sphagnum peat can be used to improve the initial porosity of a greenhouse soil. Additional applications of peat to soils before replanting is a common practice among growers of most cut flower crops. Healthy root growth, especially of the fibrous rooted crops, also helps to improve, or at least maintain soil structure. At Colorado State University we have favored the use of more easily rotted organic matter for improving soil structure. The actual aggregation of soil particles and the building of stable soil structure seems to be associated with the resins and other products released by microorganisms as they rot the organic matter. An excellent and ever improving soil structure has been accomplished at CSU by the use of a mulch of leaves following the establishment of young plants. This mulch is put on as a loose covering one to two inches thick. Most of it rots the following year. Any residue is tilled into the soil before replanting. All leaves are steamed before use to get rid of insects and animal pests, as well as possible disease organisms. Corn cob mulches have been used to accomplish the same thing on rose soils. Synthetic resins such as Krilium have been used successfully in many cases to improve the aggregation of tight soils until good root growth can take over the function.

As further evidence of how important soil porosity is to carnation growth, Gomness and Holley (2) measured the porosity and quality of flowers produced on 40 greenhouse soils. They found the flowers grown in 10 soils which had less than 10% air space immediately following irrigation averaged a weight of 0.91 grams per inch of stem, whereas the 30 soils with more than 10% air space following irrigation produced flowers averaging 0.97 grams per inch of stem. While this difference may seem small, it is approximately one grade, i.e. from short to standard grade. They also found a distinct improvement in porosity of the soil and quality of growth the first three years a soil was in use in Colorado greenhouses.

Lunt and Kohl (3) grew carnations in two widely different soils; one a fine loamy sand and the other a tight silt loam. They modified the tight soil by adding pine shavings, pumice, krilium, peat, fir bark, or redwood shavings. The sandy soil was modified with peat only. Where organic amendments were used, the soil and organic matter were mixed in equal proportions. The frequency of irrigation was determined with the aid of tensiometers, water being applied at tensions of approximately 50 millibars (Lark 50).

The untreated silt loam was slow to release water through the normal greenhouse watering range (0 - 65 millibars) hence carnations in this medium were stunted slightly during the first three months of the experiment. This problem corrected itself to the extent that average stem length, head weight, yield and shoot weight were nearly the same for all soils and mixtures over the one and a half years of the experiment.

Lunt and Kohl concluded that aeration in the media was not a limiting factor to growth. They stated "Although irrigation practices may have a marked influence on the aeration of container grown carnations, it appears that there are practically no textural limitations on soils which can be successfully adapted to container growing of carnations under conditions of management similar to those of this experiment. This generalization should not be extended to soils in which infiltration rates are so low that excess water does not drain away in reasonable time." Their waiting to irrigate until moisture tension had reached 50 millibars insured adequate aeration for normal plant growth. Had they watered by feel and appearance of the soils instead of by tensiometer, more than likely some of the media would have been poorly aerated due to overwatering.

Carnations will grow in almost any medium so long as that medium supplies nutrients, and water and air in the right proportions. Excellent growth has been obtained at the CSU Research Greenhouses for several years in scoria, an inert volcanic cinder. Coarse sand has been used successfully for two years. A mixture of fine gravel and peat has been used by some Colorado growers for a number of years. Aeration is not a problem with these media. Correct watering frequency and nutrient supply assume major importance, as with all other inert media.

Summary

The medium in which we grow plants must support the plants and supply water, air and nutrients. Soil structure and texture need not limit these functions providing we understand the problems involved. Too frequent irrigation of a tight or fine soil, especially a fine sand or silty sand, leads to poor aeration, poor root growth, plant yellowing, and poor quality. Often the only corrective measure necessary is that the irrigation interval be widened. A heavy soil containing 20 per cent or more of clay may not give up its water easily, hence may require more frequent irrigations in order to prevent stunting. Determining when to irrigate by tensiometer is the best possible aid in handling problem soils. Thorough irrigation at 50 to 70 millibars insures adequate aeration of almost any greenhouse soil.

Literature cited

1. Butterfield, Norman W. 1952. Particle size of propagating sand. Mass. Flo. Grow. Assn. Bul. 16.
2. Gomness, N. C. and W. D. Holley. A physical survey of forty Colorado greenhouse soils. Colo. Flw. Gro. Assn. Bul. 36.
3. Lunt, O. R. and H. C. Kohl, Jr. 1957. Influence of soil physical properties on the production and quality of bench grown carnations. Proc. Amer. Soc. for Hort. Sci. 69:535-542.
4. Odom, R. E. 1953. Effects of particle size of the medium on the rooting of carnation cuttings. Colo. Gro. Assn. Bul. 48.