Container-soil physics and plant growth

Plants have been grown in containers for approximately 4000 years (Baker 1957). Currently billions of container plants are produced commercially each year, with millions more grown for research. Container-grown plants include bedding plants, vegetable transplants, fruit plants, forest tree seedlings, house plants, flowering holiday plants, herbaceous perennials, and landscape trees, shrubs, vines, and groundcovers. Containers range from thimble-size plugs to turf athletic fields growing in a 30-centimeter-deep layer of sand contained by a plastic lining (Handreck and Black 1984).

Despite the widespread practice of growing plants in containers, many people are unaware of the unique physics of soils in containers (Spomer 1974). A typical silt-loam surface soil in the field at its maximal water-holding capacity has a volume composition of approximately 50% solids, 25% water, and 25% air (Figure 1, bar A). This upper limit of water held by the soil against gravity is termed *field capacity* (Brady 1984). When the silt-loam soil is placed in a container, such as a 15-centimeter-diameter standard flowerpot, the volume composition at its maximal water-holding capacity is much different, approximately 50% solids, 50% water, and 0% air (Figure 1, bar B). This upper limit of water held by a soil in a container is termed *container capacity* (White and Mastalerz 1966).

The lack of air in the container of silt-loam is detrimental to most plants, because roots require oxygen for respiration. Because loams in pots often contain virtually no air after thorough irrigation and drainage, they must be allowed to become fairly dry between irrigations so the roots

by David R. Hershey

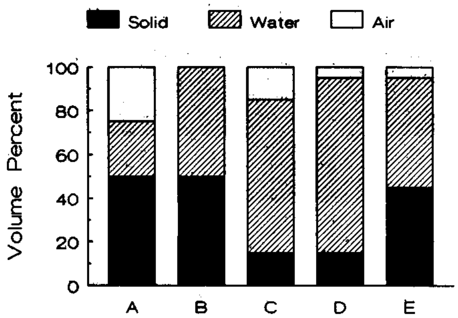


Figure 1. Volume composition. Bar A: a silt-loam surface soil in the field at field capacity. Bar B: the same silt-loam soil as in A at container capacity. Bar C: an ideal container soil at container capacity in a 15-centimeter-deep pot. Bar D: the same soil as in C at container capacity in a 3-centimeter-deep container. Bar E: the same soil as in C at container capacityin a 15-centimeter-deep pot after compaction.

receive adequate oxygen. If watering is too frequent, the plants are said to be overwatered because their roots suffer from lack of oxygen. Overwatering is considered by most horticultural authorities to be a primary cause of container plant failure (Crockett 1978, Hessayon 1987).

To overcome the problem of overwatering, an ideal composition for a container soil should be, by volume, approximately 15% solids, 70% water, and 15% air at container capacity (Figure 1, bar C; Bunt 1988). This type of container soil is nearly impossible to overwater and typically consists of a mixture of a coarse-textured organic material, such as sphagnum peat moss or compost, and a coarse-textured inorganic material, such as horticultural perlite or vermiculite. Artificial soils for containers, such as a mix of equal volumes of sphagnum peat moss and vermiculite, have more large pores than most field soils because of their coarser texture, so they contain a greater percentage of air at container capacity.

A growing medium with an ideal volume composition in a tall container, like a 15-centimeter-deep pot, may be less than ideal in a shallower container, such as a 3-centimeter-deep plug (Figure 1, bar D), because the volume percentage of air typically decreases as medium depth decreases.

People growing plants in containers may start with an ideal volume composition but lose it when they compact the soil during potting (Figure 1, bar E). Compaction reduces pore diameter and total pore volume, thereby reducing the percentage of air and water.

Researchers unaware of container-soil physics may incorrectly design experiments and misinterpret results. Experiments comparing plant growth in containers of different volume should use containers with equal soil depth to avoid poor growth due to low aeration in shallow soil. Tomato growth decreases linearly from a maximum at 10% air at container capacity to half-maximum at 2% air at container capacity (Bunt 1988).

Comparison of the fertility of field soils in containers must account for plant-growth differences caused by physical property effects. For example, a sandy soil, despite its lower natural fertility, may produce better plant growth in a container than does a clay soil, which has smaller-diameter pores, because the sandy soil has more air at container capacity (Paul and Lee 1976). Growers of container plants should be aware of the physics of soils in containers, because the physical properties have such important effects on plant growth.

References cited

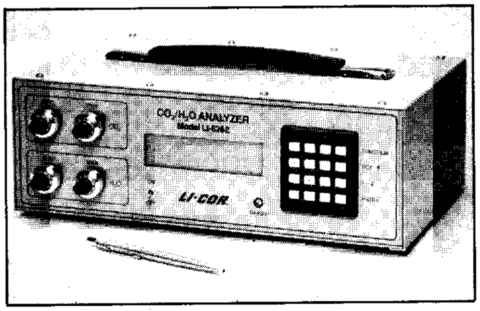
Baker, K. F., ed. 1957. *The UC System for Producing Healthy Container-grown Plants.* California Agricultural Experiment Station, Berkeley.

Brady, N. C. 1984. *The Nature and Properties of Soil.* 9th ed. MacMillan, New York.

Bunt, A. C. 1988. *Media and Mixes for Container-grown Plants*. Unwin-Hyman, Boston.
Crockett, J. U. 1978. *Crockett's Indoor Garden*. Little, Brown, Boston.
Handreck, K. A., and N. D. Black. 1984. *Growing Media for Ornamental Plants and Turf*. New South Wales University Press, Australia.
Hessayon, D. G. 1987. *The Gold Plated House Plant Expert*. Century, London.
Paul, J. L., and C. I. Lee. 1976. Relation between growth of chrysanthemums and aeration of various container media. *J. Am. Soc. Hort. Sci.* 101: 500–503.
Spomer, L. A. 1974. Two classroom exercises demonstrating the pattern of container soil water distribution. *HortScience* 9: 152–153.
White, J. W., and J. W. Mastalerz. 1966. Soil moisture as related to container capacity. *Proc. Am. Soc. Hort. Sci.* 89: 758–765.

David R. Hershey is an assistant professor in the Department of Horticulture, University of Maryland, College Park, MD 20742-5611. His research focuses on greenhouse crop nutrition, hydroponics, and container soils.

300 ppm. The H_2O channel has a typical noise level of 0.032 millibars at 20 millibars. Measurements can be displayed as mole fraction, partial pressure, mass fraction, or dewpoint (H_2O channel); data may be transferred via a RS232 port or as analog values. The analyzer uses a solid-state infrared source and detectors to minimize response time (1 second is claimed) and to enhance stability. Low power consumption permits portable operation. **Contact: Li-Cor, Inc., 4421 Superior Street, P.O. Box 4425, Lincoln, NE 68504. Tel: 402/467-3576; Fax: 402/467-2819.▼**



vide a level pool when used with normal clearance angles. **Contact: EMCorp, Electron Microscope Supplies Division, P.O. Box 67285, Chestnut Hill, MA 02167. Tel: 800/528-5252; 617/965-6340 (in MA); Fax: 617/964-1052.**

Data acquisition. Hardware and software data acquisition tools for Macintosh and IBM-compatible computers are described in a free 20-page catalog. Included are bus-based and peripheral-based data acquisition systems, waveform editing and analysis software, amplifiers, signal conditioners, and transducers. The catalog contains detailed descriptions, specifications, and prices. **Contact: World Precision Instruments, 375 Quinnipiac Avenue, New Haven, CT 06513-4445. Tel: 203/469-8281; Fax: 203/468-6207.**

Information management for the Mac. HyperLab from Asgard Software enables scientists to store, organize, and retrieve text, data, graphs,