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Measuring Pressure, Distribution Uniformity, and Improving Irrigation Management in Nurseries and Greenhouses

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Summary

Effective irrigation management in nurseries and greenhouses hinges on maintaining uniform pressure across irrigation systems to ensure consistent water distribution. Variations in pressure, due to factors such as elevation changes, friction in pipes, and improper system design, lead to non-uniform irrigation, causing inefficient water use. Measuring distribution uniformity helps assess system performance, and pressure measurements at sprinklers or driplines can guide adjustments. Distribution uniformity is calculated by comparing the water received in the lowest quarter of the irrigation block to the average, which informs how much additional water is needed to compensate for inefficiencies. Poor uniformity increases water usage, potentially resulting in runoff or infiltration that threatens environmental compliance. Implementing corrective measures like pressure regulators, filters, and proper pipe sizing can enhance system performance, reduce water waste, and improve overall irrigation efficiency.

INTRODUCTION

The main strategies to improve irrigation management in a nursery or greenhouse are measuring pressure, knowledge of the operating pressure of drippers or sprinklers; and understanding how pressure changes as water travels in a pipeline. If drippers or sprinklers in an irrigation block are exposed to different pressures, they will produce different flowrates, and irrigation will be non-uniform. Therefore, much of the irrigation manager's work is to ensure that pressure is close to the value recommended by the manufacturer and that it is uniform across the irrigation system. Poor system performance can also by caused by other factors, such as emitter plugging; wind affecting overhead sprinkler systems; uneven line drainage etc. Measuring distribution uniformity is an excellent way to investigate how these factors may affect the system and to compare different dripper or sprinklers brand/models; system designs; or corrective measures.

Generally, drippers are low-pressure devices, they need 8 to 12 psi of pressure, while impact sprinklers need 45 to 60 psi. Spray stakes need 15 to 25 psi and microsprinklers may vary between 25 to 45 psi. Senninger Wobblers sprinklers are the exception to the rule, since they only need 15 to 25 psi.

Both sprinklers and drippers will produce more flowrate with more pressure, increasing the irrigation system's application rate and the water depth applied per time. Increasing pressure in sprinklers will also increase the throw (or radius) and hence the circular area wetted by the sprinkler.

It is important that irrigators and irrigation managers are provided the tools to measure pressure at the sprinkler or at the dripline. Schrader valves can be installed on PVC pipes or on polyethylene hose fittings for measurement with a hand-held pressure gauge, such as with a car tire. Access these QR codes to view overviews of this process.

Pressure changes in an irrigation system due to two phenomena with additive effects, elevation and friction. The elevation effect on pressure is directly proportional the change in altitude, following the relationship of 1 ft = 0.44 psi or 2.31 ft = 1 psi. Every foot of difference in vertical elevation decreases pressure by 0.44 psi. For example, if a terrace is 10 ft higher in elevation than the next one, the pressure in the higher terrace will be 4.4 psi lower than in the lower terrace. This phenomenon applies whether water moves or not. You may have noticed that your ears hurt under the effect of pressure the deeper you swim deep in the ocean, the same is true in an irrigation system.

Friction affects pressure only when water flows. A certain pressure drop will occur per every foot of pipeline, the longer the pipeline the (linearly) larger the pressure loss. Additionally, more pressure losses occur in a pipe when the diameter of the pipe is smaller. Moreover, more pressure losses occur when the flowrate through the pipe is larger. Both diameter and flowrate affect pressure exponentially. Doubling the length of the pipe will double the pressure loss, but halving the diameter of the pipe or doubling the flowrate trough may increase pressure loss ten times. A common hydraulic misconception is that a reduction in pipe diameter will increase

pressure or that a smaller diameter pipe will reduce pressure loss. These statements are simply incorrect. Watch this video if you don't believe me.

Distribution uniformity measurement is performed by setting containers to collect and measure the volume of water distributed by the irrigation system. In overhead systems, we recommend setting containers of the same diameters as the containers where plants are grown. In drip systems and spray-stake systems, care must be taken to collect all the water that the plants would have received. We recommend at least 36 containers per area and 100 in each irrigation block. Various measures of data dispersion can be used, including variance, standard deviation or coefficient of variation. One of the measures traditionally most common in irrigation is the distribution uniformity of the low quarter. It is calculated by dividing the average of the lowest quarter (e.g. the lowest 9 values if the total number of containers was 36) by the average of all containers. If the average of the low quarter was 13 oz and the average of all containers was 16 oz, then distribution uniformity is 13/16=0.81, which is a high value, in the range we find in drip systems. If instead the low quarter average was 11 oz, distribution uniformity is 11/16= 0.69, similar to what we may found in an overhead sprinkler system.

Distribution uniformity is a quantitative measure of irrigation system performance useful for comparison, but it also has another application. It is used to calculate how much more water needs to be applied to the irrigation system to make up for lack of uniformity. This is done by simply dividing the irrigation requirement by distribution uniformity. For example, if the plants need 1 inch of irrigation per week, with the distribution uniformity of the drip irrigation system mentioned above, the grower will need to apply 1/0.81, which equals 1.23 inch. With the sprinkler system the grower would apply 1/0.69, which equals 1.45 inch. Note that 23% more water in the drip system and 45% more water in the sprinkler system than the plants needed was applied to make up for lack of uniformity. This additional water can produce runoff that carries pesticides and fertilizers to surface water or infiltration that can carry nitrate to groundwater. These can be a challenge for compliance with environmental regulations.

Corrective measures to improve distribution uniformity include improving pressure uniformity by correct pipe sizing and irrigation system design, installation of pressure regulators to equalize pressure in irrigation blocks or in pressure-compensating emitters; installation of filters; regular line flushing to minimize emitter plugging; replacement of worn sprinkler nozzles; and installation of check valves to minimize uneven system drainage.