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‘Puget Crimson’ Strawberry

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‘Puget Crimson’ is a new short-day strawberry (*Fragaria ×ananassa* Duchesne ex Rozier) cultivar jointly released by Washington State University (WSU), Oregon State University, and the U.S. Dept. of Agriculture–Agricultural Research Service (USDA-ARS). ‘Puget Crimson’ has been noted for high yields, very late-season ripening, large size, and excellent fresh flavor. Although suitable for processed uses, fruit of ‘Puget Crimson’ will most likely be used for the fresh market because of its late harvest season and sweet flavor.

Origin

‘Puget Crimson’ was selected from a cross of ‘Schwartze’ × ‘Valley Red’ made in 2003 at WSU Puyallup Research and Extension Center (WSU Puyallup). ‘Schwartze’ was patented (USPP 12,067) and sold under the name of ‘Puget Summer’® (Moore and Finn, 2002). Although ‘Schwartze’ has excellent processing characteristics, it has been used almost exclusively for fresh market where it receives a premium price as a result of ripening very late in the season. ‘Valley Red’ was developed by the USDA-ARS (Finn et al., 2009). ‘Valley Red’ is a high-yielding genotype that produces medium-sized fruit that are very uniform in size and shape. The fruit is primarily suited to processing because of its dark red internal and external color and relative skin tenderness. Seedlings from this cross were planted in the field in 2004. ‘Puget Crimson’ was selected in 2005 at WSU Puyallup and evaluated as WSU 2833.

Performance

Plants in all trials at WSU Puyallup were grown in a matted-row system with plants initially set 38 cm apart within the row in eight-plant plots. Fruit were harvested once a week. The average fruit weight for a season was calculated as a weighted mean based on the weight of a subsample of 25 sound fruit randomly selected from each harvest. Fruit firmness was determined by the force (N) required for a 4-mm-diameter cylinder to penetrate five randomly selected fruit from each harvest to a depth of 6 mm. The average fruit firmness for a season was calculated as a weighted mean. The fruit ripening season was characterized by the cumulative yield for each plot and the dates interpolated from the points when the cumulative yield line reached 5%, 50%, and 95% of the total. In the replicated plantings, data were analyzed as a randomized complete block (PROC analysis of variance; SAS Institute, Cary, NC).

Color of fruit and leaves was measured using a tristimulus colorimeter (Minolta CR-400; Konica Minolta Sensing Americas, Inc., Ramsey, NJ). The analyzer was calibrated to a standard white reflective plate and used CIE (Commission Internationale de l’Eclariage) Illuminant C. Measurements were recorded in L*, a*, b* (McGuire, 1992).

‘Puget Crimson’ was first evaluated in a non-replicated planting established in 2006. In this planting, ‘Puget Crimson’ was among the highest yielding and largest fruited genotypes in the 2007 and 2008 harvest seasons (data not shown). The fruit weight averaged 24.4 g in 2007 and 15.2 g in 2008. Based on its yield, large size, and excellent flavor, ‘Puget Crimson’ was further evaluated in replicated plots with three replications established in 2008 and 2009 at WSU Puyallup. In the 2008 planting, there were no significant differences among the cultivars for yield or fruit weight in 2009, but ‘Puget Crimson’ had the highest yield and had 15.0 g fruit compared with 15.1 g for ‘Tillamook’ (Table 1), which is well known for producing large fruit (Finn et al., 2004). In 2010, ‘Puget Crimson’ did not differ significantly in yield from ‘Puget Reliance’ and ‘Tillamook’, the two highest yielding cultivars. The fruit weight in the second season for ‘Puget Crimson’ was comparable to that for ‘Tillamook’. ‘Puget Crimson’ and ‘Firecracker’ were the two latest ripening cultivars with very similar ripening seasons. In the 2009 planting, ‘Puget Crimson’ continued to have high yields of large, late-season fruit (Table 2).

‘Puget Crimson’ was also tested in replicated plantings by the USDA-ARS at the Oregon State University–North Willamette Research and Extension Center (NWREC) at Aurora, OR, and by Agriculture and Agri-Food Canada at Abbotsford, British Columbia, Canada, with three replications at each site. Other cultivars widely grown in the Pacific Northwest (PNW) were evaluated in the NWREC trial established in 2008, including ‘Tillamook’, ‘Totem’, ‘Sweet Bliss’, and ‘Valley Red’ (data not shown). In 2009, the yield for ‘Puget Crimson’ was 28,721 $kg \cdot ha^{-1}$, statistically comparable to all the other cultivars. In 2010, the yield for ‘Puget Crimson’ in the same planting was 15,500 $kg \cdot ha^{-1}$, less than that of ‘Valley Red’ but comparable to the other cultivars. The average fruit weight for ‘Puget Crimson’ was 13.1 g in 2009 and 13.5 g in 2010, less than that of ‘Tillamook’ in both years and less than ‘Sweet Bliss’ and more than ‘Totem’ in 2010. In the 2008 Agriculture and Agri-Food Canada planting, ‘Puget Crimson’ was compared with the PNW cultivars Firecracker, Nisgaa, Puget Reliance, Rainier, Stolo, Tillamook, and Totem (data not shown). In 2009, the yield for ‘Puget Crimson’ was 15,800 $kg \cdot ha^{-1}$, statistically comparable to yields of the other cultivars. The average fruit weight for ‘Puget Crimson’ was 11.9 g, less than fruit weight of ‘Tillamook’ but not different from fruit weight of other cultivars. In the 2009 planting, ‘Puget Crimson’ was compared with the same cultivars with the omission of ‘Firecracker’ (data not shown). In 2010, the yield for ‘Puget Crimson’ was statistically less than ‘Nisgaa’ but not different from the other cultivars. The average fruit weight for ‘Puget Crimson’ was 11.9 g, comparable to the other cultivars but significantly less than ‘Tillamook’.

Fruit Description

The flowers and fruit of ‘Puget Crimson’ are borne at or beneath the leaf canopy. The fruit of ‘Puget Crimson’ are longer than wide, conical to wedge-shaped, without a neck Fig. (1). The achenes are even with the fruit surface to slightly inserted and vary in color from yellow–orange to dark red depending on ripeness. Larger fruit often have a small hollow center usually absent in later, smaller fruit. The fruit has a reflexed calyx. Color was measured on five fully ripe fruit. The exterior fruit color of ‘Puget Crimson’ was slightly lighter, redder, and more yellow than ‘Schwartze’ and redder than ‘Firecracker’ (Table 3). The internal color was measured at the apex of a longitudinal slice of the fruit. ‘Puget Crimson’ (L* = 46.34, a* = 40.31, b* = 34.55) did not differ significantly from ‘Firecracker’ and ‘Schwartze’ (data not shown).

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Table 1. 2009–2010 harvest data for 2008 planted strawberries grown at Puyallup, WA.

	Yield (kg·ha^{-1})[z]			Fruit rot (%)		Fruit wt (g)		Fruit firmness (N)[y]	
Cultivar	2009	2010	Total	2009	2010	2009	2010	2009	2010
Puget Crimson	28,800 a[x]	38,100 ab	66,800 ab	14.5 a	20.4 ab	15.0 a	16.8 ab	2.06 a	1.53 b
Firecracker	20,800 a	24,100 bc	44,800 bc	6.3 a	23.7 ab	14.9 a	11.3 d	2.01 a	1.47 b
Hood	24,100 a	15,700 c	39,800 c	10.9 a	29.7 a	12.2 a	12.1 cd	1.73 b	1.80 ab
Puget Reliance	28,100 a	44,400 a	72,500 a	19.7 a	12.9 b	12.8 a	14.8 bc	1.73 b	1.61 b
Tillamook	18,600 a	41,600 a	60,200 a–c	10.7 a	13.4 b	15.1 a	18.7 a	2.07 a	1.71 b
Totem	21,000 a	25,100 bc	46,100 bc	11.2 a	20.0 ab	12.3 a	12.0 cd	1.95 ab	2.08 a

	2009				2010			
	Dates for percent cumulative yield			Length of harvest	Dates for percent cumulative yield			Length of harvest
Cultivar	5%	50%	95%	season (d)	5%	50%	95%	season (d)
Puget Crimson	16 June a	25 June a	11 July a	25 a	27 June a	8 July a	18 July a	21 a
Firecracker	13 June a	23 June ab	2 July b	19 b	28 June a	8 July a	19 July a	20 a
Puget Reliance	8 June b	19 June bc	29 June b	21 ab	15 June c	26 June c	7 July c	22 a
Tillamook	9 June b	18 June bc	29 June b	20 b	20 June b	30 June b	12 July b	22 a
Hood	9 June b	16 June c	27 June b	19 b	13 June c	24 June c	4 July c	21 a
Totem	9 June b	16 June c	27 June b	19 b	15 June c	25 June c	3 July c	18 a

[z]Values represent means of three replications of 3.1-m plots.
[y]Fruit firmness was measured as the force required for a 4-mm-diameter cylinder to penetrate the shoulder of a fruit to a depth of 6 mm. Firmness was measured using a Hunter Spring mechanical force gauge (Series L; Amtec, Hatfield, PA) for five fruit per plot at each harvest. The weighted mean was calculated for the harvest season.
[x]Means followed by the same letter within a column are not significantly different using Tukey's Studentized range test at $P \leq 0.05$.

Table 2. 2010 harvest data for 2009 planted strawberries, grown at Puyallup, WA.

					Dates for percent cumulative yield			Length of harvest
Cultivar	Yield[z] (kg·ha^{-1})	Fruit rot (%)	Fruit wt (g)	Fruit firmness (N)[y]	5%	50%	95%	season (d)
Puget Crimson	30,800 a[x]	10.5 ab	15.8 a–c	1.67 b	22 June a	5 July a	18 July a	25 a
Tillamook	18,600 b	9.2 ab	18.9 a	2.14 a	11 June b	24 June b	5 July b	23 ab
Valley Red	18,400 b	10.0 ab	17.2 ab	2.09 a	5 June c	12 June c	25 June c	21 b
Puget Reliance	16,200 b	5.6 b	14.2 a–c	2.15 a	10 June b	24 June b	4 July b	24 ab
Totem	15,100 b	9.8 ab	11.3 c	2.42 a	9 June b	23 June b	3 July b	24 ab
Hood	14,800 b	15.4 a	11.4 bc	2.14 a	9 June b	23 June b	3 July b	24 ab

[z]Values represent means of three replications of 3.1-m plots.
[y]Fruit firmness was measured as the force required for a 4-mm-diameter cylinder to penetrate the shoulder of a fruit to a depth of 6 mm. Firmness was measured using a Hunter Spring mechanical force gauge (Series L; Amtec, Hatfield, PA) for five fruit per plot at each harvest. The weighted mean was calculated for the harvest season.
[x]Means followed by the same letter within a column are not significantly different using Tukey's Studentized range test at $P \leq 0.05$.

Fig. 1. Early-season fruit of 'Puget Crimson' harvested on 22 June 2010 at Puyallup, WA, with an average fruit weight of 35 g.

Table 3. Exterior fruit color of fruit harvested 9 July, 2010, Puyallup, WA.

	Fruit color[z]		
Cultivar	L*	a*	b*
Firecracker	34.75 a[y]	28.95 b	16.19 ab
Puget Crimson	33.63 a	35.46 a	20.34 a
Schwartze	29.24 b	31.36 b	14.53 b

[z]Values represent means of five fruit per clone.
[y]Means followed by the same letter within a column are not significantly different using Tukey's Studentized range test at $P \leq 0.05$.
Color measured with a Minolta CR-400 colorimeter at the shoulder of the fruit using L* a* b* color coordinates. L* is a measure of darkness/lightness with values ranging from 0 (pure black) to 100 (pure white). a* is a measure of red (a* = +100) to green (a* = –100). b* is a measure of yellow (b* = +100) to blue (b* = –100).

Frozen fruit samples of 'Puget Crimson' and other cultivars from the 2010 harvest season at WSU Puyallup were analyzed for soluble solids, pH, titratable acidity, total anthocyanins, and total phenolics (Table 4). Fruit of 'Puget Crimson' had a soluble solids level similar to 'Firecracker' and slightly less than for 'Schwartze'. The pH for 'Puget Crimson' was intermediate between 'Firecracker' and 'Schwartze', and the titratable acidity was less for 'Puget Crimson' than either 'Firecracker' or 'Schwartze'. The total anthocyanins for 'Schwartze' were greater than the other cultivars, which is consistent with the colorimeter measurements of the external color of the fruit. 'Puget Crimson' had lower total phenolics than the other cultivars. The fruit of 'Puget Crimson' has a full, well-balanced strawberry flavor and has been consistently identified by industry members, culinary professionals, and scientists as having outstanding flavor.

The fruit storage effects on 'Puget Crimson' were compared with effects on two other late-season cultivars for fruit harvested 9 July 2010 (Table 5). Fruit was harvested, evaluated for weight and color, placed in individual containers, and then stored for 4 d at 4 °C. After 4 d, the fruit was moved to room temperature (≈20 °C) for 4 h and measured a second time. 'Puget Crimson' had the lowest percentage weight loss. These differences may be a function of fruit weight and surface

Table 4. Analysis of strawberry fruit harvested July 2010 at Puyallup, WA.

Cultivar	Soluble[z] solids (%)	pH	Titratable acidity (% citric acid)	Total anthocyanins[y] (mg·g^{-1} fruit)	Total[x] phenolics (mg·g^{-1} fruit)
Puget Crimson	9.8 b[w]	3.62 b	0.88 c	0.575 b	2.94 c
Firecracker	9.6 b	3.45 c	1.17 a	0.543 b	3.21 b
Schwartze	12.9 a	3.77 a	1.02 b	0.892 a	3.52 a

[z]Values represent means of three replications of ≈200 g each.
[y]Total anthocyanins were measured as pelargonidin-3-glucoside.
[x]Total phenolics were measured as gallic acid equivalents.
[w]Means followed by the same letter within a column are not significantly different using Tukey's Studentized range test at $P \leq 0.05$.

Table 5. Changes in fruit weight during storage for fruit harvested from plots grown in Puyallup, WA.

Cultivar	Fruit wt (g)[z] Before storage	After storage	Wt loss (%)
Puget Crimson	16.2 a[y]	15.7 a	2.8 c
Firecracker	14.0 b	13.4 b	4.2 b
Schwartze	10.8 c	10.2 c	5.5 a

[z]Values represent means of 12 fruit per clone. Fruit harvested 9 July 2010, data collected on individual fruit stored in individual containers at 4 °C for 4 d, then stored at room temperature (≈20 °C) for 4 h and the same fruit measured a second time.
[y]Means followed by the same letter within a column are not significantly different using Tukey's Studentized range test at $P \leq 0.05$.

Table 6. Leaf color measurements of 'Puget Crimson' compared with 'Firecracker' for fully expanded, mature leaves harvested in June 2010 from plants grown in Puyallup, WA.

Cultivar	Leaf color[z] L*	a*	b*
Puget Crimson	36.83 a[y]	–14.86 b	19.93 a
Firecracker	35.04 b	–13.88 a	18.22 b

[z]Values represent means of 12 leaves collected 21 June 2010.
[y]Means followed by the same letter within a column are not significantly different using Tukey's Studentized range test at $P \leq 0.05$.
The central leaflet of the leaf was measured with a Minolta CR-400 colorimeter using L* a* b* color coordinates. L* is a measure of darkness/lightness with values ranging from 0 (pure black) to 100 (pure white). a* is a measure of red (a* = +100) to green (a* = –100). b* is a measure of yellow (b* = +100) to blue (b* = –100).

area of the fruit. Although color darkened during storage, the cultivar order for the color measurements was the same before and after storage. 'Puget Crimson' had acceptable storage characteristics.

Plant Description

Plants of 'Puget Crimson' are vigorous with an erect growth habit. They produce abundant runners and form a dense matted row. The leaves are slightly cupped and ≈20% of the leaves have leaf-like bracts on the petiole. The angle between the terminal leaflet base and the petiolule is ≈130°. The terminal leaflet is oval to orbicular with a rounded apex and is coarsely serrated. The terminal leaflet of 'Puget Crimson' averaged 20.4 serrations, more than 'Valley Red' (18.1). The length (67.5 mm), width (53.6 mm), and length/width ratio (1.26) of the terminal leaflet of 'Puget Crimson' did not differ from 'Valley Red'.

The color of the upper and lower leaf surfaces of 'Puget Crimson' was compared with leaf color of 'Firecracker'. The color of the upper leaf surface for 'Puget Crimson' was lighter, more green, and more yellow than that for 'Firecracker' (Table 6). The color of the lower leaf surface was similar for 'Puget Crimson' and 'Firecracker' with 'Puget Crimson' leaves being slightly more yellow than 'Firecracker (data not shown).

Disease and Pest Reaction

Similar to its parent 'Schwartze', 'Puget Crimson' is susceptible to powdery mildew [*Podosphaera aphanis* (Wallr.) U. Braun & S. Takamatsu] and moderately susceptible to leaf scorch [*Diplocarpon earlianum* (Ellis & Everh.) F.A. Wolf].

Availability

Names of propagators with certified 'Puget Crimson' plants will be supplied by P.P. Moore on request. 'Puget Crimson' will be patented, patent pending.

Literature Cited

Finn, C.E., P.P. Moore, C. Kempler, B. Yorgey, B.C. Strik, and R.R. Martin. 2009. 'Valley Red' strawberry. HortScience 44:1468–1471.

Finn, C.E., B. Yorgey, B.C. Strik, and P.P. Moore. 2004. 'Tillamook' and 'Pinnacle' strawberries. HortScience 39:1487–1489.

McGuire, R.G. 1992. Reporting objective color measurements. HortScience 27:1254–1255.

Moore, P.P. and C.E. Finn. 2002. 'Schwartze' ('Puget Summer'®) strawberry. HortScience 37:230–232.