Proc. Fla. State Hort. Soc. 116:21-25. 2003.

BLUEBERRY FRUIT SET AS RELATED TO RELATIVE HUMIDITY IN NORTH-CENTRAL FLORIDA IN SPRING 2003

PAUL M. LYRENE[1] AND JEFFREY G. WILLIAMSON
University of Florida, IFAS
Horticultural Sciences Department
P.O. Box 110690
Gainesville, FL 32611

Additional index words. Vaccinium corymbosum hybrids, pollination, weather

Abstract. **Yields of southern highbush blueberries (*Vaccinium corymbosum*) in north Florida and southeast Georgia were reduced by up to 50% in many fields in 2003 due to poor pollination and fruit set on varieties such as 'Millennia', 'Star', and 'Southern Belle'. Mean daily relative humidity during the flowering period (15 Febrary to 15 March), as recorded at the Alachua station of the Florida Automated Weather Network (FAWN), indicated that 25 of the 29 days of the pollination season in 2003 had above-average relative humidity, and only 4 had below-average relative humidity. Average values for this comparison were based on data from the same FAWN station for the past 4 years. It is hypothesized that poor pollen shed and reduced bee flight due to rain and high humidity were responsible for the poor fruit set. Despite poor pollination and yield reductions on most varieties, some varieties and test selections had excellent fruit set. Small plantings had better fruit set than large plantings, suggesting that bee activity during the few days of good pollination weather was enough to pollinate small numbers of flowers but not large numbers.**

Southern highbush blueberries (complex hybrids between *Vaccinium corymbosum* L. and *V. darrowi* Camp.) are cultivated on approximately 1000 acres in north and central Florida. The plants normally flower from mid-February through mid-March and ripen from early April through late May. The cultivars range from partly to highly self-incompatible. Varieties are inter-planted to promote cross pollination, and 2 to 10 colonies of honeybees per acre are placed in fields during flowering. Native bees, notably southeastern blueberry bees (*Habropoda laboriosa*) and queen bumblebees (*Bombus* spp.) are also important in pollinating blueberries in Florida, but their abundance when needed for blueberry pollination varies greatly from year to year.

Following a cold winter, which provided above-average chilling, flowering was heavy in blueberry fields in north-central Florida during February and March, 2003, and in the absence of freeze damage, prospects seemed excellent for a large crop. By 15 Mar., however, it was obvious in the Gainesville area that many berries on varieties such as 'Millennia' and 'Star' were not developing normally, and by early April, numerous undeveloped berries were falling from many varieties. The purpose of this paper is to describe the fruit set problem that occurred on two large blueberry farms in Alachua County in 2003 and to present data relative to the hypothesis that high humidity during flowering contributed to the poor fruit set.

Materials and Methods

Observations on flowering and fruit set were made on two commercial blueberry farms in Alachua County, Florida, one near Archer and one near Windsor. Both farms are owned and operated by Straughn Farms. Each farm contained approximately 100 acres of blueberries planted on pine-bark beds at the rate of about 1800 plants per acre. The plants ranged in age from 1 to 10 years old on the Windsor farm and from 1 to 5 years old on the Archer farm. Approximately 70% of the Windsor farm and 30% of the Archer Farm consisted of plants that were old enough to be in full production. The farms were fertilized, irrigated, and otherwise managed as recommended for commercial blueberry production in Florida. Honeybees (528 hives at Windsor and 200 hives at Archer) were brought in at the start of bloom to supplement natural populations of bumblebees and southeastern blueberry bees (*Habropoda laboriosa*).

This research was supported by the Florida Agricultural Experiment Station, and approved for publication as Journal Series No. N-02369.

[1]Corresponding author.

Percent open flowers and percent corolla drop were recorded at various times during the flowering period for the major varieties and for numerous test selections. The fields were examined frequently throughout the flowering period to determine whether flower thrips, freezing temperatures, or botrytis flower blight were affecting pollination and fruit set. At several times during the period of berry development, the fraction of the berries that appeared to be developing normally was noted.

Data on mean 24-h relative humidity at the 2 m level were obtained from the internet for the IFAS Florida Automated Weather Network (FAWN) station at Alachua. Flowering data for 2003 indicated that the period from 15 Feb. through 15 Mar. included the days during which most of the flowers of all major varieties could have been pollinated at Windsor and Archer. The mean 24-hr relative humidities for these 29 d in 2003 were compared with climatic normals for the same period. Blueberry pollen sheds poorly from flowers during periods of high humidity, and cloudy, humid weather reduces bee flight. To obtain norms for relative humidity for the period 15 Feb. through 15 Mar., FAWN data from the Alachua station for the four years 2000 through 2003 were used. The data available were mean daily relative humidities at the 2 m level for each day. The four years provided 117 daily means. These were arranged in order from lowest to highest and then were divided into 9 pollination-weather classes, from H+ to L-. The H+ class included those days that had the lowest mean relative humidity and the L- class those days that had the highest mean relative humidity. An attempt was made to set the class boundaries so that each class contained one-ninth of the days, or 13 d per class. Table 1 shows that, because of limitations on the precision of the data, class size ranged from 11 to 15 d. Using the classes, the days of the 2003 pollination season were compared with days of the same period for the previous three years. In addition, each day of the flowering periods of various varieties in 2003 was examined in terms of pollination weather class to see if fruit set differences among the varieties could be explained by relative humidity during their flowering periods.

Late in the fruit ripening season, samples of ripe berries from several varieties were collected from the Archer farm. Mean berry weight and the number of well-developed seeds per berry were determined.

Results and Discussion

Two varieties that represented a large percentage of the total planting on both farms, 'Millennia' and 'Star', had large yield losses due to fruit drop and failure of many berries to size normally (Table 2). The variety 'Santa Fe' also had very poor fruit set, but was not widely planted on either farm. Numerous test varieties not included in Table 2 also suffered large yield reductions due to poor fruit set. At least 500 test varieties of southern highbush blueberry were present in 15-plant plots at the Windsor farm. Most of these had at least some fruit drop or failure of some berries to size normally after pollination, but there was great variation among the varieties. The four numbered test selections listed in Table 2 were included because their high fruit set distinguished them from many varieties and test selections. All the varieties in Table 2 are southern highbush blueberry, except for 'Climax', 'Beckyblue', and 'Bonita' which are rabbiteye (*V. ashei* Reade). The three rabbiteye varieties were inter-planted in one field at Windsor. The southern highbush were inter-planted in alternating rows, with at least 3 varieties in each field.

The plants at both Windsor and Archer entered the flowering season in good health with an abundance of flower buds. The plants flowered heavily and the flowers appeared healthy. The winter of 2002-2003 was unusually cold in north Florida, with almost twice the normal number of chilling hours in Gainesville. Damage from freezes was prevented after 1 Feb. using overhead irrigation. Flower thrips in the blueberry flowers at Windsor were very few before 18 Mar. but became abundant and damaging by 20 Mar. Thrips were not a serious problem during the flowering of the southern highbush varieties on the farms observed for this study. If Botrytis blight was ever damaging at Windsor or Archer, it was only on the latest flowers of the latest varieties.

Pollination weather, as determined by mean daily relative humidity at the Alachua FAWN station from 15 Feb. to 15 Mar., was unusually bad during the flowering season of 2003 in Alachua (Tables 3 and 4). In addition, there were many rainy days during the pollination season (Table 4). Only 3 d out of 29 were in the best 3 pollination-weather classes in 2003, compared to 12, 10, and 11 d for the previous three years. In 2003, 19 d were in the worst three pollination-weather classes, compared to 5, 9, and 8 for the three preceding years.

Examination of the pollination weather on specific days in 2003 relative to the stage of flowering of specific cultivars supports but does not prove the link between poor fruit set and bad pollination weather. For example, 'Millennia', on which only the first-open flowers produced normal-sized berries, had 20% open flowers on 22 Feb., and the only two days with good pollination weather during 'Millennia's' flowering season were 23 and 24 Feb. (Table 4).

Table 1. Description of 9 classes of pollination days based on average percent relative humidity at the Alachua, Florida FAWN location between 15 Feb. and 15 Mar. for 4 years (2000-2003).

Class no.	Class name	Mean 24-h relative humidity	Number of d in class for 4 years 2000-2003	Number of d in class for individual years			
				2000	2001	2002	2003
1	H+	35-58	11	0	5	6	0
2	H	59-68	12	5	2	3	2
3	H-	69-71	13	7	3	2	1
4	M+	72-73	13	7	3	2	1
5	M	74-75	12	5	4	3	0
6	M-	76-77	15	1	3	5	6
7	L+	78-80	14	3	4	4	3
8	L	81-87	13	2	4	2	5
9	L-	88-96	14	0	1	2	11
Total days			117	30	29	29	29

Table 2. Estimated percent of a full crop on various clones at Straughn Farms in Archer and Windsor. Estimates were made at various times after flowering.

	Estimated percent full crop						
Clone	Archer Mar. 25	Archer Apr. 1	Windsor Apr. 7	Archer Apr. 8	Windsor Apr. 12	Windsor Apr. 18	Archer Apr. 20
Millennia	30	20	40	30	30	20	25
Star	60	30	50	50	50	40	40
Windsor	-	50	80	90	90	50	60
Emerald	70	80	90	100	100	-	-
Jewel	80	100	100	-	-	80	100
Sapphire	-	-	100	-	-	-	-
Santa Fe	50	60	5	-	-	-	-
Misty	-	-	-	-	90	-	-
86-19	90	90	100	100	100	90	90
96-96	80	80	100	100	-	100	100
98-358	90	-	100	100	-	100	100
98-363	90	-	100	100	-	100	100
Climax	-	-	-	-	-	100	-
Beckyblue	-	-	-	-	-	50	-
Bonita	-	-	-	-	-	100	-

Several varieties that flowered at approximately the same time as 'Millennia' and 'Star' had excellent fruit set. These include 'Emerald', 'Jewel', and 'Sapphire' as well as the test selections FL86-19, FL96-96 and FL98-358. Berry samples from these varieties were examined for seed content, and nearly all the berries had some well-developed seeds. There are several possible explanations for why these varieties were pollinated sufficiently during the same period that 'Millennia' and 'Star' were not being pollinated. Their flowers may have been unusually attractive to bees, the flowers may have had the ability to set fruit when self-pollinated, and the flowers of these varieties may have shed large amounts of pollen without the assistance of bees.

The number of well-developed seeds per berry from berries harvested during the last 30% of the ripening season at Archer showed that of the five varieties tested, only 'Star' produced large numbers of seedless marketable fruit (Table 5). Of 20 'Star' berries sampled, 12 had no seed. 'Millennia', which had poor fruit set, had between 4 and 25 well-developed seeds in every berry sampled. This suggests that 'Star' can produce marketable fruit even when no seeds are formed but 'Millennia' cannot.

Although both 'Star' and 'Millennia' had much-reduced crops, apparently due to pollination problems, the two varieties behaved quite differently. Both varieties had 20-30% of a normal crop of large berries that ripened early. These early berries constituted nearly the entire crop for the year for 'Millennia'. 'Star', however, after the early, large berries had been harvested, ripened numerous smaller but still marketable berries over a 3 to 4 week period. These late berries had few or no well-developed seeds. Thus, the ability of 'Star' to retain and bring to maturity seedless berries greatly increased its yield in 2003 compared to 'Millennia'. It is estimated that half of the fruit harvested from 'Star' in 2003 on these farms came from seedless or near-seedless berries that ripened 2 to 4 weeks after the seeded berries.

Table 3. Percent open flowers and percent petal fall at various dates at Windsor, Fla. in 2003 and estimated dates of 10% open flower and 80% petal fall (pollination period).

	Percent open flowers				Percent petal fall		Estimated dates	
Clone	Feb. 16	Feb. 22	Mar. 1	Mar. 11	Mar. 11	Mar. 17	10% open	80% petal drop
Millennia	0	20	70	95	40	90	Feb. 20	Mar. 15
Star	0	2	50	100	80	95	Feb. 24	Mar. 11
Windsor	0	0	2	80	5	65	Mar. 3	Mar. 20
Emerald	0	10	80	99	95	95	Feb. 22	Mar. 8
Jewel	1	20	70	98	90	98	Feb. 20	Mar. 9
Sapphire	2	25	70	98	95		Feb. 19	Mar. 6
Santa Fe	0	0.1	40	90	60	98	Feb. 26	Mar. 15
Sebring	0	10	90	99	90	90	Feb. 22	Mar. 8
Misty	—	—	10	90	70		Mar. 1	Mar. 13
86-19	5	20	80	98	90	95	Feb. 18	Mar. 8
96-96	2	30	70	100	98	99	Feb. 18	Mar. 6
98-358	0	30	90	100	95	98	Feb. 18	Mar. 6
98-363	10	80	98	100	98	99	Feb. 16	Mar. 4
90-91	0	1	30	100	50	95	Feb. 25	Mar. 14
Climax	—	—	5	50	5	80	Mar. 3	Mar. 17
Beckyblue	—	—	20	70	40	95	Feb. 27	Mar. 15
Bonita	—	—	0.1	40	0	50	Mar. 6	Mar. 21

Table 4. Pollination weather from 1 Feb. to 25 Mar. 25, 2003 classified into 9 classes (L- = poorest to H+ = best) based on mean 24-hr relative humidity at the Alachua FAWN station and daily rainfall in cm at the Alachua station.

Date	Polination weather	Daily rainfall (cm)	Date	Polination weather	Daily rainfall (cm)	Date	Polination weather	Daily rainfall (cm)
Feb. 1	M+		Feb. 21	L-		Mar. 13	M-	
Feb. 2	H		Feb. 22	L-	2.51	Mar. 14	L	
Feb. 3	H-		Feb. 23	H		Mar. 15	L-	
Feb. 4	L-	0.45	Feb. 24	H		Mar. 16	L	
Feb. 5	H		Feb. 25	M-		Mar. 17	L	0.74
Feb. 6	L+	0.28	Feb. 26	M-		Mar. 18	L+	
Feb. 7	L-	3.77	Feb. 27	L	1.70	Mar. 19	L	
Feb. 8	M+	0.02	Feb. 28	L-	0.65	Mar. 20	L	
Feb. 9	L-	1.45	Mar. 1	L-	4.41	Mar. 21	H	
Feb. 10	M+	0.56	Mar. 2	L	0.04	Mar. 22	M+	
Feb. 11	H		Mar. 3	L-	0.87	Mar. 23	L-	
Feb. 12	H		Mar. 4	L-	2.09	Mar. 24	H	
Feb. 13	H		Mar. 5	L		Mar. 25	L-	
Feb. 14	H-		Mar. 6	M-				
Feb. 15	L+		Mar. 7	L-	0.74			
Feb. 16	L-	5.78	Mar. 8	L-				
Feb. 17	L	0.02	Mar. 9	L-	4.63			
Feb. 18	L+		Mar. 10	H-	0.02			
Feb. 19	L+		Mar. 11	M+				
Feb. 20	M-		Mar. 12	M-				

Other Observations on the Blueberry Fruit Set Problem in 2003

1. Fruit set was not a serious problem in blueberry fields south of Orlando. These fields flowered 2-3 weeks earlier than in the Windsor-Archer area, at a time when the weather was much less rainy. Fruit set was poor on most commercial acreage of southern highbush blueberry in Clinch County, GA (Homerville area), where the flowering period was very wet. Five consecutive days of rain during the second week of April resulted in poor fruit set on 'Croatan', 'Reveille', and 'Bladen' which flowered during that time in eastern North Carolina (Bill Cline, personal communication). Fruit set on later-blooming varieties in North Carolina, such as 'Duke' and 'Jersey', was normal.
2. Fruit set was excellent in the high-density seedling nurseries at the University of Florida Plant Science Unit in Citra and at the University of Florida Horticultural Unit in Gainesville. Both locations are within 30 miles of Archer and Windsor. This can be explained by the relatively

Table 5. Mean berry weights and number of seeds per berry for berries harvested 9 May, 2003 from a commercial planting at Archer, Florida.

Variety	Millennia	Windsor	Star	FL98-358	FL86-19
% of crop already ripe	90	80	90	70	80
Mean berry wt (g)	1.81	1.78	1.41	1.60	1.74
Standard deviation	0.264	0.221	0.092	0.077	0.181
Number of seeds per berry for 20 berries arranged from lowest to highest.	4	2	0	6	2
	5	2	0	6	2
	5	2	0	6	2
	6	3	0	8	2
	6	3	0	9	3
	6	4	0	9	3
	6	4	0	11	3
	6	4	0	12	3
	6	5	0	13	3
	7	5	0	14	3
	9	5	0	16	4
	10	6	0	16	4
	11	6	1	17	5
	11	7	1	18	5
	12	7	1	18	6
	13	7	1	23	6
	14	8	1	24	6
	21	9	1	26	7
	23	13	2	26	8
	25	21	2	31	8

small acreage at both locations, which probably resulted in a high bee number to flower number ratio.

3. In Windsor and Archer, 'Millennia' and many other varieties dropped a large number of undeveloped berries 4-5 weeks after the flowers opened. Many of the berries that appeared to be undeveloped on 'Star' at that time continued on the bush and later ripened late in the season as smaller berries.

4. Several growers in north Florida and southeast Georgia reported that bumblebees and/or southeastern blueberry bees were numerous in blueberry fields before heavy rain fell on February 16, but were almost entirely absent thereafter.

Summary and Conclusions

Reduced fruit set observed on many southern highbush varieties in north Florida and southeast Georgia in the spring of 2003 was probably due, in part, to frequent rains and high relative humidity during the time of flowering. Although pollination weather this bad is not frequent during the period of blueberry flowering, poor pollination is always a possible cause of reduced yields. It is expected that pollination issues will become increasingly important as the size of blueberry farms increases. Ways to minimize pollination problems in blueberries include maximizing the availability and activity of both native solitary bees and honeybees, inter-planting in close proximity highly cross-compatible varieties that shed pollen abundantly, and choosing varieties that are easy to pollinate.