Growth, Yield, and Fruit Quality of 10 Lingonberry (*Vaccinium vitis-idaea*) Cultivars and Selections in the Pacific Northwest, USA

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Abstract

Lingonberry (*Vaccinium vitis- idaea* L.) has a long history of commercial harvest in Europe and parts of northern North America, but is considered a new crop in the Pacific Northwest region (PNW) of the United States. 'Koralle' and, to a lesser extent, 'Red Pearl' are the standard cultivars for the PNW industry. Three Swedish advanced selections (87102-3, 8723-10, 8724-49) from the now closed Balsgård Research Station, and seven cultivars ('Ida', 'Koralle', 'Linnea', 'Red Pearl', 'Sanna', 'Splendor', and 'Sussi') were compared in a replicated trial at the USDA-ARS in Corvallis, Ore. (USA). Genotypes were planted in a randomized complete block design in autumn 2000 on raised beds. Prior to planting, the soil pH was adjusted to 4.5 and sawdust was incorporated into the planting row. Vigorous genotypes filled their beds by late 2002. In 2002, vigor and full bloom date for the first cropping season were recorded. In 2003, most of the genotypes had two crops and some had a third fall bloom, therefore 1st bloom, full bloom, first fully colored ("ripe") and 50% of fruit fully colored for each crop were recorded along with plant vigor. Fruit were harvested in both years and berry weight determined. Soluble solids, titratable acidity, pH and total anthocyanins were determined from frozen samples. While 'Linnea' and 'Sussi' had a single crop that ripened in late July-early August, the other genotypes had two crops the first ripened in mid-July and the second in late September-early October. 'Ida' had the largest fruit and the greatest yield even though it was in the middle of the group for vigor scores. 'Ida's fruit were over 40% heavier than the second largest genotype (8723-10), and nearly twice as heavy with almost twice the yield as 'Koralle'. 'Red Pearl', which is also grown commercially in the PNW, had a very poor yield and was similar to 'Koralle' in fruit size. Those cultivars that had a significant crop in mid-summer would be of value to small farms selling to local farmers markets but the poorer fruit quality under these conditions would mean this fruit would not be valuable for harvest for the processing market or the valuable American Thanksgiving holiday market. 'Sussi' and 'Linnea's single, August harvest is too early while the environmental conditions are still somewhat unfavorable. 'Ida', 8724-49, 'Koralle', 'Linnea', and 'Red Pearl' had 80-100% of their crop ripen in September. Of these, 'Ida' and 'Koralle', and perhaps 8723-10, appear to have the best overall horticultural characteristics and fruit characteristics.

INTRODUCTION

Lingonberry (*Vaccinium vitis- idaea* L.) has a long history of commercial harvest from the wild or from managed stands in Europe and parts of northern North America. In the Pacific Northwest of the United States, they are considered a new crop but there is a small commercial industry established (Penhallegon, 2003). Most commercial plantings are very small, largely trial plantings on farms that are growing other crops. However, there are a few growers who have plantings that are larger than four hectare. While numerous cultivars such as the Ernte series (Zillmer, 1985), 'Masovia' (Gustavsson, 1999) and others were originally tried, 'Koralle' rose to the forefront as the most consistent producer of good quality fruit. Since that time, new, or previously unavailable cultivars, have become available. The objective of this trial was to compare the growth, yield, and fruit quality characteristics of

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seven cultivars, including the standard 'Koralle', and three Swedish advanced selections from the now closed Balsgård Research Station in a replicated trial at the USDA-ARS in Corvallis Ore. (USA).

MATERIALS AND METHODS

The genotypes included in the trial were the Swedish selections 87102-3, 8723-10, and 8724-49 and the cultivars 'Ida', 'Koralle', 'Linnea', 'Red Pearl', 'Sanna', 'Splendor', and 'Sussi' (Gustavsson, 1999; Gustavsson and Trajkovski, 1999; Stang et al., 1994). Three plants of each genotype were planted 0.45 m apart in each of four plots in a randomized complete block design in the autumn of 2000 on raised beds. Prior to planting, the soil pH was adjusted to 4.5 and sawdust was incorporated into the planting row. The vigorous genotypes filled their beds (0.3 x 1.2 m) by the end of 2002. In 2002, vigor and full bloom date for the first cropping season were recorded. In 2003, most of the genotypes had two crops and some had a third fall bloom, therefore 1st bloom, full bloom, first fully colored ("ripe") and 50% of fruit fully colored for each crop were recorded along with plant vigor. Fruit were harvested in both years and berry weight determined. In 2003, harvested fruit were frozen and soluble solids, titratable acidity, pH and total anthocyanins determined from these samples.

RESULTS AND DISCUSSION

Phenology (Table 1)

All genotypes except 'Linnea' and 'Sussi' had a summer and fall crop. While Gustavsson and Trajkovski (1999) reported that 'Sanna' did not have a 2nd bloom, in our planting it did. 'Koralle', 'Red Pearl' and 8723-10 were beginning a third flowering cycle at the time of harvest in autumn 2003 (data not shown). 8724-49 was the first to bloom in the spring and most flowering took place in a two week period from April 9 to 21 for all genotypes except 'Linnea' which flowered nearly 3 weeks later. The genotypes had 50% of their fruit fully red for the 1st crop between 12 July and 8 August. The earliest ripening fruit were 87102-3 and 8723-10 followed by 'Splendor', 'Sanna', 8724-9 and 'Ida'. 'Koralle' and, especially, 'Linnea' and 'Red Pearl' were later ripening. For those genotypes that produced a second crop, the second bloom began just as 10% of the fruit on the first crop were fully colored in early to mid- July. The second crop began to ripen in early to mid-September. The fruit were fully colored on 50% of the fruit in late September to mid-October. The first to ripen the fall crop was 8723-10 and the last was 'Koralle'.

Vigor (Table 2)

While the genotypes differed in vigor scores, there were no genotype x year interactions or year effects. The most vigorous genotypes were 8724-49 and 'Linnea'. These genotypes rapidly filled the bed, appeared healthy and showed no disease symptoms. 'Sussi' and 'Sanna' did not appear to be well adapted as they were slow to fill the bed, and suffered from twig dieback (unknown causal organism). 'Red Pearl' had variable vigor scores across reps. 'Ida' was intermediate in vigor, which seems surprising as its yields were quite high. While 'Ida' generally appeared healthy it did not fill its bed quickly.

Yield and Fruit Size (Table 2)

There were significant differences due to genotype and year and there was a genotype x environment interaction. 'Ida' had the highest yield and largest fruit size in both harvest years, although, in 2003, the yields were not significantly different from those of 8723-10 and 'Linnea'. 8724-49 and 'Splendor' were among the lowest producers and 'Red Pearl' had dramatic differences between the 1 st and 2nd harvest season. While fruit size is not of great importance to the processed market where the fruit is often chopped or pureed, large fruit size is an advantage in the fresh market and in the pick-your-own market. Berry size was fairly consistent from year to year for most cultivars and 'Ida' was 28% bigger than the next largest genotype 87102-3.

Fruit Chemistry (Table 3)

In general, the genotypes had high soluble solids, low pH and good titratable acidity levels. The levels for these three traits are in line with what is expected for a good processed product. 8723-10, 'Linnea' 87102-3, 'Red Pearl' and 'Splendor' had higher soluble solid levels than did 'Ida', 'Sanna' or 'Sussi'. 'Koralle' had similar soluble solids levels to 'Ida'. The pH for all samples was less than 3.5. In our breeding program, we use pH 3.5 as a target as historically berries with pH of 3.5 or below process well and their anthocyanins remain stable and bright colored. While all of the genotypes had acceptable pH levels, there was a range with 'Sussi', 'Splendor', and 87102-3 having lower levels than 'Red Pearl', 'Linnea' or 8723-10. The titratable acidity levels ranged from 1.19 for 'Koralle' to over 2.1 for 87102-3 and 'Splendor'. In general, the lower the pH the higher the titratable acidity, however, 'Red Pearl' had the highest pH and was in the middle of the genotypes for titratable acidity. 'Ida' had the highest anthocyanin levels followed by 'Linnea', 'Sussi', 'Sanna', 87102-3 and 8724-49. 'Ida's high anthocyanin levels were somewhat surprising because it was the largest fruited of the genotypes. Anthocyanins are concentrated in the lingonberry skin and it might be expected that the larger fruited genotypes, which have less skin per unit volume, might have the lower anthocyanin levels. 8723-10, 'Splendor' and 'Red Pearl' had the lowest anthocyanin levels. Gustavsson and Trajkovski also looked at fruit chemistry in 'Ida', 'Linnea', 'Koralle' and Sanna (1999). In general, their titratable acidity levels were higher and their soluble solids and anthocyanin levels lower than those in the current study. This may reflect that we were able to let the fruit hang on the plant for a long time as early, autumn cold weather is not as threatening in Oregon as in Sweden.

Overall

While several of these genotypes are capable of producing two crops, the crop that is produced in the summer on both the double and single croppers is subject to intense sunlight, low humidity, and occasionally high temperatures and as a result can suffer from heat damage. Generally, growers are going to let the first crop mature and drop and only harvest the second, fall crop. The first, real representative crop from these genotypes was produced in 2003. Based on the 2003 harvest, 'Ida' would seem to be the clear choice for growers in the Pacific Northwest as it produces a fall crop, which some genotypes do not, the yields and fruit size are outstanding for either fresh or processed markets, and the fruit chemistry is excellent for processing. 'Koralle' and 8723-10 were the other genotypes with the best potential and further testing will determine whether they are commercially viable. At this time, 'Linnea' and Sussi' cannot be recommended due to their lack of a fall crop, 8724-49 and 'Splendor' due to their poor yield, and 'Red Pearl' due to its erratic performance and poor anthocyanin levels.

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Tables

Table 1. Dates when first open flowers were noted for 1st and 2nd crop and similarly dates when 10% and 50% of the fruit were fully colored for 1st and 2nd crop in 2003 for 10 lingonberry genotypes grown in Corvallis, Ore.

	First crop			Second crop		
	First bloom	10% red	50% red	First bloom	10% red	50% red
8723-10	21-Apr b	2-Jul cd	12-Jul d	11-Jul b	13-Sep c	25-Sep c
87102-3	21-Apr b [z]	1-Jul cd	12-Jul d	3-Jul c	13-Sep c	28-Sep bc
8724-49	9-Apr d	9-Jul b-d	18-Jul b-d	8-Jul bc	16-Sep bc	1-Oct bc
Ida	21-Apr b	10-Jul bc	18-Jul b-d	3-Jul c	13-Sep c	28-Sep bc
Koralle	12-Apr cd	13-Jul b	25-Jul b	8-Jul bc	2-Oct a	14-Oct a
Linnea	12-May a	23-Jul a	8-Aug a	-	-	-
Red Pearl	15-Apr b-d	26-Jul a	5-Aug a	12-Jul b	23-Sep b	3-Oct b
Sanna	19-Apr bc	8-Jul b-d	18-Jul b-d	17-Jul a	10-Sep c	30-Sep bc
Splendor	11-Apr d	1-Jul d	16-Jul cd	11-Jul b	16-Sep bc	1-Oct bc
Sussi	19-Apr bc	10-Jul b-d	21-Jul bc	-	-	-

[z] Mean separation within columns by Duncan's multiple range test, $P \leq 0.05$.

Table 2. Plant vigor, yield and berry weight for 10 lingonberry genotypes grown in Corvallis, Ore.

	Vigor[z]		Yield (g/original plant)				Average berry weight (g)					
	2002-03		2002		2003		2002-03		2002		2003		2002-03	
Ida	6.8	bc[y]	145.27	a	229.33	a	187.30	a	0.50	a	0.51	a	0.50	a
8723-10	6.5	bc	60.30	bc	150.77	ab	105.53	b	0.35	bc	0.35	bc	0.35	bc
Koralle	7.3	b	84.43	bc	116.37	bc	100.40	bc	0.26	cd	0.27	d-f	0.27	de
Linnea	8.6	a	26.89	de	150.39	ab	88.64	b-d	0.23	cd	0.24	ef	0.24	de
87102-3	7.3	b	23.96	de	99.79	bc	61.88	b-d	0.42	ab	0.36	b	0.39	b
Red Pearl	7.4	b	84.79	bc	30.76	c	61.63	b-d	0.24	cd	0.23	f	0.23	de
Sussi	5.0	e	6.20	e	87.54	bc	60.43	b-d	0.16	de	0.34	b-d	0.28	cd
Sanna	5.5	de	6.19	e	102.48	bc	54.34	cd	0.09	e	0.31	b-e	0.20	e
8724-49	8.4	a	48.25	cd	48.33	c	48.29	d	0.31	bc	0.29	c-f	0.30	cd
Splendor	6.0	cd	21.30	de	80.11	bc	40.90	d	0.31	bc	0.29	c-f	0.30	cd

[z] Scored on 1-9 scale where 1=dead, 5= fair vigor, 9= extremely healthy and vigorous.

[y] Mean separation within columns by Duncan's multiple range test, $P \leq 0.05$.

Table 3. Brix, pH and titratable acidity for purees made from the frozen fruit of 10 lingonberry genotypes grown in Corvallis, Ore. in 2003.

	Brix[z]		pH		Titratable acidity[z]		Anthocyanins[z] (mg/100 g)	
8723-10	19.19	a	3.33	ab	1.44	cd	27.22	e
87102-3	17.98	a-c	3.10	c	2.10	ab	35.34	cd
8724-49	16.28	b-d	3.24	bc	1.50	cd	32.62	d
Ida	15.39	de	3.22	bc	1.43	cd	44.45	a
Koralle	16.09	dc	3.24	bc	1.19	d	29.27	e
Linnea	18.29	ab	3.34	ab	1.41	cd	40.80	b
Red Pearl	17.66	a-c	3.39	a	1.58	c	12.26	g
Sanna	15.09	de	3.20	bc	1.61	c	34.85	cd
Splendor	17.91	a-c	3.15	c	2.30	a	23.52	f
Sussi	13.73	e	3.16	c	1.92	b	37.09	c

[z] ^{o}Brix (percent soluble solids) at 20^{o}C; titratable acidity= g citric acid/100 g fruit; anthocyanin expressed as cyanadin-3-glucoside.