Importance of Aeration in Container Media

Nursery Production

FACTSHEET

Inadequate drainage and aeration of container media is a major limiting factor in the production of quality nursery crops. In severe cases this may lead to, or contribute to the premature death of the plant.

Placing a particular growing medium in a container reduces its aeration porosity due to the phenomenon of a "perched' water table. Therefore, it is important that the nursery operator consider various options to increase the drainage and aeration in the container growing medium, and in doing so, promote healthy and vigorous plant growth.

Aeration and Plant Roots

Plant roots, like other plant parts, require air for the process of respiration. This essential metabolic process is fundamental to living organisms, and involves oxygen from the air reacting with stored foods within the plant cells. This releases energy for essential plant functions, such as the uptake of mineral nutrients. Roots without adequate access to aeration and oxygen will result in plants that are weakened, exhibit slow growth and are predisposed to adverse environmental stresses, such as winter injury, pests and diseases.

Aeration is also necessary for the diffusion of carbon dioxide away from the roots to the soil surface. This gas is formed from the respiration of root cells and microorganisms, as well as from the decomposition of organic matter. The growing medium must be sufficiently porous to avoid the accumulation of carbon dioxide that would lead to the suffocation and eventual death of plant roots.

A lack of aeration caused by poor drainage leads to a wet, waterlogged condition that is a conducive environment for the development of soil borne diseases like *Phytophthora* and *Pythium*, responsible for devastating root rots and damping off. Under more aerated conditions these would be held in check.

Soil Porosity

Aeration is basically a function of soil porosity. Growing media consists of solid particles, such as peat or bark, as well as the pore spaces both between and within these particles. These pore spaces are categorized into either large pores, which normally are filled with air, and the smaller pores, normally filled with water (Figure 1).

BRITISH COLUMBIA

Ministry of Agriculture, Fisheries and Food
Abbotsford Agriculture Centre
1767 Angus Campbell Road
Abbotsford, BC
V3G 2M3
Phone: (604) 556-3044
Fax: (604) 556-3030

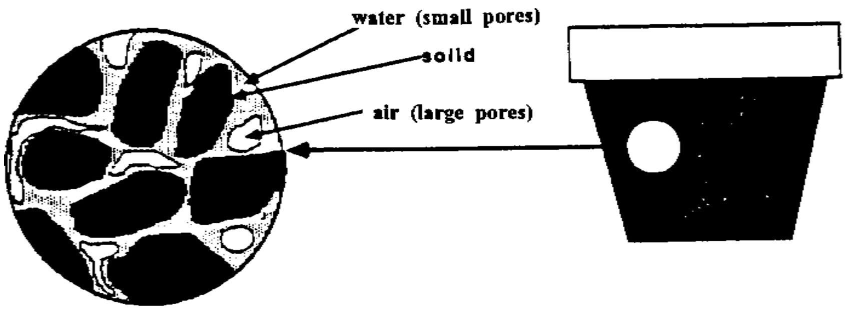


Figure 1. Water, air, and solid phases of a growing medium.

A good mix should have a total porosity in excess of 60-70%, measured as the volume of pore space compared to the total volume of growing medium. The aeration porosity, defined by the large pores, should be at least 20-25% and as high as 45% in warmer greenhouse conditions where there is increased demand for oxygen by roots, as well as an increased production of carbon dioxide. Table 1 shows the calculation of total, aeration and water-holding porosity.

Table 1.—Determining the porosity characteristics of growing media: total porosity, aeration porosity, and water-holding porosity

Equipment

1. Container with a drainage hole at the bottom.
2. Plug or waterproof tape for sealing the drainage hole.
3. Graduated cylinder or some other way of measuring liquid volume.
4. Watertight pan wider than the bottom of the container.

Procedure

1. Seal the drainage hole in the container and fill it with water. Measure the volume of water in the container and record as "container volume."
2. Empty and dry the container and fill it with growing medium. Slowly saturate the growing medium by gradually pouring water onto the surface. Continue adding water over a period of several hours until the growing medium is completely saturated (the surface glistens). Record the total volume of water added as "total pore volume."
3. Place the container over the watertight pan and remove the seal from the container drain holes. Allow all the free water to drain out of the container (this may take several hours). Measure the amount of this drainage water and record as "aeration pore volume."
4. Compute the total porosity, aeration porosity, and water holding porosity as follows:

$$\text{Total porosity (\%)} = \frac{\text{total pore volume}}{\text{container volume}} \times 100\%$$

$$\text{Aeration porosity (\%)} = \frac{\text{aeration pore volume}}{\text{container volume}} \times 100\%$$

$$\text{Water-holding porosity (\%)} = \text{total porosity} - \text{aeration porosity}$$

Although increasing aeration results in a corresponding decrease in water retention, this is the more preferred situation. It is always better to irrigate more frequently than to not have sufficient aeration.

The best way for achieving sufficient aeration is in the selection of media ingredients of sufficiently large particle size (Table 2). There should be a sufficient proportion of coarse textured components in the size range of 1-2 mm. For example, a good quality, fibrous sphagnum peat moss should be used rather than a more decomposed, less fibrous type of peat moss, like hypnum.

Table 2. Comparison porosities for standard growing media components

	Porosity relationships (% by vol)		
Component	**Water-holding**	**Aeration**	**Total**
Sphagnum peat moss	58.8	25.4	84.2
Hypnum peat moss	59.3	12.4	71.7
Vermiculite	53.0	27.5	80.5
Perlite	47.3	29.8	77.1
Fir bark	15.0	54.7	69.7
Sand	33.7	2.5	36.2

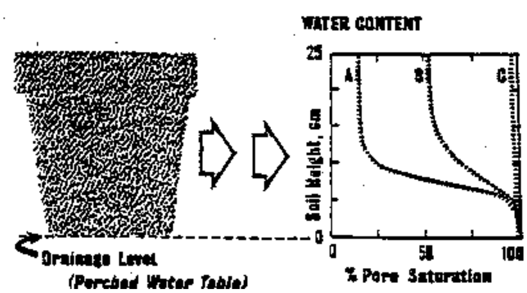
Source: modified from Johnson(1968)

The stability of a component in a nursery mix needs to be considered. Although sawdust in a mix results in high aeration porosity initially, its rapid decomposition would result in a dramatic decrease with time. Bark with its higher lignin content, is more resistant to decomposition, and therefore should be used instead of sawdust. Inorganic components like perlite and vermiculite have the advantage of not being subject to decomposition, although the latter can lose much of its porosity through compaction.

Perched Water Table

Placing a growing medium in a container creates the phenomenon of a "perched" water table at the bottom of the container, where all pore spaces are filled with water. This saturated situation, and resultant loss of aeration, occurs no matter how many drainage holes there are in the container. This is usually not a problem in a field situation, as the water table is usually relatively deep, as opposed to being almost at the surface in a shallow nursery flat Figure 2 illustrates this phenomenon of the "perched" water table.

Figure 2. Water retention in three different media[1]
(For illustration purposes only, adapted from Spomer, 1979).



[1] Media texture A= very coarse B= moderate C= fine

Container Depth

The only way to reduce the effects of a perched water table is to increase the depth of the container. The deeper the container the lower the impact of the saturated area at the bottom of the container. For example, for a moderately textured growing medium there may only be about 50% water content at the surface of a container, but 100% saturation towards the bottom (Figure 2).

The deeper the container, the greater the overall aeration and the less the pores are filled with water. For example, a particular growing medium, when used in a 6 inch pot results in 21% aeration porosity. However, when the same medium is placed in a much shallower plug tray, this results in only 3% aeration porosity (Table 3).

Table 3. Effect of container depth on aeration and water content[1] (Adapted from Fonteno, 1987)

	6" Pot	4" Pot	BP Cell	Plug Tray
% Aeration	21%	15%	9%	3%
% Water	49%	56%	61%	68%

[1]Growing medium used was 3 Pine bark: 1 Peat: 1 Sand
BP cell= Bedding plant cell (48/tray)
Plug tray= 273 plug tray
% aeration, % water as a % of total pore space

Therefore, increasing the depth of the container will increase the drainage and aeration. In many cases economics precludes the use of deeper containers, but where saturated media is a problem, for example, in propagation, this should be considered. This may make particular sense with difficult to establish species where excess water is not immediately taken up by roots. The increase in aeration and the concurrent reduction in water, especially at the surface, would reduce the presence of moisture dependent pests like algae, liverworts, moss and fungus gnats.

Improving Aeration

The key to a quality nursery crop is the provision of adequate drainage and aeration in the growing medium. This can be achieved by using:

- sufficiently coarse media components
- deeper containers where feasible,

and avoiding:

- finer components that may plug up the larger pore spaces
- overmixing that would reduce the particle size of components
- irrigation and handling practices that may compact growing media
- the use of components like sawdust that may decompose resulting in the loss of large pore spaces.

Summary

Adequate aeration in a growing medium is critical to the growth of quality nursery crops. Aeration is essential for the infiltration of oxygen to the roots for respiration, as well as to allow for the dissipation of carbon dioxide to the soil surface. Realization of the importance of aeration is a key step in the formulation of a quality growing medium.

Placing a growing medium in a container reduces its aeration porosity due to the phenomenon of a "perched' water table. To counter this, containers should be deep and media components sufficiently porous. The end result of adequate aeration is an overall healthier, more vigorous plant and one that is more resistant to environmental stresses such as winter injury, pests and diseases.

References

Davidson, H., R. Mecklenburg and C. Peterson. 1988. *Nursery Management: Administration and Culture*. Englewood Cliffs, NJ, Prentice Hall.

Fonteno, W.E. 1987. Choose the right container and medium. *Greenhouse Grower*. October 1, 1987: 66-71.

Gessert, G. 1976. Measuring air space and water-holding capacity. *Ornamentals Northwest* 3:59-60.

Johnson, P. 1968. *Horticultural and Agricultural Uses of Sawdust and Soil Amendments*. National City, CA: Paul Johnson.

Landis, T.D. et. al. 1990. *The Container Tree Nursery Manual: Volume 2, Containers and Growing Media*. Agric. Handbk. 674. Washington, DC: U.S. Department of Agriculture, Forest Service.

Spomer, L.A. 1979. Physical properties of a good container soil amendment. FL5-79. Cooperative Extension Service, University of Illinois at Urbana-Champaign.

Whitcomb, Carl. 1984. *Plant Production in Containers*. Stillwater, Oklahoma, Lacebark Publications.