

The Importance of Water in the Nutrient Management Process

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Nature of Work: Maryland's Water Quality Improvement Act of 1998 (6) requires all agricultural operations to develop and implement nitrogen and phosphorous-based nutrient management plans by December 2002. Educational programs were mandated to train professionals to write nutrient management plans, and to enable growers to implement plans. Maryland Cooperative Extension faculty have developed a nutrient management process that will enable nursery and greenhouse industry professionals to achieve these goals and ensure industry compliance with this legislation. The process satisfies the regulations and provides insight into cost-effective management changes.

Irrigation is essential for out-of-ground container production, and nutrients move with water, since nitrate-N and orthophosphate are soluble. Water management is important because compacted nursery-site characteristics, infrastructure and irrigation techniques may contribute to both water and nutrient runoff. With the wide range of plant species, containers and irrigation systems used in the industry, the challenge was to develop a relatively simple method to get an overview of the potential for runoff.

Container size was selected to be the basis for defining "management units" in the planning process, rather than plant species. Thus, we have integrated irrigation interception efficiency (plant density), leaching fraction (irrigation duration), container height, and substrate physical characteristics into a method that estimates the potential runoff that may occur. If we add the nutrient loading rate, using, for example, the nutrient concentration of liquid feed (ppm) or the rate of applying slow release (oz/pot) and the number of applications, we can determine the total maximum daily load (TDML) for the area (4). Combining the water and nutrient data, we therefore have an objective assessment of the TMDL for each management unit.

Interception efficiency and leaching fraction provide a means of assessing potential runoff, which is the excess water that flows out of the growing area being irrigated and moves toward off-site surface water. For overhead irrigation, runoff is made up of water that leaches through containers plus the water that is not intercepted by individual containers. For drip irrigation, runoff is measured by leachate.

The Interception Efficiency (IE) is a theoretical measure of the amount of applied water that is captured by the containers during an overhead irrigation event; the rest falling onto the ground around the containers (5). It is expressed as a percentage of the applied water but, in terms of area, it is the "container top area" divided by the "ground area allotted to one container" (Fig. 1). The "container top area" is the open area of the top of the container through which irrigation water enters the container. Ground area is defined by the container spacing. The term $(100 - IE, \%)$ is therefore the percentage of irrigation water or fertigation solution that falls directly onto the ground, and that contributes more directly to nutrient runoff. This value is particularly important in those operations that "fertigate", i.e., apply soluble nutrients in the irrigation water. Tightly "jammed" containers have high interception efficiency compared to spaced "unjammed" containers. Properly installed drip irrigation should have 100 percent interception efficiency.

The Leaching Fraction (LF) is a measure of the excess water that is applied to each container during an irrigation event. It is the amount of water that runs out the bottom of the container divided by the total amount of water applied to the container. The goal is to manage water applications more accurately and reduce that proportion of leaching that contributes to runoff. As a management tool, a leaching fraction test is performed during a normal irrigation cycle with the irrigation being initiated when the grower feels it is time to water and for the normal length of time. The purpose is to assess the length of the scheduled irrigation cycle used for wetting the substrate; the goal is to minimize leachate volumes to less than 15% of the applied water (Table 1).

Evaluation of LF is performed by using a pair of plastic-lined (with trash bags) containers for each plant-occupied container being measured (Fig. 2). At least five replications should be selected from various locations across a growing area. A plant-occupied container is placed into an empty lined container, using a rock to hold the plant-occupied container up for draining. An empty, lined container is placed adjacent to the plant container to collect the irrigation volume applied (Fig. 2). After allowing time for drainage, the leachate should be collected and measured from each plant-occupied container. The corresponding volume of irrigation water in each adjacent lined container is then measured. A comparison of the two volumes of water and leachate from each of the five replicates will give a reasonable estimate of the average LF, expressed as a percentage. Electrical conductivity measurements should be made to evaluate salt levels. In some cases, the substrate, the type of irrigation system or the rate of water application may require examination if the substrate is not being adequately wetted before leachate appears.

The Potential Runoff (PR) is estimated by using IE and LF values in the following equation. If the total amount of water applied to a management

unit is known, the gallon volumes can be entered into the equation to get the volume in cubic feet. If the volume of water applied is not known, a value of 100 percent can be substituted for the total applied water to calculate the percentage, i.e.,

$$\text{Potential Runoff (Percentage)} = 100\% \times [(1.00 - \text{IE}) + (\text{IE} \times \text{LF})]$$

where IE and LF are expressed in decimals, not percentage. The risk assessment criteria (Table 1) have been established to quantify LF, IE and PR in terms of low, medium, or high risk for the nutrient management process in Maryland. The LF values are based upon the best available information that is currently in the literature (1,2,7).

Table 1. Irrigation and Runoff Risk Assessment Criteria for the Nutrient Management Process in Maryland.

	Variables		
Risk Value	LF	IE	PR
Low	< 15 %	> 80 %	< 32 %
Medium	16 - 29 %	61 - 80 %	33 - 57 %
High	> 30 %	> 60 %	> 58 %

Results and Discussion: A majority of containers are irrigated by overhead irrigation in the industry (8). The water that is applied either falls into the container, onto the ground or evaporates into the air. The water that either falls between or leaches from the container may contribute to runoff. Interception efficiency provides an estimate of what enters the container, taking account of the dynamics of container size, plant size and plant density. It is recognized that water falling onto plant foliage may be directed into or away from the container and that there are infiltration and evaporative losses. Additional research is needed to more accurately define how IE is affected by plant size and canopy density.

Leaching may occur from both overhead and drip irrigation. A measure of LF in an actively growing crop assesses the irrigation duration and efficiency. A small amount of leaching may be used as a visible indicator of adequate wetting or to prevent salinity, but excess leaching contributes to excessive nutrient loss and runoff.

Significance to Industry: Various state (6) and federal (3,4) nutrient management regulations are making us reexamine the efficiency of water and nutrient applications, particularly when plants are grown in intensive, out-of-ground container operations. In Maryland, the regulations are in place and the nursery and greenhouse industries are responding. The efficient management of fertilization and irrigation practices will conserve water and nutrients and reduce the chance of nutrient runoff to the environment.

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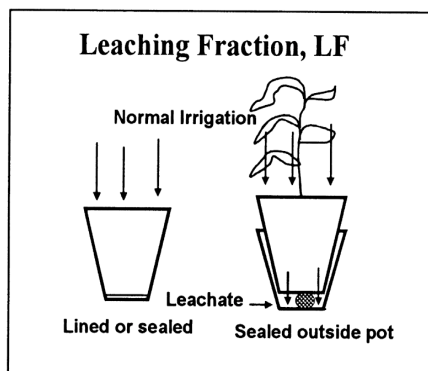
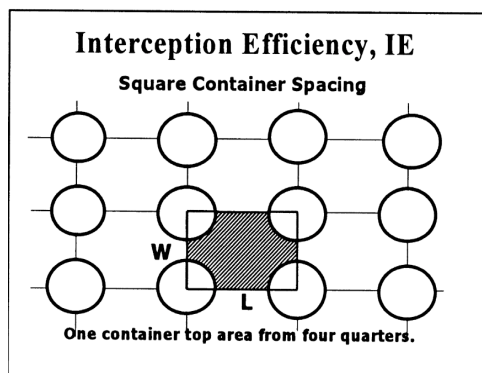


Figure 1. Interception Efficiency is calculated from container diameter and spacing. Note the relative amount of ground area allotted to each container top area.

Figure 2. Leaching Fraction compares amount of leachate to irrigation water applied.