

‘Tillamook’ and ‘Pinnacle’ Strawberries

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‘Tillamook’ and ‘Pinnacle’ (Fig. 1) are new June-bearing (short-day) strawberry (*Fragaria xananassa* Duch.) cultivars from the U.S. Department of Agriculture-Agricultural Research Service (USDA-ARS) breeding program in Corvallis, Ore., released in cooperation with the Oregon Agricultural Experiment Station, the Washington State University Agricultural Research Center and the Idaho Agricultural Experiment Station. ‘Tillamook’ is a high-yielding, large-fruited, midseason cultivar with very high fruit quality that is suited to the fresh and processed markets. ‘Tillamook’ is named after the Native American tribe who lived along the Pacific Coast on Tillamook Bay and current site of the city of Tillamook, Ore. ‘Pinnacle’ is a high-yielding, large-fruited, early midseason cultivar with very high fruit quality that is most suited to the fresh market but produces a satisfactory processed product.

Origin

‘Tillamook’ was selected in 1996 from the cross ‘Cuesta’ x ‘Puget Reliance’ and has been tested as ORUS 1816-2. ‘Puget Reliance’ (USPP 9310; BC 77-2-72 x WSU 1945) is high yielding, large fruited, and well adapted to the Pacific Northwest (Moore, 1995; Moore et al., 1995). ‘Cuesta’ (USPP 8662; ‘Seascape’ x [‘Fern’ x ‘Parker’]) was released as a replacement for ‘Chandler’ in the southern California production region but ‘Camarosa’ (USPP 8708), released simultaneously, has become the predominant commercial cultivar in this California market (Bringhurst et al. 1994; Hokanson and Finn, 2000; Voth et al., 1994b).

‘Pinnacle’ was selected in 1996 from the cross ‘Laguna’ x ORUS 1267-250 (Fig. 2) and was tested as ORUS 1826-2. ‘Laguna’ (USPP

8663; ‘Irvine’ x Cal 85.92-602) was released as a possible replacement for ‘Chandler’ (Voth et al., 1994a) but, as with ‘Cuesta’, ‘Camarosa’ has instead largely replaced ‘Chandler’. ORUS 1267-250 (‘Redcrest’ x ORUS 869-13) was an extensively tested advanced selection in the USDA-ARS program that had the outstanding fruit quality characteristics of ‘Redcrest’ along with larger fruit, however it was never deemed different enough from ‘Redcrest’ to justify its release as a cultivar.

‘Tillamook’ and ‘Pinnacle’ were tested in Aurora, Ore., Puyallup, Wash., and Abbotsford, B.C., and in grower fields in Washington and Oregon. The most thorough testing was done at the North Willamette Research and Extension Center of Oregon State University (Aurora, Ore.) where these cultivars were included in multiple nonreplicated and replicated trials established in 1998 and 1999. In 2001, they were both planted in replicated trials at Washington State University-Puyallup (WSU). In all trials, the plants were grown in a matted row system with plants initially set at 46 cm apart in the row in Oregon and 38 cm apart in Washington, in eight plant plots. During the harvest season,

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 randomly selected subsample of 25 fruit from each harvest. In Oregon, yield and average fruit weight from 2000–01 were analyzed as a split plot in time with cultivar as the main plot and year as the subplot, whereas in Washington they were analyzed as a randomized complete block for 2002 (Table 1). Fruit firmness was measured in the WSU trial. Firmness was determined by the force (N) required for a 4-mm-diameter cylinder to penetrate to a depth of 6 mm of five randomly selected fruit from each harvest. The plantings and the analyses (PROC GLM, SAS Institute, Cary, N.C.) included ‘Totem’, which is the most widely grown strawberry cultivar in the northwestern U.S. (Hokanson and Finn, 2000). In all trials, ‘Puget Reliance’ (Moore et al., 1995), ‘Puget Summer’ (Moore and Finn, 2002), and ‘Redcrest’ (Stahler et al., 1995) were represented by at least a single plot in which data were collected but not included in the statistical analysis. The fruit ripening season in Oregon was characterized by the dates at which 5%, 50%, and 95% of the total fruit yield were harvested, whereas in Washington the cumulative yield for each plot is plotted and the dates are interpolated from the points the cumulative yield line reaches 5%, 50%, and 95% of the total (Table 2). Subjective evaluations 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) for plant vigor and fresh fruit characteristics including appearance, firmness, external and internal color, capping (ease with which the calyx is removed), and flavor. The data presented are means of these observations (Table 3). In 2000 and 2001, duplicate subsamples of ≈200 g each, taken randomly from harvested fruit, were evaluated for Brix, titratable acidity, and pH (Table 4) and then evaluated informally as a thawed, individually quick-frozen (IQF) product by small fruit researchers. In addition, in January 2002, samples of ‘Tillamook’, ‘Totem’ and two selections were evaluated blindly for color, appearance, firmness, flavor and overall



Fig. 1. ‘Pinnacle’ (top left), ‘Tillamook’ (top right) and ‘Totem’ (bottom center) fruit.

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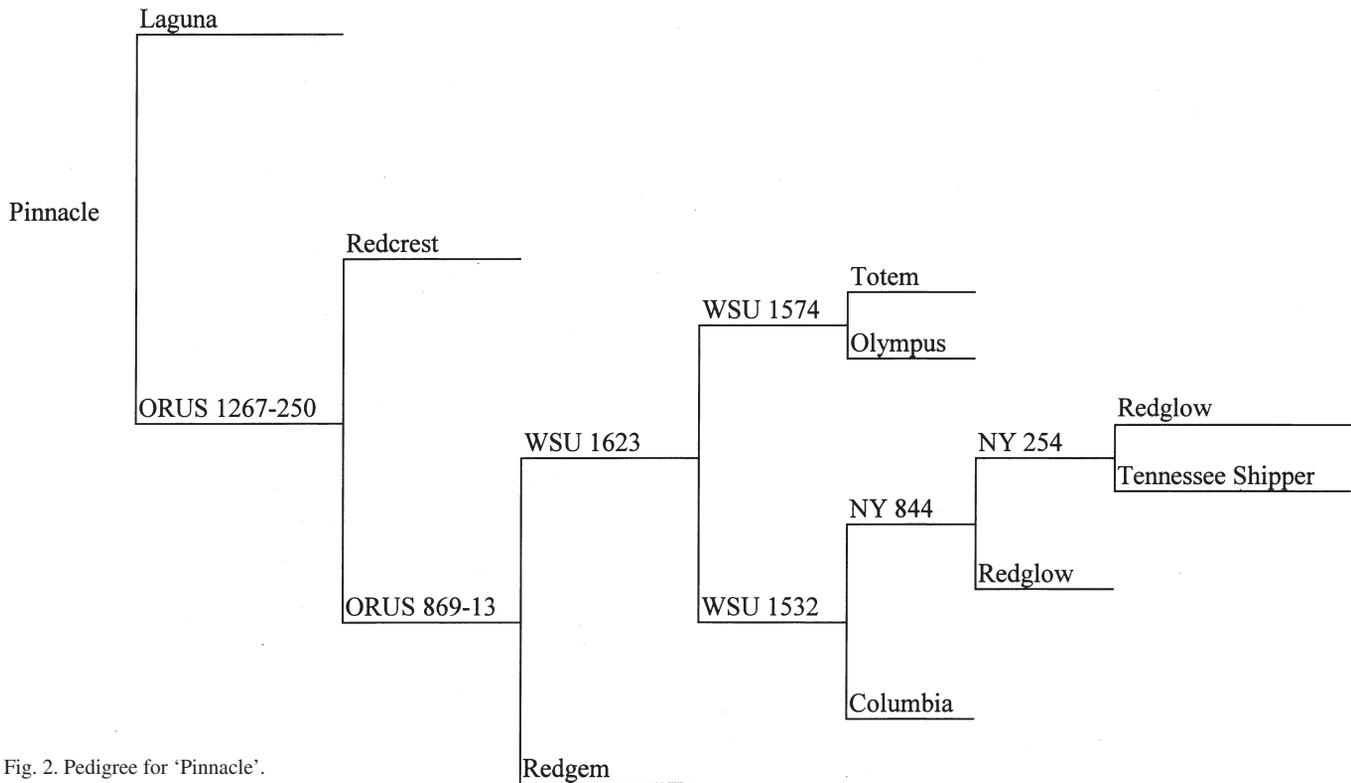


Fig. 2. Pedigree for 'Pinnacle'.

quality as thawed 4 + 1 (4 parts fruit + 1 part sugar) and sliced samples to 26 researchers and growers involved with the strawberry industry (data not shown).

Description and Performance

In Oregon, 'Tillamook' and 'Pinnacle' were higher yielding than 'Totem' in the first harvest season (1 year after planting) in the 1999-planted replicated trial but had similar yield in the second harvest season (Table 1). Over 2 years, yields of both cultivars were similar to 'Totem' (Table 1). In comparison with single observation plots, 'Tillamook' appeared to have first-year yields similar to 'Puget Summer' and 'Puget Reliance' and similar or larger second-year yields. While 'Pinnacle' behaved similarly to 'Tillamook' in the first year harvest, it had similar or smaller second-year yields. In Washington, 'Tillamook' and 'Pinnacle' have had similar first year yields similar to 'Hood', 'Puget Summer', and 'Puget Reliance' (Table 1).

'Tillamook' and 'Pinnacle' produce very large fruit in their first and second year. In the 1999 planting, while 'Tillamook's first year fruit weight was comparable to 'Totem' in Oregon, in the second year fruit weight was 76% greater and the mean fruit weight over 2 years was 46% greater than 'Totem' (Table 1). 'Tillamook' fruit were 56% heavier than 'Hood' in the first year at WSU. 'Tillamook' fruit weight was much larger than the cultivars in observation plots and while not always statistically different or possible to compare statistically, 'Pinnacle' fruit have been heavier than 'Totem', 'Puget Reliance', 'Puget Summer', 'Hood', and 'Redcrest' in every trial and every harvest year (Table 1). 'Tillamook' maintained its larger fruit size over the season compared to the other genotypes evaluated (data not shown) and this was noted

for its 'Cuesta' parent as well (Bringhurst et al., 1994). 'Pinnacle' fruit weight often decreases substantially from first to second harvest season but it is still larger than that of 'Totem'. Large fruit size, when combined with a comparable or higher yield and an open plant habit, make 'Tillamook' and 'Pinnacle' much more efficient to pick, thereby reducing the growers cost to harvest a similar yield.

Both cultivars have scored very well for fresh fruit traits in the field (Table 3). Fruit are attractive and symmetrical with outstanding firmness, very good capping and very good flavor. For fresh fruit firmness as measured by a penetrometer at WSU, 'Pinnacle' (2.66 N) was significantly firmer than 'Hood' (1.87 N) and 'Puget Reliance' (1.84 N), and 'Tillamook' (2.15 N) was significantly firmer than 'Hood'. While

Table 1. Fruit weight and yield in the first and second harvest year, and mean of both years for strawberry cultivars planted in 1998 and 1999 in a replicated (three replications) or nonreplicated (single plots interspersed with replicated plots) planting at the Oregon State University–North Willamette Research and Extension Center (Aurora, Ore.) and in a 2001-planted replicated trial at WSU–Puyallup, Wash.

Cultivar	Fruit wt (g) ^z			Yield (kg·ha ⁻¹)		
	First-year ^y	Second-year	2-Year mean	First-year ^y	Second-year	2-Year mean
1998-Planted trial (Aurora, Ore.) ^y						
Pinnacle	18.7	14.6	16.7	42870	20217	31544
Puget Summer	11.5 b	7.6	10.5	32665 a	4906	18786
Puget Reliance	14.2 a	11.3	13.5	36100 a	18639	27370
Redcrest	13.8 a	9.4	12.7	34710 a	16681	25696
Totem	13.0 ab	8.5	10.8	20678 b	11574	16126
1999-Planted trial (Aurora, Ore.)						
Replicated trial						
Tillamook	19.0 a	17.9 a	18.4 a	26042 a	19628 a	22835 a
Pinnacle	19.4 a	13.2 b	16.3 ab	23685 a	12972 a	18329 a
Totem	14.9 a	10.3 b	12.6 b	17857 b	18356 a	18107 a
Observation plots						
Puget Summer	13.6	10.1	11.8	26536	14205	20370
Puget Reliance	14.8	8.6	11.7	22080	10810	16445
Redcrest	---	9.3	---	---	22221	---
2001-Planted replicated trial (Puyallup, Wash.)						
Pinnacle	18.9 ab	---	---	33695 a	---	---
Hood	13.6 c	---	---	27630 a	---	---
Tillamook	21.2 a	---	---	26507 a	---	---
Puget Summer	14.5 c	---	---	23491 a	---	---
Puget Reliance	17.1 abc	---	---	23811 a	---	---

^zMeans within a column, within the same planting, followed by the same letter are not significantly different, $P > 0.05$, by Duncan's multiple range test.

^yAll three replications were harvested in the first harvest year, but 'Pinnacle' was only planted in a single observation plot. In the second harvest season, only 'Totem' was harvested in all replications due to fiscal restraints, so the data for 2000 represents a single plot and the combined data represents the average over years of a single plot.

Table 2. Midpoint of harvest (50%) and harvest interval (5% to 95%) of fruit harvested in 2000 and 2001 for six strawberry cultivars planted in 1999 at the Oregon State University–North Willamette Research and Extension Center (Aurora, Ore.) and in 2002 for four strawberry cultivars planted in 2001 at WSU–Puyallup, Wash.

Cultivar	First-year harvest		Second-year harvest	
	Midpoint harvest	Harvest interval (5% to 95%)	Midpoint harvest	Harvest interval (5% to 95%)
1999-Planted trial (Aurora, Ore.)				
Pinnacle	12 June	5 June–26 June	11 June	30 May–18 June
Puget Reliance	12 June	5 June–26 June	11 June	4 June–18 June
Tillamook	12 June	5 June–29 June	11 June	4 June–18 June
Totem	15 June	5 June–26 June	11 June	4 June–25 June
Redcrest	19 June	12 June–5 July	18 June	11 June–25 June
Puget Summer	19 June	15 June–29 June	18 June	11 June–25 June
2001-Planted replicated trial (Puyallup, Wash.)				
Pinnacle	18 June	11 June–1 July	---	---
Puget Reliance	20 June	11 June–1 July	---	---
Hood	21 June	11 June–1 July	---	---
Tillamook	21 June	11 June–2 July	---	---

Table 3. Mean scores for subjectively evaluated characteristics in the field of five strawberry cultivars planted in 1999 at the Oregon State University–North Willamette Research and Extension Center (Aurora, Ore.) and evaluated 2000–01.

Cultivar	Plant vigor ^z	Fresh fruit characteristics					
		Appearance	Firmness	Color		Capping	Flavor
				External	Internal		
Pinnacle	7.4 a ^y	7.6 a	8.8 a	6.9 c	6.9 ab	8.0 a	7.3 ab
Puget Reliance	7.5 a	7.8 a	6.5 c	7.7 ab	6.9 b	8.4 a	6.7 b
Redcrest	8.5 a	7.2 a	8.6 a	8.0 a	7.8 a	8.6 a	8.2 a
Tillamook	7.8 a	7.8 a	8.3 a	6.9 bc	7.1 ab	7.8 a	7.9 ab
Totem	7.4 a	7.3 a	7.2 b	7.3 bc	7.3 ab	8.3 a	7.5 ab

^zTraits scored on a 1 to 9 scale. 1 = poor vigor, uneven rough appearance, soft fruit, very light colored, poor separation of calyx from receptacle and poor flavor and 9 = very vigorous, very uniform and attractive, very firm, dark red, calyx separates easily from the receptacle, intense flavor, respectively.

^yMeans within a column followed by the same letter are not significantly different, $P > 0.05$, by Duncan's multiple range test.

Table 4. Mean value for three processing characteristics over multiple harvest dates in 2000–01 for six strawberry cultivars grown at Oregon State University–North Willamette Research and Extension Center (Aurora, Ore.).

Cultivar	Brix ^z	Titratable acidity ^z		pH
		Brix ^z	pH	
Gaviota	6.97 c ^y	0.48 d	3.91 d	
Pinnacle	9.08 b	0.80 c	3.57 c	
Puget Reliance	10.31 ab	1.13 b	3.35 ab	
Redcrest	12.13 a	1.62 a	3.26 a	
Tillamook	9.67 b	1.08 b	3.42 bc	
Totem	10.83 ab	1.02 b	3.57 c	

^zBrix (percent soluble solids) at 20 °C; titratable acidity = g citric acid/100 g fruit.

^yMean separation within columns by Duncan's multiple range test, $P \leq 0.05$.

not scored, fruit of 'Tillamook' and 'Pinnacle' are more resistant to skin abrasion than the Pacific Northwest processing cultivar standards. The main concern with both cultivars for processing is their marginal external and internal fresh fruit color. Since the USDA–ARS program in Oregon primarily breeds for the processing market, a deep red external color that would be considered too dark for the fresh market, along with uniform, red internal color is considered ideal. 'Tillamook' and 'Pinnacle' fruit, when evaluated fresh in the field, have an outstanding color (bright red, glossy) for the fresh market, but are just acceptable for processing. Brix, titratable acidity, and pH are important characteristics in the processed fruit quality characteristics of

a genotype. 'Tillamook' and 'Pinnacle' were similar to 'Totem' in most cases, but 'Pinnacle' had a lower titratable acidity (Table 4). As a processed product, in the January 2002 blind evaluation of 4 + 1 sugar and sliced preparations of 'Tillamook', its ratings were not significantly different from 'Totem' for appearance, firmness, flavor, and overall quality but 'Tillamook' did have a lower score for color (data not shown). Based on our previous experience, since color is so highly prized in frozen samples, samples that have lower color ratings usually also have lower overall ratings. The fact that 'Tillamook' had lower color ratings than 'Totem', but was similar in overall scores, suggests that while the color of sliced fruit is not ideal, it is acceptable. While 'Pinnacle' has not been compared in a controlled, blind evaluation with 'Totem', in numerous, informal evaluations personnel involved with the breeding program have scored it slightly poorer as a processed berry than 'Totem' due primarily to lighter internal color and less intense flavor.

The ripening season for both cultivars as measured by harvested fruit is typically the same as 'Puget Reliance' and slightly earlier than 'Totem' in Oregon (Table 2). Plotting the cumulative harvest over time and interpolating the harvest dates at WSU–Puyallup, picks up the subtlety that 'Pinnacle' ripens 1 to 2 d earlier and 'Tillamook' 1 to 2 d later than 'Puget Reliance' (Table 2).

'Tillamook' and 'Pinnacle' plants are vigorous, however the plants are smaller with sturdy

trusses and fewer runners than most northwestern U.S. cultivars (Table 3). This less dense habit makes picking more efficient as fruit are readily visible. 'Pinnacle' tends to show more of a decline in plant vigor in the second harvest season than does 'Tillamook'. While the precise reason for this has not been determined, it is suspected to be due to lower virus tolerance as genotypes with a lower virus tolerance are weaker in the second harvest season than the first. Other than two spray applications during bloom to control botrytis fruit rot, the plantings received no fungicides or insecticides. Under this spray program, neither cultivar showed any particular pest susceptibility. The percent fruit rot was measured (data not shown) and was low for all genotypes with no significant differences from 'Totem'.

Availability

'Tillamook' and 'Pinnacle' are not patented. However, 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. The nuclear stock plants for propagation have tested negative for tomato ringspot, strawberry mild yellow edge and tobacco streak viruses by ELISA and have indexed negative when grafted onto *F. vesca* L. and *F. virginiana* Duch. Further information or a list of nurseries propagating 'Tillamook' and 'Pinnacle' is available on written request to C. Finn. The USDA–ARS does not have commercial quantities of plants to distribute. In addition, plants of these releases have been deposited in the National Plant Germplasm System, accession number CFRA 1819 for 'Tillamook' and CFRA 1833 for 'Pinnacle', where they will be available for research purposes, including development and commercialization of new cultivars.

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