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Leaf Removal and Terminal Bud Size Affect the Fruiting Habits of Cranberry

K.D. Patten[1] and J. Wang[2]
Washington State University, Long Beach Research and Extension Unit, Long Beach, WA 98631

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Abstract. **Percentage of fruiting uprights, fruit set, number of fruit per upright, and flower bud formation of 'McFarlin' and 'Stevens' cranberries (*Vaccinium macrocarpon* Ait.) were reduced by removal of old leaves, new leaves, or both on the upright. Results varied slightly, based on which leaves were removed, time of removal, cultivar, year, and bog site. Percentage of fruiting uprights, flowers and fruit per upright, and fruit set were higher on uprights with a terminal bud size >1 mm in diameter in September than for those <1 mm in diameter. Effects were cultivar and site dependent. Terminal bud size of 'McFarlin' was negatively related to the subtending number of fruit and positively related to leaf fresh weight of the upright.**

Fruit set and development of cranberry appears to be limited by carbohydrate resources (Birrenkott et al., 1991). Leaf removal studies by Roper et al. (1992, 1993a) suggest the importance of current-season leaves for fruit set and development. Cranberries usually retain leaves for two seasons. In the continental climate of Wisconsin, leaves below the bud scale scar (old leaves) photosynthesize at only half the rate of leaves above the bud scar (current-season's leaves) and are, therefore, only a secondary source of carbohydrates (Roper et al., 1993a). During the mild winters of the Pacific Northwest, however, significant C accumulation by the old leaves may occur.

Cranberries flower from a mixed terminal bud that is formed during the summer of the previous year (Eck, 1990). Uprights tend to bear biennially (Roberts and Struckmeyer, 1942; Roper et al., 1993b; Strik et al., 1991). It is unclear, however, whether biennial bearing is hormonally controlled or due to a resource limitation (Roper et al., 1993b). Once floral induction occurs, little is known about the factors affecting the rate of flower bud differentiation and how the rate of development may influence production. Lacroix (1926) indicated that differentiation rate was influenced by cultivar vigor and growing conditions.

The objectives of this research were to 1) evaluate the importance of old leaves in the fruiting of cranberries, 2) determine the relationship of fall bud size to fruiting in the following season, and 3) quantify the relationship of leaf area and crop load to floral bud development.

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[1]Associate Horticulturist.

[2]Research Technician.

Materials and Methods

Leaf removal. Two 'McFarlin' and one 'Stevens' cranberry bog were studied in Long Beach, Wash., in 1990–91. There were five leaf removal treatments: control, removal of all leaves after harvest in November (fall-old), removal of all leaves in the spring before budbreak in March (spring-old), removal of just the current-season's leaves after shoot extension in May (spring-new), and a combination of spring-old and spring-new. Treatments were applied to all uprights (≈35/ring) within randomly placed, 10-cm-diameter rings in the bog. The experiment was a randomized complete block with four rings for each treatment. Care was taken during leaf removal not to damage the terminal bud in the fall, terminal meristem in the spring, or the flowers. In 1991–92, a 'McFarlin' and a 'Stevens' bog were studied (same bogs as were used in 1990), but one additional treatment was added: fall-old plus spring-new. All uprights within the rings were harvested in October. The percentage of fruiting uprights, fruit per upright, and fruit set was calculated. In Sept. 1992, the percentage of uprights with an apparent floral bud (based on size) was calculated.

Terminal bud diameter. The same two 'McFarlin' and 'Stevens' bogs that were used for leaf removal also were studied for terminal bud diameter effects. In early Sept. 1990, terminal buds of fruiting and nonfruiting uprights were measured with a micrometer and classified as greater than or <1 mm in diameter. There were ≈30 uprights for each classification on each bog. Each upright was labeled according to bud class. All uprights were harvested in Fall 1991. The percentage of fruiting uprights, flowers and fruit per upright, and fruit set was recorded. In a second study, ≈160 fruiting uprights were collected from one of the above 'McFarlin' cranberry bogs in Sept. 1992. Half of the uprights were from previously fruiting uprights (1991) and half were from previously nonfruiting uprights. Uprights were judged to have fruited previously if they had pedicels below the bud scale scar. For each upright, the number of fruit, diameter of terminal bud, leaf fresh weight, and total leaf surface area (Area Meter–CID, Vancouver, Wash.) were recorded. An additional 100 fruiting uprights were collected from the other previously studied 'McFarlin' bogs. Fruit count and bud diameter were recorded.

Results and Discussion

Removal of old leaves in the fall reduced the percentage of fruiting uprights for one 'McFarlin' and the 'Stevens' bog in 1991 but not in 1992 (Table 1). Fruit set results varied by cultivar and year. For one 'McFarlin' bog in 1991, all leaf removal treatments reduced set; for the other, only the spring-old treatment decreased set. In 1992, fruit set was reduced on 'McFarlin' by treatments that removed both old and new leaves. For 'Stevens' in 1991, fall-old + spring-new and spring-new reduced set, while in 1992 fall-old, spring-new, and spring-old + spring-new reduced set. Fruit per upright were reduced by all leaf removal treatments on both cultivars for both years, except spring-new and spring-old on 'McFarlin' in 1992. There were either no or minor differences in fruit per upright among leaf removal treatments. In 1992, removal of both old and new leaves reduced the percentage of uprights that formed flower buds. With 'Stevens', removal of spring-new leaves also reduced percent uprights with flower buds.

Uprights with a >1-mm-diameter terminal bud in Fall 1990 had a higher percentage of fruiting uprights and flowers and fruit per upright in 1991 than uprights with a <1-mm-diameter bud (Table 2). With 'Stevens', differences in percent fruiting uprights and flowers per upright were significant only at $P \leq 0.10$. Fruit set on 'Stevens' was higher on uprights having the larger buds in the previous fall. For both 'McFarlin' bogs sampled in 1992, the diameter of the terminal bud in the fall decreased linearly with an increase in the number of fruit on that upright (Fig. 1). Leaf fresh weight of the upright was better related to bud size than leaf area of the upright (data not shown). Because there were only minor differences in the relationship between bud diameter and leaf weight for previous fruiting and nonfruiting uprights, data were pooled. Bud diameter (y) increased linearly with leaf fresh weight of the upright (x) ($y = 2.2x + 0.82$, $r^2 = 0.28$; $y = 2.4x + 0.64$, $r^2 = 0.25$; $y = 2.7x + 0.56$, $r^2 = 0.54$ for uprights with 0, 1, and ≥2 fruit, respectively). Only one-third of the variability in bud diameter was accounted for by leaf weight and fruit count of the upright [($y = 0.75 + 0.083$ (fruit number) + 2.3 (leaf weight), $r^2 = 0.36$; $y = 0.8 + 0.086$ (fruit number) + 2.1 (leaf weight), $r^2 = 0.29$ for previously nonfruiting and fruiting uprights, respectively].

These data suggest that old leaves may play a significant role in floral bud differentiation. Removal of leaves in Fall 1990 reduced

Table 1. Effect of leaf removal time on the fruiting habits of 'McFarlin' and 'Stevens' cranberry.

	% Fruiting uprights[z]					% Fruit set					Fruit/upright						
	McFarlin			Stevens		McFarlin			Stevens		McFarlin			Stevens		Uprights with flower buds (%)[y]	
Time and type	Site a	Site b				Site a	Site b				Site a	Site b					
of leaf removal[x]	1991	1991	1992	1991	1992	1991	1991	1992	1991	1992	1991	1991	1992	1991	1992	McFarlin	Stevens
Control	63	80	82	77	80	37	26	50	48	46	1.2	0.6	1.2	1.8	1.3	66	76
Fall-old	41	---	76	51	63	11	---	42	33	28	0.3	---	0.7	0.9	0.6	61	65
Spring-old	46	54	72	53	68	22	14	47	23	33	0.5	0.3	0.8	0.9	0.7	56	51
Spring-new	---	---	---	---	---	18	17	57	32	18	0.4	0.2	1.0	0.9	0.7	52	19
Fall-old + spring-new	---	---	---	---	---	---	---	11	23	32	0.2	0.3	0.3	0.7	0.3	17	18
Spring-old + spring-new	---	---	---	---	---	8	18	11	---	9	---	---	0.3	---	0.3	26	12
$LSD_{0.05}$[w]	18	NS	NS	25	NS	13	11	16	16	17	0.5	0.2	0.4	0.1	0.5	24	24

[z]Analysis was only performed on treatments that did not have leaves removed from the new shoot.
[y]Uprights collected Sept. 1992. Treatments applied Fall 1991, Spring 1992, or both.
[x]Fall-old = removal of leaves below the bud scale scar after harvest; spring-old = removal of leaves below the bud scale scar in March; spring-new = removal of current-season's leaves above the bud scale scar in May; fall-old + spring-new and spring-old + spring-new = combinations of the above.
[w]Protected LSD.
[NS]Nonsignificant.

Table 2. Effect of terminal bud diameter in early Sept. 1990 on the fruiting habits of 'McFarlin' (McFar) and 'Stevens' cranberries in 1991.

	% Fruiting uprights			Flowers/upright			Fruit/upright			% Fruit set		
Bud diam	McFar-a	McFar-b	Stevens	McFar-a	McFar-b	Stevens	McFar-a	McFar-b	Stevens	McFar-a	McFar-b	Stevens
<1 mm	30	35	27	2.2	2.4	2.9	0.2	0.4	0.9	19	25	29
>1 mm	67	64	58	2.7	3.0	3.6	0.5	0.5	1.7	26	31	48
Significance	*	**	0.09	*	*	0.10	*	NS	*	NS	NS	*

[NS, *, **]Nonsignificant or significant analysis of variance at $P \leq 0.05$ or 0.01, respectively.

percent fruiting uprights in 1991. The lack of major differences between fall-old and spring-old treatment effects on fruit set or fruit per upright, however, suggests that old leaves probably make only minor contributions to the C pool during the winter. Old leaves appeared to be similar to new leaves as contributors of carbohydrates during the growing season. There were few consistent differences in fruit set or fruit per upright whether old or new leaves were removed. It would be interesting to determine if removal of new leaves resulted in enhanced photosynthesis of old leaves, beyond what would be expected by improving light interception of old leaves at the bottom of the canopy. Some type of compensation is implied by data presented here and by Roper et al. (1993a) in that major decreases in fruit set, fruit per upright, and flower bud formation did not occur unless both sets of leaves were removed.

We expected that terminal buds that were large in the fall would have a greater chance of fruiting and have more flowers than small buds. However, we were surprised that uprights with the larger buds usually had more fruit per upright and a tendency for increased fruit set compared to uprights with smaller buds. This effect may have been indirect. Our data suggest that large buds in the fall were subtended by more leaves and fewer fruit than small buds. These uprights potentially could have more stored C resources available for fruit set than uprights that had more fruit and fewer leaves during the prior year. Our data also suggest that these uprights probably would have more old leaves available in the spring as a source of new photosynthates. Previous research on cranberries indicates that fruit set rather than flower bud formation or flowers per upright is the limiting yield component (Eaton and MacPherson, 1978; Roberts and Struckmeyer, 1942). Our data imply that the two components may be closely linked.

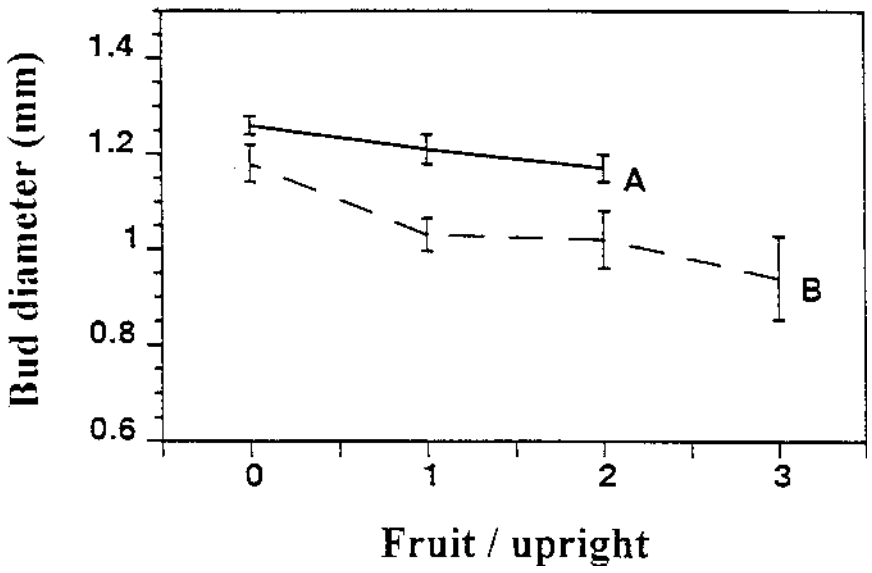

Fig. 1. Effect of fruit count per upright on the diameter of the terminal bud of 'McFarlin' cranberry collected from two bogs in Sept. 1990. (Bog A: y = –0.05(x) + 1.26, r^2 = 0.99; Bog B: y = –0.07(x) + 1.15, r^2 = 0.87; bars = standard error of means.)

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