An Irrigation Evolution©

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Saunders Brothers, Inc. is a third-generation family farm in central Virginia. The nursery portion of the business was started in 1947 by my father as a 4-H project working with his science teacher propagating *Buxus*. The first greenhouse was built in 1980. Since then, 400 more have been constructed and many new products have been added to our mix.

For many years our system of irrigating our container plants was by manually opening a below-ground valve. Later, the valve would have to be manually shut. As technology changed, solenoid valves were installed and soon Rainbird controllers turned the valves on and off. Because the nursery was terraced and greenhouse sizes were not consistent, the need was apparent for a program that allowed us to maximize our pump capacities and schedule the irrigation to take place as late as possible in the morning hours with a finish time prior to the work day beginning. This Dbase system could tell us the vertical inches of water delivered during the irrigation time and also allowed us to do cyclic irrigation and evaporative cooling of plants. Based on when a controller finished, we could have another starting to maximize our pump usage and finish as quickly as possible. Daily weather changes meant daily changes in scheduling which was determined by management with field staff entering controller changes. It was a 24/7 process and it went on for 15 years. We knew there had to be a better way.

Rolling the clock forward to the IPPS Southern Region meeting in Charlotte in 2010, I heard a talk on evapotranspiration-based (ET-based) irrigation in row crops. The technology was being trialed by the University of Florida, but not on a commercial nursery. It was at that time that we made a commitment to trial it for 5 years.

Year 1 we had an intern spend a summer doing ET-based research on several crops that we were growing. The purpose of the work was to help formulate data that could be used to determine maximum irrigation requirements for plants on our nursery under the summer growing conditions. Table 1 shows some of the data that was discovered.

Table 1. Data collected from the Davis weather station.

Zone	Name	Plant	Sched.	Time	ET (in.)	CF	IU (%)	Irrigation rate (in./h)
1	15-18	Azaleas	daily	01:45:00	0.21	1.1	100	0.4
2	28-30	*Ilex*	daily	01:45:00	0.24	1.1	100	0.3
3	BB Lower	Flowering shrubs	daily	01:45:00	0.27	1.0	100	0.5
4	503-505	Junipers	daily	01:45:00	0.24	1.0	100	0.4
9	BB Upper	Flowering shrubs	daily	01:45:00	0.22	1.0	100	0.5
8	9.11.13	Azaleas	daily	01:45:00	0.14	1.0	100	0.4
7	AA Fx	Flowering shrubs	daily	01:45:00	0.22	1.0	100	0.5
6	19-21	Azaleas	daily	01:45:00	0.21	1.1	100	0.4
5	8.10.12.14	Azaleas	daily	01:45:00	0.13	1.0	100	0.4
Solar radiation:		129.2 W/m^2	11.1 MJ/m^2					
Min temperature:		65.4°F	18.5°C					
Max temperature:		76.7°F	24.8°C					
Rainfall:		0.00 inches	0.00 cm					

Abbreviations: Sched.=scheduled, ET= evapotranspiration, CF= Capture Factor, IU=irrigation uniformity.

Year 2 we spent focusing on leachate fraction-based (LF-based) irrigation. The testing taught us that we had been over irrigating our crops. When we reduced irrigation to the desired leachate fraction, we also learned that we had to cut fertilizer rates on most of our crops. During this year and the year following, some crop losses were higher than we were accustomed to because of high EC levels since we were fertilizing as in the past. We determined that we could grow the same crops at a higher quality with less fertilizer and less water. We also noticed our herbicides lasted longer. To target a desired LF, a formula is used that incorporates the current LF and the irrigation run time. The formula is the following:

$$\text{New Irrigation Time} = \text{Current Irrigation Time} \times (1 - \text{Current LF}) \times (1 + \text{Desired LF}) \quad (1)$$

In Year 3 we installed a Davis weather system that could remotely monitor the four most important weather variables that dictate the ET levels for the particular crops. Those four variables were: solar radiation, temperature, relative humidity, and wind. Knowing these, the University of Florida professors, Tom Yeager and Jeff Million, tweaked their Cirrig program (Container Irrigation Module) and wirelessly irrigated three crops on our nursery next to three that we irrigated based on a desired leachate fraction. For their continued production of the Cirrig system, some crop information was added on regular intervals including container size, canopy cover, spacing, and whether the crop was under plastic or shade fabric. In order for them to have access to the weather station and solenoid control, Fralo Control Systems built two controllers that bypassed our normal controllers. The exercise proved successful. Table 2 shows some crops and irrigation times based on daily conditions.

The next step was for us to control zones wirelessly. For this initial in house run, irrigation times were determined through continued LF testing and downloaded through a PC directly to the controllers. Plants were grouped based on similar characteristics, pot sizes, and planting dates. They were also prioritized based on irrigation header capacities and whether the plant would be affected (from a disease standpoint) from the earlier irrigation start times which were normally around 4-5 AM during the longest and hottest days of the summer.

During this initial phase of running zones without field manual input, the UF zones continued to run based on the ET rate of the plants. There were hiccups in the early stages; the early transmitting radios proved to be unacceptable as well as other glitches. Nevertheless, we liked what we saw and soon had Fralo integrate the systems so that a daily weather download takes place and wirelessly sends the run times to the individual solenoid. These times are based on the weather information and the crop information that is input. We liked what we saw so much that the entire woody division of the nursery was converted to being irrigated wirelessly based on the ET needs of the plants in a period of less than a year.

Figure 1 shows the water savings since we implemented a portion or all of the new irrigation practice. It also touches on the fertilizer savings and improved weed control. Figure 2 shows the costs savings.

Continued tweaking of the system is taking place daily at our nursery and includes establishing LFs for different plants and irrigating some based on a saturation threshold. Recently we even had Fralo change all times to the tenths of a minute. This is not a big deal on a 20-min run time crop. On a drip system that is run for 3 min., it is.

Table 2. Data collected from our ET-based irrigation system.

Plant	Plant week	Date of max. ET	Max ET (in.)	Max. temp (°F)	From weather station Radiation (in Lydians)	From AgMaster (in.) Evaporation	Space (in.)	Sun	Shade	Container size (pot #)	Capture factor	LAI
Y – 1047: *Rhododendron* 'Chinoides'	12	14-Jul	0.18	80	769	0.27	C-C		x	300	1.563	2.35
L – L6: *Buxus sinica* var. *insularis* 'Nana'		22-Jun	0.22	90	818	0.28	3.87		x	1000	0.763	6.92
I – 5021: *Rosa* 'Meigalpio', Red Drift® groundcover rose	22	29-Jun	0.25	90	777	0.28	C-C	x		1000	0.586	5.89
K – L3: *Buxus* 'Green Velvet'		15-Jun	0.27	79	817	0.24	3.00		x	1000	1.220	6.82
H – 5005: *Ilex crenata* 'Hoogendorn'		29-Jun	0.23	90	777	0.28	C-C	x		1200	1.160	7.36
CC – 602: *Euonymus*		4-Aug	0.28	91	N/A	0.26	2.13	x		1200	0.838	
D – 1003: *Rhododendron* 'Yaku Princess'		26-May	0.33	80	801	0.29	7.60		x	1200	0.910	3.18
Q – 404: *Nandina domestica* 'Gulf Stream'		7-Jul	0.35	92	741	0.27	5.07		x	1200	0.772	4.37
E – 1002: *Rhododendron* 'Chinoides'		26-May	0.37	80	801	0.29	4.86	x		1200	1.330	3.57
F – BB1: *Buddleja* 'Adonis Blue'	17	21-Jun	0.38	92	690	0.26	C-C	x		1200	0.849	N/A
O – 1029: *Vaccinium corymbosum* 'Bluecrop'		7-Jul	0.39	92	741	0.27	6.73	x		1200	0.699	3.06
G – 5023: *Buddleja* 'Adonis Blue'	24	29-Jun	0.40	90	777	0.28	C-C	x		1200	0.676	N/A
S – 5022: *Spiraea japonica* 'Neon Flash'	24	12-Jul	0.41	99	734	0.31	C-C	x		1200	1.027	2.63
M – T4: *Cornus florida* 'Comco No. 1', Cherokee Brave® dogwood		30-Jun	0.55	86	775	0.26	20.73	x		2800	N/A	N/A
R – 940: *Rhododendron* 'Chinoides'		7-Jul	0.82	92	741	0.27	12.87	x		2800	1.273	5.67
V – 53: *Rhododendron* 'Blaauw's Pink'		26-Jul	0.91	91	712	0.27	10.40	x		2800	1.349	5.33
X – CC1: *Cupressus* × *leylandii*		26-Jul	0.92	91	712	0.27	12.27	x		2800	2.061	N/A
DD – 51: *Ilex glabra* 'Shamrock'		9-Aug	1.05	88	N/A	0.25	15.27	x		2800	2.429	

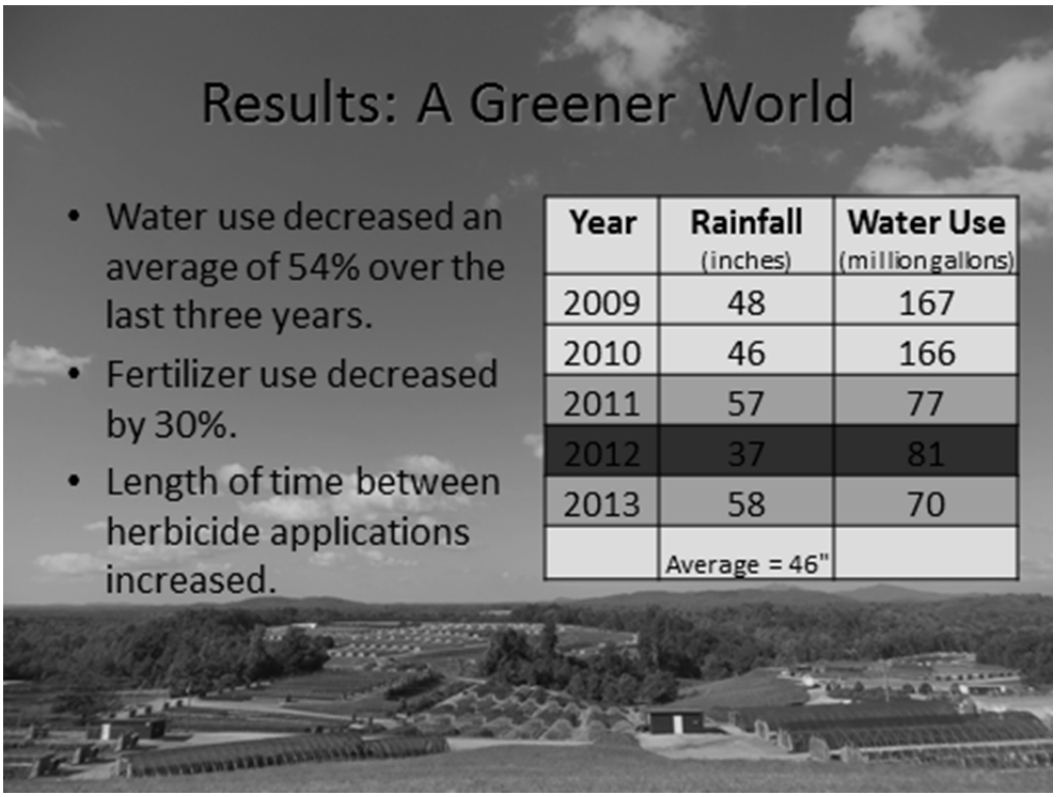

Fig. 1. Water, fertilizer and energy savings using an irrigation based on leaching fraction.

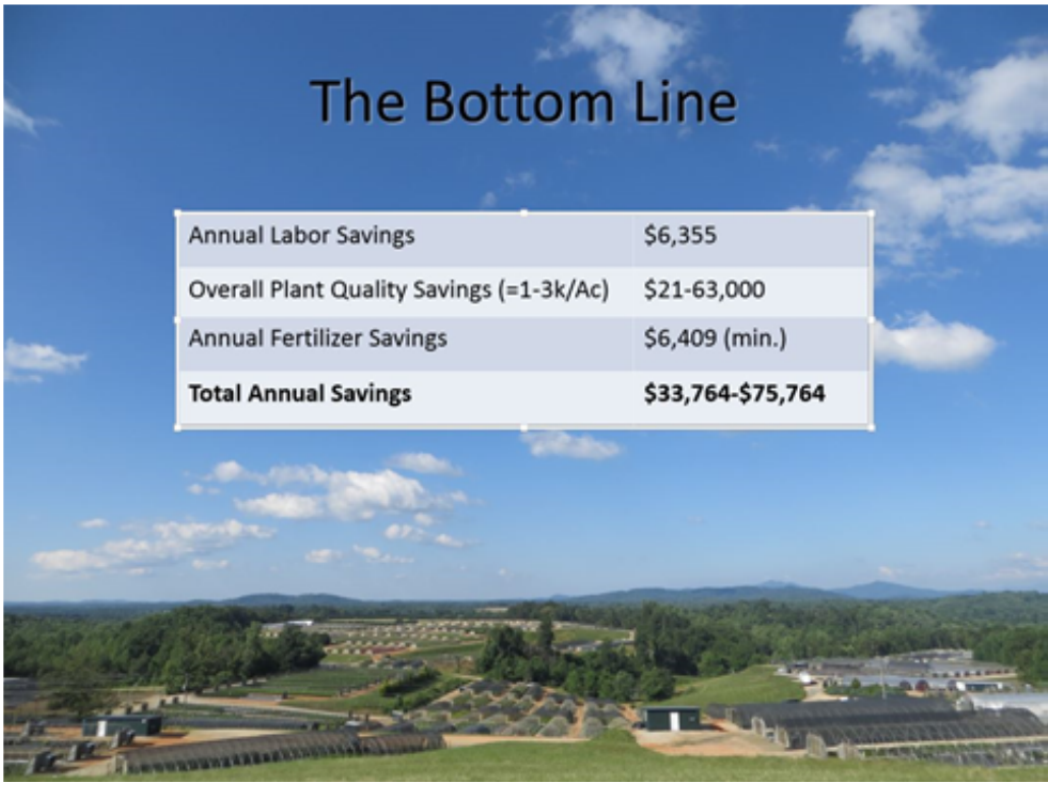

Fig. 2. Cost savings when using an irrigation system based on leaching fraction.

The Cirrig module was originally developed to be a system used during the growing season. In Florida, that season is certainly longer than it is in Virginia. We have some crops that can stay covered for half the calendar year. Because of that, the continued expansion of the system includes determining light and temperature differentials under winter-covered plastic houses. The differential between inside and outside temperature and light would then be used to determine plant water needs until the plastic was removed.

In my 30-plus years of producing plants, this type of technology is as industry changing as any that I have seen. Many may believe that they have too many types of plants and the system will not work. We are growing 400 products and have no sensors. I hope in time others will consider irrigating in this manner.

QUESTIONS AND ANSWERS

Diego Martinez: We used a similar ET-based irrigation system. How do you know what the crop coefficients are to put into the formula?

Tom Saunders: We used our leachate fraction data to help establish ET crop coefficients along with actual observations of how wet the soil was in the containers for our crops. We also took growth measurements to help fine tune things.

Todd Jones: What software did you use to run the system?

Tom Saunders: The software was developed by the University of Florida. Fralo Systems was responsible for integrating our irrigation system hardware and the software.