Table 3. In vitro rooting of micropropagated 'Blanc du Bois' shoots.

Rooting treatment	Rooted shoots[z] (%)	Roots per shoot (no.)	Root length (mm)
0	57a	1.7a	6.7a
1μM NAA[y]	70a	2.2a	23.0b

[z]Mean separation within columns by Duncan's multiple range test, 5% level.
[y]Naphthaleneacetic acid.

Table 4. In vivo rooting of micropropagated 'Blanc du Bois' shoots.

Rooting treatment	Rooted shoots[z] (%)	Roots per shoot (no.)	Root length (mm)
0	71a	4.1a	14.1a
Rootone dip	68a	9.1b	17.8a

[z]Mean separation within columns by Duncan's multiple range test, 5% level.

and indole-3-butyric acid. The stimulative effect of auxins on rooting is vividly demonstrated by these data. It appears that such exogenously supplied auxins stimulated root primordia to form during in vivo treatments because more roots developed from auxin-treated shoots. Similarly, auxin probably accelerated the in vitro rooting response since auxin-treated roots were longer (Table 3). In comparing the two, the in vivo method was clearly more efficient because more roots per shoot were formed (9.1 vs. 2.2) and a major tissue culture step was eliminated. Vigorous plants were produced with less time and effort. Elimination of a culture step also reduces possible errors that could spell disaster in commercial production.

This study demonstrated that 'Blanc du Bois' could be readily micropropagated. Because this cultivar does not require grafting to a rootstock (5), micropropagated plants can be planted directly in the field once adequate size has been obtained. The proliferation rate of 4 shoots per apex per 6 weeks in the best treatment is adequate for commercial production since, in practice, apices and nodes of proliferating cultures can be used to establish new cultures and, thus increase culture mass. For example, considering an initial plating of 20 apices that produced 4 shoots with at least 3 nodes every three weeks, over 1,300,000 shoots could be produced in 6 months since each shoot would contain 4 explants (the apex and 3 nodes). These shoots could be rooted and established in liners within an additional 2 months. Thus, successful implementation of micropropagation technology for 'Blanc du Bois' would circumvent shortages in plant availability due to rapid increases in acreage.

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YIELDS AND OTHER CHARACTERISTICS OF MUSCADINE GRAPE CULTIVARS AT LEESBURG

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Additional index words. grape root borer, mechanical harvest, *Vitis rotundifolia*.

Abstract. **Muscadine grape (*Vitis rotundifolia* Michx.) cultivars and selections planted in 1974 were evaluated in a 6-replicate trial on Blanton fine sand with single vine replicates. Vines were spaced 15.5 ft apart in rows 12 ft apart and trained to a modified Geneva Double Curtain system. Fruit was harvested once when most berries on a vine were ripe by shaking into catch frames. Yields, date of harvest, evenness of ripening, soluble solids, percentage dry scar (at pedicel attachment to berry), and ease of harvesting were measured each year from 1979 through 1986. The most productive among 30 cultivars were 'Regale', 'Redgate', 'Tarheel', 'Noble', 'Doreen', 'Carlos', and 'Welder' cultivars, Ga. 3-9-2, and N.C. selections 77-21, 80-74, 154-2, and 184-4. Yields from these cultivars averaged 6.0 to 8.9 t/a. Yields of other cultivars ranged from 0.5 t/a for 'Sugargate' to 5.8 t/ha for 'Dixie'. Mean fruit ripening dates occurred between August 17 and September 13, depending on cultivar. Decline in yields in 1986 was attributed to heavy grape root borer (*Vitacea polistiformis* Harris) infestations. Characteristics are discussed and recommendations are made of Cowart, Dixie, Fry, and Southland as cultivars for fresh market; Carlos, Doreen, and Welder for white wine; Noble for red wine.**

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Muscadine grape growing in Florida dooryards dates back many decades. More recently, with newer cultivars from Georgia (3), Mississippi, and North Carolina (4), commercial production of muscadine grapes is feasible in Florida (5). Several cultivars suitable for fresh fruit (7) and processing (2) are available. Muscadine yield trials were reported at Leesburg (6), Monticello (1, 6), and Fort Pierce (8). The purpose of this paper is to report yields and other characteristics for 8 successive years at Central Florida Research and Education Center, Leesburg and to recommend the cultivars best suited for production based on the trials.

Materials and Methods

A one-acre block of muscadine grape cultivars and selections was planted on Blanton fine sand in 1974 at Leesburg. Cultivars were set in 6 single-vine replicates for each cultivar, with 6 blocks of 30 cultivars each. A modified Geneva double curtain training and trellising system was used. There were 22 cultivars and 8 advanced selections in the test (Table 1). Individual vine records on vigor, weight of pruned wood, fruit yields, season of budbreak (early to late), date of full bloom, harvest date, speed of harvest (seconds per pound), evenness of ripening (percent green, rotted, and marketable fruit), percent dry stem scar on berries, percent soluble solids, and berry size (g per berry) were recorded between 1979 and 1986. Harvest was accomplished with a hand-held blueberry harvester, shaking fruit of a single vine into a catch frame. Beginning in 1982 sticks were used to knock the fruit off the vine into the catch frame since by then the arms were too thick to be vibrated satisfactorily by the blueberry harvester.

Results and Discussion

Although fruit yields varied from year to year, differences due to cultivar were highly significant, ranging from 0.5 ton to 8.9 tons per acre for the 8-year period (Table 2). The most productive (6.0 to 8.9 t/a) of the 30 cultivars were Regale, Redgate, Tarheel, Noble, Doreen, Carlos, and Welder cultivars along with selections Ga. 3-9-2, N.C. 184-4, N.C. 77-21, N.C. 80-74, and N.C. 154-2. Unacceptably low yields (<4 t/a) were harvested from Watergate, Hunt, Creek, Dearing, and Sugargate cultivars and U.S. selection 42-12B. Among female cultivars, yields ranged from 0.5 ton for Sugargate to 5.3 tons for Jumbo with a mean yield of 4.1 t/a. Among self-fertile cultivars, yields ranged from 1.6 tons for Dearing to 8.9 tons for N.C. 184-4 with a mean yield of 6.0 t/a.

Muscadine grapes historically ripen unevenly, which is advantageous for U-pick or dooryard use, since ripe fruit is available on the vine over a 3 to 5 week period. However, with once-over harvest for processing or fresh market, it is important that a high percentage of marketable berries ripen at the same time. Cultivars best suited for mechanical harvest also have a distinct abscission layer at the point of berry attachment, which results in a dry stem scar when harvested. Those cultivars having even ripening, relatively dry stem scar, rapid speed of harvest, and >4 tons per acre yields are as follows: Carlos, Chief, Magoon, Southland, Ga. 3-9-2, and N.C. 80-74 (Table 3). Of these, only Ga. 3-9-2 (a female selection) had larger than 5 g berries. For fresh market sales a large berry size is desired. Of the cultivars with >7 g berries and >4 t/a yields, Cowart, Fry, Higgins, Ga. 24-16, and N.C. 184-4 ripened unevenly and had wet scar; Jumbo ripened more evenly but had low solids and wet scar. Those cultivars best suited for processing—Carlos, Doreen, Noble, Regale, Tarheel, and Welder—all ripened evenly, but all except 'Carlos' had a wet scar. The amount of wood pruned from vines is a good indication of vine vigor. Hunt, Dixie, and N.C. 77-21 pro-

Table 1. Cultivars and selections of muscadine grapes in 6-replicate trials in Leesburg, 1974 to 1986.

Cultivar	Requires pollinizer	Fruit color	Origin
Carlos	no	Bronze	N.C.
Chief	no	Black	Miss.
Cowart	no	Black	Ga.
Creek	yes	Black	Ga.
Dearing	no	Bronze	N.C.
Dixie	no	Bronze	N.C.
Doreen	no	Bronze	N.C.
Fry	yes	Bronze	Ga.
Higgins	yes	Pink	Ga.
Hunt	yes	Black	Ga.
Jumbo	yes	Black	Ga.
Magnolia	no	Bronze	N.C.
Magoon	no	Black	Miss.
Noble	no	Black	N.C.
Redgate	no	Red	Ga.
Regale	no	Black	N.C.
Southland	no	Black	Miss.
Sugargate	yes	Black	Ga.
Tarheel	no	Black	N.C.
Thomas	yes	Black	S.C.
Watergate	yes	Bronze	Ga.
Welder	no	Bronze	Fla.
Ga. 3-9-2	yes	Black	Ga.
Ga. 10-6-1	no	Bronze	Ga.
Ga. 24-16	no	Black	Ga.
N.C. 77-21	no	Black	N.C.
N.C. 80-74	no	Black	N.C.
N.C. 154-2	no	Black	N.C.
N.C. 184-4	no	Bronze	N.C.
U.S. 42-12B	no	Black	Miss.

Table 2. Fruit yields during 8 years from 30 cultivars of muscadine grapes at Leesburg, FL.

Cultivar	Tons Per Acre								
	1979	1980	1981	1982	1983	1984	1985	1986	Mean[z]
N.C. 184-4	1.97	7.28	—	6.78	9.81	13.42	12.44	10.54	8.89 a
Regale	7.63	8.23	8.40	9.10	9.09	11.16	9.46	7.01	8.76 ab
Ga. 3-9-2	6.31	9.35	7.17	7.62	8.77	9.53	9.63	9.40	8.47 ab
Redgate	7.28	6.73	8.22	8.48	6.98	10.19	10.02	6.16	8.01 a-c
Tarheel	6.60	6.60	7.06	8.23	8.55	8.54	8.36	5.87	7.48 a-d
Noble	8.22	7.40	8.54	7.34	8.76	8.36	6.30	3.40	7.29 a-e
N.C. 77-21	7.25	7.39	7.01	6.65	7.90	8.65	6.44	5.71	7.13 b-e
Doreen	6.72	6.86	7.41	6.09	5.52	8.14	7.14	4.91	6.60 c-f
N.C. 80-74	6.26	7.28	5.96	7.04	7.58	7.35	5.23	4.84	6.44 c-g
N.C. 154-2	6.24	6.00	5.76	6.37	7.81	8.31	6.76	4.05	6.41 c-g
Carlos	6.24	4.88	6.14	6.83	7.41	10.01	5.71	3.03	6.28 d-g
Welder	7.44	6.17	5.77	4.68	5.19	7.13	7.21	4.45	6.01 d-g
Dixie	5.43	5.89	6.16	4.11	7.78	6.72	6.35	4.10	5.82 d-h
Ga. 10-6-1	5.89	6.12	5.25	5.19	—	—	—	—	5.61 e-i
Ga. 24-16	4.63	4.53	4.95	4.53	5.87	5.87	6.18	6.18	5.34 f-j
Jumbo	4.31	4.67	6.71	3.58	3.78	7.67	7.55	3.97	5.28 f-j
Magnolia	4.79	6.67	6.38	3.83	5.33	5.47	5.49	3.67	5.20 f-j
Southland	5.26	5.47	5.18	5.00	5.43	5.14	3.78	4.53	4.97 f-k
Cowart	4.54	4.48	4.59	3.64	4.98	5.70	6.71	4.94	4.95 f-k
Higgins	5.60	2.38	5.20	5.30	1.94	8.78	7.04	2.67	4.86 f-k
Chief	3.93	5.49	3.75	5.00	4.41	5.87	5.37	—	4.83 f-k
Magoon	4.57	4.63	4.80	4.72	3.99	4.46	6.42	4.11	4.71 g-k
Fry	4.89	3.02	5.39	0.73	2.08	5.33	6.86	4.29	4.07 h-k
Watergate	2.40	3.42	3.31	2.94	4.92	6.37	5.89	2.61	3.98 i-k
Hunt	3.51	4.59	4.22	3.84	4.51	3.68	2.62	4.12	3.89 i-k
Thomas	3.26	2.20	5.34	3.70	3.52	5.32	3.20	2.97	3.69 j-l
U.S. 42-12B	2.40	3.02	3.82	3.04	3.65	4.68	2.59	3.14	3.29 kl
Creek	2.79	4.58	1.46	1.32	1.66	2.61	1.58	—	2.29 lm
Dearing	1.67	2.00	1.44	1.15	—	—	—	—	1.57 mn
Sugargate	0.33	0.35	0.77	0.39	0.33	1.05	0.12	—	0.48 n

[z]Mean separation by Duncan's New Multiple Range Test, 5% level.

Table 3. Mean values for ten different characteristics of 30 cultivars of muscadine grapes at Leesburg, FL.

Cultivar	Fruit yield (t/a)	Pruned wood (lb./vine)	Season of budbreak	Full bloom date	Harvest date	Speed of harvest (sec/lb.)	Marketable fruit (%)	Dry scar (%)	Soluble solids (%)	Berry size (g)
Carlos	6.28	7.5	m.ely[z]	5/16	8/25	6.7	94.4	67.8	16.4	4.8
Chief	4.83	9.7	late	5/26	9/7	8.3	88.6	60.6	18.6	4.1
Cowart	4.95	3.8	mid.	5/16	8/29	5.7	87.6	34.0	16.8	7.4
Creek	2.29	6.4	late	5/29	9/13	13.4	82.3	36.5	16.3	2.9
Dearing	1.57	9.6	m.late	5/22	9/5	13.5	92.1	66.4	20.1	3.8
Dixie	5.82	11.4	m.late	5/16	8/23	8.3	95.6	24.1	19.3	4.9
Doreen	6.60	7.4	mid.	5/19	9/6	5.8	94.1	31.1	18.4	4.0
Fry	4.07	5.5	mid.	5/17	8/26	10.3	81.9	25.6	17.4	10.9
Higgins	4.86	8.1	mid	5/18	8/30	7.1	69.6	35.8	16.3	8.4
Hunt	3.89	21.4	m.late	5/17	8/24	11.7	91.1	8.4	17.0	4.5
Jumbo	5.28	9.6	m.late	5/15	8/30	7.0	90.5	32.3	15.5	11.5
Magnolia	5.20	5.0	ely	5/15	8/23	7.5	76.9	18.9	15.8	5.0
Magoon	4.71	2.8	mid.	5/18	9/1	6.6	95.6	71.5	19.6	3.7
Noble	7.29	6.3	m.ely	5/16	8/28	7.7	97.8	16.8	16.6	3.4
Redgate	8.01	4.3	m.late	5/19	9/3	5.0	94.0	22.6	16.6	5.8
Regale	8.76	6.9	m.ely	5/17	8/23	6.6	96.3	8.5	14.9	5.0
Southland	4.97	5.2	m.late	5/23	8/29	5.2	97.3	87.4	18.2	4.9
Sugargate	0.48	9.1	mid.	5/14	8/17	12.0	86.3	48.0	18.2	8.3
Tarheel	7.48	6.9	ely	5/19	8/26	7.8	98.3	34.8	15.3	2.6
Thomas	3.69	6.1	mid.	5/18	8/23	10.7	93.0	54.8	16.9	4.1
Watergate	3.98	7.7	m.late	5/20	8/26	11.9	79.3	20.9	16.4	6.8
Welder	6.01	4.7	ely	5/13	8/19	7.4	96.0	16.1	19.3	3.9
Ga. 3-9-2	8.47	7.2	m.late	5/21	8/23	5.7	94.9	66.9	16.3	6.3
Ga. 10-6-1	5.61	2.9	m.late	5/20	9/4	4.6	86.1	42.9	16.8	—
Ga. 24-16	5.34	3.3	mid.	5/18	8/28	4.8	86.6	33.0	16.6	8.0
N.C. 77-21	7.13	12.8	m.late	5/18	8/25	6.9	96.4	47.5	16.4	4.0
N.C. 80-74	6.44	7.9	mid.	5/20	8/23	8.1	98.5	50.8	16.0	3.7
N.C. 154-2	6.41	4.2	m.ely	5/20	8/25	7.7	96.6	16.8	17.0	3.9
N.C. 184-4	8.89	—	m.ely	5/14	8/27	6.9	83.9	42.3	15.0	7.9
U.S. 42-12B	3.29	9.7	late	5/22	9/2	10.7	96.8	84.8	18.9	3.7

[z]mid-early

duced an excess of 10 lb/vine each year (Table 3). Cowart, Magoon, Ga. 10-6-1, and Ga. 24-16 produced <4 lb of pruned wood/vine indicating a lack of plant vigor.

Cultivars with >4 t/a yields and soluble solids exceeding 18% were Chief, Dixie, Doreen, Magoon, Southland, and Welder. Jumbo, Magnolia, Regale, Tarheel, and N.C. 184-4 had less than 16% soluble solids.

Based on overall merit the best cultivars for fresh fruit were Cowart, Dixie, Fry, and Southland.

Best cultivars for white wine were Carlos, Doreen, and Welder. Magnolia is used somewhat for wine but ripens too unevenly for once-over harvest. Noble, Regale and Tarheel have produced red wines with good color. The best for red wine was Noble because Noble exceeded Regale and Tarheel in soluble solids. Table 2 indicates that Noble yielded less than Regale and Tarheel but not significantly less over the 8-year period at Leesburg.

Table 4. Mean yields, berry size, and soluble solids for cultivars originating in North Carolina, Georgia, and Mississippi.

Originating state[z]	No. cultivars	Yield (t/a)	Berry size (g)	Soluble solids (%)
North Carolina	12	6.5	4.4	16.8
Georgia	12	4.8	7.3	16.7
Mississippi	4	4.5	4.1	18.8

[z]See Table 1 for origin of individual cultivars by state.

The decline of vigor and yields in many cultivars in 1986 (Table 2) was a mystery until vines were uprooted in late 1986. Roots of all cultivars were infested with grape root borers. An actual cause and effect relationship has not been established, however.

Mean yields based on state of origin of the cultivar placed North Carolina in the lead at 6.5 t/a, Georgia second at 4.8 t/a, and Mississippi third at 4.5 t/a (Table 4). Longstanding interest in breeding high yielding, self-fertile cultivars at N.C. State Univ. accounts for the high mean yields from the 12 cultivars originating in North Carolina (9). The Georgia breeding objective was more for large berries than for high yields, and this is reflected in larger berries but lower yields among the 12 cultivars from Georgia (3). Emphasis was on high soluble solids and flavor in Mississippi, reflected in the last column of Table 4 and in taste panels (7).

Muscadine cultivars with superior berry size for fresh market have been released since the establishment of the 30-cultivar test in 1974. These include black cultivars Alachua (Fla.), Black Beauty and Ison (Ga.), Nesbitt (NC); bronze cultivars Granny Val, Janet, Summit, and Triumph (Ga.); and red cultivar Loomis (Miss., Ga.).

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EFFECT OF IRRIGATION ON LEAF WATER POTENTIAL, GROWTH AND YIELD OF MANGO TREES

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Abstract. **An experiment was conducted in a commercial 'Tommy Atkins' mango (*Mangifera indica* L.) orchard during the spring and summer of 1988 to determine the effect of irrigation on tree growth and yield. Eight-year old mango trees were subjected to three levels of irrigation between 28 March and 10 May using a solid-set sprinkler system. All trees were irrigated on March 28. Thereafter, the three treatments consisted of: trees irrigated at approximately 7-day intervals (7DI), 10.06 cm (3.96 inches) total irrigation; trees irrigated at approximately 14-day intervals (14DI), 3.35 cm (1.32 inches) total irrigation; and trees receiving no irrigation (NI). The orchard received 7.62 cm (3.0 inches) of precipitation during the experimental irrigation period. Irrigation treatments were discontinued on 10 May, shortly before the beginning of the rainy season. Predawn water potential of the 7DI trees remained nearly constant at –3.0 bars while predawn water potential of the NI trees decreased over time, but was never less than –5.0 bars. Predawn water potential of the 14DI trees fluctuated between that of the 7DI and NI treatments. There was some variability among treatments in net photosynthesis and transpiration, but irrigation generally had no effect on these variables. There were no differences in shoot growth among treatments. The NI trees had the smallest fruit on most harvest dates and total yield of the 14DI treatment was reduced relative to the 7DI treatment. The 7DI trees had the largest fruit for most harvest dates and the greatest yields on the earlier harvest dates. This may be advantageous since Florida mango market prices are highest early in the season.**

Mango is one of the world's most widely planted fruit crops, and is grown in over 87 countries (3). In the United States, mango production is centered in Dade County, Florida, where approximately 1,000 hectares produced a crop valued at $4,500,000 in 1986 (4). Mango acreage and production in Dade County has been increasing in recent years (4).

Although mangos have a long history of cultivation (22), there is little scientific basis for irrigation scheduling for this crop. In Dade County, mango fruit set and early fruit development occur from February to May. Soil moisture deficits are common during these months due to low precipitation rates, high evaporative conditions and poor moisture-holding capacity of the native soils (10, 17, 18). Despite these conditions, many growers do not irrigate at that time of year.

Water stress can adversely affect fruit growth (2, 8, 9, 12, 15), since cell growth and cell wall synthesis are sensitive to even slight reductions in plant water status (13). Although several studies indicate that irrigation increases yields in subtropical evergreen fruit trees (1, 2, 9, 11, 12, 14, 15), there are conflicting reports regarding the need for irrigation in mango. Several reports indicate that established mango trees are relatively drought tolerant (6, 7, 20, 22, 26). However, Marloth (19) observed a reduction in the current season's vegetative growth, on which the following season's crop is borne, due to water stress. Yan and Chen (25) found that vegetative growth and photosynthesis of potted mango trees were reduced when soil moisture content was below 40%. Panicle development, fruit set and fruit growth of mango increase with adequate soil moisture (2, 21, 24, 26). In Egypt, Azzouz et al. (2) reported that mango fruit number and fruit size increased with increasing irrigation frequency. In Florida, Young and Sauls (26) observed no yield differences between irrigated and non-irrigated mango trees except in very dry years. However, one Florida mango grower reported increased yields due to larger fruit size in irrigated trees (K. Mitchell, personal communication). The objective of this study was to determine the effects of irrigation on leaf water potential, vegetative growth and yield of mature mango trees under South Florida conditions.

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