Irrigation Nozzle Height Influences Water Captured by Containers
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Nature of Work: Production nursery operators have observed that container substrates appear wetter from rain than from an equivalent amount of water applied with overhead irrigation. A preliminary study by R. C. Beeson, Jr. (unpublished) has verified this observation. Various physical phenomena may contribute to this observation; of which, the distance a water drop falls and consequently its momentum is a factor. For example, if we assume the maximum velocity (V_{max}) of a drop of water in air is 188 ft/sec and the initial velocity ($V_{\circ}$) is 0, then 5.9 sec are required to reach V_{max} (Equation 1), where a is acceleration due to gravity and t is time.

Equation 1

$$V_{max} = V_{\circ} + at$$
$$188 \text{ ft/sec} = 0 + 32 \text{ ft/sec}^2 \cdot 5.9 \text{ sec}$$

The distance (d) needed to fall for 5.9 sec is 556 ft as calculated using Equation 2.
Equation 2

$$\text{Height} = V_{\circ}t + \tfrac{1}{2} at^2$$
$$556 \text{ ft} = 0 + \tfrac{1}{2} \cdot 32 \text{ ft/sec}^2 \cdot (5.9 \text{ sec})^2$$

The momentum of a drop is expressed as mv (mass $\cdot$ velocity) with velocity calculated using Equation 3. Velocity of a drop that falls 556 ft or 4 ft, respectively, would be calculated as follows.
Equation 3

$$V_t^2 = 2ad.$$
$$V_t^2 = (188 \text{ ft/sec})^2 = 2 \cdot 32 \text{ ft/sec}^2 \cdot 556 \text{ ft}$$
$$V_t^2 = (16 \text{ ft/sec})^2 = 2 \cdot 32 \text{ ft/sec}^2 \cdot 4 \text{ ft}$$

Thus, for water drops of equal mass, momentum is 12 times more when falling from 556 ft than 4 ft. Consequently, a rain drop would have a greater momentum than water drop from an irrigation nozzle (assuming equal masses) due to distance the rain drop falls. The force (F) exerted on a leaf would be due to change in momentum at contact or the impulse expressed as $F_t = mv_t - mv_{\circ}$. A nursery operator may increase the efficiency of an overhead irrigation system by increasing the momentum of water

drops so a greater quantity of water penetrates the plant canopy. The following study was conducted to determine the influence of a #8 Wobbler® (Senninger Irrigation, Inc., Orlando, Fla.) irrigation nozzle height on percent of applied water captured by containers. Water drops from the #8 Wobbler® are about 0.13 inch in diameter at 20 PSI (personal communication with Chris Striby, Senninger Irrigation, Inc.) while rain drops are about 0.05 - 0.25 inch in diameter (Anon. 1960).

A #8 Wobbler® irrigation nozzle (2 gal/min, 20 PSI) was placed at the end of 0.75 inch galvanized pipe and positioned 4, 8, 12, 16, or 20 ft above grade. Irrigation water distribution pattern was determined for each height by measuring water in cups placed 3 ft apart in an east, west, north, and south direction from the riser base. Sixteen, three-gallon *Rhododendron* sp `Formosa' azaleas were placed in a circle 12 ft from the riser base for 4 ft high nozzle, 15 ft from the riser base for 8 ft high nozzle, and 18 feet from the riser base for 12, 16, and 20 ft high nozzle. Located within the circle of plants in the east, west, north, and south coordinates was a control three-gallon container with substrate, but without a plant. Pre-weighed disposable diapers were placed on the substrate surface of each container with and without plants. Diapers were removed and weighed after three hours of irrigation at each height. Initial diaper weight for each container with a plant was subtracted from weight after irrigation and expressed as a percentage of weight gain (capture) for control containers without plants. Border plants were placed 3 ft inside the circle of plants that contained diapers and experiment repeated.

Results and Discussion: Percent water capture increased as nozzle height was increased to 12 ft; however, the percent capture at all heights was greater than 100, indicating containers with plants captured more water than containers without plants. The decline in percent capture for 16 and 20 ft was likely due to the fact that plants remained 18 ft from the riser base at these heights. Plants were not moved farther from the base at these heights because our water distribution data indicated little change in distribution for distances up to 30 ft from the riser base. However, we believe large drops were being distributed beyond the plants at heights of 16 and 20 ft. Consequently, smaller drops were striking the plants and percent capture was low because small drops are not as effective as large drops in penetrating the canopy. Additional research is being conducted with nozzles that deliver a more uniform drop size.

Significance to Industry: Our data indicate the significance of drop momentum on irrigation water captured by container plants. The maximum amount of irrigation water (178%) was captured when the irrigation nozzle was 12 ft above ground. A higher nozzle may result in a higher percentage of water captured; however, the practical implications of high nozzles must be considered. Additionally, plant canopies increased water captured by containers compared with containers without plants.

Literature Cited

Anonymous. 1960. The World Book Encyclopedia. Vol 15. Field Enterprises Educational Corporation. Chicago, Ill.

Equations taken from: Gamow, G. and J.M. Cleveland. 1969. Physics Foundations and Frontiers. 2nd ed. Prentice-Hall, Inc., Englewood Cliffs, N.J.