Performance of Strawberry Cultivars and Advanced Selections in the Pacific Northwest

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Introduction

The Pacific Northwest is one of the most important strawberry production areas in North America. The area has a marine climate with similar growing conditions from the Fraser Valley in British Columbia, latitude 49°0′ N, south to the Willamette Valley in Oregon, latitude 44°30′ N (15). The region has a reputation for producing the highest quality strawberries for freezing and preserving in North America, although, within the region, variability was found in the processing quality parameters soluble solids, ascorbic acid, pH and anthocyanin content (11).

The 'Northwest' cultivar, by virtue of its virus tolerance and superior qualities for processing as a frozen product, is the most important cultivar throughout the region (15). In 1970 'Northwest' ranked second behind 'Tioga' in tonnage of fruit harvested in the U. S. (12, 13). However, 'Northwest' has several disadvantages. In the northern part of the production area 'Northwest' plants have shown severe winter injury which, in some years, reduces yield by as much as 75% (7). Throughout the area 'Northwest' is susceptible to red stele root rot caused by *Phytophthora fragariae* (4, 6). Fresh market sales are becoming increasingly important throughout the Pacific Northwest and 'Northwest' is not well adapted to this use. Also, the cultivar is not adapted to mechanical harvesting which appears to be inevitable if the area is to retain its prominent position as a producer of strawberries for processing.

The three strawberry breeding programs in the region, U.S.D.A.-Oregon State University at Corvallis (OR-US selections), Washington State University at Puyallup (WSU selections), and the Canada Department of Agriculture at Agassiz (BC selections) have several common objectives. Fruit of high processing quality and plants resistant to red stele root rot and tolerant to viruses are important objectives at all locations. Major emphasis at Corvallis, and to a lesser extent at Puyallup, has been adaptation to mechanical harvesting. At Agassiz major emphasis has been placed on winter hardiness. Other important objectives include selection for low levels of *Botrytis* fruit rot susceptibility and adaptation to fresh fruit marketing.

Recently 3 new cultivars have been released for the region: 'Totem' from Agassiz (8), and 'Shuksan' and 'Rainier' from Puyallup (1, 3). 'Totem' and 'Shuksan' are more winter hardy than 'Northwest' and all three have some field tolerance to red stele root rot. In addition, each is better adapted to the fresh market. 'Shuksan' and 'Totem' have begun to replace 'Northwest' in the northern part of the region. The 'Hood' cultivar, released at Corvallis in 1965 (14) has replaced some of the 'Northwest' acreage, particularly in Oregon because of its attractiveness, ease of picking and red stele resistance. Its main disadvantage is lack of virus tolerance (9).

In 1970 cooperative trials involving established and newer cultivars and advanced selections from the three breeding programs were established at five locations throughout the region.

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The results from two years of production in these trials are presented with particular empasis placed on the potential that new cultivars and advanced selections have to replace 'Northwest' in part or all of the Pacific Northwest strawberry production area.

Materials and Methods

The trials were established at 5 locations in the Pacific Northwest (listed from north to south): the Canada Department of Agriculture Small Fruits Substation, Abbotsford, B. C., the Northwestern Washington Research Unit, Mt. Vernon, the Western Washington Research and Extension Center, Puyallup, the Southwestern Washington Research Unit, Vancouver, and the North Willamette Experiment Station, Aurora, Oregon. In addition to 'Northwest,' 'Hood' and 'Puget Beauty' and the new cultivars 'Shuksan,' 'Totem' and 'Rainier' the following advanced selections with their parentage were included:

'OR-US 3137'—
'NC-US 2840' × 'OR-US 2853'
'WSU 1019'—
'WSU 649' × 'Puget Beauty'
'WSU 1142'—
'Molalla' × 'Columbia'
'BC 25'—
('Siletz' × 'Puget Beauty') × 'Northwest'

Field grown Certified planting stock was used for 'Northwest,' 'Puget Beauty,' 'Hood,' 'WSU 1019,' 'WSU 1142,' 'Rainier,' and 'Shuksan' and virus free screenhouse stocks were used for the remaining clones. All selections with the exception of 'WSU 1019' were developed as potential replacements for 'Northwest' and, therefore, were compared directly with 'Northwest.' 'WSU 1019' is an early selection which ripens with 'Puget Beauty' and, therefore, is compared with that cultivar.

At each location the experimental design was a randomized complete block with 4 blocks of 10 plants each. Within row spacing was 2 ft. at all locations except Aurora where spacing was 15 inches. At Aurora runners were removed to establish the hill system, while at the other locations matted row culture was maintained.

Marketable yields were obtained by weighing only the sound fruit. Rotted fruit (caused primarily by *Botrytis cinerea* Pers. ex. Fr.) was also weighed and the percent culls was the proportion of the total fruit that had rotted. The weight of 25 fruits was determined at each picking and a seasonal mean calculated by; adjusting for the yield at each harvest (10).

Results

At each location in both years cultivars differed significantly ($P = .05$) from 'Northwest' in marketable yield (Table 1). For example, 'Shuksan' produced significantly greater yields than 'Northwest' in both years at Mt. Vernon, and in 1972 at Abbotsford, Puyallup and Aurora. Its yields were significantly less than 'Northwest' only at Vancouver in 1971. 'Totem' yields were significantly greater than 'Northwest' in both years at Abbotsford, and significantly less at Vancouver in 1971. 'Puget Beauty' yielded significantly less than 'Northwest' at Mt. Vernon in both years, and at Puyallup and Vancouver in 1971. Among the selections 'WSU 1142' had significantly higher marketable yields than 'Northwest' at Aurora in both years, and in 1972 at Puyallup and Vancouver (Table 1). 'WSU 1019' yields were significantly less than 'Northwest' at Vancouver in both years and at Puyallup in 1971. Fruit yields for 'WSU 1019' were greater than for 'Puget Beauty' in 5 of 6 comparisons although only in 1971 at Mt. Vernon was the increase significant ($P = .05$).

In comparison with 'Northwest' 'Shuksan' had the lowest incidence of culls and in 6 of 10 comparisons the reduction was significant (Table 2). Significantly fewer culls than 'Northwest' occurred in 3 of 8 comparisons with 'Rainier,' in 2 of 6 comparisons with 'Puget Beauty,' and in 2 of 8 comparisons with 'Hood.' 'WSU 1142'

Table 1. Marketable fruit yields as a percent of Northwest (Northwest equals 100) for 9 strawberry cultivars and selections harvested in 1971 and 1972 at 5 locations in the Pacific Northwest.

Cultivar	Year	Location					Within year mean	Cultivar mean
		Abbotsford	Mt. Vernon	Puyallup	Vancouver	Aurora		
WSU 1142	1971	76	79	117	99	238+*	122	
	1972	108	93	175+	154+	178+	142	
	Mean	92	86	146	127	208		132
OR-US 3137	1971	108	204+	102	—	138+	138	
	1972	126	112	—	87	126	113	
	Mean	117	158	102	87	132		125
Shuksan	1971	98	143+	104	58—	128	106	
	1972	153+	141+	137+	105	149+	137	
	Mean	126	142	121	82	139		122
Totem	1971	135+	90	89	65—	102	96	
	1972	190+	120	132	85	115	128	
	Mean	163	105	111	75	109		112
Rainier	1971	—	119	97	62—	144+	106	
	1972	—	89	118	93	112	103	
	Mean	—	104	108	78	128		104
Hood	1971	—	90	93	90	133	102	
	1972	—	91	144+	85	94	104	
	Mean	—	91	119	88	114		103
BC-25	1971	91	80	86	72—	128	91	
	1972	130	92	130	94	114	112	
	Mean	111	86	108	83	121		102
WSU 1019	1971	—	85	72—	70—	—	76	
	1972	—	70	116	70—	—	85	
	Mean	—	78	94	70	—		81
Puget Beauty	1971	—	58—	65—	61—	—	61	
	1972	—	63—	112	81	—	85	
	Mean	—	61	89	71	—		73
		Northwest Marketable Yield (Tons/acre)						
	1971	5.7	4.3	8.1	10.9	5.4		
	1972	3.4	3.7	7.3	8.2	6.6		

*+ significantly greater than Northwest, — significantly less than Northwest ($P = .05$).

produced significantly fewer culls in 4 of 10 comparisons with 'Northwest' and significantly more in one comparison (Table 2). Both 'BC-25' and 'OR-US 3137' produced significantly more culls than 'Northwest' in 2 comparisons. In 2 of 6 comparisons 'WSU 1019' produced significantly fewer culls than 'Northwest.' In comparison with 'Puget Beauty' 'WSU 1019' had significantly fewer culls only in 1 of 6 comparisons.

'Rainier' produced the largest fruits of any cultivar or selection, and in 5 of 7 comparisons with 'Northwest' the increase was significant (Table 3). 'OR-US 3137' produced significantly larger fruit than 'Northwest' in 3 of 6 comparisons, 'Totem' in 6 of 9 comparisons, 'Shuksan' in 4 of 9 comparisons and 'Hood' in 3 of 7 comparisons. 'Puget Beauty,' 'BC-25' and 'WSU 1019' each produced smaller fruit than 'Northwest' in most of the comparisons. 'Puget Beauty' had significantly larger fruit than 'WSU 1019' only at Puyallup in 1971.

Table 2. % Culls as a percent of Northwest (Northwest equals 100) for 9 strawberry cultivars and selections harvested in 1971 and 1972 at 5 locations in the Pacific Northwest.

Cultivar	Year	Location					Within year mean	Cultivar mean
		Abbotsford	Mt. Vernon	Puyallup	Vancouver	Aurora		
Shuksan	1971	75	44—*	46—	53	6—	45	
	1972	87	54—	49—	22—	46	52	
	Mean	81	49	48	38	26		48
WSU 1019	1971	—	65	60—	60	—	62	
	1972	—	63	18—	58	—	46	
	Mean	—	64	39	59	—		54
Puget Beauty	1971	—	82	97	102	—	94	
	1972	—	68	44—	19—	—	44	
	Mean	—	75	71	61	—		69
Totem	1971	54	69	78	90	98	78	
	1972	122	84	54—	43	58	72	
	Mean	88	77	66	67	78		75
Rainier	1971	—	59—	86	28—	88	65	
	1972	—	88	68—	67	121	86	
	Mean	—	74	77	48	105		76
WSU 1142	1971	82	72	105	41—	28—	66	
	1972	162+	95	48—	36—	119	92	
	Mean	122	84	77	39	74		79
Hood	1971	—	99	93	84	62	85	
	1972	—	96	52—	41—	155	86	
	Mean	—	98	73	63	109		85
BC-25	1971	150	111	110	86	100	111	
	1972	167+	133+	45—	95	95	107	
	Mean	159	122	78	91	98		109
OR-US 3137	1971	111	87	88	—	55	85	
	1972	163+	159+	—	35—	174	133	
	Mean	137	123	88	35	115		109
		Northwest % Culls						
	1971	8.5	17.4	21.7	3.3	5.9		
	1972	15.9	16.5	29.6	5.2	4.2		

*+ significantly greater than Northwest, — significantly less than Northwest (P = .05).

Discussion

The results from the 1970-planted cooperative trial gave further confirmation to the observation that strawberry cultivars or advanced selections tend to be localized in their adaptation (5). For example 'WSU 1142' gave high marketable yields at 3 locations, Puyallup, Vancouver and Aurora, but was among the least productive at the two most northern locations, Mt. Vernon and Abbotsford. From this, it would appear that 'WSU 1142' is not particularly well adapted to the more northern parts of the Pacific Northwest strawberry production area. In contrast, 'Totem' seems particularly well adapted to the northern part since it had the highest marketable yields at Abbotsford, but further south yielded less and in particular, at Vancouver it had a very low yield. 'Northwest' itself seemed to perform most satisfactorily at the Vancouver location although its 2-year mean marketable yield was less than 'WSU 1142.'

Table 3. Seasonally adjusted mean fruit weight of 25 fruits as a percent of Northwest (Northwest equals 100) for 9 strawberry cultivars and selections harvested in 1971 and 1972 at 5 locations in the Pacific Northwest.

Cultivar	Year	Location					Within year mean	Cultivar mean
		Abbotsford	Mt. Vernon	Puyallup	Vancouver	Aurora		
Rainier	1971	–	159+*	121+	110	–	130	
	1972	–	189+	114	124+	146+	143	
	Mean	–	174	118	117	146		137
OR-US 3137	1971	147+	–	109	–	–	128	
	1972	135+	215+	–	97	77	131	
	Mean	141	215	109	97	77		130
Totem	1971	125+	116+	115+	94	–	113	
	1972	144+	122+	122+	106	111	121	
	Mean	135	119	119	100	111		117
Hood	1971	–	142+	110	112+	–	121	
	1972	–	106	115+	108	111	110	
	Mean	–	124	113	110	111		116
Shuksan	1971	118+	129+	108	106	–	115	
	1972	117	126+	111	108	120+	116	
	Mean	118	128	110	107	120		116
WSU 1142	1971	134+	119+	91	89	–	108	
	1972	97	119+	101	98	108	105	
	Mean	116	119	96	94	108		107
BC-25	1971	80–	95	74–	76–	–	81	
	1972	108	111	77–	94	89	96	
	Mean	94	103	76	85	89		89
Puget Beauty	1971	–	82–	95	86–	–	88	
	1972	–	83	97	84	–	88	
	Mean	–	83	96	85	–		88
WSU 1019	1971	–	77–	79–	81–	–	79	
	1972	–	67–	85–	71–	–	74	
	Mean	–	72	82	76	–		77
				Northwest wt/25 fruits (gr)				
	1971	263	280	384	337	344		
	1972	232	279	305	232	247		

*+ significantly greater than Northwest, – significantly less than Northwest (P = .05).

There are undoubtedly other factors besides local climatic adaptation that result in cultivar X location interactions. Cultivars react differently to cultural practices such as runner removal (the hill system was used at Aurora), irrigation, fertilization and weed control. It is difficult to maintain exactly the same cultural practices at all trial locations.

Although the cultivar rankings for marketable yield varied considerably within locations, the interaction of cultivar and location was less pronounced for the incidence of culls and for fruit weight. For example, 'Shuksan' consistently had the lowest incidence of culls and 'BC-25' the highest, and 'Rainier' consistently had the largest fruit and 'BC-25,' 'Puget Beauty' and 'WSU 1019' the smallest fruit.

In this study 'Shuksan' had a very low incidence of cull fruit and 'Northwest' a high incidence while 'WSU 1142,' 'Rainier' and 'Hood' were intermediate. This confirms earlier work conducted only at Puyallup (2).

Interest in 'WSU 1019' pertains to its early ripening characteristics, and subsequently its potential to replace 'Puget Beauty' which is now the standard early ripening cultivar. Data from the plantings in which 'WSU 1019' was included indicate that its performance is not sufficiently different from 'Puget Beauty' to justify cultivar status. Among the other selections 'BC-25' performed similarly to, or not quite as well as 'Northwest.' Thus it will not be considered for cultivar status. The performance of 'OR-US 3137' was variable. This, along with the fact that its fruit quality is only fair, precludes it from further consideration. The high yields at the 3 southern locations for 'WSU 1142' and its adequate fruit size and moderate incidence of fruit rot suggests that this selection could have a place as a cultivar in the Pacific Northwest.

The information obtained from these cooperative trials is of particular value in justifying the release of an advanced selection and in forming cultivar recommendations for different locations within the Pacific Northwest. Future cooperative trials are planned as new cultivars and selections become available.

Literature Cited

1. Barritt, B. H., C. D. Schwartze and R.A. Norton. 1971a. Shuksan, a new winter hardy strawberry for the Pacific Northwest. Fruit Var. Hort. Dig. 25(1): 17-21.
2. Barritt, B. H., Louis Torre, and C. D. Schwartze. 1971b. Fruit rot resistance in strawberry cultivars adapted to the Pacific Northwest. HortScience 6(3): 242-244.
3. Barritt, B. H. and C. D. Schwartze. 1972. Rainier, a new dual purpose strawberry variety. Wash. Agr. Exp. Sta. Cir. No. 559.
4. Converse, Richard H. 1967. Physiological races of *Phytophthora fragariae* on strawberry in California, Oregon and Washington. Phytopathology 57:173-177.
5. Darrow, G. M. 1966. The Strawberry. Holt, Rinehart and Winston. New York.
6. Daubeny, Hugh A. and H. S. Pepin. 1964. A further report on variations in varietal susceptibility to red stele in strawberry fields of coastal British Columbia. Can. Plant Dis. Survey 44: 257-258.
7. Daubeny, Hugh A., R. A. Norton, C. D. Schwartze and B. H. Barritt. 1970. Winterhardiness in strawberries for the Pacific Northwest. HortScience 5:152-153.
8. Daubeny, Hugh A. 1971. Totem strawberry. Can. J. Plant Sci. 51:176-177.
9. Daubeny, Hugh A., R. A. Norton and B. H. Barritt. 1972. Relative differences in virus tolerance among strawberry cultivars and selections in the Pacific Northwest. Plant Diease Reptr. 56:792-795.
10. Moore, J. N. 1970. Fruit size of strawberry cultivars. Fruit Var. Hort. Dig. 24(3):58-62.
11. Nelson, J. W., B. H. Barritt, and E. R. Wolford. 1972. Influence of location and cultivar on color and chemical composition of strawberry fruit. Wash. Agr. Exp. Sta. Tech. Bul. 74.
12. Scott, D. H. 1972. Important strawberry varieties in current commercial production in the United States. Fruit Var. Hort. Dig. 26(1):3-4.
13. Scott, D. H., G. M. Darrow, and F. J. Lawrence 1972. Strawberry varieties in the United States. USDA Farmers' Bul. 1043.
14. Waldo, G. F. 1965. The Hood Strawberry. Annu. Rpt. Ore. Hort. Soc. 57: 123-125.
15. Waldo, G. F., R. S. Bringhurst and V. Voth. 1971. Commercial strawberry growing in the Pacific Coast states. USDA Farmers' Bul. No. 2236.