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TUBER PRODUCTION OF CALADIUM CULTIVARS GROWN IN A SANDY SOIL[1,2]

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Abstract. **Seventy-eight** Caladium **x** hortulanum **Birdsey cultivars were grown from 1-inch diameter chips in Myakka fine sand during 1981 and 1982. Tubers produced were weighed, graded, and categorized by shape. Market value of each cultivar was determined based upon grade and number of marketable tubers produced. Cultivars with highest yields, by weight, were 'Ivory,' 'Aaron,' 'Candidum,' and 'Sea Gull,' while those with lowest yields were 'Ace of Hearts,' 'Etta More,' 'Madam Truall,' and 'Zo Munson.' Number of marketable tubers harvested per 10 chips planted ranged from 7.4 ('Madam Truall') to 22.5 ('Ivory'), and market value extremes were represented by these same cultivars.**

Caladiums, tropical ornamentals grown for their multicolored foliage, are popular landscape and potted plants. Grown primarily from tubers produced almost exclusively in the muck soils of the Lake Placid-Sebring area of central Florida, the 110 cultivars propagated commercially in 1979 (8) are available in a multitude of leaf colors and patterns, plant heights, and leaf shapes and sizes (1). Although information is available on curing, storing, and forcing of caladiums (2, 3, 4), little is recorded on tuber yield of the various cultivars when grown from "chips" (tuber pieces). When harvested, tubers are grouped into grades according to size (1): Super Mammoth ($\geq$4.5 inches); Mammoth ($\geq$3.5 $<$4.5 inches); Jumbo ($\geq$2.5 $<$3.5 inches); No. 1 ($\geq$1.5 $<$2.5 inches); and No. 2 ($\geq$1.0 $<$1.5 inches). An additional grade of No. 3 ($\geq$0.75 $<$1.0 inches) is occasionally used but most growers utilize tubers within this grade as "seed pieces" for planting the following spring (6).

Composite yield data of 'Candidum' chips dissected from Jumbo, No. 1, and No. 2 tubers and grown in muck soils indicated that tubers dug could be graded into 1.8% Mammoth, 11.2% Jumbo, 40.0% No. 1 and 36.0% No. 2 tubers (6). Although caladiums are not normally produced in sandy soils, a recent investigation showed that chips of 'Candidum' planted in muck soils or on raised beds of Myakka fine sand produced tubers of good size, number, and quality in both soil types (5). No direct comparisons were made between the muck and sand cultures in this study but the data indicated that equivalent yields could be anticipated if the best management practices were utilized (5).

Objective of this study was to determine the yield of the commercially available caladium cultivars when grown from chips in a sandy soil in central Florida.

Materials and Methods

General. Jumbo tubers of 78 caladium cultivars were dissected in 1981 and 1982 into 1-inch cubes which contained healthy, active meristematic and fibrous cortical tissue and were dusted with cis-N-((trichloromethyl)thio)-4-cyclohexene 1,2-dicarboximide (Orthocide®) 1 day prior to planting in raised beds of Myakka fine sand at Bradenton, FL. Dolomite (1.0 ton/acre), superphosphate (0.5 ton/acre), and FTE 503 minor element mixture (30 lb./acre) were broadcast and incorporated into the soil during April. Raised beds were constructed 6 inches high and 30 inches wide on 4.5-ft centers 2 wk prior to planting. Fertilizer application to the beds consisted of 6-6-6 (30% organic) broadcast at 25 lb. N/row acre and 18-0-25 placed in a 2-inch wide band down the center of the bed at 225 lb. N/row acre. Beds were then fumigated with methyl bromide (67%)/chloropicrin (33%) at 350 lb./broadcast acre. Fumigant was injected through 3 shanks spaced 8 inches apart and 6 inches below the bed surface. White/black laminated polyethylene mulch (1.25 mil) was sealed over the bed immediately after fumigation. Beds were subirrigated by lateral ditches spaced 42 ft apart.

Holes (2-inch diameter and 3.5 inches deep) were punched through the mulch to allow planting by hand of 2 rows of chips 16 inches apart across the bed and 6 inches apart down each row. Tubers were dug, placed in polyethylene mesh bags, and air dried. After 2 months of storage, tubers were cleaned of excess sand and dried roots, weighed, and graded. Grades used were: Super Mammoth, Mammoth, Jumbo, No. 1, and No. 2. Tubers were also categorized as to type: solid (1-2 dominant growths and not segmented); intermediate (3-5 dominant growths and several segments joined together); multi (5 growths and many segments, often loosely attached). A tuber production value for each cultivar was determined by use of the following formula: (n #2's)+(2n #1's)+(4n Jumbos)+(8n Mammoths)+(12n Super Mammoths), where n = number of tubers in each grade.

The experimental design was a split-plot with years the main plots and cultivars the subplots. Each cultivar was replicated 3 times with 10 chips per experimental unit.

1981. Tubers were provided by commercial caladium propagators from the Lake Placid-Sebring area of central Florida and chips were planted on May 5. Tubers from replications 1, 2 and 3 were dug on January 18, 19, and 20, 1982, respectively.

1982. Tubers of the 78 cultivars harvested from the 1981 planting were dissected on May 12 and planted on May 13, 1982. Tubers from replications 1, 2 and 3 were dug on January 10, 11, and 12, 1983, respectively.

Results and Discussion

The 1982 season had less rain in May and June than comparable months in 1981 and this water deficiency early in the growing season is reflected in the reduced weight of the tubers dug (Table 1). Although not significantly differ-

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ent due to variability among the cultivars, the 1982 tubers were 7.5 oz/plot lighter than those of 1981. Seed pieces were slow to germinate in 1982 and many of the first leaves were burned by the sun and failed to develop. Few leaves were produced until the normal rainfall began in July, whereas in 1981 the plants were almost overlapping by the middle of July. Tuber size was also affected by the lack of early rainfall, with most of the cultivars producing more but smaller tubers in 1982 than in 1981. Rather than being fused into single large units, the tubers dug were loosely segmented and separated into more No. 1's than Jumbos or Mammoths.

Tuber production of the individual cultivars is recorded in Table 2. Weight of tubers produced per 10 chips planted ranged from 7.0 to 128.4 oz, represented by 'Madam Truall' and 'Ivory,' respectively. Total tuber weight/plot of 31 of the cultivars was less than 30 oz and only 13 of 78 cultivars produced tubers greater than 70 oz/plot. Four of the 5 heaviest tuber producers have predominantly white leaves ('Ivory,' 'Candidum,' 'Sea Gull,' and 'Aaron'). The lance leaved cultivars, such as 'Red Frill' and 'Etta More,' generally produced lighter tubers than their fancy leaved counterparts. Cultivars with leaves almost a solid color, other than green, such as 'Fannie Munson' and 'Miss Louisiana,' produced small, lightweight tubers. Presumably this is related to the reduced photosynthetic potential of leaves with little green or chlorophyll containing areas. Although leaves of many white cultivars exhibit large white areas when grown under reduced light (2), leaves of these cultivars grown in full sun generally have 50% or more of their surface area green. The green surface area undoubtedly contributes to the production of large tubers. 'Candidum Junior,' similar in color patterns to 'Candidum,' produced whiter leaves and smaller tubers in full sun than 'Candidum' (7). This relationship between highly colored leaves, which are desirable, and small tubers, which are undesirable, is a problem yet to be solved by plant breeders.

Nine of the cultivars produced fewer tubers than the number of chips planted. 'Madam Truall," 'Torchy,' 'Ace of Hearts,' and 'Zo Munson' all yielded less than 9 marketable tubers per 10 chips planted. Most of the tubers dug from these cultivars were no larger than No. 1's. At the other end of the scale 'Ivory,' 'Brandywine,' and 'Lord

Table 1. Main effects of caladium tuber yields from chips grown in Myakka fine sand (Bradenton, FL).

Year	Tuber wt (oz)[z]	No. of marketable tubers[y]	Production value[x]
1981	45.3 a[w]	12.7 a	38.0 a
1982	37.8 a	13.9 a	36.2 a

[z]Mean of 3 replications consisting of 10 seed pieces (1 inch cube) each.
[y]Total tubers No. 2 grade (≧1.0 inch diameter) or larger.
[x]Production value = n #2's + 2n #1's + 4n Jumbos + 8 n Mammoth + 12 n Super Mammoths, where n = number of tubers in each grade.
[w]Mean separation within columns by Tukey's HSD test, 5% level.

Table 2. Tuber production of caladium cultivars grown from seed pieces in Myakka fine sand (Bradenton, FL). Values are means of 1981 and 1982 yields.

Cultivar	Tubers wt (oz)[z]	Number marketable tubers[y]	Tubers by grade (%)[x]					Prod. value[w]	Tuber type[v]
			Super-mammoth	Mammoth	Jumbo	No. 1	No. 2		
Aaron	80.2	17.6	1.0	18.0	26.6	19.8	34.5	59.4	Multi
Ace of Hearts	9.4	8.2	—	—	—	38.8	61.2	11.4	Solid
Attala	33.3	12.6	—	1.2	40.6	42.1	16.0	33.5	Intermed.
Autumn Beauty	15.9	9.8	—	—	5.9	56.0	38.2	16.9	Intermed.
Big Red	28.4	13.1	—	—	14.1	59.8	26.1	26.5	Solid
Billie	23.6	12.0	—	—	25.2	45.8	29.1	26.2	Multi
Blaze	28.4	12.2	—	5.5	26.1	52.0	16.3	32.4	Intermed.
Brandywine	74.0	21.4	2.8	12.8	18.2	28.3	38.0	55.8	Multi
Buck	31.2	11.0	—	4.2	14.7	62.8	18.4	26.8	Solid
Caloosahatchee	47.8	11.6	—	10.4	28.8	39.8	21.1	39.2	Multi
Candidum	102.0	16.1	10.0	25.2	18.6	29.0	17.7	80.6	Multi
Candidum Junior	39.0	16.8	—	1.8	15.8	54.4	28.2	36.6	Multi
Carolyn Whorton	50.8	15.2	—	7.9	33.0	30.2	28.9	40.8	Intermed.
Clarice	23.0	13.2	—	—	6.8	51.8	41.4	22.8	Intermed.
Crescent Queen	45.5	11.7	—	10.0	28.5	35.4	26.1	33.6	Intermed.
Crimson Wave	63.2	14.4	5.2	15.8	22.1	36.8	20.0	55.0	Multi
Dawn	47.4	13.6	2.3	5.8	39.0	40.2	12.7	44.8	Intermed.
Dr. Groover	50.1	12.7	1.2	16.6	27.2	37.2	17.3	44.2	Intermed.
Dr. T. L. Meade	15.2	10.2	—	—	7.6	38.4	54.0	16.3	Solid
Edith Meade	14.8	10.2	—	—	4.6	58.2	37.2	17.3	Intermed.
Etta More	9.5	9.5	—	—	—	32.8	67.2	12.6	Multi
Fannie Munson	29.0	12.2	—	—	17.4	54.1	28.4	25.2	Solid
Festivia	72.2	16.6	3.6	11.2	29.1	37.4	16.9	57.6	Intermed.
Fire Chief	65.2	17.7	—	13.2	24.8	36.6	25.4	52.0	Multi
Fire Nymph	10.4	8.8	—	—	4.4	38.4	57.2	13.2	Multi
Frieda Hemple	45.9	15.4	—	6.1	27.2	45.2	21.4	42.2	Intermed.
Gypsy Rose	50.7	16.5	—	5.7	16.7	56.2	21.4	40.6	Multi
Hortulania	44.3	17.0	5.3	15.0	15.6	36.0	28.2	61.1	Multi
Irene Dank	43.7	14.4	—	6.0	28.2	44.6	21.3	37.8	Multi
Itacarpus	47.1	12.3	—	8.0	19.8	47.6	14.5	36.0	Intermed.
Ivory	128.4	22.6	10.8	20.1	21.8	37.0	10.4	110.0	Intermed.
Jackie Suthers	55.4	13.5	—	3.2	19.7	51.6	15.4	35.2	Intermed.
John Peed	46.4	14.2	—	13.8	24.6	40.2	21.3	43.7	Multi
Jubilee	56.6	11.2	4.6	16.6	46.2	17.8	15.0	49.0	Solid
June Bride	65.4	12.2	4.0	27.2	36.2	23.5	9.1	58.7	Solid
Kathleen	58.0	18.4	0.9	16.4	25.5	44.4	12.7	63.6	Intermed.
Lance Whorton	24.4	13.8	—	—	7.9	51.1	41.0	23.7	Multi
Lee Stokes	77.6	17.7	6.6	10.5	25.4	37.3	20.2	68.7	Multi

Table 2. (Continued)

Cultivar	Tuber wt (oz)[z]	Number marketable tubers[y]	Tubers by grade (%)[x]					Prod. value[w]	Tuber type[v]
			Super. mammoth	Mammoth	Jumbo	No. 1	No. 2		
Lord Derby	71.7	20.6	0.8	13.5	30.0	33.3	22.4	66.6	Intermed.
Madam Truall	7.0	7.4	—	—	—	29.5	70.5	9.4	Solid
Marie Moir	22.4	10.2	—	—	11.8	64.2	24.0	20.8	Solid
Miss Chicago	30.5	14.1	—	2.2	28.5	56.2	13.2	36.2	Intermed.
Miss Louisiana	11.2	9.0	—	—	—	18.2	81.8	12.0	Multi
Miss Muffet	24.0	12.6	—	—	21.3	51.8	26.9	26.6	Multi
Mrs. Arno Nehrling	48.2	17.2	—	1.0	26.2	35.4	32.3	38.7	Multi
Mrs. F. M. Joyner	23.9	13.0	—	—	15.0	53.2	31.8	30.6	Multi
Mrs. F. Sanders	75.0	13.0	3.7	16.0	36.2	26.5	17.6	50.0	Intermed.
Mrs. W. B. Haldeman	39.1	13.7	—	7.2	27.8	46.6	18.3	36.8	Multi
Mumbo	24.7	12.5	—	—	19.8	60.4	19.8	27.5	Multi
Pink Beauty	39.8	14.8	—	10.7	23.0	40.6	25.7	41.1	Multi
Pink Cloud	40.8	12.0	—	1.4	29.2	52.8	16.7	29.9	Intermed.
Pink Gem	11.1	11.0	—	—	1.4	32.2	66.4	15.0	Multi
Pink Symphony	22.8	11.2	—	—	9.8	58.8	31.4	20.7	Intermed.
Poecile Anglais	29.2	11.4	—	—	21.5	60.6	18.2	25.6	Solid
Postman Joyner	26.2	10.4	—	1.6	16.0	46.1	36.3	21.2	Solid
Red Ensign	82.0	13.2	7.2	31.2	14.4	35.0	7.1	67.6	Intermed.
Red Flare	43.0	10.3	1.6	12.3	21.6	33.9	34.6	31.8	Multi
Red Flash	70.6	12.2	—	24.4	45.4	22.2	8.6	51.0	Intermed.
Red Frill	21.9	13.8	—	—	6.0	54.3	39.8	23.9	Multi
Richard Deckard	24.8	12.2	—	—	8.6	62.6	28.8	23.2	Solid
Rosalie	25.6	13.0	—	2.8	21.6	60.6	14.9	31.8	Multi
Rosebud	41.7	13.1	—	10.4	18.0	52.2	19.3	35.8	Solid
Royal White Robe	18.2	12.3	—	—	9.6	47.8	42.6	21.9	Multi
Scarlet Beauty	17.2	10.5	—	—	8.5	48.7	42.8	18.1	Multi
Scarlet Pimpernell	17.9	14.4	—	—	13.8	39.1	47.1	27.0	Multi
Sea Gull	101.2	17.2	5.8	28.8	26.5	24.8	14.0	84.0	Intermed.
Sunburst	70.3	15.2	—	19.4	37.4	28.0	15.4	58.2	Solid
Sunset	62.0	17.8	1.9	13.6	32.0	30.8	21.8	60.8	Multi
Texas Beauty	42.4	13.5	—	4.8	19.7	57.0	18.4	33.6	Solid
Tom Tomlinson	36.6	17.8	—	2.4	16.8	49.9	31.0	38.5	Multi
Torchy	11.1	8.1	—	—	2.2	55.6	42.1	13.4	Solid
Triumph deL. Exposition	62.7	12.0	5.6	13.9	31.7	33.7	15.0	47.0	Intermed.
Tropicana	17.4	9.4	—	1.7	7.8	54.3	36.2	17.9	Solid
White Christmas	66.4	13.2	—	25.6	26.9	34.8	12.8	52.2	Intermed.
White Princess	30.7	11.9	—	5.2	15.2	56.6	23.0	28.2	Multi
White Queen	37.4	11.8	—	—	23.8	62.0	14.2	27.6	Solid
White Wing	30.0	15.2	—	—	9.8	70.6	19.7	30.0	Intermed.
Zo Munson	9.1	8.4	—	—	—	21.0	79.0	10.0	Solid
HSD 5%	12.8	5.3	—	—	—	—	—	8.9	

[z]Mean of 1981 and 1982 plantings of 3 replications each, containing 10 chips (1 inch cubes) per experimental unit.
[y]Number of tubers of No. 2 grade or larger.
[x]Super Mammoth (≥4.5 inches), Mammoth (≥3.5 <4.5 inches), Jumbo (≥2.5 <3.5 inches), No. 1 ≥1.5 <2.5 inches), and No. 2 (≥1.0 <1.4 inches) diameter.
[w]Value = n No. 2's + 2n #1's + 4n Jumbos + 8n Mammoths + 12n Super Mammoths, where n = number of tubers in each grade.
[v]Solid = 1-2 dominant growths and not segmented; intermed. = 3-5 dominant growths and several segments joined together; multi = >5 growths and many segments, often loosely attached.

Derby' had yields of 22.6, 21.4, and 20.6 marketable tubers/plot, respectively. Tubers of these 3 cultivars were distributed in all 5 grades. 'Ivory,' 'Candidum,' and 'June Bride,' all white-leaved cultivars, produced the greatest percentage of Super Mammoth and Mammoth tubers, while 'Miss Louisiana' and 'Zo Munson' yielded 80% No. 2's.

The number of marketable tubers and their grade distribution determine the production value of the cultivars. These values ranged from 9.4 to 110.0, represented by 'Madam Truall' and 'Ivory,' respectively, with a median of 33.2 and a mean of 37.1. A monetary value may be estimated by multiplying the production value by $0.085, which is the approximate wholesale price of a No. 2 tuber in 1983 (unpublished data). Using this figure, tubers harvested from a plot of 10 chips of 'Madam Truall' would have a value of $0.80 while an equivalent plot of 'Ivory' would have a value of $9.35. 'Candidum,' a cultivar used in most research projects and most universally grown by commercial propagators in Florida (8), would yield $6.85 per 10 chips planted. 'Candidum Junior,' which grows shorter and is more proportional to 6 inch diameter pots, would generate only $3.11, less than half that of 'Candidum.'

Selection of cultivars which produce marketable tubers in large quantities and sizes is essential for commercial propagators to maintain a profitable business. Use of these data will allow growers to determine which cultivars will give the most return for their investment. Of course, certain low yield but high demand cultivars, such as 'Fannie Munson,' must be propagated to satisfy the market, even if grown with a low or non-existent profit margin. Comparisons presented might allow substitution of similarly-colored and higher yielding cultivars for those with lower yields.

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SOIL FUMIGATION INCREASES CALADIUM TUBER PRODUCTION ON SANDY SOIL[1]

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Abstract. **Soil fumigation improved tuber production of** Caladium **x** hortulanum **Birdsey cv. Candidum on Myakka fine sand by increasing tuber number and size (grade). However, there was no residual benefit from year to year in soil where fumigation alternated or was repeated each year. In a second test, gross tuber yields, by weight, were increased 227% and 331% by methyl bromide 67%/chloropicrin 33% (MBC) (350 and 435 lb./acre), 105% and 98% by 1,3-dichloropropene (1,3-D) (15 or 30 gal/acre), and 298% by 1,3-D/chloropicrin 17% (35 gal/acre). Supplemental applications of granular formulations of nonvolatile nematicides ethoprop (20 lb./acre), carbofuran (16 lb./acre), or fenamiphos (8 lb./acre) to soil fumigated with MBC (350 lb./acre) did not improve tuber production.**

The muck soil of Highlands County, Florida is the center of the nation's caladium tuber industry. Because muck soil is limited and subsides approximately 1 inch annually under cultivation, a program for producing tubers on sandy spodosols is being developed. When the best available horticultural practices are followed, tuber production on sandy soil can equal or exceed that obtained with present commercial methods on muck (1, 2).

Root-knot nematodes, *Meloidogyne* spp., are major pests of caladiums grown on sand and muck. Christie (1) maintained that some of the most severe root-knot damage in Florida occurs on muck and that nematodes thrived best in fairly loose, well aerated, moderately dry soils. But, probably because of the difference in biological activity and moisture management of the 2 soil types, infestations in sandy soil can be particularly devastating.

The experiments reported here were designed to answer the following questions pertinent to refining the best management practices now evolving through research for tuber production on sands: 1.) Is annual soil fumigation in the best interest of optimum soil productivity and tuber yield increases, 2.) Does the use of certain fumigants over others result in greater tuber production, and 3.) Are supplemental nonvolatile nematicides effective in improving tuber quality and production in fumigated soil?

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Materials and Methods

Cultural practices for managing field preparation, irrigation, bed construction, soil fumigant, fertilizer placement, use of full-bed mulch, and planting stock management were similar in all tests to those published previously (3) for sandy soil. Fumigant rates presented are based on a net acre treated under the plastic mulch; each gross acre of beds on 4.5 ft centers using 3 fumigant streams 12 inches apart, requires 2/3 the rate of the net acre. All yield data were calculated to a base of 1000 ft of a single row planting in which chips were set 4 or 5 inches apart in the row. A production index (PI) to estimate crop value was calculated for each fumigation treatment (3): PI = n #3's + 1.5 n #2's + 6 n Jumbos + 9 n Mammoths + 12 N Super Mammoths, where n = number of tubers in each grade.

Test 1. A crop management system was initiated in 1977 in a field of subsurface irrigated Myakka fine sand to determine the effect of soil fumigation scheduling on caladium tuber production. Treatments in the 1977 and 1978 caladium crops included a preplant application of methyl bromide 67%/chloropicrin 33% (MBC) (Terr-O-Gas 67®) at 350 lb./acre compared with a nonfumigated control plot. In 1979, these treatments were split to establish the following combinations: 1.) Fumigated 1977, 1978, and 1979; 2.) Nonfumigated 1977, 1978, and 1979; 3.) Fumigated 1977, and 1978 but nonfumigated 1979; and 4.) Nonfumigated 1977 and 1978 but fumigated 1979.

Two weeks after 5 replicates of 40-ft long plots were prepared in a randomized block and fumigated, Candidum stock grown commercially the previous year on muck soil were hot water treated (4), hand chipped, and dusted with captan (Captan® 50WP). Eight chips of 'Candidum' were planted through the plastic mulch 4 inches apart in a randomly selected 3-ft section of each 40-ft main plot. Cultivars with other histories occupied the rest of each main plot; these data are not presented herein.

Plots were fumigated April 16, 1979, planted April 30, and harvested January 3, 1980. Plant roots were indexed for severity of root-knot nematode galls immediately after digging, using a scale of 0 to 5 where 0 = no galls and 5 = severe galling. Tubers were air cured for 2 wk and graded (5) by hand. Plant survival, number of tubers in each grade, and total weight of harvest were recorded.

Test 2. Three fumigants at 1 or more rates per acre were evaluated for effects on caladium tuber production on Myakka fine sand in the spring of 1981: 1,3-D (Telone II®) at 15 or 30 gal/acre, 1,3-D/chloropicrin 17% (1,3-D/C) (Telone C-17®) at 35 gal/acre, and MBC at 350 or 435 lb./acre. Treatments were applied in 50 ft plots replicated 4 times in randomized blocks. Fumigants were applied with full-bed mulch on April 8, 1981. 'Candidum' tubers har-