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Percent Drupelet Set Varies among Blackberry Genotypes

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Abstract. **Twenty-one genotypes of blackberry (*Rubus* L. subgenus *Rubus* Watson) were evaluated for percent drupelet set in 1993 and eleven genotypes were evaluated in 1994. Commercial cultivars were chosen to represent types (trailing, erect, and semi-erect) of blackberries grown in the United States. Secondary fruit were picked when green but developing a red blush during the early- and late-ripening season. Drupelets and pistils per fruit were counted to calculate percent set. In 1994, ripe fruit ranging in size were harvested for 'Boysen', 'Marion', 'Thornless Evergreen', and 'Chester Thornless' and drupelet per fruit were counted. Drupelet set among genotypes ranged from 40% to 86% in 1993 and 39% to 78% in 1994. Most genotypes had a higher percent set on early flowers compared to later ones. Drupelet set and number were not correlated with fruit weight among genotypes. In 'Boysen', 'Marion', 'Thornless Evergreen', and 'Chester Thornless', drupelet number was correlated with fruit weight, although the relationship in 'Chester Thornless' was not as strong as the others. It is unclear what factors limit drupelet set in the genotypes studied.**

The weight of a blackberry fruit is a function of the number of drupelets, the weight of each drupelet, and the receptacle weight. Fruit weight could be increased by increasing one or more of these components. In red raspberry, fruit with many drupelets are firmer than fruit with a similar weight having fewer, larger drupelets (Robbins and Sjulin, 1989). Increased seed weight was also an important factor associated with increased fruit cohesiveness (Robbins and Sjulin, 1989). However, with >95% of the blackberry production in Oregon used for processing, cultivars with large seeds (or receptacles) are undesirable. Larger fruit size, with corresponding higher yields, fruit with small receptacles, and increased fruit firmness are desirable traits for the Oregon processing industry.

The first step in breeding for increased fruit weight is to evaluate the extent of variation for the main components related to fruit weight and, if possible, determine which traits are most important. Drupelet number is a function of the number of ovaries/pistils per flower and the percent drupelet set. Drupelet weight and number, as well as seed weight, vary among blackberry genotypes (Darrow and Sherwood, 1931; Moore et al., 1974). While Moore et al. (1974) studied the relationship between seed (drupelet) number and berry weight in erect blackberries, no one has studied percent drupelet set or compared different types of blackberries (erect, semi-erect, trailing) for this trait.

The blackberry fruit is an aggregation of drupelets that develop independently while adhering to a common receptacle. Although ovule abortion frequently takes place, there is no abscission of the individual blackberry ovaries as occurs in many other types of fruit. Thus, the drupelets and unset ovules can be counted to determine percent drupelet set.

This project was undertaken to study the variation among blackberry genotypes (representing different types of blackberries) for number of set and unset drupelets and percent drupelet set and their relationship to fruit weight.

Materials and Methods

Drupelet set. Blackberry fruit from genotypes of trailing, erect, and semi-erect types of blackberry (*Rubus* L. subgenus *Rubus* Watson) were collected in Summer 1993 and 1994 from a mature cultivar/advanced selection planting at the North Willamette Research and Extension Center, Aurora, Ore. In 1993, 100 secondary fruit at the green/red stage (green fruit developing red blush) were collected from 20 genotypes during the early part of the harvest season. An additional 50 secondary fruit were collected per genotype at a later ripening date. In 1994, 50 secondary fruit at the green/red stage were collected on each of two ripening dates (early and late). Fruit were stored in 90% ethanol until data collection. To determine percent drupelet set, drupelets and pistils (unset ovaries) were counted for each berry by pulling set and unset drupelets off the receptacle.

An additional 25 secondary fruit per genotype were collected at the ripe stage for the first harvest date in 1994, and fresh weight was measured for each. Drupelet weight was calculated by dividing fruit weight by set drupelet number. Thus, drupelet weight also included the receptacle. It was not possible in our study to obtain an accurate weight of each receptacle after drupelet counting.

Drupelet/berry weight relationship. About 100 fruit of the cultivars 'Marion', 'Boysen', 'Thornless Evergreen', and 'Chester Thornless' were collected throughout the ripening season in 1994. Each fruit was weighed immediately after harvest and individually frozen for later determination of drupelet number by pulling partially thawed drupelets from the receptacle.

Data were analyzed by regression and analysis of variance (ANOVA) (SAS Institute, Cary, N.C.) for effects of genotype, harvest date, and year.

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Table 1. Drupelet set of blackberry genotypes for early- and late-season harvests, 1993. Genotypes are arranged in order of decreasing percent drupelet set in early season.

	Early season[z]			Late season[y]		
Genotype	Set drupelets (no.)	Unset ovaries (no.)	% Set[x]	Set drupelets (no.)	Unset ovaries (no.)	% Set
ORUS 840-8	99.5	16.1	86.0	67.3	39.1	62.0
Tayberry	85.4	18.3	82.5	56.6	29.9	64.9
Lincoln Logan	63.7	15.5	80.7	57.5	30.3	64.7
Thornless Evergreen	67.4	17.5	79.5	48.9	22.3	68.6
Waldo	121.8	36.2	77.1	102.2	43.4	70.5
Kotata	77.3	27.0	74.2	66.7	32.0	67.2
Marion	78.9	28.7	73.6	56.0	52.1	52.4
Boysen Clone 5[w]	49.5	21.8	69.4	49.3	28.7	63.4
Clone 34	55.3	26.1	68.1	52.0	26.9	65.4
Clone 43	48.9	28.9	63.0	41.1	27.9	59.1
Riwaka's Choice	57.6	24.6	70.1	51.6	35.2	59.3
Shawnee	80.8	40.8	66.8	75.7	43.7	63.1
ORUS 1826	77.2	41.3	65.3	73.7	44.2	62.8
Chester Thornless	60.9	39.0	62.8	53.6	55.3	49.7
ORUS 830-4	142.7	101.0	60.3	77.1	133.6	40.5
Silvan	47.5	35.4	57.4	54.0	33.5	61.4
Choctaw	86.3	68.5	56.1	67.6	73.9	48.0
Hull Thornless	59.5	46.7	55.8	52.7	50.8	51.0
Navaho	58.2	54.0	53.1	64.2	30.6	67.7
Olallie	49.5	52.7	48.6	41.0	62.0	40.1
LSD ($P < 0.05$)	4.1	4.7	2.9	6.8	8.7	5.2

[z]n = 100 fruit.
[y]n = 50 fruit.
[x]Percent drupelet set.
[w]Clones 5 and 34 were collected from two growers' fields in Oregon. Clone 43 was selected by George Waldo from a grower's field in Oregon. 'Riwaka's Choice' is a New Zealand boysenberry cultivar.

Results and Discussion

There were significant effects for year, date of harvest, genotype, and all interactions for drupelet and ovary number and percent drupelet set. Data for the genotypes studied are presented in Tables 1 and 2 for 1993 and 1994, respectively.

In 1993, drupelet set ranged from 49% to 86% on the first harvest date and 40% to 71% for fruit harvested later in the season (Table 1). Genotypes had a higher percent drupelet set on earlier flowers than later ones ($P < 0.0001$), except for 'Silvan' and 'Navaho' (Table 1). This may have been related to weather conditions, although this trend did not occur under similar temperatures in 1994. The greater amount of precipitation in late Spring 1993 may have reduced percent drupelet set in later flowers (Table 1).

In 1994, drupelet set ranged from 39% to 78% for early fruit and 44% to 74% for later-ripening fruit (Table 2). We do not know why percent drupelet set was lower, in general, in 1994 than 1993.

Table 2. Fruit weight components of blackberry genotypes for early- and late-season harvest, 1994. Genotypes are arranged in order of decreasing percent drupelet set in early season.

	Early season[z]					Late season		
Genotype	Set drupelets (no.)	Unset ovaries (no.)	Set (%)	Avg berry mass (g)[y]	Drupelet mass (mg)	Set druplets (no.)	Unset ovaries (no.)	Set (%)
ORUS 840-8	88.6	24.7	78.3	4.7	53.3	79.1	27.5	72.3
Kotata	67.5	27.8	70.9	5.3	78.3	77.1	27.4	73.8
Lincoln Logan	57.6	24.8	70.5	3.5	60.9	49.1	16.4	74.1
Waldo	106.2	46.8	70.5	4.5	42.6	109.0	47.9	69.9
Marion	64.2	39.1	61.8	4.4	68.4	62.4	40.5	60.1
Shawnee	78.5	53.8	59.4	6.0	76.8	97.0	48.0	66.5
Boysen 43	48.3	34.3	58.2	6.2	128.9	49.5	37.2	57.0
Thornless Evergreen	38.4	31.6	55.4	3.4	87.4	42.0	30.7	58.9
Olallie	62.2	51.5	54.2	4.4	70.8	61.7	50.0	55.1
Chester Thornless	56.2	70.8	44.4	5.1	89.9	56.4	74.0	44.0
ORUS 830-4	95.8	149.7	39.1	7.0	72.9	119.3	137.9	48.0
LSD ($P < 0.05$)	7.0	7.5	4.7	0.6	---	7.4	8.5	4.7

[z]n = 50 fruit.
[y]n = 25 fruit.

Temperatures in the spring were similar; however, a low temperature of –5.5C in February 1994 that caused cold damage and reduced yield (data not shown) may also have adversely affected flower viability or set. Percent drupelet set of red raspberry differed with year and site (Daubeny, 1971). In our study, although differences for percent drupelet set were significant with the genotypes pooled, for many genotypes the total number of pistils per blossom (number set + unset drupelets) did not vary a great deal between years within harvest date. Differences in pistil number may therefore be genetic effects rather than environmental.

The average percent drupelet set in most of the blackberry genotypes in our study was lower than that reported for open-pollinated red raspberry genotypes (Daubeny, 1969, 1971). In Pacific Northwest red raspberry cultivars studied by Daubeny (1969), the percent drupelet set ranged from 84% to 94% on open-pollinated flowers. Possible reasons for the low drupelet set observed in this study include poor self- or cross-compatibility (Perry and Moore, 1985), lack of full female fertility, as has been speculated to occur in red raspberry (Daubeny, 1971), environmental limitations, and source–sink competition within the blackberry fruit.

Trailing blackberries tended to have more pistils per blossom and higher percent drupelet set than erect ('Shawnee', 'Choctaw', and 'Navaho') or semi-erect ('Chester Thornless' and 'Hull Thornless') types in 1993 and 1994 (Tables 1 and 2). The drupelet number per fruit for genotypes studied by other researchers was similar to what we found for 'Thornless Evergreen' in the first harvest in 1994 (34; Kerr, 1954), 'Shawnee' (78; Perkins-Veazie et al., 1993), and late-season 'Choctaw' (71; Perkins-Veazie et al., 1993). However, in our study, 'Lincoln Logan' and 'Navaho' had a higher drupelet number than that found by other researchers ('Logan'; Darrow and Sherwood, 1931; 'Navaho', Perkins-Veazie et al., 1993).

Fruit weight among genotypes in 1994 (Table 2) was not correlated with percent drupelet set, drupelet weight, or number of drupelets (data not shown). However, fruit weight among genotypes was significantly correlated with the total number of pistils (number of drupelets + unset ovaries) per flower ($r = 0.64$, $P < 0.05$). Thus, fruit with a higher number of pistils also had a greater fruit weight. The fact that fruit weight was not correlated with drupelet number or weight among genotypes contrasts the results of Moore et al. (1974), where seed number and fruit weight per seed were correlated to fruit weight in erect blackberry. However, Moore et al. (1974) reported correlations for pooled data of 41 clones. They noted that exceptions, large fruit with few seeds, occurred. In blackberry, receptacle weight may vary enough among genotypes to mask any relationship between drupelet number and fruit weight. It was not possible in our study to obtain an accurate weight of each receptacle after drupelet counting. However, we found that drupelet weight was negatively correlated with drupelet number ($r = –0.75$; $P < 0.01$), as was found by Moore (1993) in red raspberry. As these components are closely tied, it may not be possible to make significant increases in either of these independently.

Within the genotypes studied, however, drupelet number was significantly correlated with fruit weight (Table 3). The relationship between fruit weight and drupelet number was linear for each genotype. The R^2 was highest for 'Marion' and 'Boysen' (Table 3). In 'Chester Thornless', although the relationship was significant, there was greater variability in fruit weight at a given drupelet number. In blackberry, fruit weight is composed of set drupelets, unset ovaries, and receptacle tissue. We speculate that in 'Marion' and 'Boysen' there was less variability in receptacle weight than in 'Chester Thornless' at a given drupelet number.

Table 3. Relationship between berry weight and drupelet number of four blackberry genotypes, 1994, (n = 100 berries).

Cultivar	Regression equation[z]	R^2
Marion	y = 0.07x – 0.06	0.70
Thornless Evergreen	y = 0.05x + 0.96	0.51
Boysen	y = 0.12x + 0.41	0.76
Chester Thornless	y = 0.05x + 1.64	0.34

[z]All linear regression equations are significant at $P < 0.01$. y = Berry weight (g) and x = drupelet number per berry.

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