Evapotranspiration based irrigation at Saunders Brothers Nursery©

L. Day[a]

Saunders Brothers Inc., 2717 Tye Brook Hwy, Piney River, Virginia 22964, USA.

INTRODUCTION

Saunders Brothers is a wholesale nursery located in central Virginia — in the foothills of the Blue Ridge Mountains. The company began in 1915 as a family farm, growing corn, tobacco, and raising cattle. In 1947, Paul Saunders stuck his first boxwood cuttings as part of a 4H project. In the 1980s as some of Paul's seven sons were finishing school and returning to the family business, the farm expanded to include an ornamental nursery. Like many folks in the industry, Saunders Brothers grew quickly in the 1990s and through the 2000s. We now grow over 500 different taxa of ornamental plants, 25 different cultivars of boxwoods, and 50 different types of fruit.

The company and the industry suffered during the recession of 2008. Supply outstripped demand and customers were reluctant to buy nursery product, as their expectations for quality increased. At the same time, the costs of our inputs were also increasing. This got us thinking: what can we do to decrease our input costs while also increasing quality?

OPPORTUNITIES TO IMPROVE IRRIGATION, ENVIRONMENTAL IMPACT AND PLANT QUALITY

At the 2010 IPPS Southern Region of North America Annual Meeting, we were presented with the opportunity to work with Tom Yeager and Jeff Million at the University of Florida to look at irrigation and plant water needs. Tom Saunders has always been fond of saying, "the person who controls irrigation does more to affect the quality of your crops than anyone else." So it seemed that this work had the potential to help with the challenges we were facing. Specifically, we were aiming to improve on the following areas:

- Plant quality: less disease, fewer losses, more repeat orders.
- Bottom line: the Saunders family has a very close connection to Nelson County and the Piney River area, and we strive to be good stewards of the land. But we are also practical, so anything we do needs to make financial sense for the company.
- Environmental impact and risk: even though we are fortunate enough to live in an area where water use is not heavily restricted, there are still obvious benefits to better utilizing and conserving resources. Our water supply can be unpredictable which impacts nursery production. We utilize the Tye River as our primary water source. During the past 100 years, Saunders Brothers has seen the river flood during Hurricane Camille and go dry during a hard drought year. Being less dependent upon water makes us more secure in the long term.

So that is why we were interested. But what is the big idea behind the project? What is driving this irrigation research? We like to call it the "Goldilocks Dilemma;" the idea that plants need a certain amount of water for optimal growth. Too much and they rot, too little and they are scorched. We want it to be "just right." If plants are at field capacity in a well-drained medium, they should be neither limited nor saturated. So the goal of the research and the system that developed from it was to quantify the amount of water a plant loses in a given day and to resupply that amount of water without excess.

COMPONENTS OF THE IRRIGATION SYSTEM

Our irrigation system has three major components that we categorize into two sections: the brains and the brawn. Basically, we want to be able to gather information about

[a]E-mail: Lday@saundersbrothers.com

the environmental conditions the plants are experiencing each day, use that information to determine how much water our plants need, have the irrigation system process the information, create a schedule, and replace that water.

"The brains" are the science behind the system. The container irrigation (C-IRRIG) software program was developed to generate daily irrigation run times. These times are based on a couple of different pieces. First is evapotranspiration (ET) which is how much water a plant loses during the day. Second is irrigation rate and uniformity, which tells us how much water we are applying during an irrigation cycle. Lastly, leaching fractions (LF) which tells us how much irrigation water is actually making it into the container and available to the plant.

Evapotranspiration (ET) is measured by taking a weight of the plants in containers at the beginning of the day, after a normal irrigation cycle to get a wet weight. They are then again weighed at the end of day, around sunset after the plants are no longer transpiring and losing water, to get a dry weight. The difference between those weights enables us to find the volume lost and quantify how much water was lost in vertical inches. That is the plant's evaporative needs or what we refer to as the plant's ET for the day.

Irrigation rate and uniformity are how much water is applied and how it differs over a given area. This is an important component because it affects how long one can irrigate to get a certain, desired volume of water. Consider it much like calibrating something to know you are getting the volume you think you are getting. We measured this by setting up a grid of cups/containers in a house, ran a normal irrigation cycle, and recorded the volume in each cup. This data gives us a representation of how much water plants are getting relative to each other in the house. If you have variable results then the grower needs to improve irrigation uniformity and avoid the edge effect.

At Saunders Brothers we had a lot of challenges with this component. Our nursery is anything but level since it is located in the foothills of the Blue Ridge Mountains. There is a 61 m (200 ft) change in elevation from the river where water is pumped to the distribution pond to the highest point in the nursery. In order to put out the same volume of water, we may have to irrigate in the lower areas for 30 min [8 mm (0.3 in.) h^{-1}] and valves in the upper areas for 60 min [15 mm (0.6 in.) h^{-1}].

Leachate Fraction (LF) is measured much like ET, however we are starting with dry weight measured at the end of the day and taking the wet weight (the weight of the saturated plant and the collected leachate) the following morning. This is done after a typical irrigation cycle to determine how much water the plant received.

We spent the first 2-3 years of this process working with the University of Florida to fine-tune these measurements. The components and tests were a large part of what went into the research and development of C-IRRIG software.

THE CONTROL SYSTEM

The heart of C-IRRIG is the zone-editing page where one enters individual grower inputs for separate areas, houses or crops. This is where irrigation rate, uniformity and desired leaching fraction are entered as well as information about the plants. When all this information is combined with the weather station data, and the grower inputs — C-IRRIG will calculate the previous day's ET and determine how long you need to run irrigation in a given zone to replace the water loss.

One important aspect about C-IRRIG — it can be run independently. If one is happy with the controllers used and just want something that will give you run times based on ET, C-IRRIG will do that. There is no need for added wires or sensors, just the grower inputs. However, we quickly found ourselves adjusting and reprogramming Irritrol boxes daily. It became very time consuming and soon we realized we needed a better controller.

"The brawn," as we call it, is the FRALO control system. This portion manages and runs the irrigation schedule. It consists of two pieces: a software portion that allows you to edit the schedule and a hardware portion, and the control boxes in the field.

The software portion, based in Microsoft access is where the grower has the ability to build and edit the irrigation schedule. The grower has the option to enter and edit irrigation run times and priorities. Using individual valves, one can set a priority (which could mean running X before Y), duration times, etc. The software also displays information about flow volume and pumping capacity, and total gallons used by zone. There are options for setting days to run and start times. The nice thing about the program is that it offers a lot of flexibility. One can separate different crops based on medium and irrigate crops differently. You can also set up cooling cycles or cyclic irrigation.

Once the schedule is set, it is sent wirelessly to the control boxes in the field. The controllers can be operated remotely from a PC, laptop, phone, or manually in the field. Each controller has a touch screen that shows information about flow, pressure, and run times for each valve. These boxes help to optimize system pressure and maximize efficiency.

Both C-IRRIG and FRALO can be used independently. However, we have found the magic happens when used together. At Saunders Brothers, we have spent the last 2 years working to combine "the brains" and "the brawn" to get an irrigation system that alters run times daily and is automated from start to finish.

We have covered a lot about the development of the system, but what does it actually take to get it set up and manage it on a day to day basis? It all starts with the configuration of the system, everything from installing infrastructure to doing the uniformity and rate tests. Obviously, there is a significant time investment at the beginning, but minimal time once the system is up and running. The majority of day-to-day time spent on the irrigation program is updating grower inputs and verifying that the program is working. It is definitely not a "plug and play" system, and requires active time in the field checking to make sure the system is functioning.

BENEFITS OF OUR IRRIGATION SYSTEM ON PLANT QUALITY AND COST REDUCTION

Our irrigation system has led to increased plant quality and a reduction in production costs. With the improvement of the irrigation system in conjunction with IPM practices, pesticide usage has decreased by 50% during the past 3 years. There are decreased weeds and reduced losses in overall plant production. This system has enhanced our ability to grow better plants that were difficult to produce in the past.

The system has impacted our financial bottom line. Keep in mind that these financial benefits will vary among nurseries. Our total annual nursery savings are estimated at $80,355 (Table 1). The annual labor savings are from the reduction of time that irrigation managers are in the field opening and closing valves, or changing Irritrol boxes in the field. With the automated system, all those daily changes are taken care of, freeing management for other tasks. Single crop quality savings is the opportunity cost to grow crops that we had previously struggled with. Overall plant quality savings comes from an estimated reduction in losses by 1% per acre of growing space. At our nursery this is an estimated 100 plants for every 15 houses. The fertilizer savings is an estimate of where we were able to reduce our fertilizer use. In a single year we saved more than $10,000. Hence, the estimated annual savings is $80,355 for the nursery. This creates a new bottom line and raises the bar for us as a company.

Table 1. Estimated savings and plant quality enhancement of irrigation system at Saunders Brothers Nursery.

Annual labor savings	$6,355
Single crop quality savings	$4,000
Overall plant quality savings	$63,000
Fertilizer savings	>$10,000
Total annual savings	$83,355

Lastly, the environmental benefits of reduced water usage were significant (Table 2). With an average rainfall in our area of 1194 mm (47 in.), we use some 630 million L (166.5 million gal) of water (Table 2). In 2012, which was considered a dry year, we were able to reduce water usage by 51%. We have continued to do so in subsequent years, with an overall reduction of 56% during the past four years. Because we are using water more efficiently, we have been able to decrease fertilizer rates of some crops by 30%, since less is leached from containers. In addition, we can extend the time between herbicide applications because less herbicide is being washed away.

Table 2. Environmental benefits of reduced water and fertilizer usage of irrigation system at Saunders Brothers Nursery.

Year	Rainfall (in.)	Rainfall (mm)	Water Use (million gal)	Water Use (million L)
2009	48	1219	167	632
2010	46	1168	166	628
2011	57	1448	77	291
2012	37	940	81	307
2013	58	1473	70	265
2014	40	1016	67	254

All in all, this has been a great project to be a part of and we have been extremely fortunate to work with some fantastic people. We thank Russ Illig from FRALO control systems, and Tom Yeager and Jeff Million of the University of Florida.