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Effect of Splitting Drip Irrigation on the Depth and Width of the Wetted Zone in a Sandy Soil

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Splitting a long irrigation duration into several small events is expected to decrease the wetted depth while increasing the width as water moves sideways by capillarity during the irrigation interval. Irrigation treatments (all for a total of 4 h of irrigation or 96 gal/100 ft) were 1) four alternations of 1-h irrigation followed by 1-h waiting period [(1+1) × 4]; 2) a 2-h irrigation event followed by a 2-h waiting period followed by another 2-h irrigation event (2 + 2 + 2); 3) a 3-h irrigation event followed by 1-h waiting period followed by 1-h irrigation event (3 + 1 + 1); and 4) a continuous 4-h irrigation event (1 × 4). The response of wetted depth and width was nonsignificant ($P = 0.10$ and $P = 0.42$, respectively) and depth and width remained constant at 16.34 inches and 16.24 inches, respectively. These results do not contradict the need to split irrigation events longer than 2 h into multiple events of shorter durations. However, these results show that splitting irrigation with intervals of 1 to 2 h would not be effective in preventing water from moving out of the root zone.

Drip irrigation was developed in the United States in the late 1960s and was used on 5% of irrigated crops (Locascio, 2005). In Florida, drip irrigation was a recent addition to farming and had only been adopted by growers from some 20 years ago, with about 25% of polyethylene-mulched vegetables irrigated by drip in the 1990s (Hochmuth et al., 1993). In drip irrigation, water is applied in small amounts through emitters placed at close proximity to the crop, enabling precise delivery of water and nutrients. Drip irrigation is known to have high water use efficiency (90% to 95%) and allows better management of water and nutrients, which is important for farming during the Best Management Practices (BMP) era (FDACS, 2005).

The predominant soil type in Florida, where most of the growing takes place, is generally sandy, and light-textured with low organic matter (Simonne and Hochmuth, 2009). In these soils, water percolates quickly (for example, 6–20 inches/h for an Alpin-Blanton-Foxworth sandy soil; NRCS, 2006) and the water front has been found to move below the root zone after a 2- to 3-h irrigation event using a flow rate of 24 gal/100 ft per hour (Simonne et al., 2006). Water-soluble nutrients such as N and K would be carried out of the root zone quickly, resulting in higher nutrient leaching and reduced crop yields (Locascio et al., 1997).

The length of irrigation affects the shape of the wetted zone, thereby affecting not only water and nutrient management (Farneselli et al., 2008; Simonne et al., 2006) but also fumigant distribution and efficacy (Ajwa et al., 2002; Hochmuth et al., 2002; Santos et al., 2003). One way to keep the wetting front, and hence nutrients, within the crop root zone, is to reduce the wetted soil depth and increase wetted width. This might be achieved through pulsing or having short and frequent irrigations, as some speculate that water is expected to move sideways by capillarity when gravity movement stops during the irrigation interval. In practice, splitting irrigation has to be a compromise between two constraints. On one side, frequent and short irrigations are less likely to leach soluble nutrients below the root zone. On the other side, frequent and short irrigations can waste water and reduce irrigation uniformity due to a large portion of the irrigation cycle being used for system charge and flush. Also, each irrigation cycle must deliver enough water to completely wet the soil between two adjacent emitters to maintain crop uniformity, especially when the plants are small.

The distribution of water in the root zone can be assessed by visualizing water movement in the soil using soluble dye (Flury and Wai, 2003; German-Heins and Flury, 2000). Dye has been used to visualize depth and width responses to drip-irrigation volumes applied during single irrigation events on Florida's sandy (Simonne et al., 2006), loamy (Simonne et al., 2003), and rocky (Simonne et al., 2004) soils and to improve the drip irrigation practices of Florida vegetable growers (Hochmuth et al., 2003). Measurements of soil nitrate distribution have shown that the position of the dye is also a good representation of nitrate distribution in the soil (Simonne et al., 2006).

Although the University of Florida, IFAS, recommendation calls for splitting irrigation events longer than 2 h into multiple events of less than 2 h, limited research exists on how splitting irrigation affects the wetted zone. The objective of this project was to determine if splitting irrigation reduces wetted depth and increases the wetted width on a sandy soil.

Materials and Methods

A dye test was conducted on 3 Dec. 2003 at the North Florida Research and Education Center–Suwannee Valley, near Live Oak, FL, on an Alpin-Blanton-Foxworth series sandy soil. Raised beds (150 ft long) with polyethylene mulch were formed with a single drip tape (John Deere Ro-Drip, San Marcos, CA; 24 gal/100 ft per hour at 12 psi; 12-inch emitter spacing) laid per bed. The dye test consisted of injecting the dye into the irrigating system, irrigating according to treatment, digging longitudinal and transverse sections of the raised beds, and taking measurements. After

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pressurizing the irrigation system, a blue dye (Brilliant Blue CF, Terramark SPI High Concentrate; ProSource One, Memphis, TN) was injected at a 1:49 (v:v) dye : water dilution rate for 30 min, which was then followed by the irrigation treatment thereafter. Dye patterns after irrigation in the soil appeared as a 1-inch-thick blue ring surrounding an uncolored section of soil, and measurements were taken of the maximum depth and width of each selected dye pattern.

All treatments received a total of 4 h of irrigation (96 gal/100 ft) applied as 1) four alternations of 1-h irrigation followed by 1-h waiting period [(1+1) × 4]; 2) a 2-h irrigation event followed by a 2-h waiting period followed by another 2-h irrigation event (2 + 2 + 2); 3) a 3-h irrigation event followed by 1-h waiting period followed by 1-h irrigation event (3 + 1 + 1); and 4) a continuous 4-h irrigation event (1 × 4). The response of depth and width of the wetted zone to initial irrigation length was determined using SAS PROC REG (SAS, 2004).

Results and Discussion

Through splitting irrigation duration into multiple events, it was hoped that the percolation of water through the soil would be slowed down and water would move sideways by capillary action between irrigation cycles, thus reducing the advance of the water front downwards and increasing its lateral movement. However, the response of depth and width of wetted area to initial irrigation length was nonsignificant. Depths and widths of irrigated area remained constant (slope = –0.012, P = 0.10, and slope = –0.008, P = 0.42, respectively) regardless of the split irrigation regime used (Fig. 1) at depth = 16.34 inches and width = 16.24

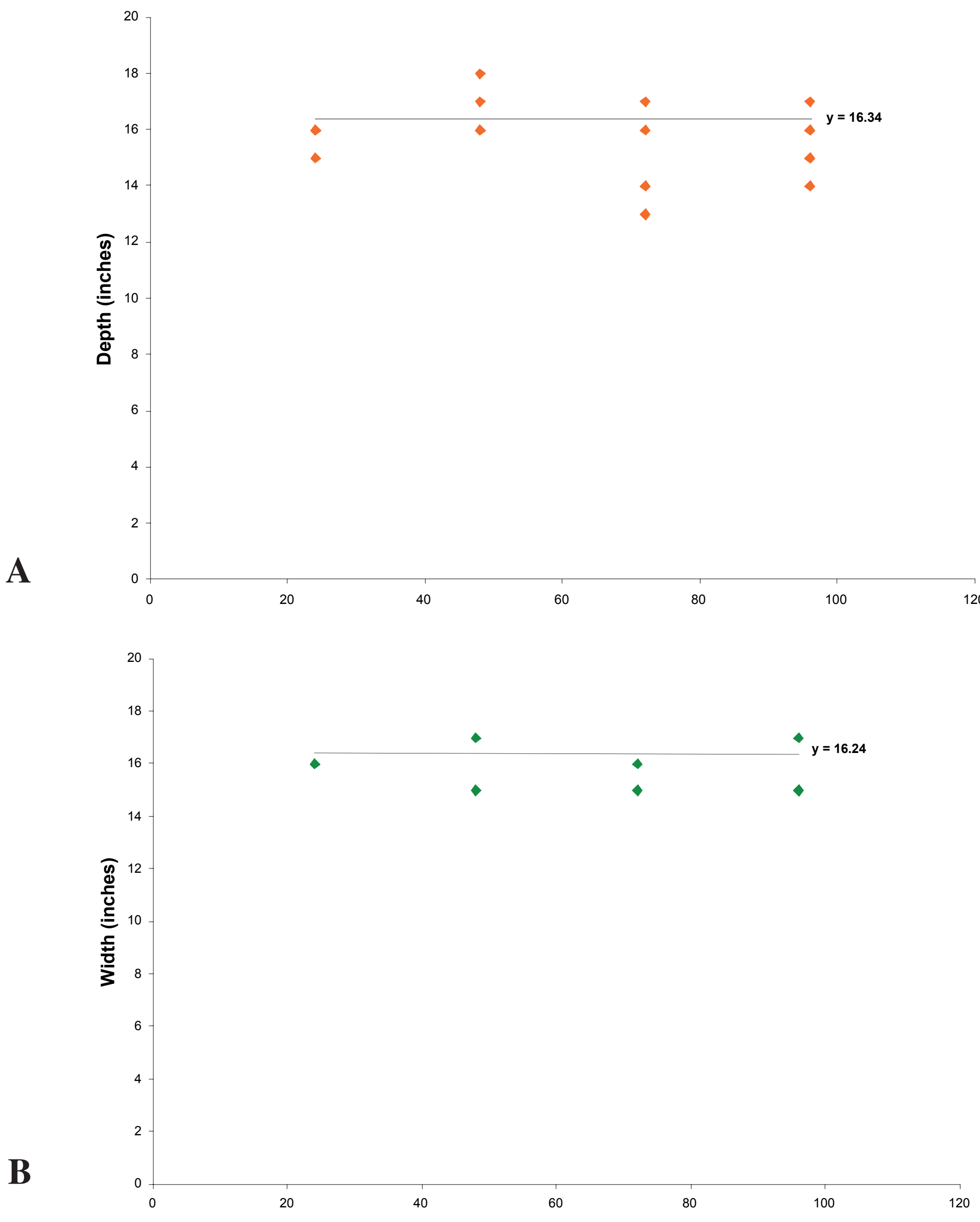

Fig. 1. Responses of depth (**A**) and width (**B**) of the wetted zone to irrigation volume applied at first pulse (1, 2, 3, or 4 h using a 24 gal/100 ft drip tape) after 4-h irrigation events (96 gal/100 ft) (based on 30 measurements for depth and 10 measurements for width).

inches (both $P < 0.001$). Similar depths of 16.4 inches but lower widths of 12 inches had been reported for such a sandy soil with 96 gal/100 ft of irrigation (Simonne et al., 2003). Consecutive dye patterns were touching each other since emitter spacing was 12 inches and complete emitter-to-emitter wetting occurred between 2 to 3 h (Simonne et al., 2006). These results do not support the hypothesis that splitting irrigation results in reducing the depth and increasing the width of the wetted zone on a sandy soil.

Despite irrigation intervals of 1 to 2 h, the wetting front pattern obtained was as if irrigating continuously for 4 h after which the water front had advanced below the root zone (typically 12 inches for vegetable crops). In scheduling irrigation for vegetables, splitting irrigation is necessary when the volume of irrigation needed exceeds the amount of water that can be stored in the root zone (Clark and Smajstrla, 1993). These results do not contradict the need to split irrigation events longer than 2 h into multiple events of less than 2 h. However, splitting irrigation using such regimes would not keep the water front from moving out of the root zone nor would it increase fumigant application across the bed.

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