

Tipping Bucket Rain Gauge for Measuring Leaching Fraction in Container Nurseries  
Task 5: Nursery Use of Technology

Tom Yeager and Jeff Million

Dept. of Environmental Horticulture, University of Florida (UF), IFAS

Craig Warner

Dept. of Astronomy, University of Florida, Gainesville

**Abstract**

It was proposed that instead of catching container drainage or leachate in a pan and measuring manually the amount of leachate, a mini tipping electronic rain gauge (tipper) will be placed under a container to measure the drainage. That drainage information or amount will be transferred to a microprocessor that has Bluetooth capability and an app will be developed to monitor the amount of drainage or leaching on a mobile device. Thus, personnel growing plants can quickly determine the amount of leaching as they move about the field. The information on the mobile device can then be used to establish the amount of time the irrigation system should be operated for the irrigation zone or plants where the information is collected. This will automate the process of conducting leaching fractions, a Best Management Practice, and provide a history needed for the future. A future where NHF made an idea a reality for Growing Forward!

**Background**

Container nursery personnel can routinely monitor the *Leaching Fraction* (LF = amount of leachate ÷ amount of water applied to the container) and adjust irrigation rates to maintain low LF (e.g., 15-30%). By adjusting irrigation to maintain low LF target values, economic plant production can be achieved while conserving water and agrichemical resources. We have found, however, a major issue for adopting routine LF testing is the hesitancy of nursery managers to dedicate labor for this practice. Currently, LF testing requires staff to set up several leachate collections in each of the irrigation zones in the nursery and measure leachate and irrigation amounts by weighing with a portable scale. Our proposed project tests a new technology for measuring leachate volumes that would replace the more labor-intensive, weighing method. The new technology would include a small rain gauge and a data acquisition/communication system that could be left in the field. The tipping bucket rain gauge would be used for both micro-irrigated ( $\geq$  trade 7-gallon containers) and sprinkler-irrigated ( $<$  trade 7-gallon containers) nursery crops. By placing a tipping rain gauge under the container, the amount of leachate or drainage could be automatically determined. For deployment in a commercial nursery, a data acquisition system using Bluetooth or similar wireless communication will be needed for nursery staff to gather the LF data. Fortunately,

microprocessor technology has become very cost-effective so that a battery-powered system could be assembled and tested for this important task.

## Methods

An Arduino or data acquisition/communication device connected to a small tipping gauge was used to measure container leachate. The device used Bluetooth communication to transfer daily tip counts to an application (WaterTips) on a mobile device. In the first report we described the assemblage of components and their functions. In the second report we described the development of the WaterTips' app. In the third report, we described the initial testing of the system at the University of Florida (UF) and noted the changes needed to make WaterTips reliable and easier to navigate. We also described the use of a small solar panel to keep the Arduino powered indefinitely. In the fourth report, we described engagement with two nurseries to evaluate the WaterTips' technology. In this fifth report, we describe the interaction with two nurseries in which the tipping gauges were placed in production areas and monitored with WaterTips. BigTrees Plantation and Sunshine State Nursery were the participants.

For BigTrees Plantation located near Newberry in Alachua County Florida, one Arduino was used to monitor leachate from four trade #15-gallon containers of Nellie R. Stevens holly (*Ilex* x 'Nellie R. Stevens') in a spray-stake irrigated irrigation zone. Irrigation delivery was approximately 6 gal per hour. Photo of the zone at BigTrees Plantation is given in Fig. 1.

The other nursery engaged was Sunshine State, located near Palm City in Martin County Florida. Unlike BigTrees Plantation, there was limited micro-irrigated plant production, so an Arduino was set up in an overhead sprinkler irrigated zone. Irrigation delivery was approximately 0.5 inch per hour. One Arduino was set up to monitor leachate from four trade #3-gallon containers (9.1-inch diameter) of *Podocarpus macrophyllus* 'Pringles.' Photo of the zone at Sunshine State is given in Fig. 2.

Tipper systems or gauges and Arduinos were initially set up in February 2022 at BigTrees Plantation and April 2022 at Sunshine State. UF personnel worked with nursery personnel to set up the leachate collectors, tippers, and Arduinos. Each nursery had an Android phone with the WaterTips' app downloaded. Nursery personnel were shown how to operate the WaterTips' application. Follow-up trips by UF personnel were made to get feedback on using WaterTips. The systems were removed from both nurseries in October 2022. A summary of our experiences with each nursery is given in the results section along with information about educational events that were conducted.



Fig. 1. Leachate from Nellie R. Stevens holly grown in trade #15-gallon containers with spray-stake irrigation at BigTrees Plantation in central Florida. The Arduino, housed in the plastic tote with white lid and solar panel on top (left), was connected to four tipping gauges (one on right) to monitor container leachate using WaterTips' app. The site was initially set up in February 2022.



Fig. 2. *Podocarpus* grown in trade #3-gallon containers with sprinkler irrigation at Sunshine State Nursery in south Florida. The Arduino, housed in the plastic tote with solar panel (right), was connected to four tipping gauges (one on left) to monitor container leachate. The above photo was taken in April 2022 when tippers were initially set up.

## **Results**

Users found the application easy to understand and comprehend the use of LF for guiding irrigation. Both nurseries engaged the application to monitor the appropriateness of their previously selected irrigation amounts or amount currently used. While this is an effective way to use the application, another possibility would have been to use the application to directly determine the need or amount of irrigation to apply, rather than as a verification for what they had chosen to apply. However, irrigation at each business is often managed differently and the participants engaged the application in the best way for their business.

At BigTrees Plantation, the irrigation was initially operating for 15 minutes once per day based on previous experience. However, during a site visit the manager was encouraged to use at 7-minute duration as LFs were high as noted using WaterTips (March 2 – April 20, Fig. 3). On May 16, a 7-minute run time (RT) was selected and resulted in LF of 26% on May 22, close to the target of 25%. Subsequently, the manager used a 7-minute run time once per day to achieve a water savings of approximately of 50%. The high LF of 41% on Oct. 6 was likely due to rain because the run time was 6.8 minutes.



Fig. 3. Screenshot of WaterTips' app during use at BigTrees Plantation, Newberry, Florida. The run time (RT) was changed to 7 minutes on May 16.

At Sunshine State, the management was irrigating for approximately 20 minutes based on experience. When using WaterTips, the run time was verified (RTT) indicating the irrigation cycle duration (Fig. 4) was appropriate to achieve approximately a 15% leaching fraction (LF). The management found the verification helpful as weather conditions varied.

| LF History |            |        |             |           |        |
|------------|------------|--------|-------------|-----------|--------|
| ID         | Name       |        | Description |           |        |
| 8          | Podocarpus |        | 3 gal       |           |        |
| Date       | LFT (%)    | LF (%) | RT (min)    | RTT (min) | Delete |
| 2022-06-29 | 15         | 13     | 20.0        | 20.2      | [X]    |

 Home
 Scan Arduino
 Settings

Fig. 4. Screenshot of WaterTips' app during use at Sunshine State Nursery in Palm City, Florida. The desired run time (RTT) for this day should be used as the irrigation run time going forward until another desired run time is selected.

## **Educational Events**

Use of the application by producers or nursery personnel can be an important step for others implementing the technology. Thus, an educational event was conducted at BigTrees Plantation and at an alternative location close to Sunshine State Nursery. The alternative location was selected due to the desires of Sunshine State management. However, that was a great decision because on the date selected for the event, electrical service was not available at the nursery.

An event was conducted subsequently to meeting of the Board of Directors of the Frontrunner's Chapter of FNGLA at BigTrees Plantation in Newberry on September 8. Twelve people participated in the event focused on the technology demonstration. Participants learned about leaching fraction for guiding irrigation, development of the Arduino technology for monitoring leaching fraction, and the benefits of using the technology.

The second educational event was conducted in Palm City during the Treasure Coast Chapter of FNGLA meeting at Alpha Zeta Landscape's service facility on September 22. Thirty-nine people participated in the event. A power point presentation was used to convey information regarding the use of application at Sunshine State Nursery. Participants learned about leaching fraction for guiding irrigation, development of the Arduino technology for monitoring leaching fraction, and the benefits of using the technology.

The management of Sunshine State Nursery was not present during the meeting at Alpha Zeta due to the repair being performed to electrical service at the nursery. However, information from the management was conveyed to Yvette Goodiel, Martin County Extension Horticulturist. Yvette provided the information, regarding use of technology in the nursery and greenhouse industry, to the participants. That information is summarized in Table 1 below.

Table 1. The following information regarding the use of WaterTips' application and Arduino system for monitoring container plant irrigation was provided by management of Sunshine State Nursery.

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*Reduce labor inputs because no need to feel substrate moisture.*

*Apply correct amount of water especially during dry times.*

*Prevent soil borne diseases because not over-watering.*

*Easy to use!*

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### **Summary**

The WaterTips' application was used by two production nurseries and educational events were conducted. Users found the application easy to understand and comprehend the use of LF for guiding irrigation. Both nurseries used the application to verify the appropriateness of their previously selected irrigation amounts rather than relying on the WaterTips' application to provide the irrigation operation duration. However, irrigation at each business is often managed differently and the participants engaged the application in the best way for their business or the way they felt comfortable. Event participants were intrigued by the possibility of using wireless technology to monitor plant water need.

The investigators are grateful for the opportunity provided by National Horticulture Foundation to share with the industry a new technological application for a microprocessor. A future advancement might include modularization of the system's components.

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