A Nondestructive Method for Measuring the Volume of Container-Grown Conifers[1]

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Abstract

A nondestructive method of determining plant volume involving measurement of water displaced from a cylinder fitted with an overflow drain tube is described. The technique is reliable and is particularly suited to conifers grown in containers. Volumes of plant tops correlated very closely with plant fresh weight.

Index words: growth evaluation

Introduction

Woody plant research often involves studies which continue for several years and it may be desirable to determine the extent of top growth at successive intervals on the same plant during an experiment. Periodic evaluations by parameters such as length of shoots or number of shoots may be satisfactory for broadleaf plants, but for conifers such as juniper and white cedar, these measurements are difficult while measurements of height or spread give no indication of denseness of foliage. For such species, plant top volume is useful as a means of evaluating total plant top growth. The portability of container plants makes nondestructive volume determinations feasible. Apparatus for determining plant volumes using the principle of water displacement from a larger cylinder into a smaller one for accurate measurement of the volume of small root systems have previously been described (1,3). These might be suitable for the measurement of tops of small conifer cuttings during the first season of growth, but cuttings are often grown in 6 l (2 gal) containers and the awkwardness of the heavy root ball would make operation of the apparatus difficult. Burdett (2) described a reliable method of determining the volume of small bareroot stock, involving change in weight of water displaced by the plant. However, potted plants present some restrictions to this method since all plants must be immersed to the same depth and plants must be held steady without touching the sides of the container. The precision provided by the above systems may not be essential for the evaluation of larger plants. Thus, the following apparatus was designed to measure the volume of tops of one- to three-year-old container-grown conifers.

Materials and Methods

A section of 10 cm (4 in) diameter polyvinylchloride drain pipe (cylinder) was fitted with an end cap and mounted upright on a wooden base. One end of a 10 cm (4 in) length of 6 mm (0.25 in) diameter thin wall brass tube (overflow drain tube) was ground to a fine edge, polished and inserted through a hole in the cylinder 2.5 cm (1 in) from the top, projecting approximately 1 cm (0.4 in) into the interior, and sealed to the cylinder on the exterior using silicone sealant. The overflow drain tube was positioned on a slope (25° from horizontal) to promote drainage (Fig. 1).

Prior to each measurement the cylinder was filled with water and allowed to drain to the level of the overflow tube. Loose branches of the plant to be measured

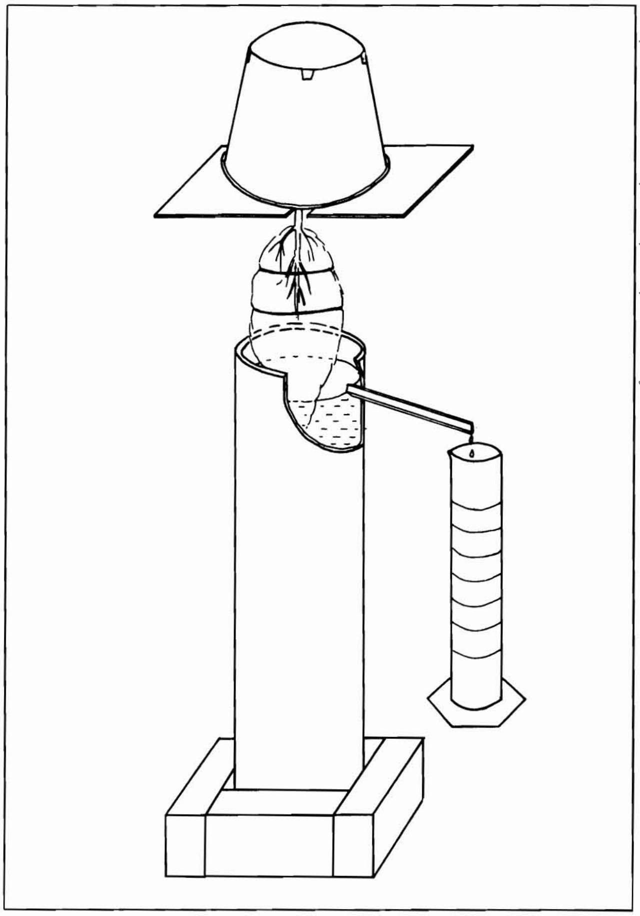

Fig. 1. Water displacement apparatus, with cut-away section showing insertion of the overflow drain tube and internal water level. A plant is shown partially immersed. Note the slotted board to support the soil ball and the wooden base to hold the cylinder upright.

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were held together with several elastic bands. The top of the pot was covered with plastic to prevent soil loss and a rigid board with a slot to accommodate the stem was placed over the plastic to support the soil and pot. The plant was then inverted with the soil ball falling onto the support board and the plant slowly immersed in the cylinder until the board rested on the top of the cylinder. Water from the overflow tube was collected in a graduated cylinder (Fig. 1).

Results and Discussion

This apparatus allows each potted plant to be immersed to the same depth. If the plant were immersed in a cylinder without an overflow drainage tube and the change in level recorded, the water level would be higher on larger plants and the measurement would include a greater proportion of larger than of smaller plants. Small errors due to variations among plants in diameter and branching at the base of the stem are minimized by the overflow drainage tube being as close as possible to the top of the cylinder while still allowing space for the water level to rise above the overflow drainage tube during immersion of the plant. Accuracy of the technique is enhanced by using the smallest diameter cylinder into which the plant will conveniently fit since this provides greater change in water levels. When using a small diameter cylinder for small plants growing in large pots, it may be necessary to supply extra support for the pot to avoid tilting of the apparatus during use. Care must be taken to prevent foliage or debris from touching the inlet of the overflow drainage tube as this will cause variations in the meniscus formation and thus variations in the equilibrium water level in the cylinder. The effect of extended dripping from the overflow drainage tube on accuracy can be minimized by allowing equal times for drainage before and after immersion of plants.

The reproducibility of the technique was evaluated by measuring 8 times each the volumes of tops of 4 plants of *Taxus* x *media* Rehd. 'Hicksii' (Hicks yew) in a 10 cm (4 in) diameter cylinder as described above, and of 2 plants of *Thuja occidentalis* L. (white cedar) in a 15 cm (6 in) diameter cylinder with 12 mm (0.5 in) diameter overflow drainage tube. Plants were growing in 6 l (2 gal) containers. Surface moisture on the foliage was allowed to evaporate between measurements. Readings for white cedar were somewhat more variable than those for Hicks yew due to the more fragile foliage which broke off with successive measurements. The coefficient of variability for measurements of each plant was low (0.5-1.6%) for both plant species (Table 1).

Table 1. Reproducibility of the water displacement apparatus in determining top volume of container-grown white cedar and Hicks yew.

Plant	Volume (cm^3)		Coefficient of
	Mean[z]	Range	variation (%)
Hicks yew	90.6	90-92	0.6
Hicks yew	102.9	102-104	0.5
Hicks yew	50.9	50-52	1.6
Hicks yew	79.4	78-80	0.9
white cedar	262.9	258-266	1.0
white cedar	329.3	325-333	0.9

[z]Values are a mean of 8 successive measurements of the same plant.

Two-year-old *Juniperus sabina* L. (savin juniper) was found to have a very high degree of correlation (r = 0.99) between volume and fresh weight of tops.

Significance to the Nursery Industry

This easily constructed, inexpensive apparatus for rapid nondestructive evaluation of plant growth could be particularly useful in grower trials. For growers who conduct their own trials, visual observations may not be adequate and due to the high value of nursery crops, cutting off plants at the end of the trial for weight records is usually not desirable. Volume measurements offer a solution to this by providing accurate growth evaluations while leaving the plant intact for future sale. Volume measurement gives an indication of overall growth similar to that of fresh weight and thus could be useful as a means of periodically evaluating top growth of individual plants in long term research studies of container grown nursery crops.

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