Table 3. Comparison of fruit yield from papaya plants in field experiment No. 2, inoculated with PRV HA 5-1 mild strain of papaya ringspot virus.

	Protected w/PRSV HA 5-1[y,w]			Unprotected[x]		
Month[z]	Symptomless fruits (kg)	Spotted fruits (kg)	Yield (kg)	Symptomless fruits (kg)	Spotted fruits (kg)	Yield (kg)
February	162	0	162	0	136	136
March	261	0	261	0	122	122
April	663	0	663	0	139	139
May	872	0	872	0	218	63
June	920	81	1000	0	168	168
Total	2877	81	2958	0	783	783

[z]A total of 272 papaya plants were planted in June 1985.
[y]Means of 136 papaya plants from two protected blocks with PRV HA 5-1.
[x]Means of 136 papaya plants from two unprotected blocks.
[w]Papaya seedlings were mechanically inoculated with an inoculum P suspension of PRV HA 5-1 and carborundum, by a DeVilibiss paint spray gun attached to an air compressor.

Disease incidence on papaya plant used in the field experiments inoculated by the cotton swab and the pressure spray were not noticeably different. No noticeable leaf injury was noted from the spray guns as reported by Wang et al. (12). However, under commercial practice the swab would be slow and the chance of missing a seedling in the tray would be higher than with the gun which is passed over the seedlings twice.

Based on these successful results cross-protection of PRV by mutant PRV HA 5-1 could be a highly effective method of protecting papaya plantings against the virus. Further tests are warranted.

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Proc. Fla. State Hort. Soc. 100:296-300. 1987.

EARLY-FLOWERING, EARLY-RIPENING BLUEBERRY GERMPLASM FOR CENTRAL FLORIDA

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Additional index words. Vaccinium, blueberry breeding, highbush blueberry.

Abstract. **The mild winter of 1986-87 and subsequent early spring made it possible to screen the wide range of blueberry germplasm at the University of Florida Horticultural Unit in Gainesville for clones with possible adaptation farther south in the state. A number of crosses produced seedlings that combined early leafing, early flowering, early ripening, and high fruit quality. Backcrosses of the type [highbush x *Vaccinium darrowi* Camp] x highbush, where both highbush parents were lowchill Florida selections, appeared most promising. Crosses between a lowchill highbush cultivar from North Carolina ('O'Neal') and Florida highbush clones also produced many promising selections. The earliest-ripening selections with commercial-quality fruit from these and other crosses ripened about 14 days before 'Sharpblue' and 'Flordablue' at the Horticultural Unit in Gainesville, and reached the commercial first picking stage about 20 Apr.**

Florida Agricultural Experiment Station Journal Series No. 8702.

At present, most commercial blueberries in Florida are grown from Marion County north (2). Some small experimental plantings have been made farther south. These have had varying levels of success, but it is too early to assess with confidence the potential of blueberry culture in central Florida. Some of the problems encountered have been due to insufficient chilling received by some of the cultivars tested. Lack of chilling has resulted in low yields from most rabbiteye (*V. ashei* Reade) cultivars (4) and has somewhat delayed the flowering dates of 'Sharpblue' and 'Flordablue', making them ripen later than they would with more chilling.

Excellent market potential makes it desirable to extend blueberry culture into central Florida. The urban centers from St. Petersburg northeast through Tampa, Orlando, and Daytona Beach offer possibilities for U-pick marketing. In addition, areas which seldom have temperatures below 28°F after 15 Feb. could market fresh blueberries by 15 Apr. if the proper cultivars were available. The national and international markets for fresh blueberries are currently completely open to any area that can ship blueberries before 1 May when 'Sharpblue' begins to ripen in north Florida. High prices received on the national and international markets for 'Sharpblue' during recent years indicate that April blueberries could be quite profitable if they could be produced.

Production of blueberries in April will require a combination of the right environment with the right cultivars. Cultivars bred to flower and ripen early will be unsuccessful in locations that receive killing freezes in late February and early March in more than 1 year out of three. Conversely, areas relatively free of late freezes cannot produce April blueberries with cultivars that are genetically programed to flower in March and ripen in May.

The blueberry breeding program in Gainesville has assembled over the past 10 years a large collection of blueberry cultivars, hybrids, native species, breeding lines from other southeastern states, and selections from crosses made in Gainesville (5, 6, 8). Weather conditions during the winter of 1986-87 and spring of 1987 provided an unusual opportunity to screen this diverse germplasm for clones with the potential to ripen in April if grown in milder areas farther south. This paper describes the results of this evaluation.

Materials and Methods

The plants studied were in the blueberry breeding nurseries at the University of Florida Horticultural Unit 10 km northwest of Gainesville. Except for the random seedlings described in Table 3, which were grown at a 15 cm x 40 cm spacing, the plants were spaced at 4 m x 1.5 m. The plants that were evaluated ranged from 4 to 15 years old and were growing under good conditions of soil fertility, moisture, and mulch. Overhead irrigation was used on one cold morning in March and five cold mornings in early April to prevent freeze damage to flowers and fruit. Fruit were thinned by hand in March wherever necessary to prevent overfruiting.

The plant material studied included the Florida native species *V. ashei* (rabbiteye blueberry), *V. corymbosum* L. (Florida native highbush selections), and *V. elliottii* (Chapm.) Small. Rabbiteye and highbush cultivars and breeding lines were also studied. The cultivated highbush that are adapted to Florida are complex interspecific hybrids involving (most importantly) *V. corymbosum*, but, also to a lesser extent, *V. angustifolium* Ait. and *V. darrowi* (1971). Various interspecific hybrid populations were studied. These were mainly F_2 highbush x *V. elliottii* or backcrosses with the makeup [highbush x *V. elliottii*] x highbush and [highbush x *V. darrowi*] x highbush. The highbush clones used in these crosses were low-chill Florida cultivars and breeding lines. The *V. elliottii* was from the Santa Fe River in Alachua County and the *V. darrowi* from the Winter Haven area and from the Ocala National Forest (3). Seven F_2 populations of highbush cultivars x selected wild Alachua County *V. corymbosum* (7) were studied (Table 3). None of the F_2 populations used in this study were true F_2's obtained by self-pollinating F_1 plants, but rather were produced by crossing different F_1 plants of similar but distinct parentage. True F_2 blueberries are weak due to inbreeding depression and are distinctly inferior to "quasi-F_2's" such as those used in this study.

Most of the seedling populations on which data were gathered consisted, not of random seedlings, but rather of plants that had been selected from much larger populations in previous years based on desirable fruit and plant characters and on early fruit ripening. Thus, the populations studied were already highly enriched in early-ripening clones of good fruit quality compared to random seedlings from the various crosses. Exceptions are found in Table 3 where all but the first and the last two populations consisted of random, unselected seedlings.

Data were taken on time of flower development (Tables 1, 2, and 3) and on dates of flowering, leafing, and fruit ripening and on fruit quality (Table 4). The flower development data in Tables 1, 2, and 3 were taken on 12 Feb., one day after the last freeze in the test plots (later freezes were prevented by overhead irrigation). A stage of flower development termed "stage 4" (illustrated by Spiers, 12), in which individual flowers first become distinguishable and the corollas are first visible, was used to measure earliness of flower development. The percentage of all flower buds that had reached or passes stage four by 12 Feb. was recorded for 19 rabbiteye and five highbush cultivars (Table 1). Seedling and ramet (vegetatively propagated clonal) populations from various crosses and cultivars were studied to record the number of plants with various levels of flower development on 12 Feb. (Table 2). Seedling populations from various low-chill crosses and species were examined to determine the frequency of very early flowering seedlings, which were defined as plants on which more than 70% of the flowers were at or past stage four by 12 Feb. (Table 3). A large population of highbush selections from previous years were evaluated throughout the spring of 1987 for flowering date, leafing date, ripening date and fruit quality. Thirty one selections, whose characteristics are given in Table 4, were selected for further testing as possible early-ripening, low-chill blueberry cultivars. Also selected for further testing were 10 seedlings (FL 87-215 through FL 87-224) from backcross-1 populations consisting of 75% highbush genes and 25% *V. darrowi* genes.

Results and Discussion

A number of crosses produced seedlings with commercial quality berries that ripened before the fruit of all cultivars (Table 1). The earliest seedlings ripened 16 days before the earliest cultivar, 'Sharpblue'. The cultivar 'O'Neal', which was developed in North Carolina from a cross between a Florida highbush and a northern highbush breeding line, produced a number of early offspring, particularly when crossed, with 'Sharpblue' (Table 1). Crosses of 'O'Neal x Florida highbush cultivars tended to produce seedlings with high vigor. Unfortunately, 'O'Neal' is somewhat susceptible to blueberry cane canker disease caused by the fungus *Botryosphaeria corticis* (Demaree and Wilcox) Arx and Muller, the primary control for which is varietal resistance. Some seedlings that otherwise would have been

Table 1. Characteristics of four low-chill, early-ripening highbush cultivars and of 31 seedling selections that ripened before 'Sharpblue' at the *Horticultural Unit* in Gainesville in 1987.

Clone	Origin[z]	Date 50% ripe	Flower[y] % open 3/3	Plant and fruit qualities[x] Leafing 3/31	Size	Color	Scar	Firm	Flavor	Vigor
Sharpblue	A	5/9[w]	80	8	8	5	6	6	8	8
Flordablue	A	5/9	90	7	8	7	6	6	8	7
O'Neal	A	5/15	70	5	8	6	9	9	8	8
Georgiagem	A	5/21	1	8	8	8	4	5	8	6
87-109	B	4/23	100	8	7	3	8	6	7	6
87-76	C	4/24	90	9	5	2	9	9	7	9
87-77	C	4/28	90	9	5	4	4	5	6	9
87-122	B	4/29	100	8	8	3	8	8	9	8
87-135	C	4/30	70	9	7	8	4	6	6	8
87-134	B	5/1	95	7	7	3	8	8	8	9
87-120	B	5/1	80	7	7	8	5	8	8	6
87-136	D	5/1	90	4	9	5	9	9	8	5
87-139-N	B	5/2	100	8	7	4	8	9	8	8
87-84	E	5/2	100	9	8	8	8	9	8	5
87-168	F	5/2	—	8	8	8	8	9	8	8
86-19	G	5/2	70	6	9	6	6	6	9	8
86-7	G	5/2	80	6	6	7	8	8	8	8
86-15	B	5/3	70	8	8	4	9	9	8	8
87-71	H	5/4	95	9	8	5	9	9	5	8
86-22	G	5/4	60	4	9	4	5	5	9	8
86-23	G	5/4	60	5	9	8	9	9	5	7
87-139-S	G	5/5	30	8	8	9	8	9	5	8
87-160	I	5/5	80	8	6	4	9	9	8	8
87-161	B	5/5	80	4	9	4	6	5	8	6
87-137	B	5/5	50	8	8	4	4	5	9	6
86-1	B	5/5	20	6	9	4	7	7	8	8
87-159	B	5/6	100	8	7	4	8	5	8	8
87-162	D	5/6	60	7	6	4	9	7	8	8
87-138	B	5/6	90	7	9	5	9	9	8	9
86-20	G	5/6	10	8	8	8	8	9	6	8
86-25	D	5/6	80	8	8	7	9	9	8	7
86-11	G	5/6	90	7	8	6	8	9	5	9
87-165	G	5/7	5	6	8	4	7	6	8	6
86-24	D	5/7	50	8	8	5	9	6	8	8
86-8	G	5/8	40	4	8	5	9	9	4	9

[z]A = Commercial highbush cultivar; B = 'Sharpblue' x 'O'Neal'; C = FL 81-15 (highbush x *V. elliottii* tetraploid hybrid) open pollinated, most likely F_2 or backcrosses to highbush; D = 'Avonblue' x 'O'Neal'; E = highbush from cross between unidentified Florida clones; F = [Fla. cultivated highbush x Fla. wild *V. corymbosum*] x Fla. cultivated highbush; G = Florida highbush 80-31 x 'O'Neal'; H = ['Harrison' x 'Avonblue'] x 'Sharpblue'; I = 'Bluechip' x 'Flordablue'.
[y]The higher the percent, the earlier the flowering.
[x]Scale 1 to 9 where 9 = early, abundant leafing, very large fruit, very light-colored and durable surface fruit wax, small, dry picking scar, excellent firmness, flavor, and plant vigor.
[w]Month/day.

included in Table 1 were eliminated as susceptible, and a fraction of the clones included in the Table will undoubtedly be discarded later as their lack of resistance becomes apparent.

Another good source of early-ripening seedlings was FL 81-15, a tetraploid F_1 hybrid between a Florida cultivated highbush breeding clone and a wild *V. elliottii* plant selected from Alachua County. Open-pollinated seedlings of this clone had excellent vigor, very low-chilling requirement, and early ripening, but the fruit tended to be small, dark, soft, and seedy. The best of these seedlings were included in Table 1.

One other interspecific hybrid combination, [Florida cultivated highbush x *V. darrowi*] x Florida cultivated highbush, produced excellent seedlings which leafed, flowered, and ripened very early, and had high quality fruit. Individual selections were not included in Table 1, but the best of them ripened 12 to 15 days before 'Sharpblue' and had large, firm, light-blue fruit of excellent flavor and texture. Ten of the best were selected for propagation and further testing.

Early-season, uniform flowering is necessary to obtain early fruit ripening. Clones vary widely in the number of days required between flowering and ripening (9), but almost all varieties require more than 50 days, given the February through April temperatures normal to central Florida. Tables 2 through 4 describe sources of early flowering seedlings. All these data were taken on 12 Feb., at a time when no commercial rabbiteye or highbush cultivar (Table 2) had more than 30% of its flowers advanced to the point where individual corollas were distinguishable (stage 4).

Early flowering, as measured by early attainment of stage 4 of flower bud development was shown most strongly among the commercial rabbiteye cultivars by 'Chaucer' and 'Beckyblue' and among commercial highbush cultivars by 'Flordablue', 'Sharpblue', and 'O'Neal' (Table 2). Much earlier flower development was shown by both highbush and rabbiteye test selections (Tables 3 and 4). The extent of nongenetic plant-to-plant variation for flower development is indicated in Table 2 by the within-clone variation among ramets (plants derived from rooted

Table 2. Percent of buds with individual flowers distinguishable[z] for various cultivars and selections at the Horticultural Unit, Gainesville, 12 Feb. 1987.

Clone	Type[y]	Percent of flowers
Aliceblue	R	0
Choice	R	0
Powderblue	R	0
Tifblue	R	0
Delite	R	0
Woodard	R	0
Bluegem	R	0
Premier	R	0
Brightwell	R	0
Brightblue	R	0
Climax	R	1
Bluebelle	R	2
Bonita	R	2
Avonblue	H	3
80-150	R	5
Beckyblue	R	20
Sharpblue	H	20
O'Neal	H	20
81-31	R	20
Chaucer	R	30
Flordablue	H	30
83-63	R	30
80-141	R	50
TH 275	H	80

[z]At or past flower development stage four (see text).
[y]R = rabbiteye; H = highbush.

cuttings) of 'O'Neal', 'Sharpblue', and 'TH 275'. Despite some variation among ramets within clones, clones tended to show a uniform response compared to seedling populations.

The cross that produced the highest percentage of seedlings (61.5%) with more than 70% of their flowers at or past developmental stage four by 12 Feb. was FL 80-76 x FL 1-2 (Table 4). The female parent is a 'Sharpblue' x *V. darrowi* hybrid and the male a commercial-quality low-chill highbush line. Many seedlings from this cross were early leafing and produced fruit with surprisingly good size, color, firmness and flavor. *V. darrowi* is an evergreen, drought-tolerant, ornamental species native in Florida as far south as Lake Okeechobee (1, 13). It has no chilling requirement and has a remarkable ability to produce low-chilling hybrids when crossed with high chilling northern highbush cultivars (11).

Early leafing is important in any blueberry variety developed for central Florida. Blueberry seedlings differ markedly in the chronology of leafing and flowering in the spring. Most flower before the leaf buds break dormancy, but some leaf before the flowers open. After mild winters, plants in the first category sometimes flower so much in advance of leafing that the berries ripen before the plant is well leafed (10). This greatly reduces the vigor of the plant and results in fruit of reduced size and quality. Thus, plants that leaf early and well are needed for central Florida, and evergreen *V. darrowi* appears to be a good source of this characteristic.

A problem that has been encountered in breeding early-ripening blueberries and early-ripening varieties of other crops is reduced fruit flavor. In blueberries, fruit of early-ripening varieties tend to be excessively tart when they first become blue. Four measures of berry ripeness: the color change from green to blue, a rise in sugar content, a drop in acid content, and fruit softening are not synchronized in the same way for all genotypes. Selection for earliness has tended to separate the ripening components chronologically. Selection has been for berries that acquire the ripe color while they still have sufficient acidity and firmness to permit mechanical harvest and long-distance shipment. For very early ripening fruit it may be necessary to select against varieties whose fruit look ripe but still have excessive acidity.

Table 3. Number of plants of selected species, crosses and clones at various stages of flower development 12 Feb. 1987 at the Horticultural Unit, Gainesville.

Native seedlings			Hybrid seedlings				Ramets[v] of *V. corymbosum* cultivars			
Flower stage class[t]	ELL[z]	Cory[y]	FL81-15 O.P.[x]	FL80-31 x O'Neal[w]	Avonblue x O'Neal[w]	Sharpblue x O'Neal[w]	O'Neal	Avonblue	Sharpblue	TH275[u]
0				21	9	11				
1			1	1	1	3				
5	3		2	6		3	4	1		
10	3	2	2	1		2	2		1	
20	2		3	1	5	4	4		1	
30	1	1	1	2	2	1	1		2	
40	1	1			2	1				
50	2		3							
60		1	1	1	1	1				1
70	2	1	3			1				
80			1		1	2				1
90		1	4		1	2				7
100			2			3				2

[z]*V. elliottii* selected from Santa Fe River, northern Alachua County, for large fruit.
[y]*V. corymbosum* selected from Alachua County for large fruit and early ripening. One diploid and 6 tetraploids.
[x]81-15 is a tetraploid hybrid of a cultivated low-chill highbush (FL 2-9) x *V. elliottii*. The seedlings were selected in May 1983 based on high vigor, large fruit, and early ripening.
[w]FL 80-31 is a Florida highbush breeding line. 'O'Neal' is a highbush cultivar released from North Carolina. 'Avonblue' and 'Sharpblue' are Florida highbush cultivars. These seedlings were selected in 1982 and 1983 for early ripening and good fruit quality.
[v]Plants obtained from rooted softwood cuttings.
[u]TH 275 is a [highbush x *V. darrowi*] x highbush selection made in Tifton, Georgia.
[t]Class defined as percent of flower buds at or past development stage 4.

Table 4. Genetic composition and percentage of plants having more than 70% of their buds with individual flowers visible for various populations at the *Horticultural* Unit in Gainesville on 12 Feb. 1987.

Population	Percent of genes from[t]: CV ASH	CV HB	W COR	W ELL	W DAR	No of plants examined	% with more than 70% of individual flowers distinguishable
V. ashei selections[z]	100					790	2.7
FL81-21[y] x FL 81-15[y]		50		50		70	47.1
FL81-15[y] O.P.		50 to 75		25 to 50		45	11.1
FL81-13[y] x highbush cv.[x]		75		25		49	16.3
FL81-15[y] x highbush cv.[x]		75		25		116	19.8
FL80-76[w] x FL 1-2[x]		75			25	96	61.5
FL80-75[w] x Avonblue[x]		75			25	105	16.2
FL82-50[w] x F_1 polycross[v]		50	50			56	10.7
FL82-48[w] x F_1 polycross[v]		50	50			38	23.7
FL82-53[w] x F_1 polycross[v]		50	50			33	24.2
FL82-51[w] x F_1 polycross[v]		50	50			49	26.5
FL82-57[w] x F_1 polycross[v]		50	50			37	5.4
FL82-54[w] x F_1 polycross[v]		50	50			46	19.6
FL82-55[w] x F_1 polycross[v]		50	50			24	25.0
V. elliottii selections[u]				100		14	14.3
Native *V. corymbosum*[u]			100			7	28.6

[z]Selected in 1984 and 1985 from large seedling populations obtained by crosses within cultivated *V. ashei.* Selection criteria were large fruit of high quality and early ripening.
[y]FL 81-21, FL 81-15, and FL 81-13 are F_1 tetraploid hybrids from crosses of cultivated highbush x *V. elliottii.*
[x]Low-chill Florida highbush cultivar or breeding line.
[w]Low-chill wild x cultivated selections.
[v]Composite of pollen from F_1 (highbush x wild *V. corymbosum*) clones 82-50 through 82-55.
[u]Selected from Alachua County in 1978 based on early ripening and high fruit quality.
[t]CV ASH = cultivated *V. ashei;* CV HB = cultivated highbush; W COR = native tetraploid *V. corymbosum;* W ELL = native diploid *V. elliottii;* W DAR = native diploid *V. darrowi.*

Conclusion

Blueberries that could be harvested during April would have no competition in the market and would bring excellent prices. Consistent April blueberry production will require particular cultivars grown in particular locations. The locations should not experience killing freezes (temperature below 29°F) after 15 Feb. more than 1 year out of three. In marginal locations, overhead irrigation could be used to reduce damage from late freezes. The cultivars must have little or no chilling requirement, should leaf during or before flowering, should require 60 days or less to go from open flower to ripe fruit given normal springtime temperatures in central Florida, and should have reasonably high yields, good plant vigor, and high-quality fruit. Thirty-one highbush clones that appear to meet the requirements for central Florida cultivars were selected in preliminary tests in Gainesville in April and May, 1987. These will be propagated for further testing in central Florida. The earliest-ripening of these could probably be harvested during the second half of April in average years in relatively warm sites in central Florida.

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