A Comparison of Five Pacific Northwest Strawberry Cultivars for Hand and Machine Harvesting

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The strawberry cultivars compared in this report were developed for the Pacific Northwest in local breeding programs and are primarily grown for commercial processing. Cultivar differences and yield performance for hand and machine harvest are discussed.

Cultivar Characteristics

Benton, the leading cultivar grown in Oregon, has red stele resistance, some mildew resistance, and above average virus tolerance. The plant has dark green leaves and is vigorous, with an upright growth habit. The fruit is large, bright red and of moderate firmness. It is highly rated for fresh consumption and is more appropriate for jam than frozen product. Benton holds for long periods between pickings, yields a large volume of ripe fruit at one picking, and can be machine harvested (9). It has average winter hardiness and good runner production. Benton was developed by the U. S. Department of Agriculture and the Oregon Agricultural Experiment Station at Corvallis, Oregon (6).

Linn was developed by the U. S. Department of Agriculture and the Oregon Agricultural Experiment Station at Corvallis, Oregon, in cooperation with the Washington Agricultural Experiment Station at Pullman, Washington (7). Linn is most notable for its very firm fruit, which is an advantage in mechanical harvesting and capping (9). The relatively high acid content contributes to its maintenance of superior color in a processed product but detracts from its fresh flavor. It bears fruit on long trusses that extend beyond the leaf canopy, leaving the fruit exposed for easy harvest by hand or machine (8). Linn has had very limited acceptance because of its susceptibility to viruses and root rots other than red stele.

Olympus was developed by Washington State University (1). It is a vigorous plant, producing many branching crowns but few runners. It is resistant to several races of red stele, but susceptible to a root rot complex. The foliage is susceptible to powdery mildew and to leaf spot. Olympus is popular because of high yields and good processing fruit quality. The primary and secondary fruits are medium to large in size but the lower order fruits are much smaller. The large volume of ripe fruit that can be retrieved at one time is an asset to mechanical harvesting. However, there are difficulties in handling Olympus with automated capping systems (9). Acreage has been limited by the availability and higher than average cost of plants, which is caused by poor runner production in the nurseries.

Totem was developed by the University of British Columbia and is the major strawberry cultivar there (2). It has some degree of resistance to fruit rot and red stele and the plants are very winter hardy. Fruits are produced on long scapes acceptable for machine harvest, and they cap easily. The fruit is firm, large and has good internal color, but turns excessively dark if overripe. The overripe berries detract from the appearance and flavor of preserves and frozen product.

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Some growers have had difficulties with stand establishment, which may be due to the timing of nursery digging and/or length of storage. Totem plants dug in March and April generally do not do as well as those dug in December, January and February (5). However, poor stands generally fill in by the second year.

Tyee is a 1980 release from the University of British Columbia and is from a Totem x Olympus cross (3). Abundant runner production in the year of planting aids establishment of this vigorous plant. Its foliage is notably darker green than other cultivars. The fruit processes well and is similar to Totem, except a white core line is sometimes evident and it does not turn excessively dark. The primary fruits are produced on long scapes and hold their quality on the plant while the secondaries ripen, allowing for a single, high yield machine harvest. Berry firmness and conformation are suitable for mechanical harvest and capping (4). Tyee occasionally develops scattered yellowing on the leaves early in the season. The yellowing resembles "June Yellows" but some of the affected plants become stunted and others appear to recover. Unless clean planting stock can be developed, the commercial acceptance of Tyee will be limited.

Comparison of Cultivar Performance

Picking machines are now being commercially developed, but their efficiency is limited because of existing cultivar characteristics. Multiple hand harvests recover more usable fruit than a single machine harvest on existing cultivars. Strawberries generally ripen over a period of 3 weeks in the Pacific Northwest, but machine harvest is a one-time operation. An early season machine-harvest results in the harvesting of too many green fruit, and a late harvest often includes too many over-ripe and damaged fruit. Cultivars with a more concentrated ripening period are the most desirable to obtain the greatest usable fruit and the least waste. Until such cultivars are available, the practice of one or more hand harvests followed by mechanical harvesting is the most feasible (Tables 2 and 3).

Four cultivars, Linn, Olympus, Totem and Tyee, were planted in 1978 in adjacent plots and a second plot of Tyee was planted in a nearby field Close by was a 1977 planting of Benton. Row spacing was 107cm and plant spacing in the row were 38 cm except for a sub-plot of Olympus planted at 19cm. From 1978 through 1980 cultivars were harvested mechanically and by hand from repli-

Table 1. A comparison of hand harvest data for 5 strawberry cvs at the North Willamette Experiment Station in 1979 and 1980.

Strawberry cultivar	Metric tonnes per hectare		Percentage rot[y] by weight		Grams per individual berry	
	1979	1980	1979	1980	1979	1980
Linn	18.0	15.4	15.4	16.0	18.8	12.7
Olympus	30.2	22.7	10.4	17.4	11.5	12.5
Totem	11.8	21.4	19.3	5.1	11.8	17.1
Olympus (19)[z]	33.6	—	14.0	—	10.7	—
Tyee	—	34.1	—	7.9	—	14.9

[z]Olympus at 19 cm between plants, doubling the original plant population.
[y]Primarily *Botytris cinerea.*

Table 2. Usable ripe fruit from variable combinations of hand harvests (HH) and/or mechanical harvest (MH) of Benton strawberries planted in 1977.

Harvest method	1978 Yield[z] (metric tonnes per hectare) June 13	June 22	June 28	Total
HH-3[y]	2.4	15.2	6.9	24.5
HH-2 + MH[x]	2.4	15.2	3.8	21.4
HH-1 + MH	2.4	—	10.4	12.8
MH	—	—	11.5	11.5
	1979 Yield (metric tonnes per hectare) June 13	June 19		Total
HH-1	16.6	—		16.6
MH	—	9.7		9.7

[z]Usable ripe fruit — undersized, mechanically damaged and non-capped fruit excluded.
[y]Number of hand harvests from four replications.
[x]An average of three replicates each from the SKH&S (commercial clipper harvester, Charles Hecht and associates, Stayton, OR) and the OSU experimental harvester.

Table 3. Usable ripe fruit from variable combinations of hand harvests (HH) and/or mechanical harvest (MH) of Tyee strawberries planted in 1978.

Harvest method	1979 Yield[z] (metric tonnes per hectare) June 11	June 16	June 19	Total
HH-1 + MH	9.2	—	1.3	10.5
MH	—	4.4	—	4.4
MH	—	—	3.5	3.5
	1980 Yield (metric tonnes per hectare) June 16	June 24	June 25	Total
HH-2	10.1	5.1	—	15.2
HH-1 + MH	10.0	—	3.3	13.4
MH	—	—	6.7	6.7

[z]Usable ripe fruit — undersized, mechanically damaged and non-capped fruit excluded.
[y]Number of hand harvests, from 10 replications in 1979 and three replications in 1980.
[x]An average of three replicates each from the SKH&S (commercial clipper harvester, Charles Hecht and associates, Stayton, OR) and the OSU experimental harvester in 1979. In 1980 only the OSU harvester was used.

Table 4. Effects of strawberry cultivar and machine on mechanical harvesting efficiency.

Cultivar	OSU[z] Recovered fruit (MT)	Not recovered (%)	Potential yield (MT)[x]	SKH&S[y] Recovered fruit (MT)	Not recovered (%)	Potential yield (MT)
Benton[w]	9.2	46.5	17.2	10.1	32.7	15.0
Linn	13.7	45.3	25.1	12.3	35.7	19.2
Olympus	21.1	20.7	26.6	17.0	31.1	24.7
Totem	8.1	25.2	10.8	7.6	49.3	15.0
Tyee	8.8	23.6	11.6	11.7	22.4	15.0

[z]Experimental clipper harvester, Department of Agricultural Engineering, Oregon State University.
[y]Commercial clipper harvester, Charles Hecht and Associates, Stayton, Oregon.
[x]Ripe, usable fruit recovered by machine, plus ripe, usable fruit left on plant or ground.
[w]Benton planting was 2 years old, others were 1 year old.

cated sub-plots. Data on Benton are summarized in Table 2 and data from the second Tyee plot are included in Table 3. Mechanical harvest data were obtained from the field containing one-year-old Linn, Olympus, Totem and Tyee cultivars and the two-year-old Benton in 1979 with 2 different mechanical harvesters.

Hand Harvest

Overall Olympus compared well with the other hand harvested cultivars for the two years, although it did better in 1979 than in 1980 (Table 1). This contrasts with Totem which had a poor first year but did well the second year in berry size as well as yield. Linn gave an average performance both years. Tyee was not hand harvested in 1979, but the 1980 yield was remarkably high (34.1 Mt/Ha). The fruit of Totem and Tyee in 1980 was larger and had less percent fruit rot than Olympus or Linn. The closely spaced Olympus plot produced more fruit than the standard spaced Olympus plot in 1979, but they were slightly smaller with a higher percentage of fruit rot.

Combined Hand and Machine Harvest

Benton data (Table 2) show that more hand harvests result in high total yields. A mechanical clean-up harvest yielded less usable fruit as the number of previous hand harvests increases. One hand harvest early to get the large, premium quality, primary fruit followed by a later machine harvest may be a workable compromise. Using this system, Benton produced 12.8 Mt/Ha in 1978 (Table 2) and Tyee produced 10.5 Mt/Ha in 1979 and 13.4 Mt/Ha in 1980 (Table 3).

Machine Harvest

The two harvesters used are similar in that both use a sickle bar to cut off and harvest the entire plant. The SKH&S[1] machine has air blast nozzles to lift fruit clusters above the sickle bar, whereas the OSU machine has a tined pick-up reel to assist in lifting the clusters. The OSU machine harvested more fruit in Olympus and less in Tyee compared to the SKH&S machine (Table 4). The recovered fruit from Linn, Totem and Benton was approximately the same from both machines.

Although both of the strawberry harvesting machines had air cleaning systems for removing leaves and other debris, some is left with the harvested fruit. The percentage of fruit in the total harvested product was consistent across cultivars, except for a slightly lower percentage in Benton, which

Table 5. Characteristics of fruit from a once-over mechanical harvest of five cultivars in 1979.

Cultivar	Percentage of total harvested product[z] Total fruit	Percentage of sort-outs from total fruit			
		Undersize[y]	Nonripe[x]	Mechanical damage	Total sort-outs
Benton	81.2	15.5	31.7	6.9	52.8
Linn	87.2	6.6	28.8	4.2	39.6
Olympus	82.7	16.0	38.0	7.7	61.7
Totem	87.6	6.6	29.5	4.4	40.5
Tyee	86.9	8.3	25.5	2.5	36.3

[z]Includes all berries, leaves, stems and other debris in the harvest container—percentage on wt. basis.
[y]Less than 1.6 cm diameter.
[x]Less than 80% of berry surface color was red.

was an older planting (Table 5). The fruit was sorted and found acceptable or put into one of 3 categories for non-usable fruit. Olympus had the highest percentage of non-usable fruit, although it out yielded the other cultivars and thus more usable ripe fruit was recovered. Tyee had the lowest percentage of non-usable fruit.

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Literature Cited

1. Barritt, B. H. and C. D. Schwartze. 1974. 'Olympus' strawberry. HortScience 9(3) 244-245.
2. Daubeny, H. A. 1971. Totem strawberry. Canad J of Plant Sci 51:176-177.
3. Daubeny, H. A. 1980. Tyee strawberry. Canad J of Plant Sci 60:743-746.
4. Daubeny, H. A., Lawrence, F. J., Martin, L. W., and B. H. Barritt. 1980 'Tyee' a new strawberry cultivar suited to machine harvest. *In* Martin, L. W. and J. R. Morris (eds.) Strawberry mechanization, Station Bulletin 645. Oregon Agricultural Experiment Station. 40-41.
5. Decker, B. R., D. G. Richardson, and L. W. Martin. 1981. (Unpublished data).
6. Lawrence, F. J. 1975. 'Benton' strawberry. HortScience 10(3)282-283.
7. Lawrence, F. J., Martin, L. W., Varseveld, G. W., and D. E. Booster. 1978. 'Linn' strawberry. HortScience 13(4) 489-490.
8. Lawrence, F. J. 1980. Characteristics and performance of the 'Linn' strawberry in 1979. *In* Martin, L. W. and J. R. Morris (eds.) Strawberry Mechanization, Station Bulletin 645. Oregon Agricultural Experiment Station. 38-39.
9. Varseveld, G. W., Machine harvesting and in-process handling effects on Pacific Northwest strawberry quality. *In* Martin, L. W. and J. R. Morris (eds.) Experiment Station. 161-170.

Modesto, California, Plant Scientist Honored by French Government

C. Floyd Zaiger, plant breeder of Modesto, California, has been presented the Chevalier Award for eminence of personal achievement by the French Government for his contribution to their fruit industry. The award, comparable to English knighthood, was granted to Mr. Zaiger in Nimes, France, at the International Plant Breeders Conference where Mr. and Mrs. Zaiger were honored guests.