Early and Mid-fall Defoliation Reduces Flower Bud Number and Yield of Southern Highbush Blueberry

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SUMMARY. **Three experiments were conducted in north-central Florida to determine the effects of fall defoliation on flower bud initiation and yield of southern highbush (SHB) blueberry (*Vaccinium corymbosum* hybrid). In 1998, randomly selected upright shoots of mature, field-grown 'Misty' and 'Sharpblue' plants were hand-defoliated at monthly intervals beginning 4 Sept. and ending 7 Dec. In 1999, a similar study was conducted using different plants of the same cultivars. Representative shoots were defoliated at monthly intervals beginning 14 Sept. and ending 15 Dec. Additional shoots were also partially defoliated by removing the distal two-thirds of each leaf at monthly intervals from 15 Oct. through 15 Dec. In a third experiment, 2-year-old container-grown 'Star' SHB plants were completely defoliated at monthly intervals beginning 13 Sept. and ending 15 Dec. In each experiment, control shoots, or plants ('Star'), were not defoliated. Although there were differences among cultivars and years, all cultivars tested demonstrated negative effects on reproductive growth and development from September and October defoliations. For 'Sharpblue', reduced fruit yield from early fall defoliation appeared to be due to fewer fruit set per flower bud. However, for 'Misty', reduced fruit yield from early fall defoliation was the result of large reductions in flower bud numbers as well as fewer fruit set per flower bud. September and October defoliations of 'Star' reduced yields or delayed fruit ripening. Collectively, these experiments demonstrate the importance of maintaining healthy foliage through October in the lower southeastern United States for adequate flower bud initiation and high yields of SHB blueberry the following spring.**

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Florida's long, humid, growing seasons with frequent summer rains are conducive to disease development on blueberry by a number of fungal leaf spot diseases including septoria leaf spot (*Septoria albopunctata*), phyllosticta leaf spot (*Phyllosticta vaccinii*), and blueberry leaf rust (*Pucciniastrum vaccinii*). When uncontrolled, these leaf spot diseases often cause partial or complete defoliation of SHB blueberries by mid-fall (4 to 8 weeks before natural leaf senescence and abscission) (Williamson and Lyrene, 1995). Flower bud induction in lowbush (*V. angustifolium*) (Hall and Luwig, 1961), highbush (*V. corymbosum*) (Hall, et al., 1963) and rabbiteye (RE) (*V. ashei*) (Darnell, 1991) is initiated during short photoperiods. In Florida, Lyrene (1992) concluded that early fall defoliation of 'Aliceblue' RE blueberry reduced flower bud induction either by eliminating photoreceptors, or by lowering carbohydrate reserves, during critical periods. While the effects of premature fall defoliation on reproductive growth and development of SHB blueberry have not been studied, field observations suggest that there are negative effects on both flower bud initiation and yield the following spring. The following experiments were conducted to determine if complete or partial premature fall defoliation inhibits flower bud induction, or reduces fruit yield, of SHB blueberry.

Materials and methods

Two field experiments and one container experiment were conducted in Alachua County in north-central Florida.

1998 FIELD EXPERIMENTS. Mature, field-grown 'Misty' and 'Sharpblue' SHB blueberry plants located in a commercial blueberry farm in north-central Florida were used. The plants had been in the field 7 years and averaged about 1.5 m (4.9 ft) tall. All plants were topped with a mechanical hedger about 15 June to stimulate growth of new upright shoots during mid to late summer. Randomly selected upright shoots were hand defoliated on 4 Sept., 2 Oct., 6 Nov., or 7 Dec. Control shoots were not defoliated. Natural defoliation of control shoots occurred during late December. Each defoliation treatment was replicated 10 times in a randomized complete block design. Blocks consisted of individual plants that contained one replicate (shoot) of each treatment. Since the cultivars were in separate rows, each cultivar was considered a separate experiment and no comparisons were made between cultivars. Flower buds were counted during Jan. 1999, and expressed as number of buds per length of shoot. Fruit were harvested at maturity during Spring 1999. Fruit number, and mean and total fresh weights were determined for all fruit from each shoot.

1999 FIELD EXPERIMENTS. Two experiments ('Misty' and 'Sharpblue') were conducted in a commercial blueberry planting in north-central Florida using different plants of the same cultivars as described for 1998. The plants had been in the field 8 years and averaged about 1.5 m tall. All plants were topped with a mechanical hedger about mid-June as described for the 1998 experiment. Randomly selected upright shoots were selected and hand defoliated on 14 Sept., 15 Oct., 15 Nov. or 15 Dec. Additional shoots were partially defoliated by cutting-off the distal 2/3 of each leaf on 15 Oct., 15 Nov., or 15 Dec. Natural defoliation of control shoots occurred during late December. All treatments were replicated 10 times and arranged in a randomized complete block design with single plant plots as described for 1998. The variables measured in 1999 were the same as in 1998.

1999 CONTAINER EXPERIMENT. Two-year-old 'Star' SHB blueberry plants that were grown in 3-gal (11.4-L) containers outdoors were completely hand defoliated on 13 Sept., 13 Oct., 15 Nov., or 15 Dec. Control plants were not defoliated. Natural defoliation of control plants occurred during late December. Bloom period, and total and mean fruit fresh weights were determined during Spring 2000. There were seven single-plant replications in a completely random design. Data for all experiments were analyzed by analysis of variance and means were separated by Duncan's multiple range test.

Results and discussion

1998 Field experiments. 'Sharpblue' SHB flower bud numbers were not affected by any of the defoliation treatments (Table 1). However, early fall defoliation (September and October) reduced flower bud number of 'Misty' (Table 1). Additionally, the mean number of 'Misty' fruit per flower bud was reduced by defoliation treatments applied on, or before, 6 Nov. For 'Sharpblue', mean fruit number per flower bud was reduced by the 2 Oct. and 4 Sept. defoliation treatments, but not by later defoliation treatments. Reduced total fruit fresh weight was observed for the October and earlier defoliations for 'Sharpblue', and for the November and earlier defoliations of 'Misty'. Reduced total fruit fresh weight appears to be due to fewer fruit per flower bud ('Sharpblue') or a combination of fewer fruit per flower bud and reduced flower bud initiation ('Misty').

1999 Field experiments. No interactions were found between defoliation date and type; therefore, the main effects of each are presented. For 'Misty', all defoliation dates, except 15 Nov., reduced flower bud number compared to controls (Table 2). In general, the number of flower buds for 'Sharpblue' was not affected by fall defoliation. 'Misty' fruit number per flower bud was not reduced by any of the defoliation treatments compared to controls. However, there were more fruit per flower bud for the 15 Dec. defoliation treatment than for the 14 Sept. treatment. For 'Sharpblue', the earliest defoliation (14 Sept.) reduced fruit number per flower bud compared to any of the other treatments. Total fruit fresh weight of 'Misty' was reduced by all defoliation treatments compared to nondefoliated controls. For 'Sharpblue', only the 14 Sept. defoliation reduced total fruit fresh weight relative to the control.

Flower bud number and fruit fresh weight were similar for complete and partial defoliation treatments for both cultivars (Table 2). However, fruit number per flower bud was affected by defoliation type. For 'Sharpblue', mean fruit number per flower bud was less for complete defoliation than for partial defoliation. For 'Misty', the opposite was true. This apparent discrepancy, and in particular the results from 'Misty', are difficult to explain. Fruit number per flower bud was not greatly affected by any defoliation treatment for 'Misty' during 1999 and the small but statistically significant increase in fruit number for complete defoliation compared to partial defoliation may not be important biologically.

The effects of premature fall defoliation on reproductive growth of SHB were similar in 1998 and 1999 but differences were observed between cultivars. During both years, 'Misty' flower bud numbers were reduced most

Table 1. Effect of fall defoliation of individual shoots on reproductive growth and development of 'Misty' and 'Sharpblue' southern highbush blueberry, 1998.

Defoliation date	Flower buds per unit shoot length (no./cm)[z]		Fruit per flower bud (no.)		Fruit fresh wt per unit shoot length ($g \cdot cm^{-1}$)[y]	
	'Misty'	'Sharpblue'	'Misty'	'Sharpblue'	'Misty'	'Sharpblue'
4 Sept.	0.14 b[x]	0.27 a	1.85 c	0.82 b	0.26 b	0.18 b
2 Oct.	0.23 b	0.26 a	1.09 c	0.94 b	0.23 b	0.24 b
6 Nov.	0.34 a	0.21 a	1.83 bc	2.81 a	0.75 b	0.67 a
7 Dec.	0.44 a	0.23 a	2.58 ab	3.01 a	1.45 a	0.95 a
Control	0.38 a	0.18 a	3.15 a	3.73 a	1.50 a	0.67 a

[z]2.5 cm = 1.0 inch.
[y]28.4 g = 1.0 oz.
[x]Means followed by the same letter, within columns, are not significantly different, Duncan's multiple range test, $P \leq 0.05$.

Table 2. Effect of fall defoliation of individual shoots on reproductive growth and development of 'Misty' and 'Sharpblue' southern highbush blueberry, 1999.

Defoliation date	Flower buds per unit shoot length (no./cm)[z]		Fruit per flower bud (no.)		Fruit fresh wt per unit shoot length ($g \cdot cm^{-1}$)[y]	
	'Misty'	'Sharpblue'	'Misty'	'Sharpblue'	'Misty'	'Sharpblue'
14 Sept.[x]	0.05 c[w]	0.05 b	2.68 b	1.50 b	0.22 d	0.11 c
15 Oct.	0.09 c	0.08 ab	5.14 ab	6.94 a	0.87 c	0.59 b
15 Nov.	0.19 ab	0.10 ab	4.44 ab	7.61 a	1.70 b	0.81 ab
15 Dec.	0.16 b	0.11 a	6.35 a	9.20 a	1.89 b	1.09 a
Control	0.24 a	0.09 ab	5.01 ab	8.29 a	2.60 a	0.82 ab
Defoliation type						
Complete	0.13	0.10	6.16	5.30	1.53	0.88
Partial	0.16	0.10	4.49	7.65	1.45	0.73
Significance	NS	NS	*	**	NS	NS

[z]2.5 cm = 1.0 inch.
[y]28.4 g = 1.0 oz.
[x]Only complete defoliation was applied on this date.
[w]Means followed by the same letter, within columns, are not significantly different, Duncan's multiple range test, $P \leq 0.05$.
[ns,*,**]Nonsignificant or significant at $P \leq 0.05$ or 0.01, respectively.

Table 3. Effect of whole-plant fall defoliation on flowering and fruit yield (grams fresh weight) of 'Star' southern highbush blueberry.

Defoliation date	Open flowers (%)			Fruit yield (g/plant)[z]			
	22 Feb.	1 Mar.	15 Mar.	5–24 Apr.	26 Apr. to 8 May	10–23 May	Total
Control	45 a[y]	86 a	99 a	524 a	424 b	54 bc	1001 b
13 Sept.	3 b	16 c	67 b	77 b	848 a	350 a	1275 a
13 Oct.	34 a	57 b	94 a	201 b	309 bc	62 b	571 d
15 Nov.	51 a	89 a	100 a	545 a	229 c	12 c	782 c
15 Dec.	37 a	89 a	100 a	614 a	221 c	9 c	847 bc

[z]28.4 g = 1.0 oz.
[y]Means followed by the same letter, within columns, are not significantly different, Duncan's multiple range test, $P \leq 0.05$.

severely by the earliest (September and October) defoliation treatments. Conversely, 'Sharpblue' flower bud numbers were not affected by any of the treatments in either year when compared to controls. The mean number of fruit per flower bud was reduced by defoliation during both years for 'Sharpblue' and in 1998 for 'Misty'. Early fall defoliation reduced total fruit fresh weight during both years for both cultivars. Reduction in total fruit fresh weight appears to be the result of both reduced flower bud initiation and fewer fruit per flower bud. For 'Sharpblue', the major factor affecting total fruit fresh weight was the number of fruit per flower bud. For 'Misty', flower bud number appeared to be the major factor affecting total fruit fresh weight.

1999 CONTAINER EXPERIMENT. Treatments for this experiment differed from the 1998 and 1999 field experiments in that whole plants, instead of representative shoots, were defoliated. Fall defoliation delayed flowering of containerized 'Star' plants the following spring. By 22 Feb., nondefoliated control plants were approaching 50% bloom while the plants defoliated on 13 Sept. were less than 5% bloom (Table 3). By 1 Mar., bloom for the 13 Sept. and 13 Oct. defoliation treatments were 16 % and 57 %, respectively, compared with nearly 90% for the controls. The 13 Sept. defoliation treatment stimulated a late vegetative growth flush which consisted of many small lateral shoots forming from leaf axils on defoliated canes (data not shown). Flower buds that initiate on shoots that develop late in the summer growing season are known to be delayed in development and anthesis the following spring (Williamson and Lyrene, 1995). The delay in flowering from the 13 Sept. defoliation treatment occurred because most of the flowers from this treatment were located on the late-developing lateral shoots that grew in response to early fall defoliation. Total fruit fresh weight (yield) was reduced by the 13 Oct. and 15 Nov. defoliation treatments compared to controls. Surprisingly, the 13 Sept. defoliation treatment increased total fruit fresh weight compared to any other treatment. Apparently this occurred because the September defoliation treatment caused much budbreak during late September and early October. As a result, numerous side branches developed which initiated flower buds in the newly developed leaf axils. Consequently, most fruit from the 13 Sept. defoliation treatment were delayed in maturity which dramatically reduced total fruit at harvest periods before 26 Apr. Since blueberry fresh fruit prices are much higher in April than in May (VanSickle, 2000), the increase in total fruit yield late in the harvest season from the 13 Sept. treatment is of questionable benefit.

Collectively, these results illustrate the importance of maintaining healthy foliage on SHB plants until late fall in the north Florida area. Although responses varied between cultivars and years, all cultivars tested demonstrated some negative effects on reproductive growth and development from defoliation treatments in September and October. For 'Sharpblue', reduced total fruit fresh weight from early defoliation treatments appeared to be primarily the result of fewer fruit set per flower bud. For 'Misty', reduced total fruit fresh weight from fall defoliation was due to large reductions in flower bud numbers as well as fewer fruit set per flower bud. Early fall defoliations also reduced total fruit fresh weight of 'Star' with the exception of the 13 Sept. treatment, where fruit yields were increased but delayed in maturity compared to controls.

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