Automated Rain Gauge Device to Monitor Container Drainage for Irrigation Management

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ABSTRACT

Leaching fraction (LF=container drainage ÷ irrigation applied) has been used to determine the irrigation application run time for container-grown plants. LFs are calculated from leachate or drainage weight measurements conducted in the field. The purpose of this investigation was to evaluate the use of tipping rain gauges instead of weight measurements for determining the amount of leachate or drainage from containers. Counts or tips recorded with the gauges were used to calculate LF. A preliminary evaluation was conducted at Hibernia Nursery and modified tipper counter systems were used at University of Florida.

OBJECTIVES AND METHODS

Objective: Evaluate tipping bucket rain gauges for determining the leaching fractions of container plants in the nursery.

Methods: Six pairs of tipping bucket rain gauges or tippers (**Figure 1**) were placed in a 7-gallon container plant production area at Hibernia Nursery, Webster, Florida in August 2019. Each pair consisted of one gauge measuring leachate and one measuring irrigation applied. To measure leachate, containers were placed on pizza pans with a 0.5-inch drain hole to direct drainage or leachate into a tipper placed below the hole. To measure irrigation water applied, an adjacent emitter was placed in a 5-gal bucket with a drain hole to direct irrigation into another tipper. Nursery staff was directed to monitor these setups and record tip counts for both leachate and irrigation. Leaching Fraction (LF) was calculated as leachate tipper count divided by the irrigation tipper count times 100 to convert to percent. Several problems arose immediately that prevented staff from using the tipper system for LF testing and further evaluation. In the field, there was a tremendous amount of sand and woody debris that clogged pizza pan drain holes.

Figure 1. Tipping bucket rain gauges (left) were used to measure leachate and irrigation volume. When wired with a pulse counter (middle and right), the number of tips can be counted and converted to volume knowing the tipping bucket volume per tip (e.g. 1.5 cm^3/tip).

This was especially a problem due to rains that splashed sand and debris into the tipper and pizza pans. Surprisingly, small drain holes in the 5-gal buckets became clogged as well. We found this was due to iron phosphate sediment that resulted from the nursery treating their well water with a phosphate material to reduce soluble iron. A second group of problems was with the tipper counter system itself. Batteries became powerless fast and often wiring became disconnected. The tippers were brought back to University of Florida and overhauled to correct these problems. The following describes the improvements that were implemented.

RESULTS

Pairs of rain gauge devices were wired to pairs of LCD pulse counters mounted on a wood stand (**Fig. 1**). During field testing, maximum battery life was 10-14 days. Because LF testing only needed to be conducted once every 1-2 weeks, an on/off switch was wired into the 9VDC battery circuit. Initially, we used a toggle switch to reset counters to zero. During field testing, it was found that nursery staff often left the reset toggle switch in 'on' position which caused batteries to deplete the charge rapidly. To remedy this problem, the toggle switch was replaced with a push-button switch that stays on only when the button is depressed. Wiring was improved greatly by using a terminal block eliminating the use of wire caps, which proved to be unreliable in the field. The 9V battery holders purchased from a guitar parts store helped relieve tugging on the battery. Another improvement was the use of 18-gauge, single-strand wire rather than stranded wire.

For remedying the problem of debris and sand clogging, we glued a standard hose filter screen on the underside of the pizza pan drain hole. Above the drain hole, we placed approximately 200 ml of sand (used in swimming pool filter systems) so that all drainage was filtered through sand before leaving through the drain hole (**Figure 2**). The same sand filter system was used to filter irrigation water in the 5-gal buckets. Another improvement we made was to raise each tipper slightly above the production surface by screwing on two legs that allowed water passing through the tipper to move away readily (**Figure 1**).

Figure 2. Seven-gallon container was place on 17-inch pizza pan elevated 5 inches on wooden platform to direct drainage into tipping bucket rain gauge to measure leachate volume. The aluminum foil covers a layer of sand that filters out debris and slows the flow of leachate into the tipping bucket.

The volume of water per tip was found to increase as the rate of water flowing into the tipper increased (**Figure 3**). Typical irrigation rates are 300 – 1000 cm3/min, much higher than the tippers can accommodate. However, we found that the volume per tip can be kept consistent (±10%) if the flow rate is <30 cm3/min. One benefit of the sand filters is that the maximum flow rates leaving the sand filter are maintained at <30 cm3/min. Because the reduced flow rate can cause leachate to collect in the pizza pans, we elevated the containers on 1-inch high metal pieces to keep the containers from reabsorbing leachate (**Figure 2**). Also, the sand filter retains water, so we placed an aluminum foil cover over the sand to limit evaporation so that once wet, the sand remains wet between irrigation cycles.

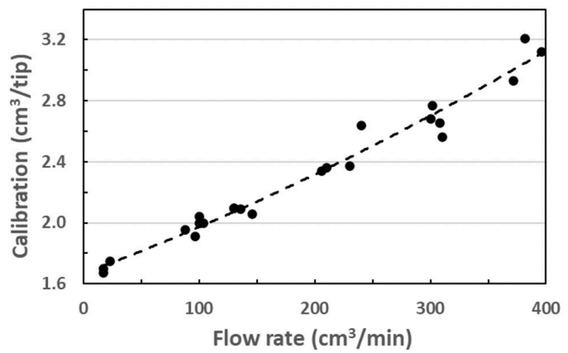

Figure 3. Example calibration tests used to determine the effect of flow rate of water into the tipping bucket gauge on the volume of water per tip (1 cm^3 ≈1 ml).

Due to COVID restrictions, we have postponed the follow-up phase of testing in the nursery. In the meantime, the tipping bucket system improvements have been working well at the University of Florida where we evaluate their daily use in our research projects.

CONCLUSIONS

A rain gauge tipping bucket system for measuring container drainage or leachate was developed so that leaching fractions can be rapidly calculated without weighing leachate or drainage. An initial evaluation at a container plant nursery resulted in several improvements in design and components. The tipping bucket system is currently used to measure leaching from container plants in experiments at University of Florida and will be reevaluated in the nursery once COVID subsides.

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