Using Leaching Fractions to Maximize Irrigation Efficiency©

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Irrigation efficiency has ramifications for growers in the horticultural industry at multiple levels. At the immediate level, irrigation costs account for a substantial portion of operating costs. At a broader level, environmental regulations are becoming more restrictive, requiring more record keeping about water usage, increasing testing of runoff, and in some cases limiting water usage for agricultural purposes. Over the course of a growing season, Saunders Brothers, Inc. measured irrigation efficiency on numerous woody crops in a wholesale nursery. Leaching fractions were used to determine the percentage of irrigation water that remained in the container and available to the plant and what percentage was leached out of the container as excess. Results showed that by adjusting practices to eliminate excess irrigation, we were able to decrease our overall water usage from April to August by 43%, compared with the previous three years. Decreased water usage also reduces costs associated with chlorine, electricity, fertilizer, and herbicide.

INTRODUCTION

The economic downturn in recent years has prompted growers to reevaluate their practices to make more efficient use of resources. Also, as consumers' disposal incomes have decreased, their demands for higher quality plant material have increased. Beginning in 2011, Saunders Brothers began the process of examining our irrigation practices to identify areas where we could increase our efficiency. By controlling our water use, we hoped to control the quality of our end product as well. The past two growing seasons, we have worked with researchers from

University of Florida to develop a system where we irrigate based on evapotranspiration, replacing only water lost the previous day. This season, we added measurements of leaching fractions to our studies. Leaching fractions allow us to determine whether our predictions based on evapotranspiration are correct by measuring the excess water applied during an irrigation cycle. The goal was to maximize efficiency by eliminating excess. This report describes the results of our work with leaching fractions in the past year.

MATERIALS AND METHODS

Beginning in March 2012, Saunders Brothers took daily measurements of leaching fractions in woody crops throughout the 30.3 ha (75 acre) nursery. A leaching fraction is defined as the ratio of excess water that flows out of the bottom of a container during an irrigation cycle to the total water applied to that container during the irrigation cycle. Leaching fraction is often measured by using two units, one sleeve containing the potted plant that is used to measure leachate and one sleeve containing an empty pot that is used to measure the total irrigation. The volume of water in each is measured after an irrigation cycle and divided to get the leaching fraction. In our study, we chose to use only one unit, the one with the sleeve containing the plant, and to measure the change in weight of the unit before and after the irrigation cycle. We assumed that any change in weight was due to the addition of water. Then we removed the potted plant and measured the weight of the sleeve containing only water that had drained from the potted plant (the leachate). The change in weight was divided into the weight of the leachate to obtain the leaching fraction

$$\textit{Leaching Fraction} = \frac{\textit{Weight of Leachate}}{\textit{Weight of Total Irrigation}}$$

Using only one unit reduced the amount of labor involved in setting up the measurements and meant we could take measurements in crops that were spaced can tight. Additionally, our methodology allowed us to account for the capture factor. Capture factor refers to the characteristics of a plant's canopy that enable it to funnel water into its root zone that does not fall directly into the pot. Using an empty pot to collect the total irrigation could potentially lead to an artificially high leaching fraction because it does not account for capture factor.

The pre-irrigation measurements were taken after sunset, when plants were no longer transpiring. Irrigation cycles ran between 3am-7am depending on the crop. Post-irrigation measurements were taken approximately one hour after irrigation to allow time for draining, or at sunrise. For each crop, three replications were set up in each house, typically including an edge, a corner, and the middle of the house. Leaching fraction measurements were rotated through different crops on a schedule throughout the summer, with each irrigation zone being checked every three weeks.

Results from leaching fraction data were used to guide decisions about whether to increase or decrease irrigation times. In order to quantify the change, we used a second calculation, using the current irrigation time, current leaching fraction, and the desired leaching fraction to determine the new irrigation time (Formula 2).

$$New\ Irrigation\ Time = Current\ Irrigation\ Time * (1 - Current\ LF) * (1 + Desired\ LF)$$

RESULTS AND DISCUSSION

We measured leaching fractions for many crops over the course of the season. We found that by adjusting our irrigation practices to yield a leaching fraction of 10-20%, we were able to decrease the total volume of water used from April to August an average of 43% over the previous three years (Fig. 1). We saw an equal decrease in our chlorine use. Even though the rate of our electricity billing increased, our costs did not increase, because our usage decreased. Because we irrigated more efficiently, we lost fewer nutrients from excess watering, allowing us to decrease our fertilizer rate for the upcoming year by one third. Also, the uppermost layer of the potting media was able to dry between waterings, which made it less conducive to weed seed germination. As a result, we anticipate reducing herbicide usage by 15-20% in 2013.

We can use leaching fractions to determine adjustments to irrigation time in response to both short term (i.e. daily) and long term (i.e. seasonal) changes.

Short Term. Short term adjustments deal with changes in water usage due to weather, specifically temperature, solar radiation, and evapotranspiration. Every morning, the Saunders Brothers' office receives a weather report including forecast data as well as a summary, by day, of the past week's weather. We can use the weather from the previous day to determine plants' water usage so that we know how much water we need to replace today. For example, we can see that the max temp for a given day was 31 ºC (87 ºF) with a solar radiation reading of 502 lydians. On that day, the evaporate was 0.53 cm (0.21 in.). The water lost due to transpiration is different for each plant, so the total evapotranspiration value will be different for each crop, but we can use the evaporate to make relative adjustments. Because of the record breaking heat in July 2012, we have good data on what to expect for a maximum evaporate on the hottest, sunniest day of the year. We can set all of our irrigation values so that we are meeting plants' needs under those maximum conditions and then scale back our irrigation time as a percentage of that maximum. For example, the maximum evaporate that we expect is around 0.97 cm (0.30 in.). If the evaporate for yesterday was 0.53 cm (0.21 in.), then today's irrigation cycle should run at 70% of the maximum. We are able to establish this relationship by checking the leaching fraction after the irrigation cycle to ensure that our assumptions about the inputs we are not measuring (namely transpiration) hold true.

Long Term. Long term adjustments deal with changes in water usage due to crop status, specifically spacing, pruning, and crop age.

Spacing. Most nurseries will overwinter crops pot tight under plastic covered houses. When the temperature increases and plants begin to flush, spacing will increase and plastic is eventually removed from the house. With overhead irrigation, either the nozzle must be changed to provide a greater volume of water over a greater area in the same amount of time, or the irrigation time has to increase to provide the same volume of water over a greater area. Checking the leaching fraction for a crop after these changes are made is a quick and easy way to make sure that plants on the edges and corners are receiving sufficient water.

Pruning. Pruning has the potential to drastically change the evapotranspiration and capture factor of a plant. For an unpruned plant, the leaves are likely to be larger, fully expanded and more numerous. The pot will be more shaded and there will be less exposed media. For a pruned plant, the total leaf area will be less. Leaves may not be fully expanded. Soil media is more likely to be exposed and the pot will not be as shaded. All of these factors lead to very different water needs. Here again, the leaching fraction provides a way to quantify the difference and allow the grower to adjust the irrigation cycle accordingly after a pruning.

Crop Age. Even if two crops are the same species and same container size, the water needs can vary depending on the age of the crop. For example, a first year crop of newly potted *Ilex verticillata* will be pot tight, but there will be a lot of exposed media and little leaf area (Fig. 2). This means the crop will have relatively higher evaporative losses but lower transpirational water loss. By contrast, a second year crop of the same *I. verticillata* will likely be spaced so that pots are not touching, but leaf area will be much greater (Fig. 3). There will be relatively little evaporative water loss from the exposed media (although the pot may be affected by solar radiation more than the pot tight crop), but the transpirational water loss will be much higher. Leaching fractions allow a grower to distill the many differences mentioned above down to a single, easily quantified measurement.

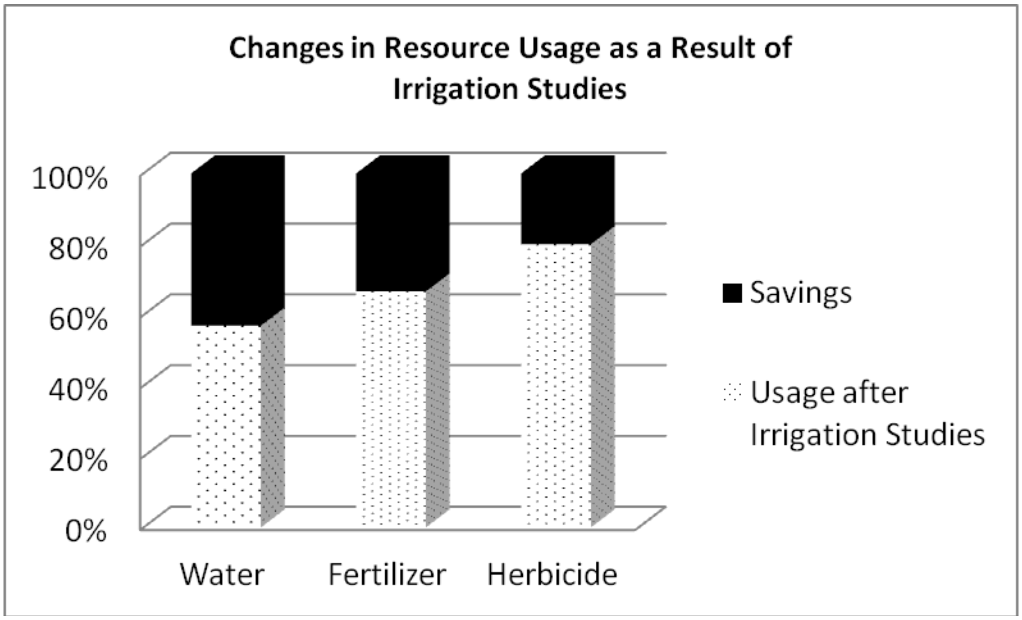

Figure 1. Changes in resource usage at Saunders Brothers, Inc. as a result of irrigation studies.

Figure 2. One year-old crop of *Ilex verticillata*.

Figure 3. T year-old crop of *Ilex verticillata*.

- **<u>Charles – See the three Figure Files</u>**