A Laboratory Exercise to Demonstrate the Effect of Container Size on Substrate Water & Air Content

Often students have trouble understanding perched water tables and how it relates to the balance between the water-holding capacity and air-filled porosity of soils and soilless growing substrates. This is an especially important concept in horticulture with the use of various sized containers and soilless growing substrates that vary in water-holding capacity and air-filled porosity. Typically shallow containers such as plug trays and seed flats have a higher percentage of saturated substrate than deeper containers such as six-inch pots or gallon containers. However, many new and young horticulturists do not have a good grasp on how soil-water relations change with container size and thus over-water or under-water crops. Spomer (1974) developed two classroom exercises using sponges to demonstrate the relationship between a free-draining container water content and average height. In his demonstrations the sponge's volume remains constant from the flat to the side to the end positions but the average water content decreases as the average height increases.

These demonstrations are a good way to introduce the topic of soil water distribution but do not show how this can impact plant growth. For example, soil water distribution is very important when considering seed germination. The germination substrate must provide contact between the seeds and the water films surrounding soil particles if the seeds are to germinate. However, too much water can drown a seed or seedling because of a lack of air. Again the concept is a balance between water and air in any substrate that will result in optimum plant growth and performance. To demonstrate the idea of balance between water and air content in substrates, a laboratory exercise was developed to investigate the effects of using columns of different heights on seed germination.

All of the materials for this laboratory were purchased at a local home improvement center. To begin, 10 cm interior diameter polyvinyl chloride pipe (PVC) was cut into pieces measuring 6.5, 9.0, 11.0, 13.5, 21.0, 30.0 and 37.5 cm tall. The bottom of each column was covered with a fine mesh screen and the columns were placed into an adjustable closet flange hub (4"). The columns were filled with washed sand to within 1 cm of the top. It is better to purchase washed sand because it is nearly free of clay, silt and other organic matter. Other substrates may be used, but sand is preferred because it is heavy, provides aeration and has a negligible water holding and cation exchange capacity. Ten seeds of a relatively fast germinating plant were sown on the top of the sand in each column. In past exercises, students have used geranium, tomato, and pea seeds, all of which should germinate in 7 to 10 days. All columns received 400 ml of water daily. Students were asked to record the number of seeds that had germinated after 7 or 10 days in order to calculate percent germination. A seed was considered germinated if the radical had emerged. To demonstrate the effect of container height on germination, students were asked to graph percent germination for each container height. The students were then asked to explain the results as it related to the relationship between container height and substrate water and air content.

Ideally, as column height increases from 6.5 to 13.5 cm, percent germination should increase but decrease as column height continues to increase to 37.5 cm. Students should be able to graph a bell curve. As an explanation students should comment that the average water content decreased as the average height increased and that poor germination in the lower column heights was due to the effects of low aeration due to saturation. Highest germination rates in past exercises using geranium, tomato and pea seeds was always in the 13.5 and 21.0 cm tall containers with the least germination in the 6.5, 9.0, and 37.5 cm tall columns.

In general, the biggest problem associated with this exercise has been inconsistent watering. Students want to give the seeds in the shallow containers less water and the seeds in taller columns more water to compensate. Other problems encountered in the past were some seeds rotted before they germinated and other seeds did not germinate at all. However, these problems can be avoided by careful selection and use of high quality seeds.

Comments from students after seeing the sponge demonstration described by Spomer and collecting data from the column experiment have been positive. Test scores on quizzes and exams also improved after adding the column experiment. One student stated, “I now understand the reason why recommendations will tell you to place some plants in a shallow pot versus a standard pot – it is because that plant needs more water and a shallow pot will have water remaining in the container after it has finished draining.”

Reference

Spomer, L.A. 1974. Two classroom exercises demonstrating the pattern of container soil water distribution. HortScience 9(2):152-153

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