if the fruit shows exceptional characteristics. If a seedling is bearing for the first time, a single fruit may be taken as a record that the juvenile period of that seedling has ended. Samples of cultivars and selections are pressure tested at harvest and handled much the same as the samples of seedlings. Several samples of some cultivars may be taken as a check on the best harvest date and the optimum length of storage life.

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Yield and Its Components in the Strawberry Cultivar Olympus

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Abstract

Shoot and fruit development in the strawberry cultivar Olympus were examined at 2 sites, one in Washington and the other in Oregon. It differed from conventional cultivars in its marked crown-branching habit, and showed early and vigorous vegetative growth and a high number of flowers per inflorescence. Analysis of yield components indicated a yield potential of about 44+ ot/ha (19 t/a) but there was a tendency for flower failure or fruit malformation in the primary and secondary ranks of the inflorescence. Plants at the Oregon site exhibited a much greater development of secondary inflorescences than those in Washington.

Experiments at the North Willamette Experiment Station (NWES), Oregon (3) have shown that the new cultivar Olympus has the greatest yield potential of any cultivar so far released in the Pacific Northwest. The aims of the present work were to investigate the form of the development of the cultivar in the field, and to assess the relative importance of its various yield components.

Materials and Methods

Olympus shows a high degree of crown branching and only limited runnering (1). The cultivar Totem (2) was selected as a standard because of its more conventional runnering habit.

Plants for dissection were lifted from a field near Puyallup, Wa, at approximately 2 week intervals from March until May. The plants were in the first full fruiting year, i.e., in their second year after (spring) planting, and were grown on the hill system at about 40 cm (18") spacing in the row. On each sampling date 2 plants of each cultivar were divided into individual crowns and these were further

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[2]The author is indebted to Dr. L. W. Martin and Dr. B. H. Barritt at the North Willamette Experiment Station, Aurora, Oregon, and the Western Washington Research and Extension Center, Puyallup, respectively, for their observations and to the Washington State Raspberry Commission and Oregon Strawberry Commission for financial assistance.

dissected to give records of leaf, shoot, and inflorescence development.

At the end of May, the investigation was transferred to the NWES, Aurora, Oregon, where the final stages of fruit development in Olympus were recorded. Plants of Totem were not available at that site.

Results

Samples were taken at Puyallup on March 16, April 11 and 24 and May 12 and 25. At the first sampling, little growth had occurred and dissection showed only that each crown contained a single inflorescence ("Crown" here refers to the visually separate shoots each made up of an axis with enclosing unexpanded leaves.) From the time of the second sampling, the inflorescenses were large enough to permit counting of individual flowers per truss.

Olympus produces few runners and in a hill system these would normally be removed. Runner plants were found only occasionally in sampling and were discarded. The dense crown-branching habit of this cultivar caused some suppression and rotting of a few small branch crowns on the main axes. These have also been ignored in the figures which follow. Totem is a relatively prolific runner producer and, even though the plants were nominally in hills, many runners had rooted close to the parent plant, forming a clump.

Records for Totem are presented separately for parent and runner plants.

By April 11 several leaves on each of the main crowns and runners had expanded, and growth of the new vegetative shoots had commenced in both cultivars (Table 1). These vegetative shoots arose in the axils of the first one or two leaves below the terminal inflorescence. The contrasting growth habits of the two cultivars at this date is shown in Figure 2.

The first stolons were visible in the axils of leaves on the vegetative shoots by May 12 in both cultivars.

At the time of the final sampling at Puyallup (May 25), there were slightly more expanded leaves per vegetative shoot in Olympus and these were considerably longer than in Totem (Table 2).

Table 1. Leaf and shoot development by April 11.

	No. expanded leaves per crown	Mean length of longest leaf per crown (cm)	Mean length of new vegetative shoots (cm)
Olympus	5.9	30.0	7.4
Totem parent crowns	4.4	24.6	3.3
Totem runner crowns	3.3	17.5	1.0

Table 2. Leaf and shoot development by May 25.

	No. expanded leaves per new vegetative shoot	Mean length of longest leaf of new vegetative shoots (cm)
Olympus	3.5	43.2
Totem parent crowns	2.7	30.7
Totem runner crowns	2.6	26.2

Prior to the April 24 sampling, there was a radiation frost which blackened a number of open flowers in Totem but not in Olympus, possibly because the latter provided a better screening canopy. However, at the final sampling on May 25 there was appreciably more malformation in the developing primary and secondary fruits of Olympus than in Totem.

Inflorescence structure was recorded at each of the sampling dates except the first, and the mean values were calculated (Table 3).

The number of inflorescences per plant was slightly greater than the number of crowns because of the presence of secondary inflorescences. These arose in the positions normally occupied by the sub-terminal vegetative shoots. They were uncommon at Puyallup, being found in only 8% of Olympus crowns and 3% of Totem crowns.

The structure of an Olympus crown at Puyallup on May 25 is shown in diagramatic form (Fig. 1). The shoot axes have been extended for clarification.

Of the three shoots in the leaf axils of the main axis, only the lowest had grown out and it was weak. The axillary shoots on the two new crowns were small and flattened and probably would not develop further in the current year.

Both cultivars had basal branching inflorescences, and in Olympus the first branch was particularly strong

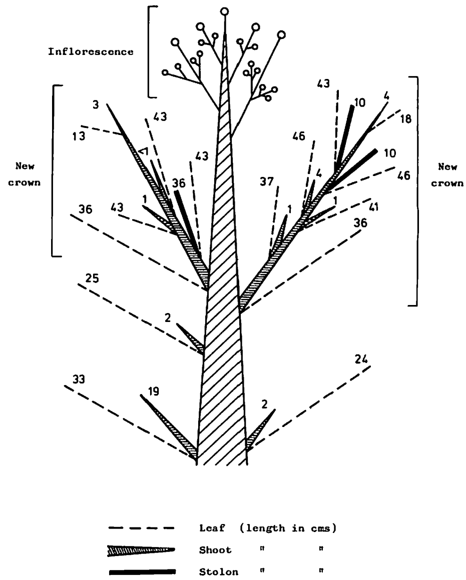

Fig. 1. Diagram of an Olympus crown from Puyallup, May 25, 1978.

and could easily have been mistaken for a second truss if the sampling had not been destructive.

The subsequent samples of Olympus were taken in Oregon, at the NWES on June 8, 12 and 23, during the fruit ripening period. Plant structure differed from that at Puyallup in the greater incidence of secondary inflorescences. Table 4 shows the development of crowns in two plants with the same numbers of main crowns, one from Puyallup and one from NWES. Beneath each main

Table 3. Crown and inflorescence structure (Means of all samples at Puyallup).

	No. of crowns per plant	No. inflorescences per plant	No. flowers per inflorescence	Total no. flowers per plant
Olympus	9.4	10.2	16.3	166
Totem parent crowns	2.4	2.7	10.1	92
Totem runner crowns	8.1	8.1	8.2	92

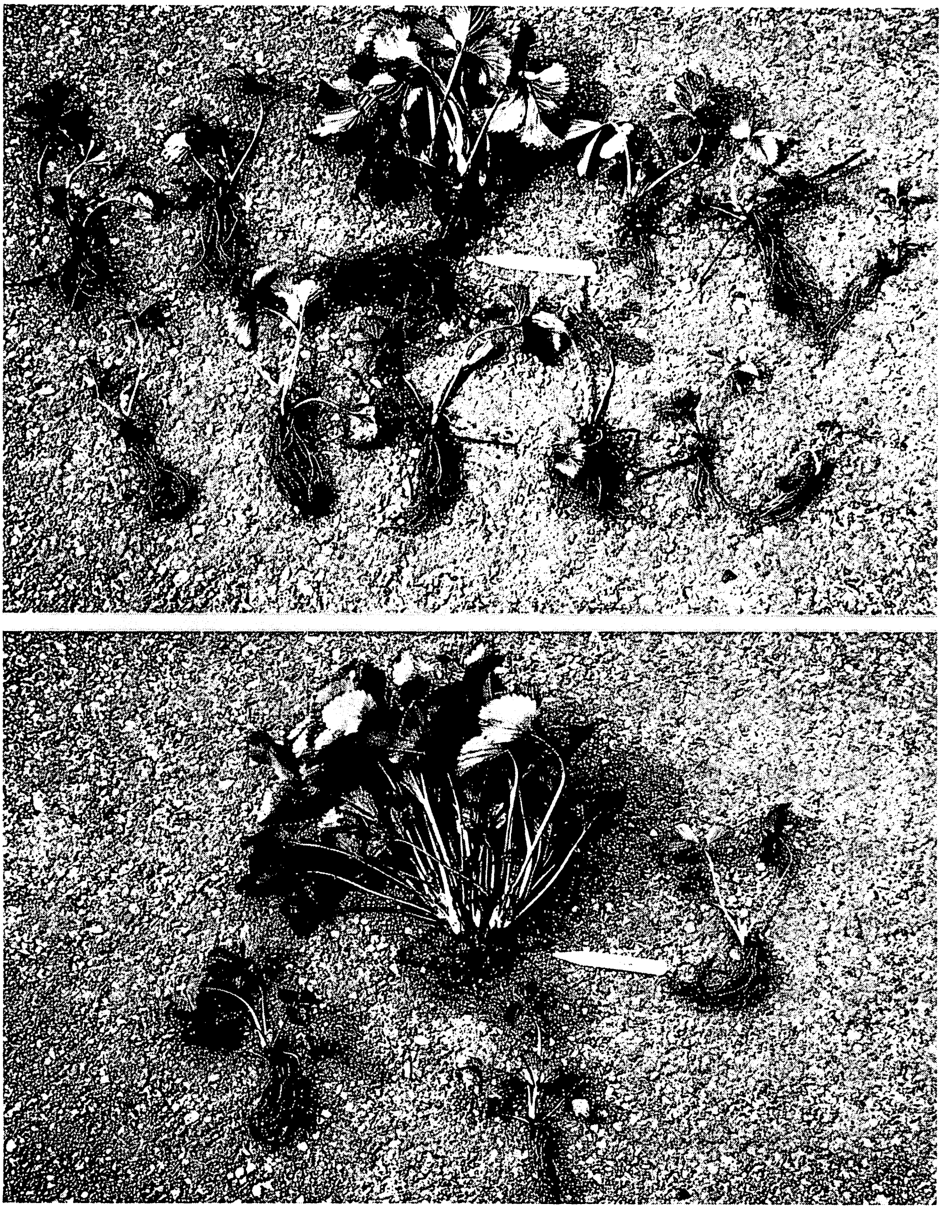

Fig. 2. Growth habit of cvs. Totem (above) and Olympus. Each plant occupied approximately the same area of ground, but has been arranged to show the relative numbers of parent and runner crowns.

terminal inflorescence there may be one or more axillary shoots, each of which may be vegetative (V), terminate in an inflorescence (I_S) or terminate in an inflorescence with a new developing vegetative shoot beneath it (I_SV_S).

Secondary inflorescences differed from the main inflorescences in that they had smaller numbers of flowers and were not basal branching (Fig. 3).

All fruits on a previously unharvested plant were picked on June 23 and classified according to development and stage of maturity (Table 5).

Fruits classified as aborted were those in which no receptacle development had occurred after the flowers had opened. "Malformed" fruits were those with so few developed achenes that receptacle swelling was insufficient to give a marketable fruit. This sample was taken near what would have been the end of a commercial harvest season, and fruits in the "green" category would not subsequently have been harvested.

Only 52% of the flowers originally present developed into marketable fruits. Most of the aborted and malformed fruits were probably in the primary and secondary ranks, and would therefore have been the larger fruits. Those in the green category would be mainly small higher order fruits which would have contributed little to yield even if harvested when ripe.

In an attempt to obtain some estimate of relative fruit sizes in the various inflorescence positions, use was made of color photographs of three main inflorescences which were almost complete in their complement of fruits. From these, and a relationship established between dimensions

Table 4. Structure of plants at NWES and Puyallup.

	NWES plant				Puyallup plant			
	I	V	I_S	I_SV_S	I	V	I_S	I_SV_S
Crown 1	+			+	+	+		
2	+	+	+		+	+		
3	+			++	+	+		
4	+		++		+	+		
5	+		+	+	+	++		
6	+		+	+	+	++		
7	+		+	+	+	+		
8	+	+	+		+	++		
9	+		+	+	+		++	

Table 5. Classification of fruits from a single plant at NWES on June 23.

	Aborted	Malformed (grossly)	Over-ripe	Ripe	White-orange	Green	Total
Numbers	64	15	81	43	32	63	298
Percent	21	5	27	14	11	21	
		Max. harvestable		52%			

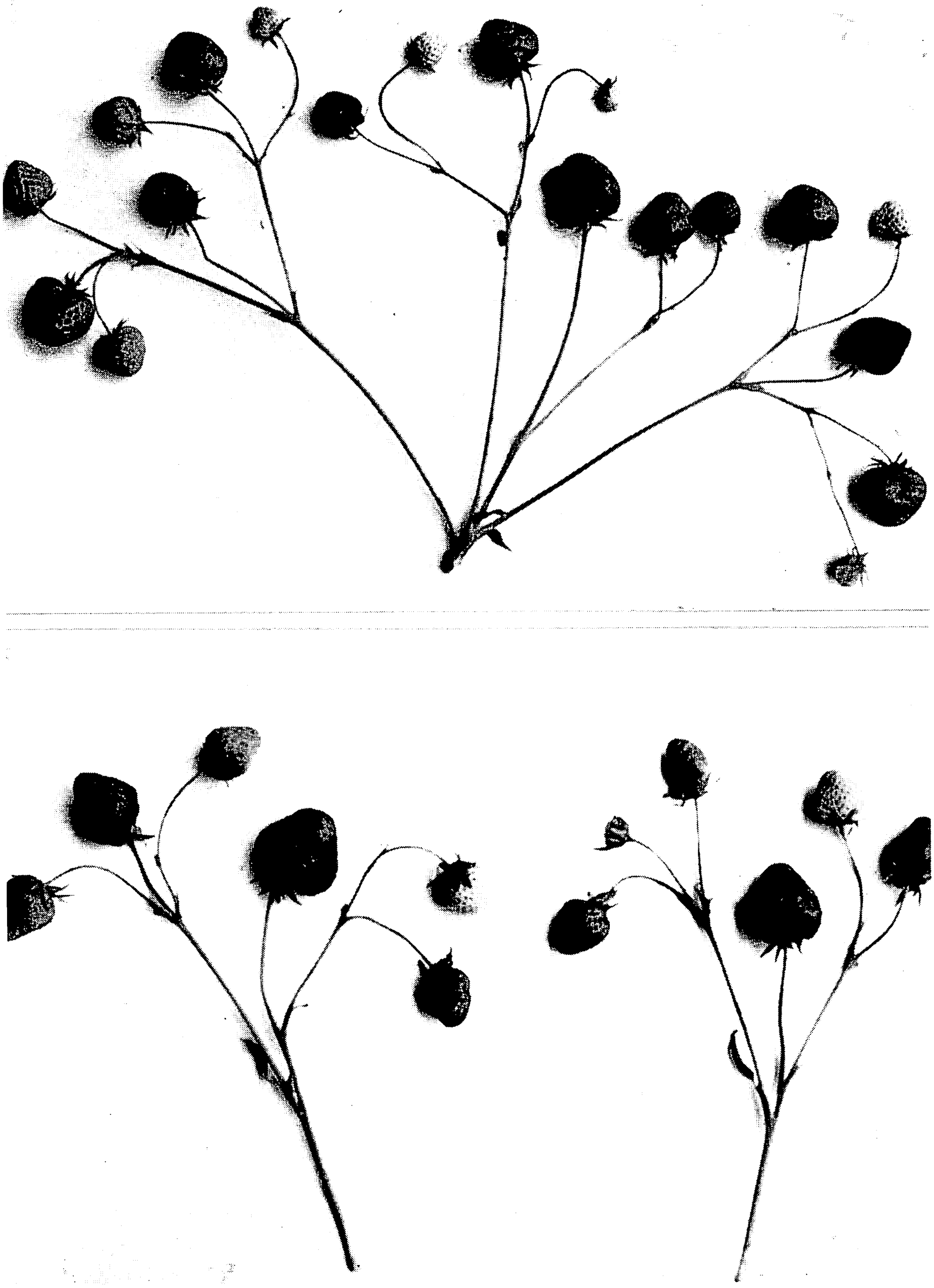

Fig. 3. A primary fruit truss and two secondaries from a single crown of cv. Olympus at NWES, Aurora, OR.

and weight in previous fruit samples, the estimates shown in Table 6 were derived. Only the ripe fruits were measured.

The ratios of numbers of flowers per rank on the two inflorescence types at NWES were calculated, and were merged on a weighted basis to give the mean ratios across all inflorescences (Table 7).

As indicated in Table 5, about 20% of the fruits on the Olympus plant would not have been harvested because they were late and small. These were mainly in the 4th and 5th ranks of the inflorescence, so the ratios of harvestable fruits in the various ranks would probably be about 1.0:2.9:4.4:1.1.

Using this ratio and the fruit weights from Table 6, the potentially harvestable crop per rank of the inflorescence may be calculated (Table 8), and also the mean weight per fruit (9.42 g).

Finally, using the estimates of each yield component, the potential yield for a crop at 92 cm (36″) row spacing and 46 cm (18″) between plants is:

Table 6. Estimated mean weight of fruits of each rank of the truss.

	g
Primary	17.1
Secondary	9.1
Tertiary	8.7
Quaternary	6.2

Table 7. Ratio of numbers of flowers per rank (June 13).

	Main	Secondary	Weighted means
Primary	1.0	1.0	1.0
Secondary	3.5	2.0	2.9
Tertiary	6.5	1.4	4.4
Quaternary	5.0	0	2.9
Quinary	1.2	0	0.7
Totals	17.2	4.4	11.9

Table 8. Ratio of weight of fruit per rank of the inflorescence.

	Ratio	% of crop
Primary	1.0	19.3
Secondary	1.8	29.8
Tertiary	2.6	43.2
Quaternary	0.5	7.7

24,200	×	11.4	×	1.80	×	9.4	×	9.42	=	44 ot/ha (19.4 t/a)
Plants/ha (9680 plants/a)		Crowns/ plant		Inflorescences/ crown		Fruits/ inflorescence		Mean fruit wt. (g)		

Though this yield is much in excess of what has been achieved commercially in the Pacific Northwest, it is in line with the yields recorded at NWES in a plastic mulch experiment (3).

Discussion

The number of samples taken for these observations was small, so caution is needed in generalizing about the developmental behavior of Olympus. However, the data provide a basis for some speculation about the more important characteristics of the cultivar, and may indicate those aspects most likely to need closer examination.

The comparison with Totem at Puyallup emphasized the marked crown-branching habit of Olympus, the vigor of its early leaf growth, and the earliness of development of the strong vegetative shoots which form the following year's fruiting crowns. Its flower numbers per inflorescence and per plant were also appreciably higher, though the significance of this in terms of fruit yield was not determined at Puyallup.

Olympus plants growing at NWES, 240 km (150 miles) to the south of

Puyallup, differed in showing a much greater development of secondary inflorescences, which suggested a greater yield potential. It is not possible to say whether this difference is attributable to environment or to the nature of the planting stocks used, the effects of which could still be apparent in this first main fruiting year. However, it is interesting that Barritt and Schwartze (1) considered that the cultivar was not well adapted to conditions in areas north of Puyallup, and H. J. Gooding (personal communication) reported crown barrenness in this cultivar in Scotland at a latitude of 56°N.

Both at Puyallup and NWES there was appreciable loss of primary and secondary fruits through abortion or gross malformation. There was no obvious reason for this, but possibilities include stamen sterility, low temperature at flowering, *Botrytis* and insect damage. The pattern of the disorder was very similar to that described by Way (4), both in the severity in the lower ranks of the inflorescence and in the decreased incidence in the secondary inflorescences.

There have been some grower reports in the Pacific Northwest that Olympus appears more drought susceptible than other cultivars. Its crown-branching habit and vigorous vegetative growth must place large demands upon a single root system, in contrast to the spreading of the load in matted rows of runnering type. Adverse rooting conditions, whether of physical or pathological origin, might therefore be more critical in this cultivar.

Winter injury in strawberries generally seems to increase with the age of the plantation, with older crowns showing greater damage than young ones. In the virtual absence of runner plants in Olympus grown on the hill system, all crowns of a plant will age together in the sense of sharing a common main axis. The effect of this on the susceptibility of the cultivar to frost is unknown, and perhaps should be examined.

Whatever its limitations, Olympus represents a very significant step forward in breeding for yield potential, and suggests that the extreme crown-branching form may merit greater attention in breeding programs.

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