‘Kokanee’ Primocane-fruiting Red Raspberry

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bit asymmetrical with uneven surface) fruit that ripen late. ‘Vintage’ is a smaller, less vigorous plant than ORUS 1173-2 with outstanding flavored, bright-colored, and firm fruit (Finn et al., 2013). ‘Kokanee’ is being released primarily because of its outstanding fresh fruit quality (large, attractive, good flavor, and bright color), its adaption to handling in the wholesale fresh market, and its adaptation to production in regions as diverse as the Pacific Northwest and the central highlands of Mexico.

Description and Performance

‘Kokanee’ has been evaluated most extensively in trials at Oregon State University’s North Willamette Research and Extension Center (OSU-NWREC, Aurora, OR) as well as observation plots with the U.S. Dept. of Agriculture-Agricultural Research Service (USDA-ARS) in Corvallis, OR, and in commercial trials in northern (Watsonville) and southern (Oxnard) California, central Mexico (Zamora), and southwestern Spain (Huelva). At OSU-NWREC (lat. 45°16’48”N, long. 122°45’3”W; USDA-ARS Hardiness Zone 8b), trials were established in 2010 and 2015 and arranged in a randomized complete block design, with three 3-plant replications (0.9 m between plants) used for measuring fresh fruit characteristics, harvest season, yield, and fruit weight. ‘Heritage’ and/or ‘Vintage’ were included as comparison cultivars. The plants were allowed to fill in the row but the hedgerow was narrowed to 0.6 m wide during the growing season and cut to ground level during the dormant season. A trellis with wires at 1.0 and 1.5 m height was used to support the canes.

Fruit were hand harvested weekly, and data collected on harvest season, yield, and average fruit weight (randomly selected 25-berry subsample per harvest) (Finn et al., 2004). The fruit-ripening season in Oregon was characterized by the dates on which 5%, 50%, and 95% of the total fruit were harvested. Subjective evaluations for fresh fruit characteristics were made at least three times each year using a 1 to 9 scale (9 = the best expression of each trait except color where 9 = dark red color, which is undesirable, as it appears overripe). The fruit ratings included firmness (as measured subjectively by hand in the field on six to eight fruit), color (ideal color is bright red and would be score 7 or 8), shape (with uniform, conic berry being ideal), coherence (the ability of the fruit to hold together when handled while being rated by hand in the field on six to eight fruit), texture (rated when chewed while tasting fruit in the field), separation (rating of how easily the ripe fruit were separated from the plant), and flavor (rated by tasting fruit in the field). Fruit were also evaluated informally as a thawed, individually quick-frozen (IQF) product by growers, processors, and researchers. Basic fruit chemistry traits, including soluble solids, pH, and titratable acidity, were evaluated in 2011–13 and 2016

‘Kokanee’ (Fig. 1) is a new primocane-fruiting red raspberry (*Rubus idaeus* L.) from the U.S. Dept. of Agriculture-Agricultural Research Service (USDA-ARS) breeding program in Corvallis, OR released in cooperation with the Oregon State Agricultural Experiment Station. ‘Kokanee’ is a high-yielding cultivar that produces large, firm fruit that are bright-red-colored and have very good, sweet flavor. The cultivar should be widely adapted to wherever primocane-fruiting raspberries are grown and has looked promising in trials as a wholesale, fresh market berry produced in tunnels in northern hemisphere, off season market regions (e.g., Mexico, Spain). An application for a U.S. plant patent (Appl. No. 14/999,027) has been submitted.

Origin

‘Kokanee’, tested as ORUS 4090-1, was selected from a seedling field in Corvallis, OR, in 2009 from a cross made in 2007 of ORUS 1173-2 × ‘Vintage’ (USPP24,198) (Finn, 2014; Finn et al., 2013) (Fig. 1). ORUS 1173-2 is a vigorous advanced selection that is productive and well adapted to the Pacific Northwest with large, somewhat “rough” (a

on fruit frozen from two to three harvests. Duplicate subsamples of ≈ 200 g each were taken randomly from frozen and thawed harvested fruit and were evaluated for percent soluble solids, pH, and titratable acidity in the laboratory as described for strawberry by Mathey et al. (2013). ‘Kokanee’, ‘Heritage’, and ‘Meeker’ fruits were analyzed for anthocyanin concentrations using previously described separation and identification procedures (Lee and Finn, 2007) with the following change: longer high-performance liquid chromatography analytical column (Synergi Hydro-RP 80 Å, 250 mm $\times$ 2 mm, 4 μ m; Phenomenex, Inc., Torrance, CA). Plant ratings were conducted one time each year during the fruiting season for primocane vigor and prickles (1 = numerous and large prickles; 9 = smooth, no prickles).

Yield and average fruit weight from 2011 to 2013 and 2016 were analyzed as a split-plot in time with cultivar as the main plot and year as the subplot (for the multiple year harvested trial) with mean separation by least significant difference. The planting and the

analysis (PROC GLM; SAS Institute, Cary, NC) included ‘Kokanee’ and ‘Heritage’, which is among the most widely grown, nonproprietary, primocane-fruiting cultivar (Daubeny et al., 1992).

There was no genotype $\times$ year interaction for fruit weight but this interaction was significant for yield; therefore mean yields are presented for each year of each trial (Table 1). In all years and trials, ‘Kokanee’s yields were numerically higher than those for ‘Heritage’ and this was significant in the 3 year mean yield in the 2010 planting and for the 2016 yield in the 2015-planted trial (Table 1). ‘Heritage’ is considered high yielding in Oregon. ‘Kokanee’ had significantly higher yield than ‘Vintage’ in the 2015-planted trial (Table 1).

‘Kokanee’ plants were scored as more vigorous than ‘Heritage’ (Table 2; Fig. 2). ‘Kokanee’s vigor and habit were more comparable to its ORUS 1173-2 parent and ‘Heritage’ than the stockier ‘Vintage’ (Table 2; Finn et al., 2013). ‘Kokanee’ canes were rated as being smoother and less prickly

than those of ‘Heritage’ (Table 2). The canes showed no symptoms of disease and were not sprayed with any fungicides. ‘Kokanee’ was susceptible to phytophthora root rot [*Phytophthora rubi* (W.F. Wilcox and J.M. Duncan) W.A. Man in’t Veld] in screening trials at WSU-Puyallup. Multiple plots that were scored 18 months after planting (Nov. 2015) had very little noted root rot and scored well; 4.25/5.00 scale, with 5 = no symptoms. However, by 30 months after planting (Nov. 2016), the scores had dropped to 2.33/5.00 with one of three plots completely dead.

Fig. 2. Entire fruiting plant of ‘Kokanee’.

Fig. 3. Fruiting truss of ‘Kokanee’.

Fig. 4. Harvested ‘Kokanee’ fruit.

Fig. 1. Pedigree of ‘Kokanee’ red raspberry.

Table 1. Fruit yield, mean fruit weight, and harvest season (2011–13) for primocane-fruiting red raspberry cultivars planted in replicated trial (three reps) in 2010 and 2015 at the Oregon State University’s North Willamette Research and Extension Center.

	Fruit wt (g)		Yield (kg/plant)			
	2011–13 ^a		2011	2012	2013	2011–13
2010-planted						
Kokanee	3.5 a	1.74 a	2.86 a	1.83 a	2.30 a	
Heritage	2.9 b	0.58 b	2.59 a	1.19 a	1.58 b	
2015-planted						
Kokanee	3.0 a	3.16 a				
Heritage	2.1 b	1.96 b				
Vintage	3.3 a	1.77 b				

^aMeans within a column, and within the same planting, followed by the same letter are not significantly different, $P > 0.05$, by least significant difference test.

Table 2. Subjectively evaluated fruit quality traits and vigor for two raspberry cultivars in a replicated trial at the Oregon State University’s North Willamette Research and Extension Center and evaluated in 2011–13.

	Primocane characteristics							Fruit characteristics	
	Vigor ^a	Prickles	Firmness	Color	Shape	Coherence	Texture	Separation	Flavor
Heritage	7.3 b ^a	4.3 b	7.6 b	8.6 a	7.4 a	8.0 a	5.8 b	5.8 b	5.6 b
Kokanee	8.0 a	5.4 a	8.0 a	6.5 b	7.4 a	8.3 a	7.3 a	7.3 a	7.0 a

^aTraits scored on a 1 to 9 scale: 1 = poor vigor, extremely spiny, very soft, very light, very uneven shape, crumbly, uncomfortably chewy, fruit does not pick easily, and poor flavor and 9 = very vigorous, smooth, very firm, dark red, uniform conic, drupelets hold together well, pleasant when chewed, easy separation of fruit from receptacle, and intense flavor, respectively.

^bMeans within a column followed by the same letter are not significantly different, $P > 0.05$, by least significant difference test.

'Kokanee' plants in tunnel production in a subtropical environment were susceptible to powdery mildew [*Podosphaera aphanis* (Wallr.) U. Braun and S. Takamatsu var. *aphanis* U. Braun]. In research trials, 'Kokanee' has tested positive for *Raspberry bushy dwarf virus*.

'Kokanee' consistently produced fruit that were around 30% heavier than those of 'Heritage' and comparable in size to 'Vintage' (Table 1) and were of similar firmness (Table 2). The fruit were an ideal color for the fresh market being bright and not as dark as those of 'Heritage' (Figs. 3 and 4). 'Heritage' and 'Kokanee' had similar conic fruit shape (Table 2). When picked, both cultivars had very good drupelet coherence with little or no crumble (Fig. 4). 'Kokanee' fruit consistently separated much more easily from the plant than 'Heritage' fruit but probably not easily enough to be machine harvested (Table 2).

'Heritage' fruit were perceived to be seedier than those of 'Kokanee' when eaten (Table 2). As with its parent 'Vintage', 'Kokanee' fruit were perceived to have excellent, sweet flavor, whereas those of 'Heritage' were scored as being bland but inoffensive. 'Kokanee's perceived sweetness would appear to be because of fruit with a higher pH and lower titratable acidity than 'Heritage' as its percent soluble solids, although high, was lower than that of 'Heritage' (Table 3). Although 'Kokanee's primary initial use is expected to be as a fresh market berry, its pH and titratable acidity were appropriate for a processed product. In informal evaluations of IQF fruit by a panel

of untrained industry members and researchers, 'Kokanee' consistently scored similarly to 'Vintage' and the floricane-fruited cultivar 'Meeker' for the overall quality as perceived by the panel and better than 'Heritage' or the floricane-fruited cultivar 'Wakefield' (data not shown). In addition to the outstanding color, size, firmness, and flavor that make 'Kokanee' a good fresh market option, the fruit were non-darkening when stored in plastic clam shells under refrigeration (0.5 to 1.5 °C) but softened after 7 d in storage (data not shown). In similar storage trials with another company, fruit refrigerated for 7 d followed by 1 d at room temperature were rated as acceptable (74% to 85% "good" over course of the season). 'Kokanee' fruit harvested from the second primocane crop from plants in tunnel production under commercial conditions in a subtropical environment were smaller (4.5 g) than those of 'Kwanza' (5.4 g) and similar in size to those of 'Kweli' (4.6 g), 'BP-1' (Amira®) (4.1 g), and 'Imara' (4.1 g); had a comparable percentage of defective fruit to those of 'Kwanza', 'Kweli', and 'BP-1' (Amira®) (34% to 36%) but fewer than 'Imara' (42%); and the plant yield was comparable to that for 'Kwanza', 'Kweli', and 'Imara' but greater than for 'BP-1' (Amira®) (data not shown).

'Kokanee' had a unique anthocyanin profile compared with the well-established red raspberries 'Heritage' or 'Meeker' (Table 4). Whereas the predominant anthocyanin in 'Heritage' and 'Meeker' fruit was cyanidin-3-sophoroside (>58% of total), for 'Kokanee', it was cyanidin-3-glucosylrutinoside (40% of

total). The total anthocyanin concentration of 'Kokanee' fruit (35.3 mg/100 g) was more than 50% lower than in fruit of either 'Heritage' or 'Meeker'. Proportionally, cyanidin-3-rutinoside levels were much higher in 'Kokanee' (19%) than in 'Meeker' (5%), and were not detected in 'Heritage'. Pelargonidin-3-rutinoside was measured at low concentrations in 'Kokanee' fruit, but not detected in the fruit of 'Heritage' or 'Meeker'. Conversely, pelargonidin-3-sophoroside was found in both 'Heritage' and 'Meeker', but not detected in 'Kokanee'.

Compared with 'Heritage', the harvest season of 'Kokanee' started 10–14 d earlier, reached 50% harvest up to 5 d earlier and finished 5 d earlier to 14 d later in research trials (Table 5). 'Kokanee' ripened later than 'Vintage' and 'BP-1' (Amira®) in the 2015-planted trial (Table 5). In commercial trials in Mexico, Spain, and California, 'Kokanee' ripened later than 'Vintage', which was a preferable season as it was more removed from the days with the hottest temperatures (data not shown).

'Kokanee' is introduced as a high-quality, primocane-fruited red raspberry with a bright red color, large size, and very good flavor for the fresh market and with yields comparable to or better than industry standards.

'Kokanee' nuclear stock has tested negative for *Apple mosaic virus*, *Arabidopsis mosaic virus*, *Cherry leafroll virus*, *Cherry rasp leaf virus*, *Prunus necrotic ringspot virus*, *Raspberry bushy dwarf virus*, *Raspberry ringspot virus*, *Strawberry necrotic shock virus*, *Tobacco ringspot virus*, and *Tomato ringspot virus* by ELISA, for *Black raspberry necrosis virus*, *Blackberry chlorotic ringspot virus*, *Blackberry virus Y*, *Blackberry yellow vein associated virus*, *Raspberry latent virus*, *Raspberry leaf mottle virus*, *Rubus yellow net virus*, and *Strawberry latent ringspot virus* in real-time polymerase chain reaction (PCR) tests, for *Xylella fastidiosa* and phytoplasmas by PCR, and has indexed negative when grafted onto *Rubus occidentalis* L.

Table 3. Soluble solids, pH, and titratable acidity for fruit of two red raspberry cultivars grown at Oregon State University's North Willamette Research and Extension Center and harvested in 2011–13.

Cultivar	Percent soluble solids (°Brix) ^a	pH	Titratable acidity (g·L ⁻¹ as citric)
Heritage	14.03 a	3.12 b	19.55 a
Kokanee	11.59 b	3.30 a	14.62 b

^aMeans within a column followed by the same letter are not significantly different, $P > 0.05$, by least significant difference test.

Table 4. Individual and total anthocyanin concentrations (mg of cyanidin-3-glucoside/100 g) of 'Kokanee' and 'Heritage' primocane-fruited and 'Meeker' floricane-fruited red raspberry fruit in 2015 from trial at Oregon State University's North Willamette Research and Extension Center.^a

Cultivar	Cyanidin-3-sophoroside	Cyanidin-3-glucosylrutinoside	Cyanidin-3-sambubioside	Cyanidin-3-glucoside	Pelargonidin-3-sophoroside	Cyanidin-3-rutinoside	Pelargonidin-3-glucoside	Pelargonidin-3-rutinoside	Total
Heritage	52.1 (60)	nd ^b	1.8 (2)	26.1 (30)	4.0 (5)	nd	2.3 (3)	nd	86.3
Kokanee	6.1 (17)	14.0 (40)	1.4 (4)	4.0 (11)	nd	6.7 (19)	1.5 (4)	1.5 (4)	35.3
Meeker	48.2 (58)	10.6 (13)	1.8 (2)	11.0 (13)	5.2 (6)	4.2 (5)	1.9 (2)	nd	82.9

^aAnthocyanins are listed in the order of high-performance liquid chromatography elution. Italicized values in parenthesis are proportions of the total anthocyanins.

^bnd = not detected.

Table 5. Mean dates when harvest passed 5%, 50%, and 95% of total yield and the length of the harvest season for 'Kokanee' and other cultivars picked in the same years from trials at Oregon State University's North Willamette Research and Extension Center.

	n ^a	Harvest season		
		5%	50%	95%
2010 planting				
Kokanee	3	9 Aug.	30 Aug.	18 Sept.
Heritage	3	19 Aug.	4 Sept.	23 Sept.
2015 planting				
BP-1 (Amira®)	1	26 July	9 Aug.	16 Aug.
Vintage	1	2 Aug.	16 Aug.	30 Aug.
Kokanee	1	9 Aug.	23 Aug.	13 Sept.
Heritage	1	16 Aug.	23 Aug.	30 Aug.

^aThe number of trials where the cultivar was harvested in the same years as 'Kokanee' and that were included in the mean.

‘Kokanee’ is patent pending. When this germplasm contributes to the development of a new cultivar, hybrid, or germplasm, it is requested that appropriate recognition be given to the source. Further information or a list of nurseries propagating ‘Kokanee’ is available on written request to C.E. Finn. The USDA-ARS does not sell plants. In addition, genetic material of this release has been deposited in the National Plant Germplasm System as CRUB 2806 (PI 682652).

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