The increased productivity of Montmorency with WA 900 roots results from a more sustained yield over the entire 15 year fruiting period. Fruit production of Montmorency on the other rootstocks peaked during the first 10 years and thereafter declined. Differences in yields amongst the Montmorency with different mahaleb roots and the greater productivity of Montmorency with mahaleb roots over those with mazzard roots were also noted by Westwood *et al.* (8).

The greater vigor of trees with *P. avium* roots found in this study supports the observations of Howe (5) but other studies (3, 8) found that mahaleb roots induced more vigor to the scion. Soil type and environment may be the reason that such conflicting observations led Clarke and Anthony (2) to conclude, and we concur, that the source of the seedling is as influential on the productivity of the scion as is the species of the rootstock. This reduced vigor associated with mahaleb roots has obvious advantages in orchard management costs.

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Influences of Rootstocks and Support Systems on Yield, Tree size and Cork Spot on Spur and Non-Spur Delicious Apple Trees

R. M. Crassweller and M. E. Ferree[1]

Delicious is the leading apple cultivar being planted today. There have been many reports in the literature comparing yields of various strains on different rootstocks (1, 2, 3, 4, 8, 11); however, most of these studies report only total accumulated yields after several years. The early yields are often not presented or are combined in a 10-year total.

The current trend of higher density apple orchards on size controlling rootstocks has increased establishment costs considerably in the past two decades. Funt *et al.* (6) has shown that planting densities which produce an earlier return are more desirable than ones which have an equal or higher return later.

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[2]Appreciation is expressed to Van Well Nurseries, Wenatchee, WA for donating the trees.

The purpose of this research was to determine early yields and growth of spur-type Oregon Spur and non-spur type Early Red One[2] on several rootstocks.

Materials and Methods

Oregon Spur and Early Red One trees on M.9, M.26, and M.7 rootstocks were planted December, 1975, on a steep gravelly silty clay loam soil of the Hayesville series.

Two trellis rows were established in which 4 trees of each scion rootstock combination were planted. Trellised trees were trained as oblique palmettes with branches projecting into the row either removed or pulled back into the trellis plane and tied. One row of 5 trees of each scion rootstock trained to a central leader was planted and supported by a post. Each cultivar rootstock combination was separated by a Winter Banana/M.7 pollinizer tree set 3.0 m from each group. To minimize any possible effects of shading, between row spacing of the trellis rows was 7.6 m, and the post row 9.1 m. Within row spacing was varied by cultivar/rootstock combination to allow for natural size differences (Table 1). All trees were headed at planting to a height of 76 cm. Weed control consisted of strip application of a contact herbicide in 1976, 1977, and a residual herbicide thereafter.

Fertilization in the first year consisted of a single application of 454 g 10-10-10 applied in March to each tree at planting. Thereafter until 1981 each tree received 45.4 g of actual N per year age of tree in the form of $Ca(NO_3)_2$. In 1981, fertilization was based on terminal growth. Trees with greater than 38 cm of growth received no fertilizer while those with less received 908 g of $Ca(NO_3)_2$. A foliar spray of boron (Solubor, 20.5% B) at 1.2 g/l was applied in the fall of 1980 and spring of 1981. Calcium chloride was not applied during the 1980 growing season, but was included in 7 cover sprays at a rate of 3.6 g/l in 1981.

Table 1. Within row tree spacings of the various cultivar/rootstock plantings.

	Training System	
	Trellis	Central Leader
Oregon Spur		
M.9	1.5	2.1
M.26	2.4	2.4
M.7	2.4	2.7
Early Red One		
M.9	2.4	2.4
M.26	2.7	3.0
M.7	3.0	3.0

All flower clusters were removed in the spring of 1977 to encourage growth. In 1978, a severe frost prevented any fruit set. Fruit weight and number of fruit were recorded from 3 trees of each combination in 1979 through 1981. Percent of fruit with corkspot was determined in 1980 and 1981. Trunk circumference 20 cm above ground, tree height, and within-row spread was measured in October of 1981.

Results and Discussion

Strains. Early Red One (ERO) had a greater average number of fruits/tree than Oregon Spur (OS) in 1979 and 1981, but on a weight basis only outyielded OS in 1981 (Table 2). Lord *et al.* (8) in comparing 9 different strains of Delicious on M.7 did not report any yield differences in per tree yield until the 7th year, with non-spurs generally producing more than the 2 spur types. Seeley *et al.* (10) however reported cumulative yield of Millerspur on various rootstocks was greater than Red Prince, a nonspur in the 4th through 9th years. Red Prince however has been reported to be a

Table 2. Average number of fruit/tree, weight of crop/tree percent fruit with corking and total accumulated efficiency of Early Red One (ERO) and Oregon Spur (OS). Delicious on M.9, M.26, and M.7 trained to either a trellis or as a central leader in 1979 through 1981.

	1979		1980			1981			3-yr. Accumulated Efficiency kg/cm²
	Fruit/ Tree	Wt. (kg)	Fruit/ Tree	Wt. (kg)	% cork	Fruit/ Tree	Wt. (kg)	% cork	
Strains									
ERO	48a[z]	9a	65a	27a	27a	272	39	17a	3a
OS	38b	7a	57a	26a	25a	221	33	4b	3a
Rootstocks									
M.9	29b	6b	37b	8c	30a	154	21	9a	3a
M.26	63a	12a	80a	16a	26a	331	48	11a	3a
M.7	35b	6b	65a	12b	22a	243	40	10a	2b
Training System									
Trellis	49a	9a	62a	12a	24a	256a	36a	8b	2a
Staked	30b	6b	58a	11a	30a	224b	36a	14a	2b

[z]Means within columns and groups followed by the same letter are not significantly different, 5% level, Duncan's New Multiple Range Test.

poor yielding strain of Delicious (7, 8) and may account for this discrepancy.

In individual years ERO outyielded OS by 19% in 1979, 4% in 1980, and 17% in 1981. The smaller difference in 1980 may be due to the biennial bearing pattern observed in a previous study (10); unfortunately, a severe freeze in 1982 destroyed the crop and prevented confirmation of biennial bearing. The 2 strains selected in this study are more recent introductions without reports on differences in yield (5). Total accumulated efficiency for the first 3 years was the same for each strain (Table 2).

The difference in yield in 1981 cannot be explained due to total tree size. Early Red One trees were similar to OS trees in tree height and trunk circumference (Table 4). Most reports do mention that non-spurs tend to outyield spur-types. However, due to closer recommended spacings, the spurs will outvield non-spurs on a per hectare basis (4).

There was a significant strain rootstock interaction upon yield in 1981. ERO on M.9 and M.7 had equal yields whereas OS/M.9 produced considerably less than OS/M.7 (Table 3). This was further emphasized by the observation that the OS/M.9 combination produced the smallest trees in the study. The average trunk circumference of the OS/M.9 was 11.4 cm versus 13.9 cm for ERO/M.9.

Percent of fruit with corking was not significantly different in 1980. However, in 1981 when $CaCl_2$ foliar sprays were applied, OS had fewer fruit with corking than ERO. This phenomena may be related to a dilution effect due to competition between fruit and shoot for calcium. A composite leaf sample in 1979 from each cultivar rootstock combination showed that calcium levels ranged from 0.75% (OS/M.7) to 1.1% (ERO/M.9). In 1980, the lowest calcium level was 0.69% (OS/M.7) and the highest 1.2% (OS/M.9). In general, trees on M.9 had higher calcium levels than those on M.26 and M.7.

Rootstock. Average crop weight/tree and number of fruit/tree was

Table 3. Average weight of crop/tree and number of fruit/tree of Early Red One and Oregon Spur on M.9, M.26 and M.7 rootstocks in 1981.

Rootstock	Avg. weight/tree (kg)		Avg. no. tree/fruit	
	ERO	OS	ERO	OS
M.9	28.8	15.6	196	117
M.26	53.4	43.6	387	274
M.7	29.6	40.8	199	272
LSD .05	15.1	6.1	153	129

greater on M.26 than on M.9 or M.7 in all three years (Table 2). Seeley *et al.* (10) reported greater total accumulative yield increases for Red Prince Delicious on M.7, MM.111, and MM.106 compared to seedling rootstocks. The 3-year total accumulated yields of trees of M.26 were twice that of trees on M.9 and 31% more than those on M.7. Significant strain rootstock interaction occurred only in 1981 (Table 3).

In comparing yields on a per tree basis, one would expect trees on M.9 to produce less than those on M.7 due to their size (Table 4). However, when comparing total accumulated efficiency as measured by kg fruit/cm^2 of trunk area, trees on M.9 and M.26 were equal in efficiency and both had greater efficiency than trees on M.7 (Table 2). There was no difference in percent of fruit with corkspot on any rootstock.

In contrast to a previous report (2), M.26 had the greatest early yields with the 2 Delicious strains tested in this study. The greatest differences in yield occurred during the first cropping year. M.7 and M.9 trees produced only 53% and 47% as much as M.26 trees, respectively. However, the freeze in 1978 may be responsible for this large difference. In subsequent years, the difference in yield between M.9 and M.26 increased each year whereas M.7 slowly began to catch up.

Trees on M.9 were the smallest of the three rootstocks in height, within-row spread and trunk circumference. There were no differences between M.26 and M.7; although based on reports by Seeley *et al.* (10), one might expect M.7 to produce larger trees in future years.

Training System. Trees trained to the trellis had a greater number of fruit/tree in 1979 and 1981 but only outyielded the other system in 1979. However, based on tree efficiency, the trellised trees produced more fruit/cm^2 of trunk area. This is similar to earlier findings comparing various training systems (3). There were no differences in tree height although trellised trees did have a greater within-row spread. The difference in spread is probably related to pruning and training practices. In the trellis system only limbs projecting out into the row were removed, within-row limbs were tied to the trellis wires. Central leader trees, although not taller at the end of the 6th growing season, were larger, based on trunk circumference. Tree height of the trellised trees was similar to a previous study (3). In future years, it is expected that the central leader trees will become larger since the trellis trees had reached the top of the wires.

The percent of fruit with corking in the training systems followed the same trend as it did with strains. The trellis trees had fewer fruit with corking in 1981. The difference may be the result of better spray coverage or as Schneider *et al.* (9) indicated, the tendency of closer spaced trees tended to have higher levels of Ca, Mg, and Mn. In general, the trellised trees in this study were spaced closer together than the free-standing trees.

Conclusions: Based on these data gathered in the first three cropping years, strain did not influence yield as much as rootstock. Trees on M.26,

out-produced those on M.9 and M.7 on a per tree basis. As reported previously (3), trees trained to a trellis are more efficient than central leader trees.

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Table 4. Average tree height, within row spread and trunk circumference of Early Red One and Oregon Spur Delicious on M.9, M.26, and M.7 rootstocks trained to a trellis or a central leader at the end of the 6th growing season.

	Avg. tree height (cm)	Avg. within row spread (cm)	Trunk circumference (cm)
Strains			
Oregon Spur	254.2a[z]	209.1a	17.4a
Early Red One	250.8a	293.2b	17.2a
Rootstocks			
M.9	184.8b	200.9a	12.6a
M.26	245.8a	273.7b	19.3b
M.7	285.6a	277.7b	20.2b
Training System			
Trellis	247.8a	264.2a	16.8a
Central Leader	261.5a	223.4b	18.4b

[z]Means within columns and groups followed by the same letter are not significantly different, 5% level Duncan's New Multiple Range Test.

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