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‘Cascade Harvest’ Red Raspberry

Patrick P. Moore[1] and Wendy Hoashi-Erhardt
Washington State University Puyallup Research and Extension Center, 2606 West Pioneer, Puyallup, WA 98371

Chad E. Finn and Robert R. Martin
United States Department of Agriculture-Agricultural Research Service, Horticultural Crops Research Unit, 3420 Northwest Orchard Avenue, Corvallis, OR 97730

Michael Dossett
BC Blueberry Council, in partnership with Agriculture and Agri-Food Canada, Pacific Agri-Food Research Centre, 6947 Highway 7, P.O. Box 1000, Agassiz, BC, Canada, V0M 1A0

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‘Cascade Harvest’ is a new floricane fruiting raspberry cultivar (*Rubus idaeus* L.) jointly released by Washington State University (WSU), Oregon State University (OSU), and the U.S. Department of Agriculture (USDA). ‘Cascade Harvest’ produces a high yield of large, firm fruit suited to machine harvesting, and is well suited for processing. Because of its flavor, large fruit, attractive appearance and easy fruit release at an early stage of maturity, ‘Cascade Harvest’ may also be suitable for fresh market use. It is root rot [*Phytophthora rubi* (W.F. Wilcox & J.M. Duncan) W.A. Man in‘t Veld] tolerant and resistant to the common strain of *Raspberry bushy dwarf virus* (RBDV). Because of its adaptation to machine harvest, high yield, tolerance to root rot and RBDV resistance, it is recommended as a possible replacement for ‘Meeker’, the primary cultivar of the Pacific Northwest raspberry industry.

Origin

‘Cascade Harvest’ was selected from a cross of ‘Cascade Dawn’ and WSU 1145 (Fig. 1) made in 1998 at Washington State University Puyallup Research and Extension Center (WSU Puyallup). ‘Cascade Dawn’ was released from the WSU program in 2005 (Moore, 2006). WSU 1145 is a highly root rot tolerant selection that was selected from a cross between ‘Newburgh’ and WSU 0933 (‘Centennial’ × ‘Haida’). Seedlings from the cross were planted at the WSU Puyallup Goss Farm in 1999. ‘Cascade Harvest’ was selected from the seedlings in 2001 and designated as WSU 1507.

Performance and Description

After ‘Cascade Harvest’ was selected, it was propagated by tissue culture from primocane shoot tips. It was planted in nonreplicated 10 plant plots with a cooperating grower in Lynden, WA in 2002, 2005, and 2010 and with another grower in Burlington, WA in 2003. These plantings were maintained by the growers using typical commercial methods. The plantings were subjectively evaluated weekly for adaptation to machine harvesting during the harvest season for two fruiting seasons. The 2003 planting was harvested beginning in 2004 and all other plantings were harvested beginning 2 years after planting.

Fruit of ‘Cascade Harvest’ were harvested from replicated plantings at WSU Puyallup planted in 2005 and 2009. Plantings were arranged in randomized complete block designs with three replications of plots consisting of three plants, with 0.9 m between plants and 2.4 m between rows. The plantings were not sprayed for disease, but the planting established in 2009 was sprayed for spotted wing drosophila (*Drosophila suzukii* Matsumura). Fruit were harvested one or two times a week depending on environmental conditions and rate of ripening. The weight of sound fruit and fruit with rot (mainly botrytis) was determined at each harvest. Yield was the sum of sound fruit and fruit with rot. The average fruit weight for the season is a weighted mean based on the weight of a randomly selected 25 fruit subsample from each plot from each harvest and the yield for each harvest. Fruit firmness was measured as the force required to close the opening of the fruit using a Hunter Spring Mechanical Force Gauge (Series L; Ametek, Hatfield, PA) and was calculated as a weighted mean based on a randomly selected five-fruit subsample from each plot from each harvest.

Fruit samples were collected from machine harvest plots in Burlington, WA in 2005 and in 2008 from plots in Lynden, WA. Samples of ≈300 g were collected from five dates in 2005 and two dates in 2008. The samples were analyzed for total anthocyanins, soluble solids, pH, and titratable acidity. The pH of the juice was measured with a Corning 430 pH meter (Corning, NY), titratable acidity by titration to pH 8.1 with 0.1 N NaOH, soluble solids with a Atago PAL-1 refractometer (Atago USA, Inc., Bellevue, WA) and the total anthocyanins as described by Torre and Barritt (1977). Fruit samples were hand harvested from plots at WSU Puyallup on 6 July 2012. ‘Cascade Harvest’ was compared with its parents, ‘Cascade Dawn’ and WSU 1145 for fruit color measured with a Minolta CR-400 colorimeter (Konica Minolta Sensing Americas, Inc., Ramsey, NJ) and for weight and

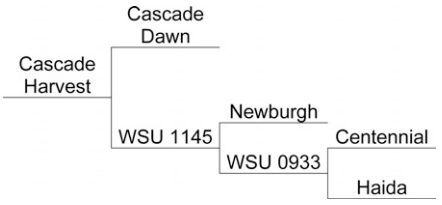

Fig. 1. Pedigree of ‘Cascade Harvest’ red raspberry.

Table 1. Yield, fruit rot, fruit weight, fruit firmness and harvest season were measured in 2009 for three red raspberry cultivars planted at Puyallup, WA in 2005 in a replicated trial (three, three-plant plots).

	Cultivar		
	Cascade Harvest	Meeker	Willamette
Yield (kg/hill)	4.51 b[z]	6.16 a	4.21 b
Fruit rot (%)	11.0 a	6.6 b	4.6 b
Fruit weight (g)	4.0 a	3.6 b	3.7 b
Fruit firmness (N)	1.92 a	1.85 a	1.80 a
Date of cumulative harvest			
5%	1 July b	5 July a	27 June c
50%	11 July b	16 July a	8 July b
95%	26 July b	30 July a	21 July c
Length of harvest season (d)	25 a	24 a	23 a

[z]Means within a row followed by the same letter are not significantly different at $P \leq 0.05$, by Tukey’s studentized range test.

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[1]To whom reprint requests should be addressed; e-mail moorepp@wsu.edu.

Table 2. Yield, fruit rot, fruit weight, fruit firmness and harvest season were measured in 2011–12 for five red raspberry cultivars planted at Puyallup, WA in 2009 in a replicated trial (three, three-plant plots).

		Cultivar				
		Cascade Harvest	Meeker	Cascade Bounty	Willamette	Ukee
Yield (kg/hill)	2011	2.6 a[z]	1.6 ab	1.8 ab	2.0 ab	0.5 b
	2012	4.0 a	4.5 a	4.1 a	3.5 a	3.2 a
	Total	6.6 a	6.1 ab	5.9 ab	5.5 ab	3.7 b
Fruit rot (%)	2011	11.8 ab	7.0 c	12.8 a	7.2 bc	12.2 a
	2012	3.8 b	4.5 b	11.7 a	4.9 b	4.0 b
Fruit weight (g)	2011	3.8 a	2.8 c	3.3 b	2.9 c	3.1 bc
	2012	3.7 a	3.1 a	3.7 a	3.5 a	3.3 a
Fruit firmness (N)	2011	0.88 a	0.64 ab	0.44 b	0.71 ab	0.48 ab
	2012	0.69 b	0.70 b	0.72 ab	0.80 a	0.67 b
Date of cumulative harvest						
5%	2011	6 July bc	8 July bc	10 July ab	4 July c	15 July a
50%	2011	18 July bc	20 July ab	18 July bc	15 July c	22 July a
95%	2011	1 Aug. ab	2 Aug. ab	30 July ab	27 July b	1 Aug. ab
5%	2012	2 July b	4 July ab	29 June bc	25 June c	8 July a
50%	2012	14 July b	16 July ab	14 July b	5 July c	19 July a
95%	2012	28 July ab	30 July ab	29 July a	20 July b	31 July a
Length of harvest season (d)	2011	26 a	25 a	20 ab	23 ab	17 b
	2012	26 b	27 ab	30 a	20 b	23 b

[z]Means within a row followed by the same letter are not significantly different at $P \leq 0.05$, by Tukey's Studentized range test.

Fig. 2. Fruit of 'Cascade Harvest' red raspberry. Numbers represent the scale in centimeters.

Table 3. Anthocyanin content, soluble solids, pH, and titratable acidity of raspberry fruit machine harvested from three cultivars in 2005 at Burlington, WA.[z]

Cultivar	Anthocyanin[y] content (mg·g^{-1} fruit)	Soluble solids (%)	pH	Titratable acidity (as % citric acid)
Cascade Harvest	52.8 c[x]	8.1 ab	3.27 a	0.93 b
Meeker	60.8 b	9.3 a	3.35 ab	0.99 b
Willamette	91.6 a	7.3 b	3.08 b	1.33 a

[z]Fruit samples of ≈300 g collected on each harvest date. Raspberry plots machine harvested on 20 and 28 June and 6, 11 and 18 July 2005.
[y]Total anthocyanins determined spectrophotometrically from acidified ethanol extracts and expressed as cyanidin 3-galactoside (Torre and Barritt, 1977).
[x]Means within a column followed by the same letter are not significantly different at $P \leq 0.05$, by Tukey's studentized range test.

dimensions of the fruit. Measurements were recorded in L*, a*, and b* (McGuire, 1992) based on calibration to a standard white reflective plate and the CIE Illuminant C (Commission Internationale de l'Eclariage, Vienna). Fruit samples for 'Cascade Harvest', 'Cascade Delight', and 'Tulameen' were harvested on 16 July 2012, stored for 4 d at 4 °C, then held at room temperature (20 °C) for 4 h. Fruit weight, firmness, and color measurements were taken on fruit before storage and after storage. Since firmness measurement was a destructive measurement, the initial firmness was measured on a separate set of fruit than the stored fruit. All other storage measurements were made on the same fruit both before and after storage.

Each data set was analyzed as a randomized block design using analysis of variance and Tukey's studentized range test (honestly significant difference) for mean separation (SAS 9.3, SAS Institute Inc., Cary, NC).

'Cascade Harvest' was subjectively evaluated in plots established in 2002, 2005, and 2010 with a commercial grower in Lynden, WA. These plots were machine harvested for two fruiting seasons beginning 2 years after planting. Another planting was established in 2003 with a commercial grower in Burlington, WA and was machine harvested in 2004 and 2005. In all of the plantings, 'Cascade Harvest' was productive, the fruit harvested easily, with large fruit size and good flavor. Based on these evaluations, 'Cascade Harvest' is suitable for machine harvesting for processing use.

Fruit production was measured in hand-harvested plantings at established in 2005 and 2009 at WSU Puyallup. The 2005 planting was harvested in 2009 and the 2009 planting in 2011 and 2012. In 2009, the yield was large, but less than 'Meeker' and was not different from 'Willamette' (Table 1). The fruit of 'Cascade Harvest' had greater average fruit weight than 'Meeker' and 'Willamette'. Fruit firmness of 'Cascade Harvest' was similar to 'Meeker' and 'Willamette'. The date of midpoint of harvest for 'Cascade Harvest' was intermediate between 'Meeker' and 'Willamette'. In the 2011 harvest of the 2009 planting, the 'Cascade Harvest' had the greatest yield, but was only significantly greater than 'Ukee' (Table 2). 'Cascade Harvest' had the greatest average fruit weight in 2011.

'Cascade Harvest' performed well in a planting established in 2010 with the USDA-ARS at Oregon State University's North Willamette Research and Extension Center, Aurora, OR. 'Cascade Harvest' was comparable to 'Meeker' for yield in 2012 and had less yield than 'Meeker' in 2013 (data not shown). Fruit weight of 'Cascade Harvest' was significantly greater than 'Meeker' in both harvest seasons (4.8 vs. 3.6 g). 'Cascade Harvest' was also included in a nonreplicated plot in 2011. Yield of the nonreplicated plot of 'Cascade Harvest' was numerically greater than the yield of 'Meeker' in replicated plots.

Fruit Description

Fruit of 'Cascade Harvest' were attractive and large with a long, conic shape with many drupelets per fruit (Fig. 2). Fruit of 'Cascade Harvest' were sweet, with a mild tart flavor. Fruit characteristics of machine harvested 'Cascade Harvest' were compared with 'Meeker' and 'Willamette'. Machine harvested fruit samples of ≈300 g were collected on five dates in 2005. In the 2005 harvest season, 'Cascade Harvest' had less total anthocyanin content than 'Meeker', but did not differ significantly from 'Meeker' for soluble solids, pH, or titratable acidity (Table 3). 'Willamette' had significantly greater total anthocyanin content, lower pH, and greater titratable acidity than 'Cascade Harvest'.

Morphological measurements of 'Cascade Harvest' fruit were compared with its parents, WSU 1145 and 'Cascade Dawn' (Table 4). The primary differences from 'Cascade Harvest' were that the fruit length was greater than WSU 1145 and that fruit were not as dark as 'Cascade Dawn'. 'Cascade Harvest' had more drupelets, smaller drupelets, and smaller individual seed weight than 'Meeker', but the same fruit weight as 'Meeker' (Table 5).

Because of the easy fruit release, large size, attractive appearance, and lighter fruit color, 'Cascade Harvest' is suited to fresh use as well as processing use. Fresh fruit of 'Cascade Harvest', 'Cascade Dawn', and 'Tulameen' were evaluated for their suitability for storage. Fruit weight, firmness, and color were measured before storage and the same parameters were measured after storage (Table 6). 'Cascade Harvest' had similar fruit weight as 'Tulameen' but less than 'Cascade Delight'. Firmness of the three cultivars was similar going into storage, but 'Tulameen' was much softer after storage. Color of 'Cascade Harvest' fruit was similar to

'Tulameen' before and after storage, but 'Cascade Delight' was darker. 'Cascade Harvest' had good storage qualities.

Plant Description

'Cascade Harvest' is a floricane fruiting raspberry and has not been observed with primocane fruit at WSU Puyallup. Dark purple prickles are numerous at the base of primocanes, but few to no prickles were present at 1.2 m. The prickles were straight and point toward the base of the canes. The pigmented spots at the base of the prickles were the same color as the prickles. Primocanes of 'Cascade Harvest' in midsummer were a light green color with dark purple streaks. There was no pubescence on the canes of 'Cascade Harvest, while 'Meeker' canes had slight pubescence. The primocane leaflets were pinnately compound and generally with five leaflets. The petiolule of the terminal leaflet of the primocane leaves of 'Cascade Harvest' were longer than that of 'Meeker' (data not shown). The terminal leaflet of floricane leaves of 'Cascade Harvest' were longer and wider than that of 'Meeker' (data not shown).

Disease and Pest Reaction

'Cascade Harvest' was evaluated for susceptibility to *Phytophthora* root rot in naturally infested plots at WSU Puyallup Goss Farm in plantings established in 2005. The presence of *P. rubi* in these plots was verified via polymerase chain reaction (PCR). Four plants of each clone were planted in a completely randomized design. Plants were subjectively rated for vigor in the fall of each year from 0 to 5, with 0 being dead and 5 a healthy and vigorous plant. In the fall of the 4th year, 'Cascade Harvest' had a rating of 5.0 for all four plants, while 'Willamette' had an average of 1.75 and 'Meeker' was 0.5. Based on this trial, 'Cascade Harvest' is expected to have a very good level of root rot tolerance.

'Cascade Harvest' tested virus negative after graft inoculation using leaflets from a field-grown plant naturally infected with RBDV. Plants of 'Cascade Harvest' that have been exposed to virus-infected pollen in the field for over 5 years have continued to test negative for RBDV. On the basis of this testing, 'Cascade Harvest' appears to be resistant to the common strain of RBDV.

Plants of 'Cascade Harvest' were screened in duplicate in the greenhouse for resistance to the raspberry aphid, *Amphorophora agathonica* Hottes, the primary vector for *Raspberry leaf mottle virus*, *Raspberry latent virus*, *Black raspberry necrosis virus*, and *Rubus yellow net virus* in North America. Similar to its grandparent 'Newburgh', 'Cascade Harvest' was determined to be resistant to biotypes A and C and susceptible to biotypes B, D, E, and F of *A. agathonica* (Dossett and Kempler, 2012).

Uses

'Cascade Harvest' is high yielding and produces large, firm fruit with excellent sweet flavor. Fruit of 'Cascade Harvest' machine harvest easily and are suitable for processing. Because of the flavor, large fruit size, attractive appearance, and easy fruit release at an early stage of maturity, 'Cascade Harvest' is also suitable for fresh market. 'Cascade Harvest' may allow for longer planting rotations because of resistance to the common strain of RBDV and tolerance to *Phytophthora* root rot.

Table 4. Fruit morphological measurements of raspberry fruit harvested from three raspberry clones on 6 July 2012 grown at Puyallup, WA.[z]

	Raspberry clones		
	Cascade Harvest	WSU 1145	Cascade Dawn
Fruit			
Weight (g)	5.1 ab[y]	4.5 b	6.0 a
Length (mm)	26.6 a	20.8 b	27.5 a
Width (mm)	20.5 a	22.2 a	22.2 a
Length/width ratio	1.30 a	0.94 b	1.24 a
Fruit opening			
Length (mm)	22.2 a	14.9 b	21.7 a
Width (mm)	8.8 a	10.0 a	9.7 a
Length/width	2.52 a	1.48 b	2.27 a
Drupelet			
Length (mm)	4.7 b	5.5 a	5.7 a
Width (mm)	3.6 a	4.0 a	4.2 a
Color[x]			
L*	30.47 a	31.70 a	25.87 b
a*	27.96 ab	30.45 a	23.53 b
b*	12.90 ab	14.32 a	9.05 b

[z]Five fruit of each cultivar were measured.
[y]Means within a row followed by the same letter are not significantly different at $P \leq 0.05$, by Tukey's studentized range test.
[x]Color 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).

Table 5. Fruit and drupelet characteristics of 'Cascade Harvest' and 'Meeker' red raspberries from fruit harvested during July 2013, Puyallup, WA.[z]

	Cultivar	
	Cascade Harvest	Meeker
Fruit weight (g)	3.6 a[y]	3.7 a
Drupelet number	122 a	91 b
Drupelet weight (mg)	30 b	40 a
Individual seed weight (mg)	1.37 b	1.76 a

[z]Five fruit of each cultivar were measured.
[y]Means within a row followed by the same letter are not significantly different at $P \leq 0.05$, by Tukey's studentized range test.

Table 6. Changes in fruit weight, firmness, and color during storage for fruit of three red raspberry cultivars harvested from plots at Puyallup, WA.[z]

	Cultivar		
	Cascade Harvest	Cascade Delight	Tulameen
Fruit weight (g)			
Into storage	5.57 b[y]	8.05 a	5.38 b
After storage	5.38 b	7.54 a	5.19 b
Weight loss	0.19 a	0.51 a	0.19 a
Firmness (N)			
Into storage	1.49 a	1.64 a	1.38 a
After storage	1.25 a	1.23 a	0.71 b
Color into storage[x]			
L*	29.3 a	26.4 b	30.3 a
a*	25.1 a	25.4 a	27.7 a
b*	11.3 b	10.6 b	14.8 a
Color after storage			
L*	29.2 a	27.2 b	30.1 a
a*	25.2 a	25.6 a	25.7 a
b*	10.7 ab	10.2 b	12.3 a

[z]Values represent means of 12 fruit per cultivar. Fruit were harvested 16 July, 2012, with pre-storage data collected on individual fruit, which were then stored in individual containers at 4 °C for 4 d, then stored at room temperature (≈20 °C) for 4 h with weight and color measured on the same fruit a second time. The initial firmness was measured on a separate set of 12 fruit.
[y]Means within a row followed by the same letter are not significantly different at $P \leq 0.05$, by Tukey's studentized range test.
[x]Color 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).

Availability

Nuclear stock of 'Cascade Harvest' has tested negative for *Arabis mosaic virus*, *Cherry leaf roll virus*, *Prunus necrotic ringspot virus*, RBDV, *Raspberry ringspot virus*, *Tobacco ringspot virus*, *Tobacco streak virus*, *Tomato ringspot virus*, and *Strawberry necrotic shock virus* by enzyme-linked immunosorbent assay, has indexed negative on grafting to *R. occidentalis* L., and has tested negative for *Black raspberry necrosis virus*, *Blackberry chlorotic ringspot virus*, *Blackberry virus Y*, *Blackberry yellow vein associated virus*, *Cherry rasp leaf virus*, *Raspberry latent virus*, *Raspberry leaf mottle virus*, *Rubus yellow net virus*, *Strawberry latent ringspot virus*, and *Tomato black ring virus*, in reverse transcription PCR assays.

Nuclear stocks of 'Cascade Harvest' are maintained at the USDA-ARS Horticultural Crops Research Unit in Corvallis, OR. Neither the Washington Agricultural Research Center nor the USDA-ARS has plants for sale. Names of propagators with certified 'Cascade Harvest' plants will be supplied on request. An application for a U.S. Plant Patent has been submitted for 'Cascade Harvest'.

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