Table 3. Effect of Triacontanol on fruit composition of 'Tangi' and 'Dover' strawberries.

Triacontanol (mg/liter)	pH	Soluble solids (%)	Titratable acidity (%)	Solids-acid ratio	Ascorbic acid (mg/100 g)	Color[z] L	a	b
2.00	3.43[y]	6.0	0.85	7.27	55.48	17.60	28.16	8.86
1.75	3.45	5.9	0.83	7.34	49.46	17.78	27.75	8.82
1.50	3.43	5.8	0.86	7.06	50.92	18.47	27.68	9.40
1.25	3.44	5.8	0.82	7.20	50.29	17.55	27.47	8.82
1.00	3.44	5.8	0.83	7.21	52.18	17.93	28.40	9.04
0.00	3.44	5.9	0.84	7.25	52.88	17.80	28.66	9.09

[y]ANOVA showed all factors analyzed exhibited no significant differences due to treatment.
[z]Hunter color values

A randomized complete block design was used for compositional analysis of the fruit. The data were analyzed using the analysis of variance. Where significance was observed, an LSD means separation test was done.

Exogenously applied triacontanol had no effect on the fruit yields in the early and mid season, but 2.00 mg/liter triacontanol decreased the late season yield by 24% compared to the control (Table 1). There was no significant interaction between triacontanol and cultivars.

Quantitative evaluation of fruit from triacontanol-treated plants revealed an improvement in the average fruit size in the early harvest season (Table 2). Fruit from plants treated with 2.00 mg/liter triacontanol were significantly larger than the fruit in the control plots.

Applications of triacontanol had no effect on the pH, soluble solids, titratable acidity, solids:acid ratio, ascorbic acid content, and color of the fruit (Table 3). Also, under this one season's conditions, triacontanol applications did not influence the internal color nor intensify the red pigmentation in the skin of the fruit.

Under the existing experimental conditions, triacontanol applications had no effect on yield, pH, soluble solids, titratable acidity, color, and ascorbic acid content of the field-ripened fruit. An early increase in fruit size from 2.00 mg/liter triacontanol was not large enough to justify the application of triacontanol commercially. Sensory evaluations (data unreported) revealed that triacontanol treatments did not affect the flavor of the fruit. No phytotoxic effects from either triacontanol or the control (oleic acid + Triton X) were observed throughout the experimental period.

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Yield Component Analysis of 'Benton' and OR-US 4356 Strawberries

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Additional index words. achenes, trusses, barrenness, berry expansion, *Fragaria* × *ananassa*

Abstract. **In the 1st (1981) and 2nd (1982) fruiting years, 'Benton' strawberry (*Fragaria* × *ananassa* Duch.) formed 25% to 30% more crowns/plant than the advanced breeding selection OR-US 4356. 'Benton' had fewer trusses/crown than OR-US 4356 in 1981 (0.93 vs. 1.47) but both had 1.5 in 1982. OR-US 4356 had about 60% more fruit/truss in each season; however, 'Benton' had 75% greater mean berry weight than OR-US 4356, so that the 2 genotypes produced essentially the same yields/plant in each season, averaging 0.82 kg (1981) and 0.94 kg (1982). The genotypes did not differ in the total number of achenes/berry. Both showed a linear increase in berry weight with achenes/berry; yet OR-US 4356 had significantly lower berry weight than 'Benton' at equivalent achenes/berry. Increased berry expansion in 'Benton' was reflected by a reduction in number of achenes/cm^2 of berry surface. The values, averaged over both seasons, were 10.6 ('Benton') and 14.0 (OR-US 4356). OR-US 4356 failed to produce higher yields than 'Benton' because of limitation in fruit expansion.**

Yield component analysis can be used to evaluate strawberry genotypes by identifying strengths or weaknesses in the balance of their components. Yield per plant can be attributed to the multiplicative effects of 4 yield components: 1) the number of crowns/plant, 2) number of trusses (inflorescences)/crown, 3) number of berries/truss, and 4) mean berry weight (9, 14).

The degree of berry expansion also is a useful parameter in assessing yield potential. The number of achenes per unit area of berry surface can be used to quantify the extent of berry expansion (1). Low values represent increased berry enlargement. A value of 8 achenes/cm^2 may reflect the maximum berry expansion to be expected under field conditions (14).

A yield component analysis was undertaken in order to quantify yield characteristics of field grown strawberries in Oregon. 'Benton', Oregon's leading cultivar, and an advanced breeding selection, OR-US 4356, were chosen for study because of their apparent differences in growth and fruiting habits.

Planting occurred in mid-May of 1980, on a Willamette silt loam soil at the North Willamette Experiment Station. Plants were set 38 cm apart in rows with 1.0 m between rows. Fertilizer (10N–9P–8K, 336 kg/ha) was applied in June, after plant establishment, and again the following year during August renovation.

On 15 of June 1981 and 1982, near the start of fruit harvest, 25 random plants of each cultivar were harvested destructively to determine the numbers of crowns/plant, trusses/crown, and fruit/truss. Fruit also was harvested as it ripened during the season from

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Table 1. Mean values of yield components for 'Benton' and OR-US 4356 strawberry clones.

Yield component	1981 'Benton'	1981 OR-US 4356	1982 'Benton'	1982 OR-US 4356
Crowns/plant	11.40	8.76**[z]	15.68	12.48*
Trusses/crown	0.93	1.47**	1.53	1.54
Number of fruit/truss	5.72	9.01**	4.69	7.90**
Mean berry wt. (g)	11.11	5.84	7.63	4.76**
Measured yield/plant (g)	811.93	832.77	929.32	952.31

[z]Significant difference between cultivars at the 5% (*) or 1% (**) levels.

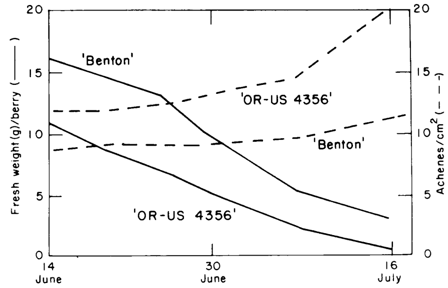

Fig. 1. Change in mean berry fresh weight (g/berry) and achene density (achenes/cm^2) for the 1st fruiting year (1981) of 'Benton' and OR-US 4356 strawberries.

an additional 25 plants to obtain total yield and mean berry weight. A subsample was stored in a freezer for subsequent determination of total achenes/fruit and achenes/cm^2. The latter was obtained by averaging the number of achenes visible within a circular 1 cm^2 aperture held against the shoulder of the berry at 2 randomly selected locations (1). After final harvest in the 2nd year, the leaf area of plants used in yield determinations was measured using an electronic leaf area meter.

'Benton' and OR-US 4356 produced yields/plant that were not significantly different in either fruiting year (Table 1), averaging 21,300 kg/ha for 1981 and 24,000 kg/ha for 1982. The 2 genotypes, however, achieved their yields with a decidedly different composition of yield components.

'Benton' produced 25% to 30% more crowns/plant than OR-US 4356 in each year (Table 1). Several investigators have documented increased yields with increasing crown numbers on a per unit area basis (2, 4, 5, 6, 9, 13). Guttridge and Anderson (8), however, concluded that the number of crowns is not the most reliable guide in assessing yield potential for strawberries. Rather, individual plant records of trusses/crown or plant, fruit/truss, mean berry weight, and some measure of plant size other than crown numbers, are necessary to assess the yield characteristics and potential of a strawberry gentotype. In the present study, the similar yields attained with differences in crowns per plant support this contention.

'Benton' averaged less than one truss/crown in its first fruiting year, whereas OR-US 4356 produced nearly 1.5 trusses/crown (Table 1). Obviously, some of Benton's first year crowns were barren. Breen and Martin (3) also observed that 'Benton' produced less than one truss/crown in its 1st fruiting year. By the 2nd year, 'Benton' showed less barrenness, and each genotype averaged 1.5 trusses/crown. Mason (11) suggests that a tendency toward barrenness is related to genotypic sensitivity to photoperiodic induction of the flower trusses with low sensitivity causing increased barrenness. A genotype's sensitivity to this process may change with age, thus helping to explain 'Benton's' 1st, but not 2nd year barrenness.

For the 2 year period, OR-US 4356 averaged 8.5 fruit/truss as compared to 5.2 for 'Benton' (Table 1). OR-US 4356 had 92% more fruit/plant than 'Benton' in the 1st year, and 35% more in the 2nd year. Mean berry weight of 'Benton', however, was nearly twice that of OR-US 4356 (Table 1), allowing 'Benton' to achieve yields equal to OR-US 4356. Similar compensatory effects of strawberry yield components have been reported (7).

Berry size depends directly upon the number of ovules formed on the receptacle, the efficiency of fertilization, and the amount of tissue which develops along with each achene (1, 14). Within an inflorescence, both berry size and number of achenes/berry decrease with berry rank (10).

The difference in berry size between 'Benton' and OR-US 4356 cannot be attributed to number of achenes/berry, as there was no significant difference either year (Table 2). As others conclude (12), however, fruit size differences among strawberry clones vary not only with achene number but with size of achenes and their differential activity in relation to growth hormones.

Regression analysis for both genotypes showed that the increase in berry fresh weight with the number of achenes/berry was linear (OR-US 4356, R^2 = 0.60; 'Benton', R^2 = 0.32). The regression lines were nearly parallel but sigificantly different (P = 0.01), with OR-US 4356 producing about 2.4 g less berry weight than 'Benton' for an equivalent number of achenes/berry.

The lowest values of achenes/cm^2 determined in this study, which reflect the greatest berry expansion, were 6 and 8.5 for 'Benton' and OR-US 4356, respectively. Webb et al. (14) adopted 8 achenes/cm^2 as a practical level indicative of maximum berry expansion in field plantings. 'Benton' achieved 83% of this standard level of berry expansion in the 1st year and 69% in the 2nd, whereas comparable values for OR-US 4356 were only 59% and 55%, respectively (Table 2). 'Benton' maintained a lower achene density than OR-US 4356 throughout the 1st (Fig. 1) and 2nd (data not shown) fruiting seasons. The trend for both genotypes was an increasing achene density accompanied by a decreasing mean berry weight as the fruiting season progressed. 'Benton' maintained a nearly constant level of achenes/cm^2 (8–12 achenes/cm^2), indicating that even smaller berries of lower rank are able to attain near maximum levels of berry swelling (Fig. 1). Most of the increases in achenes/cm^2 for both genotypes occurred after berry weight had decreased to about 5 g, near the time commercial harvest is complete.

The failure of OR-US 4356 to size its fruit apparently was not the result of a small photosynthetic surface, since the 2nd year leaf area per plant was 0.42 m^2 for both genotypes. However, there may have been insufficient photosynthate to support the large number of fruit per truss in OR-US 4356 and/or the fruit may have been less competitive with other organs. Strawberry genotypes vary in dry matter partitioned to the fruit (8). Reduced berry expansion also could result from impaired hormonal or water transport systems.

Abbott et al. (1) suggest that, since there is a decrease in potential berry size at each successive stage of inflorescence branching, the most efficient use of available achenes would occur with an increased number of trusses per plant, each having fewer flowers. This seems to be the pattern of development with 'Benton' as it sets fewer fruit/truss than OR-US 4356 (5.2 and 8.5, respectively) while producing sufficient trusses/plant to achieve satisfactory yields.

Table 2. A comparison of achenes for 'Benton' and OR-US 4356 strawberry clones in relation to berry weight and fruit surface.

Achenes	1981 'Benton'	1981 OR-US 4356	1982 'Benton'	1982 OR-US 4356
Number of achenes/berry	217.17	186.21	238.63	239.60
Achenes/g fresh wt.	21.58	32.79**[z]	26.53	36.13**
Achenes/cm^2	9.64	13.51**	11.56	14.53**

[z]Significant different between cultivars at the 1% level.

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Effect of GA_{4+7} + BA Tank-mixed with Fungicides on 'Delicious' Apples

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Additional index words. cytokinin, 6-benzyladenine, gibberellins A_4 and A_7, elongation, climate, *Malus domestica*

Abstract. **The effects at 2 different rates of the gibberellins A_4 and A_7 plus 6-beneyladenine (GA_{4+7} + BA) on the length/diameter (L/D) ratios of both standard- and spur-type 'Delicious' apples (*Malus domestica* Borkh.), when combined with bloom-period fungicides applied at different stages of blossom development, were evaluated. The effectiveness of GA_{4+7} + BA was not reduced by combining it with selected fungicides. GA_{4+7} + BA at twice the suggested rate usually resulted in increased fruit L/D ratios. Full-bloom applications were most effective for fruit elongation of spur-type strains, whereas full-pink applications were most effective for standard-type strains.**

In the marketplace, 'Delicious' apples are recognized easily by their conical shape and 5 prominent calyx lobes. 'Delicious' apples exhibiting these characteristics are said to be "typey", and these apples are recognized by consumers as premium fruit, although shape has no bearing on eating quality. Growers in the northwestern United States produce these premium 'Delicious' fruit consistently, whereas growers in southern regions have only variable success.

Several factors affect the "typiness" of 'Delicious' apples. Climatic influences, whether direct or indirect, have the greatest effect on shape. In areas where temperatures are cool for 2–3 weeks after bloom, apples attain type most regularly (4, 7, 8, 10, 11). Rootstock, strain, crop density, and flower position also affect length/diameter (L/D) ratios of 'Delicious' fruit (9, 12, 15). High postbloom temperatures apparently affect the balance of endogenous auxins, gibberellins, and cytokinins, resulting in the cessation of cell division and elongation and ultimately causing flattened fruit (9, 12). Exogenous applications of cytokinins and gibberellins stimulate additional cell division and elongation in apple fruitlets, resulting in improved type of mature fruit (1, 2, 3, 5, 6, 11, 13, 16, 17).

Treatments were designed to detect any reduction in the effectiveness of the gibberellins A_4 and A_7 plus 6-benzyladenine (GA_{4+7} + BA: Promalin, Abbott Laboratories, North Chicago, IL 60064) on 'Delicious' apples when combined with fungicides, and to ascertain optimal time and rate of GA_{4+7} + BA application. Nine spray combinations were applied to 2 blocks of 81 trees each. These treatments were applied to different plots at 3 different stages of blossom development. Of the 9 treatments, 4 included GA_{4+7} + BA at the recommended rate (25 ppm), either alone or in combination with fungicides, 4 utilized GA_{4+7} + BA at a double rate (50 ppm) and with the same fungicides, and one was a control without GA_{4+7} + BA or fungicides. The GA_{4+7} + BA-fungicide combinations were: 1. GA_{4+7} + BA alone, 2. GA_{4+7} + BA with benomyl 50 W and mancozeb 80 W, each at 0.34 kg/378 liters, 3. GA_{4+7} + BA with mancozeb 80 W at 0.68 kg/378 liters, and 4. GA_{4+7} + BA with captan 50 W and zineb 50 W at 0.45 kg/378 liters. All treatments included the surfactant Regulaid at 1.25 liters/kl. The treatments were applied at full-pink (petals loosely clustered and only 1% of the blossoms open), full-bloom (90% of the king blossoms open), or petal-fall (50% of the petals fallen from the king blossoms). Materials were applied by hand gun as a fine mist until the point of runoff.

A total of 162 trees was used, 81 standard-type trees in block 1 and 81 spur-type trees in block 2. Strain, rootstock, age, and vigor varied among trees within the respective blocks. No consideration was given to these differences. Each block was divided into 27 plots of 3 trees each (9 spray combinations × 3 application times). This was duplicated for both spur- and standard-types strains for a total of 54 plots. From each of the 3 trees in each plot, 50 fruit were selected from exterior branches. Only representative fruit at eye level (about 1.5–1.8 m) were harvested; fruit extremely large or small were not taken. The 3 samples of 50 fruit per tree from a single plot were combined, and a random sample of 25 fruit was taken. Length and diameter measurements were made and the L/D ratio calculated for each fruit. Fruit were measured at their longest and widest points.

Block 1: standard types. GA_{4+7} + BA alone and with all fungicide combinations resulted in fruit of greater L/D ratios than control fruits (Table 1). All 3 times of application increased L/D ratios over control fruit, regardless of rate of application or fungicide combination (Table 2). The full-pink application was more effective than the petal-fall application. Both rates of GA_{4+7} + BA resulted in a linear increase in L/D ratio over control fruit, regardless of time of applica-

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Table 1. Effect of fungicide combinations with GA_{4+7} + BA (both rates combined) on the L/D ratio of 'Delicious' apples.

Treatment	Mean L/D ratio[z] Standard type	Spur type
GA_{4+7} + BA only	1.01 a	1.01 b
GA_{4+7} + BA, captan, and zineb	1.01 a	1.04 a
GA_{4+7} + BA, benomyl, and mancozeb	1.00 a	1.01 b
GA_{4+7} + BA and mancozeb	1.00 a	1.02 b
Control	0.92 b	0.96 c

[z]Mean separation within columns by LSD, 5% level.