Water Table Depth Effect on Water Use and Tuber Yield for Subirrigated Caladium Production

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Summary. **A study was conducted to determine the effect of water table depth on water use and tuber yields for subirrigated caladium (*Caladium ×hortulanum*) production. A field-situated drainage lysimeter system was used to control water table depths at 30, 45 and 60 cm (11.8, 17.7, and 23.6 inches). Water use was estimated by accounting for water added or removed (after rain events) to maintain the desired water table depth treatments. In 1998, tuber weights, the number of Jumbo grade tubers, and the production index (tuber value index) of 'White Christmas' were greater when plants were grown with the water table maintained at 30 or 45 cm compared to 60 cm. In 1999, tuber weights, the number of Mammoth grade tubers, and the production index, also were greater when plants were grown at water table depths of 30 or 45 cm compared to 60 cm. The average estimated daily water use was 6.6, 5.1, and 3.3 mm (0.26, 0.20, and 0.13 inch) for plants grown at water table depths of 30, 45, and 60 cm, respectively, indicating an inverse relationship with water table depth. While current water management practices in the caladium industry attempt to maintain a 60-cm water table, results from this study indicate that, for subirrigated caladium tuber production, the water table should be maintained in at 30 to 45 cm for maximum production on an organic soil.**

Most of the commercial caladium tuber production in the United States occurs on organic soils in Florida with a typically high natural water table, although recently some production has been occurring on sandy soils with deep water tables. Much of the past research on field production management has dealt with nutritional problems (Forbes and Westgate, 1964; Harbaugh; 1986; Harbaugh and Overman, 1983; Wilfret and Harbaugh, 1988) or control of pests and weeds (Gilreath and Harbaugh, 1985; Harbaugh et al., 1988; Overman and Harbaugh, 1983; Rhoades, 1964). Although water was shown to be an important production input (Overman and Harbaugh, 1983) little work has been done to understand water management of this crop under these unique growing conditions. Recently, water management has become an important issue since other cultural problems have occurred which may be linked to deficit or excessive soil moisture conditions, and there is increasing pressure from state water governing boards that issue water use permits to reduce water use.

While caladiums are grown on both organic and mineral soils in Florida, the primary production area is on organic soils in the central part of the state near Lake Placid/Sebring. Typically, for this type of production, surface water from nearby Lake Istokpoga is released through a network of canals for use by agriculture as needed. Caladium producers are self-regulating with respect to when, where, and how much water is directed into production fields. Mole drains are used to attempt to distribute water uniformly throughout a production field during an irrigation period and drain the fields when excessive rainfall occurs. These drains are mechanically created by using a tractor-mounted implement with a bullet-shaped plug which is pulled through the soil at a depth of 30 to 45 cm below the soil surface, creating a continuous channel in the soil. The drain is exposed only at the banks of the rim ditches where water moves in and out of the drains depending on whether the field is to be irrigated or drained. Most caladium growers maintain the water table depth in the field at about 60 cm below the soil surface. The common practice is to raise or lower the water level in rim ditches surrounding the production areas in order to achieve the target water table depth. There is evidence that this practice may have little or no effect on the resulting water table depth in the field, since in a preliminary field study, no relationship between rim ditch water level and field water table depth was detected for an entire season (Stanley and Harbaugh, unpublished data).

Since few caladium producers monitor water table position in their production fields, they commonly are unaware of what is actually happening in the field. Caladium production is expanding to new production areas where wells are the source of water. Current water allocation criteria by water governing boards require estimations of water requirement to secure a permit. These estimations have not been determined for caladiums. These studies were conducted to determine what the target water table depth should be for optimum caladium tuber production, and to determine subsequent water use estimations.

Materials and methods

This study was conducted over two growing seasons at the University of Florida's Gulf Coast Research and Education Center in Bradenton, Fla. A field-located lysimeter installation was used to control water table depth treatments of 30, 45, and 60 cm depths replicated five times. Each experimental unit consisted of four growing tanks [58 cm (22.8 inch) diameter and 76 cm (29.9 inch) deep] connected by a manifold (mounted at the bottom of the tanks) that was connected to a water table depth controller and reservoir tank. As the water table depth in an experimental unit declined due to water uptake by the plants, a float-controlled valve opened to allow water to flow into a tank connected to the manifold until the water level was equilibrated at the desired depth after which the valve closed. After rainfall events, treatment water table depths

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Table 1. Mean caladium tuber size class, weight and numbers, and production index (PI) for each water table depth treatment for 1998 ('White Christmas') and 1999 ('Florida Cardinal').

Water table depth (cm)[z]	Total tuber wt (g)[y]	Mean no. of tubers					PI[x]
		No. 3	No. 2	No. 1	Jumbo	Mammoth	
'White Christmas' (1998)							
30	1791 a[w]	1.6 a	5.8 a	21 a	15 a	1.4 a	43 a
45	1400 b	1.4 a	6.6 a	20 a	13 ab	1.2 a	41 a
60	1052 c	1.6 a	7.2 a	23 a	8 b	0.4 b	32 b
'Florida Cardinal' (1999)							
30	1741 a	0.12 a	0.5 b	3.9 a	5.5 a	5.2 a	94 a
45	1601 a	0.46 a	0.9 ab	3.9 a	5.9 a	4.4 a	88 a
60	1044 b	0.46 a	1.5 a	5.9 a	5.8 a	1.5 b	69 b

[z]2.54 cm = 1.0 inch.
[y]454 g = 1.0 lb.
[x]PI denotes production index where PI = a + 1.5b + 3c + 6d + 9e, where a, b, c, d, and e were the numbers of tubers in the No. 3, No. 2, No. 1, Jumbo and Mammoth size grades, respectively.
[w]Means followed by different letters within columns indicate significant statistical differences ($P = 0.05$).

were checked and reestablished if necessary by removing and recording excess water. The total amount of water needed to maintain the target water table depths (including that added from the reservoir tank and rainfall, and subtracting any amounts removed) for a specific period was assumed to be the evapotranspiration which occurred for that period.

Caladium seed pieces were planted in two rows, 18 cm (7.1 inches) apart, with 20 seed pieces in each row [10 cm (3.9 inches) apart] for a total of 40 plants per experimental unit. All seed pieces were hot water treated for disease and nematode prevention and dusted with dolomite. Planting dates were 29 Apr. 1998 and 12 May 1999 for 'White Christmas' and 'Florida Cardinal', respectively.

A Florida sedge peat was used in the growing tanks to simulate the common organic muck soils in the geographic areas of central Florida where caladiums are commonly grown. A 10N–4.4P–14K slow release fertilizer formulated for 100-d release (Nutricote 10–10–17; Agrivert Inc., Webster, Texas) was applied at a rate of 5 g (0.18 oz) per plant. All border areas between lysimeter units and within the facility were planted with buffer plants to simulate plant density and foliage coverage under actual field conditions. These plants were microirrigated so that none of the applied water would interfere with the water table treatments.

Harvest dates for 'White Christmas' and 'Florida Cardinal' were 17 Nov. 1998 and 8 Dec. 1999, respectively. Caladiums tubers were graded into diameter-sized classes with numbers and weights measured for tubers in each class. The size classes for tubers were Mammoth = >3.5 inches (8.9 cm); Jumbo = 2.5 to 3.5 inches (6.4 to 8.9 cm); No. 1 = 1.5 to 2.5 inches (3.8 to 6.4 cm); No. 2 = 1.0 to 1.5 inches (2.5 to 3.8 cm); and No. 3 = <1.0 inches (2.5 cm) in diameter. A production index (Harbaugh and Overman, 1983) which integrated the relative value of different tuber size classifications was used to provide an overall measure of the total value of the harvested crop. This production index (PI) was determined by: PI = a+ 1.5b + 3c + 6d + 9e, where a, b, c, d, and e were the numbers of tubers in the No. 3, No. 2, No. 1, Jumbo, and Mammoth size grades, respectively.

Yield data were statistically analyzed (SAS Institute, 1989) using analysis of variance and treatment means were separated where appropriate using Duncan's multiple range test. In addition, regression analyses were used to test the relationship of tuber weight with estimated daily water use. Since crop water use could be estimated for each individual replication within each water table depth treatment, a comparison of total tuber production for each experimental unit to the corresponding water use was made using regression analysis. This analysis procedure treated each experimental unit independently regardless of its imposed water table treatment while recognizing that the water use was influenced by the water table depth treatment.

Results and discussion

Total tuber weight for 'White Christmas' (1998) was greater for production with a 30 cm water table depth

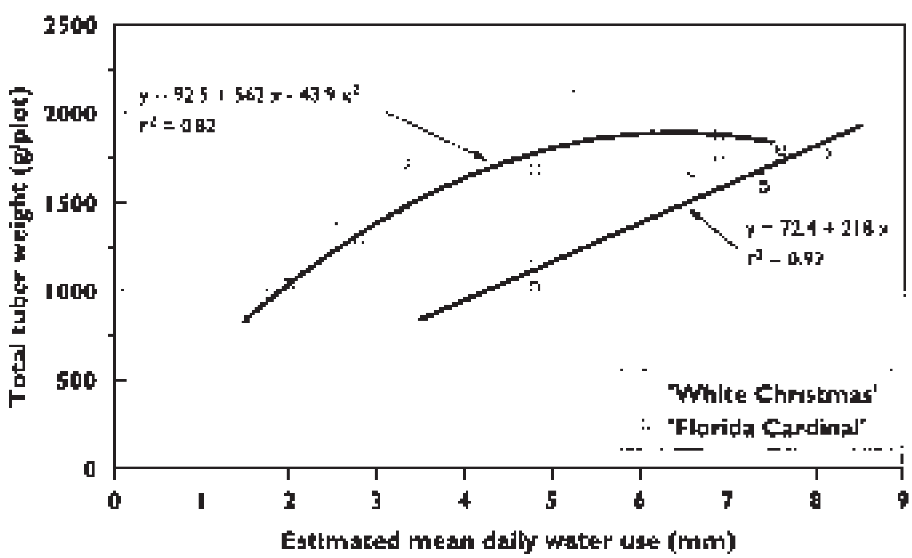

Fig. 1. Response of total tuber weight to estimated daily water use for caladium cultivars 'White Christmas' and 'Florida Cardinal' (25.4 mm = 1.0 inch, 454 g = 1.0 lb).

compared to production with a 45 or 60 cm water table, and tuber weights were greater at the 45 cm treatment than at the 60 cm treatment (Table 1). The numbers of tubers in the No. 3, No. 2, and No. 1 grades did not differ. There were more Jumbo and Mammoth tubers from production at 30 and 45 cm water tables compared to tubers from a 60 cm water table. The PI also was higher at 30 and 45 cm compared to 60 cm. For 'Florida Cardinal' (1999), total tuber weights, the number of Mammoth tubers, and the PI were greater at 30 and 45 cm water tables compared to 60 cm water table.

Both cultivars show a very significant relationship between water use and weight of tubers produced each season with coefficients of determination (r^2) for the relationships being 0.82 and 0.92 for 'White Christmas' and 'Florida Cardinal', respectively (Fig. 1). While both linear and quadratic models were significant for 'White Christmas', only the quadratic model is shown because the r^2 was significantly higher. The quadratic model for 'Florida Cardinal' did not improve the r^2 significantly over the linear model, thus only the linear model is shown.

The relationships shown in Fig. 1 were developed from the yield and water use data regardless of water table depth treatments which significantly affected daily water use. Combining the water use for both cultivars, the average estimated daily water use amounts were 6.6, 5.1, and 3.3 mm (0.26, 0.20, and 0.13 inch) per day for plants grown at the water table depths of 30, 45, and 60 cm, respectively. Thus, these results indicated a relationship where water use increased with rising water table depth.

Water use is directly influenced by the availability of water to the plant and subsequent plant mass production. It is logical that at the higher water table, more water would be available leading to less potential for plant water stress to occur, and that more water would allow for maximum plant mass production. Even though a water table depth 30 cm might be considered excessively high for most crops, it was not the case for caladiums in this study. This trend in optimizing tuber production with respect to water use is consistent with results from a greenhouse pot study where tuber weights increased with increased irrigation rates (Overman and Harbaugh, 1988).

Conclusions

It is apparent from these results that caladiums are a crop which thrive under high soil moisture conditions. The comparison between water use and tuber production indicates that more tuber weight is produced when more water is available. Since it is known that waterlogged conditions can cause aeration problems affecting tuber growth, a proper balance between drainage and irrigation must be maintained. However, from these results, it appears that a higher target water table depth of 30 to 45 cm compared to the current industry standard of 60 cm, might be warranted to maximize tuber production as long as the ability exists to drain the field of excessive amounts of water from rainfall.

The results from this study showed that daily water use changed from 3.3 to 6.6 mm as water table depths changed from 60 to 30 cm, and optimal tuber yields were produced with the higher daily water use rates. While it may seem that these results advocate increased water applications, what really is necessary is intensified and improved water table management. When producers use subirrigation, they must make frequent decisions as to whether to irrigate or drain fields as a result of rainfall causing water table depths to fluctuate greatly. The ability to effectively perform both tasks is essential. This may mean the use of alternative irrigation or drainage systems. The use of corrugated plastic drain pipe instead of mole drains is one possibility for improved drainage (Lucas, 1982). Microirrigation systems are currently being commercially evaluated as an irrigation system alternative. The daily water use information from this study is essential for scheduling microirrigation applications to take full advantage of its water conserving potential. In addition, these results provide essential data to water regulating agencies for making science-based decisions in allocation of water amounts needed for caladium production.

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