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‘WSU 2188’ (Cascade Legacy™) Red Raspberry

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‘WSU 2188’ is a new floricane-fruiting raspberry cultivar (*Rubus idaeus* L.) released by Washington State University (WSU) and marketed as ‘Cascade Legacy’™ in the United States. ‘WSU 2188’ produces large, firm fruit in the midseason. It is well suited to machine harvesting and for processing. The flavor, large size, firmness, attractive appearance, and ease of fruit release make ‘WSU 2188’ suitable for fresh market use. ‘WSU 2188’ appears to have good levels of tolerance to *Phytophthora rubi* (Man in ’t Veld 2007) in field trials.

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Origin

‘WSU 2188’ was selected from a controlled half-sib cross of WSU 1638 and WSU 1447 (Fig. 1) made in 2007 at WSU Puyallup Research and Extension Center (WSU Puyallup). The seed parent WSU 1638 (‘Qualicum’ × ‘Haida’) was selected from a cross made in 1999 and produces machine-harvestable fruit with large size and high firmness. WSU 1447 (WSU 1096 × ‘Qualicum’) was selected from a cross made in 1996 and has fruit with excellent fruit quality, including large size, color, and firmness. Seedlings from WSU 1638 × WSU 1447 were planted with a cooperating commercial grower in Skagit County, WA, USA, in 2008. In 2010, these seedlings were subjectively evaluated by machine harvesting, resulting in the selection of ‘WSU 2188’. Fruit of ‘WSU 2188’ machine harvested very easily with good firmness, color, and flavor.

Performance and Description

‘WSU 2188’ was propagated in vitro from primocane shoot tips at WSU Puyallup. It was planted in a nonreplicated plot consisting of eight or 10 plants with cooperating growers in Lynden, WA, USA, in 2011 (data not shown) and in 2014 (Table 1). These plantings were maintained by the growers using standard commercial production practices and harvested by an over-the-row machine harvester (Litthau, Stayton, OR, USA) every 2 to 3 d during the season. Fruit was subjectively evaluated for machine harvestability and overall fruit quality weekly over two harvest seasons, beginning 2 years after planting. In the 2014 planting, fruit were also weighed at each harvest to determine yield and date of 50% yield. ‘WSU 2188’ was evaluated side-by-side with standard cultivars ‘Cascade Harvest’ (Moore et al. 2015), ‘WSU 2166’ (marketed as ‘Cascade Premier’; Moore et al. 2019), ‘Meeker’ (Moore and Daubeny 1993), and ‘Willamette’ (Daubeny et al. 1989). ‘WSU 2188’ had favorable yield potential, machine harvestability, large fruit size, and good flavor compared with these cultivars.

‘WSU 2188’ was established in a replicated trial planting at WSU Puyallup in 2014. The planting was arranged in a randomized complete-block design with three replications. Each plot had three plants, with 0.9 m between plants and 2.4 m between rows. The plantings were not treated for disease but were managed for spotted wing *Drosophila* (*Drosophila suzukii* Matsumura). Fruit were harvested by hand in 2016 and 2017 twice a week and weighed to determine total yield. The weight of fruit with visible symptoms of botrytis fruit rot was measured separately at each harvest and divided by total yield to determine the percent of culled fruit. ‘WSU 2188’ yielded similar to the three standard cultivars Cascade Harvest, Meeker, and Willamette and numerically greater than ‘Meeker’ and ‘Willamette’ in both years. (Table 2).

The seasonal fruit weight was calculated as a weighted arithmetic mean of 25 randomly selected fruit per harvest. The seasonal mean was determined using the formula:

$$\text{Weighted Mean} = \Sigma xw/\Sigma \mathbf{w},$$

where x = average berry weight in g from an individual harvest and w = the weight (importance) of each harvest relative to total season yield.

The fruit weight of ‘WSU 2188’ was significantly greater than ‘Meeker’ and ‘Willamette’ in 2016 and 2017 and greater than ‘Cascade Harvest’ in 2017 (Table 2). The cull rate of ‘WSU 2188’ was generally numerically lower and statistically comparable to ‘Cascade Harvest’, ‘Meeker’, and ‘Willamette’ in both years. The midpoint harvest date of ‘WSU 2188’ was similar to that of ‘Meeker’ and later than ‘WSU 2166’ and ‘Willamette’ in both years (Table 2).

Average fruit firmness was measured with a Hunter Spring Mechanical Force Gauge (Series L; Ametek, Hatfield, PA, USA) and reported as the force required to close the opening (compression strength) of five randomly selected berries from each plot per harvest (Barritt et al. 1980). The weighted seasonal mean for fruit firmness was calculated. ‘WSU 2188’ was the firmest berry of the four genotypes over 2 years. ‘WSU 2188’ had greater firmness than ‘Meeker’ and ‘Cascade Harvest’ in both years, and greater than ‘Willamette’ in 2016 (Table 2).

‘WSU 2188’ was evaluated in the US Department of Agriculture-Agricultural Research Service (USDA-ARS)/Oregon State University (OSU) cooperative breeding trials at the OSU-North Willamette Research and Extension Center (NWREC) in Aurora, OR, USA. Fruit production was measured in three-plant plots with three replicates in two plantings. One study was established in 2014 and evaluated in 2016 and 2017 (Table 3), and the second was

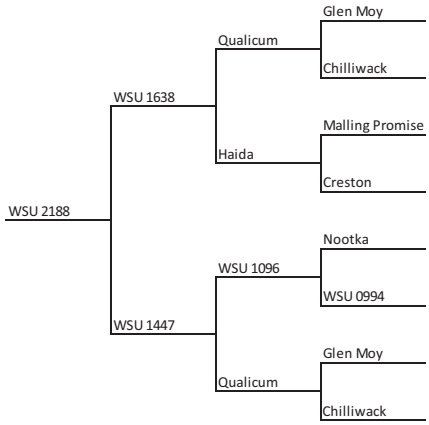

Fig. 1. Pedigree of 'WSU 2188' red raspberry.

established in 2017 and evaluated in 2019 and 2020 (Table 4). Yield and fruit size were measured and analyzed as a split-plot in time with a fixed effect model with cultivar as the main plot and year as the subplot. Means separation was tested by least significant difference (SAS PROC GLM, Cary, NC, USA) when there was a significant effect of genotype. Compared with 'Meeker', 'WSU 2188' had similar yields and significantly larger fruit in both plantings in all harvest years (Tables 3 and 4).

In British Columbia, 'WSU 2188' was planted in 2014 and 2017 at Agriculture and Agri-Food Canada's substation in Abbotsford. The trial consisted of four replicated plots with five plants in a completely randomized design. The 2014 planting was machine harvested every 3 to 4 d in 2016 and 2017. In this planting, 'WSU 2188' had higher yield and larger fruit than 'Saanich', 'Rudi', 'Lewis', and 'Meeker' (Table 5). In 2016, 'WSU 2188' had an earlier midpoint of harvest than 'Lewis', whereas in 2017, 'WSU 2188' had a similar midpoint of harvest with 'Meeker'. The 2017 planting was harvested every 3 to 4 d with an over-the-row machine harvester (Litthau, Stayton, OR, USA) in 2019 and 2020. In this planting, 'WSU 2188' had comparable yield to 'Chemainus', and higher yields than 'Meeker' and 'Cascade Bounty' in both years. 'WSU 2188' yielded more than 'WSU 2166' in 2020 (Table 6). Fruit of WSU 2188 were significantly larger than 'Chemainus', 'Meeker', and 'Cascade Bounty' in all British Columbia trials.

Based on these evaluations in Oregon, Washington, and British Columbia, 'WSU 2188' has good performance for yield and fruit quality in the major raspberry regions in the Pacific Northwest.

Table 1. Yield and midpoint of harvest of four floricane fruiting red raspberry cultivars planted in a grower field in Lynden, WA, USA, in 2014 and machine harvested in 2016–17.

	Yield (kg/plant)			Midpoint of harvest	
	2016[i]	2017	Total	2016	2017
C Harvest	4.42	3.53	7.95	1 Jul	17 Jul
WSU 2188	3.92	2.83	6.74	2 Jul	20 Jul
Meeker	2.90	3.44	6.33	3 Jul	19 Jul
Willamette	3.01	2.75	5.76	23 Jun	12 Jul

[i]Numeric values from nonreplicated eight-plant plots.

Table 2. Yield, fruit weight, culls, firmness, and midpoint of harvest measured in 2016–17 for four floricane fruiting red raspberry cultivars planted at Puyallup, WA, USA in a replicated trial with three replications containing three plants.

		WSU 2188	Cascade Harvest	Meeker	Willamette
Yield (kg/plant)	2016	3.84 ab[i]	5.20 a	3.22 abc	3.72 abc
	2017	3.41 ab	3.30 ab	3.10 ab	2.99 ab
	Total	7.25 abc	8.50 a	6.32 bcd	6.71 bcd
Fruit weight (g)	2016	4.4 a	4.2 ab	3.1 de	3.1 def
	2017	4.1 a	3.5 bc	3.2 cd	3.4 bc
Culls (%)	2016	7.8 bc	9.8 abc	11.4 ab	7.2 bc
	2017	5.7 de	14.5 ab	10.6 abcd	6.6 de
Fruit firmness (g)	2016	102 a	90 abc	74 cde	74 bcde
	2017	168 abc	106 def	107 def	122 cdef
Midpoint of harvest	2016	27 Jun abcd	23 Jun def	28 Jun ab	19 Jun fg
	2017	13 Jul ab	12 Jul bcd	9 Jul bcdef	6 Jul f

[i]Means separation within each row indicates significant difference by Fisher's protected least significant difference, $P \leq 0.05$.

Fruit Description

Fruit of 'WSU 2188' are attractive, have a mass of 4 to 6 g, and have a long, conical shape with an average 107 drupelets per fruit (Fig. 2; Table 6). Fruit of 'WSU 2188' are sweet, balanced by tartness, and have excellent flavor. From the replicated planting at WSU Puyallup established in 2014, fruit of 'WSU 2188' were harvested 17 Jul 2017 and compared with 'Cascade Harvest', 'WSU 2166', and 'Meeker' (Table 7). The fruit of 'WSU 2188' were similar in fruit and drupelet weight to 'Cascade Harvest,' and greater than that of 'WSU 2166' and 'Meeker'. The fruit of 'WSU 2188' had similar berry length and receptacle length to 'Cascade Harvest' but shorter fruit width and receptacle width.

Storage characteristics of 'WSU 2188' were compared with 'Cascade Harvest' (Table 8). Fruit were hand harvested 3 Jul 2017 to determine color (McGuire 1992), firmness, and weight of 18 fruit of each cultivar. Firmness was destructively measured on nine of the harvested fruit for each cultivar as described previously then discarded. The remaining nine fruit were stored at 4 °C for 7 d, then stored at room temperature (~20 °C) for 4 h, then evaluated for poststorage color, weight, and firmness. The effect of cultivar and storage on firmness, berry weight, and color (L*a*b*) was determined by analysis of variance using a mixed models procedure (Proc Mixed) in SAS 9.4. There was a highly significant effect of cultivar and storage for firmness (data not shown). There was a highly significant effect of storage for berry weight, a*, and b* (data not shown). There were no significant interactions between cultivar and storage for any variable. Absent interaction effects, data for each trait were analyzed separately for each storage condition of before and after (Table 8). The fruit of 'WSU 2188' had greater firmness than 'Cascade Harvest' in both storage conditions. There were no significant differences for 'WSU 2188' and 'Cascade Harvest' for berry weight or color components except b*, which was slightly, but significantly, lower for 'WSU 2188' than for 'Cascade Harvest' poststorage. There were no significant effects of cultivar or storage on L*, and no significant effect of cultivar on a* or b*. Storage had a significant effect on a* and b*, and poststorage values were lower than before storage for both cultivars (data not shown).

Fruit of 'WSU 2188' was analyzed for pH, titratable acidity, soluble solids, total anthocyanins, and total phenolics. Machine-harvested fruit samples of ~300 g were collected in 2013, 2014, and 2017 from the two nonreplicated plantings (established 2011, 2014) in Lynden, WA, USA. The pH of the juice was measured with a Thermo Scientific Orion Star A211 pH meter (Beverly, MA,

Table 3. Mean yield and fruit size for floricane-fruiting raspberry genotypes at Oregon State University–North Willamette Research and Extension Center planted in 2014 and evaluated 2016–17.

	Berry size (g)	Yield (kg/plant)		
Genotype	2016–17[i]	2016	2017	2016–17
Annual mean				
2016	4.5 a			1.80
2017	4.0 a			1.47
Replicated plots				
Lewis	4.4 bc	2.29 a	1.31 a	1.80 a
Meeker	3.5 d	1.76 a	1.65 a	1.70 a
WSU 2188	4.7 ab	1.49 a	1.45 a	1.47 a

[i]Mean separation within columns by least significant difference, $P \leq 0.05$.

Table 4. Mean yield and fruit size for floricane-fruiting raspberry genotypes at Oregon State University–North Willamette Research and Extension Center planted in 2017 and evaluated 2019–20.

	Berry Size (g)	Yield (kg/plant)		
Genotype	2019–20[i]	2019	2020	2019–20
Annual mean				
2019	3.6 a			2.20
2020	3.0 a			1.70
Replicated plots				
WSU 2188	4.2 a	2.51 a	1.69 a	2.10 a
Meeker	2.6 c	2.06 a	1.55 a	1.80 a
WSU 1914	3.1 b	1.96 a	1.34 a	1.65 a

[i]Mean separation within columns by least significant difference, $P \leq 0.05$.

Table 5. Mean yield and fruit weight in 2016–17 for floricane-fruiting raspberry cultivars in Abbotsford, British Columbia, planted in 2014 and harvested with a machine harvester.

Cultivar	Fruit wt (g) 2016–17[i]	Yield (kg/plant) 2016	Yield (kg/plant) 2017	Harvest midpoint 2016	Harvest midpoint 2017
WSU 2188	4.4 a	3.19 a	3.82 a	24 Jun a	20 Jul b
WSU 2166	4.3 a	3.01 a	3.63 a	22 Jun a	13 Jul a
Saanich	3.6 b	2.45 b	2.81 b	26 Jun ab	21 Jul b
Rudi	3.7 b	2.05 bc	2.24 bc	22 Jun a	12 Jul a
Lewis	3.7 b	1.95 bc	2.33 bc	28 Jun b	22 Jul b
Meeker	3.1 c	1.67 c	1.82 c	24 Jun a	19 Jul b

[i] Mean separation within columns by Fisher's protected least significant difference, $P \leq 0.05$.

Table 6. Mean yield and fruit size in 2019–20 for floricane-fruiting raspberry cultivars in Abbotsford, British Columbia, planted in 2017 and machine harvested.

Cultivar	Fruit wt (g) 2019–20[i]	Yield (kg/plant) 2019	Yield (kg/plant) 2020	Harvest midpoint 2019	Harvest midpoint 2020
WSU 2188	3.7 a	3.41 a	3.98 a	12 Jul b	14 Jul c
WSU 2166	3.4 a	3.29 a	3.05 b	5 Jul a	3 Jul a
Chemainus	2.9 b	3.44 a	3.76 a	10 Jul b	14 Jul c
Cascade Bounty	2.3 c	2.34 b	2.51 c	10 Jul b	9 Jul b
Meeker	2.3 c	1.06 c	2.43 c	13 Jul b	13 Jul bc

[i] Mean separation within columns by Fisher's protected least significant difference, $P \leq 0.05$.

Fig. 2. Fruit of 'WSU 2188' red raspberry.

USA); titratable acidity by titration to pH 8.1 with 0.1 N NaOH; and soluble solids with an Atago PAL-1 refractometer (Atago U.S.A., Inc., Bellevue, WA, USA). Total anthocyanins were determined by a pH differential method described by Lee et al. (2005) using a Shimadzu UV-1201 spectrophotometer (Shimadzu Corp., Kyoto, Japan), and expressed as cyanidine-3-glucoside (molar extinction coefficient = 26,900 $L \cdot cm^{-1} \cdot mol^{-1}$, molecular weight = 449.2 $g \cdot mol^{-1}$). Total phenolics were determined with the Folin-Ciocalteu method described by Waterhouse (2001) and expressed as gallic acid equivalents. Samples were analyzed in duplicate and averages presented without statistical analysis (Table 9). Compared with 'Meeker', 'WSU 2188' tended to have lower soluble solids, lower pH, higher titratable acidity, higher levels of anthocyanins, and lower levels of total phenolics (Table 9).

Because of the ease of fruit release, firmness, large size, and attractive appearance with darker fruit color than 'Cascade Harvest', 'WSU 2188' is suitable for processed and fresh market uses.

Plant Description

'WSU 2188' is a floricane-fruiting raspberry that 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 are present at 1.2 m. The prickles are straight and pointed toward the base of the canes. The pigmented spots at the base of the prickles were the same color as the prickles and oval in shape. The laterals on floricanes and leaves of primocanes are long and have a droopy appearance, especially in the second year after establishment. Primocanes of 'WSU 2188' are a light green in midsummer. There is no visible pubescence on the canes of 'WSU 2188'. The primocane leaflets are pinnately compound and generally with five leaflets. During the evaluation years of 2016 and 2017, fruit of 'WSU 2188' had midseason fruit production with a midpoint harvest date similar to 'Meeker' (Tables 1 and 2).

In Apr 2019, bud survival/injury was rated in the replicated plantings in British Columbia. Local growers were noting significant winter injury in many plantings, and this was attributed to somewhat mild temperatures in January (12 d with high temperatures of 10 °C or higher) leading to bud swell in many fields followed by cold stress in early and mid-February (low temps of –9 °C and 6 d in a 9-d period in which high temperatures did not go above freezing). 'WSU 2188' had very good bud survival, similar to 'Chemainus', 'Cascade Bounty', and 'WSU 2166', and significantly better than 'Meeker' (Table 10).

Table 7. Morphological measurements of fruit of four red raspberry cultivars, hand harvested on 17 Jul 2017 in Puyallup, WA, USA.

		Cascade Harvest	WSU 2166	Meeker	WSU 2188
Fruit	Weight (g)	5.7 a[i]	4.6 b	3.8 c	5.3 a
	Length (mm)	28.4 a	26.4 b	21.7 c	28.5 a
	Width (mm)	22.3 a	21.0 ab	20.0 b	20.6 b
Drupelet	Weight (mg)	51.3 a	42.0 b	33.2 c	49.9 a
	Length (mm)	5.2 ns	5.0	5.1	5.6
	Width (mm)	4.5 a	4.3 a	3.7 b	4.1 ab
Seeds	Number of seeds	112 ns	110	114	107
	Total seed wt (g)	0.22 ns	0.19	0.20	0.21
Receptacle	Length (mm)	22.0 b	21.7 b	16.8 c	23.2 a
	Width (mm)	8.9 a	8.8 a	9.0 a	8.1 b
Pedicle	Length (mm)	28 a	24 a	16 b	30 a
Fruit	Weight (g)	5.7 a	4.6 b	3.8 c	5.3 a

[i] Five fruit of each clone were measured. Mean separation within rows by Tukey's honestly significant difference at $P \leq 0.05$; "ns" indicates difference is not significant.

Table 8. Fruit weight, firmness, and color before and after storage for hand-harvested fruit of two cultivars in plots Puyallup, WA, USA.[i]

	Cultivar: WSU 2188	Cultivar: Cascade Harvest
Fruit weight (g)		
Into storage	4.2 a[ii]	4.04 a
After storage	2.8 a	2.5 a
Firmness (N)		
Into storage	2.2 a	0.9 b
After storage	0.7 a	0.3 a
Color into storage[iii]		
L*	24.3 a	23.4 a
a*	21.4 a	18.3 a
b*	6.9 a	6.4 a
Color after storage		
L*	22.4 a	24.1 a
a*	15.9 a	16.8 a
b*	3.9 b	4.9 a

[i] Values represent means of nine fruit per cultivar. Fruit were harvested 3 Jul 2017, with data collected on individual fruit. Firmness was destructively measured on nine fruit of each cultivar that were subsequently discarded. Fruits were stored at 4 °C for 7 d, then brought to room temperature (~20 °C) for 4 h for after storage measurements.
[ii] Means within a row followed by the same letter are not significantly different at $P \leq 0.05$, by Fisher's protected least significant differences test.
[iii] Color measured as L*, a*, b* with a Minolta Chroma Meter CR200b (Minolta, Ramsey, NJ, USA).

Disease and Pest Reaction

Phytophthora root rot is the most important soilborne disease of raspberry in the Pacific Northwest (Weiland et al. 2018). 'WSU 2188' was evaluated for root rot in naturally infested plots established in 2014 at WSU Puyallup. The presence of *P. rubi* in these plots has been verified previously using ITS primers DC1 and MP5 (Bonants et al. 1997, 2004). The root rot trial consisted of 32 total clones, including cultivars 'WSU 2166',

Table 9. Soluble solids, pH, titratable acidity, anthocyanin content, and total phenolics in machine harvested fruit collected from two trials in Lynden, WA, USA, over 3 years.

	Clone			
	WSU 2188	Meeker	Willamette	WSU 2166
Soluble solids (%)[i]	9.7	10.5	8.3	8.3
pH	3.12	3.50	3.34	3.25
Titratable acidity (as % citric acid)	2.01	1.54	1.63	1.83
Anthocyanin content (mg/100 g juice)	70	62	93	50
Total phenolics (mg GAE/100 g FW)	241	282	285	241

[i] Fruit samples of each clone were collected in 2013, 2014, and 2017 from nonreplicated plots and analyzed in duplicate. Numeric values are presented without statistical analysis.
FW = fresh weight; GAE = gallic acid equivalent.

Table 10. Bud survival/injury ratings in Apr 2019 in Abbotsford, British Columbia, for plants established in 2017.

Cultivar	Bud survival[i]
Chemainus	4.9 a[ii]
WSU 2166	4.9 a
C Bounty	4.8 a
WSU 2188	4.6 a
Meeker	2.7 b

[i] Ratings are on a scale of 0 to 5, where 0 represents complete death of all of the floricane buds, and 5 is no apparent injury to any floricane buds.
[ii] Mean separation within columns by Fisher's protected least significant difference, $P \leq 0.05$.

'Meeker', 'Cascade Harvest', 'Vintage', and 'Lewis'. Four replicates of each clone were planted in a randomized complete block design. Plants were evaluated in the fall of each year after planting using a subjective rating for vigor from 0 to 5, with 0 being dead and 5 a healthy and vigorous plant free of root rot symptoms. The high disease pressure in the field affected plant survival and introduced a large amount of error into statistical analysis. In 2015, 1 year after establishment, 'WSU 2188' had significantly lower ratings than the best performing clones (Table 11). However, in the second and third evaluation years, 'WSU 2188' showed moderate levels of root rot tolerance, with ratings similar to the most tolerant clones and significantly higher than the least tolerant clones. Based on this evaluation, 'WSU 2188' has moderate tolerance to root rot. This response has been observed in multiple regional plantings.

'WSU 2188' plants in multiple fields between 2014 and 2024 exposed to virus-infected pollen across Oregon and Washington have tested negative for *Raspberry bushy dwarf virus* (RBDV) by enzyme-linked immunosorbent assay (ELISA). In British Columbia, under high field pressure conditions, 'WSU 2188' has tested positive for RBDV in some, but not all of the trials in which it was planted. In the 2014 yield trial in British Columbia, three of four replicate plots of 'WSU 2188' tested positive for RBDV in 2016, whereas none of the plots of 'WSU 2188' tested positive for RBDV in the 2017 replicated planting while under evaluation. A single plant of 'WSU 2188' was also planted in a long-term germplasm observation block in 2017 and first tested positive for RBDV starting in 2022. Based on these observations, it appears that 'WSU 2188' does not carry the gene *Bu* conferring immunity to the common strain of RBDV, but 'WSU 2188' may be somewhat slower to acquire RBDV than 'Meeker', 'Chemainus', and 'Cascade Bounty', which tested positive more quickly in these same plantings (data not shown).

Uses

'WSU 2188' produces large, firm fruit with excellent flavor. Fruit of 'WSU 2188' machine harvest easily and have demonstrated suitability for IQF processing. In addition, the good flavor, large fruit size, attractive appearance, and ease of fruit release of 'WSU 2188' makes this cultivar suitable for the fresh market. Based on these traits and response to major diseases, 'WSU 2188' has the potential to perform well as a midseason cultivar in the raspberry growing areas of the Pacific Northwest.

Virus Testing Status and Availability

'WSU 2188' nuclear stock tested negative for *Apple mosaic virus*, *Arabis mosaic virus*, *Cherry leaf roll virus*, *Cherry rasp leaf virus*, *Prunus necrotic ringspot virus*, *Raspberry bushy dwarf virus*, *Raspberry ringspot virus*, *Strawberry necrotic shock virus*, *Tobacco ringspot virus*, *Tobacco streak virus*, *Tomato black ring virus*, *Tomato ringspot virus*, and *Xylella* by ELISA. In grafts to *Rubus occidentalis* 'Munger', it also indexed as negative for virus. 'WSU 2188' tested negative for *Blackberry chlorotic ringspot virus*, *Beet pseudo yellows virus*, *Blackberry virus Y*, *Blackberry yellow vein associated virus*, *Black raspberry necrosis virus*, *Raspberry latent virus*, *Raspberry leaf mottle virus*, *Rubus yellow net virus*, and *Strawberry latent ringspot virus* in reverse transcription polymerase chain reaction assays for phytoplasmas and *Xylella.* It was also negative in bioassays when it was grafted onto *R. occidentalis* 'Munger'. Nuclear stocks of 'WSU 2188' are maintained at the Corvallis-National Clean Plant Network of the USDA-ARS in Corvallis, OR, USA. Neither the Washington Agricultural Research Center nor the USDA-ARS have plants for sale. Names of propagators with certified 'WSU 2188' plants will be supplied on request. 'WSU 2188' is the subject of a grant of US Plant Patent 36,320.

Table 11. Root rot ratings for 'WSU 2188' compared with commercial red raspberry cultivars in plots containing 32 clones established in 2014 in a site infested with *Phytophthora rubi* and evaluated for 3 subsequent years in Puyallup, WA, USA.

Clone	2015 Rating[i]	2016 Rating	2017 Rating	Ranking out of 32
WSU 2166	2.5[ii]	4.5	3.5	#7
WSU 2188	4.0	3.3	3.0	#9
Meeker	4.0	4.7	1.7	#18
Cascade Harvest	4.3	5.0	1.3	#24
Vintage	4.3	1.3	1.0	#25
Lewis	4.3	2.5	0.8	#27

[i] Ratings are on a scale of 0 to 5, where 0 represents a dead plant, and 5 represents a healthy, vigorous plant free of root rot symptoms.
[ii] Means given are numeric means of surviving plants, as high pest pressure affected plant establishment and mortality in this field.

References Cited

Barritt BH, Torre LC, Pepin HS, Daubeny HA. 1980. Fruit firmness measurements in red raspberry. HortScience. 15(1):38–39. https://doi.org/10.21273/HORTSCI.15.1.38.

Bonants P, Hagenaar-de Weerdt M, van Gent-Pelzer M, Lacourt I, Cooke D, Duncan J. 1997. Detection and identification of *Phytophthora fragariae* Hickman by the polymerase chain reaction. Eur J Plant Pathol. 103(4):345–355. https://doi.org/10.1023/A:1008640227432.

Bonants PJM, van Gent-Pelzer MPE, Hooftman R, Cooke DEL, Guy DC, Duncan JM. 2004. A combination of baiting and different PCR formats, including measurement of real-time quantitative fluorescence, for the detection of *Phytophthora fragariae* in strawberry plants. Eur J Plant Pathol. 110(7):689–702. https://doi.org/10.1023/B:EJPP.0000041551.26970.0e.

Daubeny HA, Lawrence FJ, McGregor GR. 1989. 'Willamette' red raspberry. Fruit Var J. 43:46–48.

Lee J, Durst RW, Wrolstad RE, Collaborators 2005. Determination of total monomeric anthocyanin pigment content of fruit juices, beverages, natural colorants, and wines by the pH differential method: Collaborative study. J AOAC Int. 88(5):1269–1278. https://doi.org/10.1093/jaoac/88.5.1269.

Man in 't Veld WA. 2007. Gene flow analysis demonstrates that *Phytophthora fragariae* var. *rubi* constitutes a distinct species, *Phytophthora rubi* comb. nov. Mycologia. 99(2):222–226. https://doi.org/10.1080/15572536.2007.11832581.

McGuire RG. 1992. Reporting of objective color measurements. HortScience. 27(12):1254–1255. https://doi.org/10.21273/HORTSCI.27.12.1254.

Moore PP, Daubeny HA. 1993. 'Meeker' red raspberry. Fruit Var J. 47(1):2–4.

Moore PP, Hoashi-Erhardt W, Finn CE, Martin RR, Dossett M. 2015. 'Cascade Harvest' red raspberry. HortScience. 50(4):624–627. https://doi.org/10.21273/HORTSCI.50.4.624.

Moore PP, Hoashi-Erhardt W, Finn CE, Martin RR, Dossett M. 2019. 'WSU 2166' red raspberry. HortScience. 54(3):564–567. https://doi.org/10.21273/HORTSCI13652-18.

Waterhouse AL. 2001. Determination of total phenolics, p I1.1.1–I1.1.8. In: Wrolstad RE (ed). Current protocols in food analytical chemistry. Wiley, New York, NY, USA.

Weiland JE, Benedict C, Zasada IA, Scagel CR, Beck BR, Davis A, Graham K, Peetz A, Martin RR, Dung JKS, Gaige AR, Thiessen L. 2018. Late-summer disease symptoms in western Washington red raspberry fields associated with co-occurrence of *Phytophthora rubi*, *Verticillium dahliae*, and *Pratylenchus penetrans*, but not raspberry bushy dwarf virus. Plant Dis. 102(5): 938–947. https://doi.org/10.1094/PDIS-08-17-1293-RE.