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Effects of Apple Rootstock, Tree Spacing, and Cultivar on Fruit and Tree Size, Yield, and Foliar Mineral Composition[1]

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Abstract. **The influence of 3 spacings, 4 rootstocks, and 2 cultivars of apple (*Malus domestica* Borkh.) on yield, fruit and tree size and mineral composition of leaves during the 3rd through the 6th year of growth in the orchard were investigated. Scion cultivar had the greatest effect on mineral composition; all elements except manganese were significantly different in the 2 spur-type cultivars ('Goldenspur' and 'Redspur'). Trees on Malling Merton (MM) 106 rootstock produced larger yields than those on other rootstocks, and the foliage was usually among the highest in respect to each nutrient measured. Closely spaced trees had smaller fruit and the least amount of foliar P and K but Ca, Mg, and Mn were high in the same trees.**

Research with apple (1, 2, 3, 5, 6, 9) has shown the effect of stock and scion on yield and on foliar mineral composition, but most workers have not related findings on one phase of rootstock effect to other factors. Tubbs (7) has stressed the need to relate all factors and the need for additional definitive data on rootstock-scion relationships. This paper presents results from the 3rd through 6th year of the orchard and examines the effect of rootstock, scion cultivar and tree spacing on foliar mineral composition (N, P, K, Ca, Mg, Mn, Fe, Zn and Cu) yield per tree and per ha, fruit size and tree size.

Methods

The orchard was planted in March 1971 using vigorous 1-year-old trees. The spur-type cultivars 'Goldspur' and 'Redspur' were each grafted on Malling (M) 7, MM 106, MM 111 and seedling rootstock. Trees were planted in rows 4.9 m apart with spacings in the row of 1.8 m, 3.0 m, and 4.3 m (6, 10, 14 ft). Main blocks were the different spacings and were randomized within spacings, with 2 trees of each cultivar on each rootstock at each spacing. Buffer trees were planted between different spacings and surrounding the entire planting.

The soil, a Tilset silt loam, has a fragipan at about 0.5 m and a pH of about 6.0. Elevation and slope are adequate for good surface water and air drainage. A fescue sod was established the 2nd year and vegetative growth was controlled in a circle to the drip line with paraquat and simizine. The sprayed area was gradually increased as trees increased in size, to a continuous band along the row to the drip line. All other cultural and fertility practices were similar for all trees which were pruned to a modified leader.

Tree ht, width, and trunk diam (30 cm above ground) were recorded annually. Foliar samples were collected in mid-July from mid-portions of terminal shoots each year from the 3rd through the 6th growing seasons. Leaves were washed, dried, and analyzed for N, P, K, Ca, Mg, Mn, Fe, Cu, and Zn as described by Lockard (4). All trees in this experiment grew vigorously and had only partial crops until the 6th growing season, but number and weight of fruit were recorded annually.

Results and Discussion

While mineral content varied significantly by years, for brevity, only the averages are presented in Table 1. Some of the small differences in mineral composition that are statistically significant, may be of limited biological significance in the early life of this orchard since almost all essential minerals were present in adequate quantities.

Scion cultivar had the most consistent effect on foliar

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Table 1. Effect of spacing, rootstock, and apple cultivar on fruit and tree size, yield, and mineral composition of foliage[z].

	Cultivar		Spacing			Rootstock				Significance of	Tree
Variable	Redspur	Goldspur	1.8 m	3.0 m	4.3 m	M 7	MM 106	MM 111	Sdlg	Interaction[y]	age[x]
Foliage composition											
N (%)	2.52a	2.45b	2.51a	2.47a	2.47a	2.52a	2.48b	2.51a	2.43c	N.S	4–6
P (%)	.21a	.18b	.18c	.20b	.21a	.21a	.19b	.17c	.21a	N.S	3–6
K (%)	1.19a	1.08b	1.10c	1.14b	1.16a	1.14a	1.12a	1.16a	1.13a	N.S	3–6
Ca (%)	1.09a	1.21a	1.17a	1.13b	1.15ab	1.10b	1.28a	1.11b	1.11b	xx	3–6
Mg (%)	.38b	.35b	.38a	.37ab	.36b	.36a	.38a	.37a	.37a	N.S	3–6
Mn (ppm)	108a	106a	126a	99b	97b	91c	114a	116a	108b	x	3–6
Fe (ppm)	77a	71b	75a	73a	74a	74a	74a	72a	76a	N.S	3–6
Zn (ppm)	26a	23b	24a	24a	25a	22c	24b	26a	25a	N.S	3–6
Cu (ppm)	8.4a	8.3b	8.3b	8.4a	8.4a	9.3a	8.6b	8.0c	7.6d	N.S	5–6
Yield (kg/tree)	18.9b	25.7a	25.7a	22.7a	23.6a	23.8b	27.3a	21.8c	16.4d	xx	5–6
Yield (MT/ha)	14.3b	19.4b	23.2a	15.3b	11.3c	18.0b	20.7a	16.5c	12.4d	xx	5–6
Fruit size (g)	209a	177b	186b	191b	200a	191a	191a	195a	191a	xx	5–6
Trunk-cross-section (cm^2)	51.5a	41.9b	41.9b	47.8b	50.3a	41.9bc	40.7c	43.0b	60.8a	N.S	6

[z]Mean separation within rows and treatment by Duncan's multiple range test, 5% level.
[y]Interaction between rootstock and scion; xx significant 1% level; x significant 5% level.
[x]Consecutive years in life or orchard during which data was secured and included in averages presented.

mineral content; there was a significant difference in leaf composition owing to cultivar of all nutrients determined except Mn (Table 1) confirming the finding of Tukey et al. (8). The averaged nutrient content of 'Redspur' leaves from trees on all 4 rootstocks was higher in N, P, K, Mg, Fe, Zn and Cu than were those from 'Goldspur' which was higher only in Ca. As is typical of the 2 cultivars, the 'Redspur' trees were larger than the 'Goldspur' (Table 1). One might expect a lower nutrient content in the larger 'Redspur' trees based on simple dilution. Apparently the scion somehow affected the root system's capacity to absorb and/or translocate nutrients out of the roots of the tree and thus the less growth of the 'Goldspur' trees was due to something other than an inadequate supply of available nutrients in the soil. Reduced 'Goldspur' tree growth cannot be explained by greater fruit production since tree size was smaller at the end of 5 years when average yield of the 2 cultivars was not different (data not presented). At the end of 6 years, average total yield per tree and per ha was greater on 'Goldspur' than 'Redspur', and fruit size was greater for 'Redspur' though fruit size of each cultivar was very good (Table 1).

After 6 years the trees were not touching, and did not appear to be crowded. However, tree size, as estimated by trunk cross section area was largest at the widest spacing (Table 1). Fruit from the closest spaced trees were smaller (but good commercial size) than those from the widest spaced trees. Thus, increased competition among closely spaced trees may be influencing tree growth and fruit size even though yield per tree was not significantly affected (Table 1). Thus, yield per ha was proportional to tree spacing.

Tree spacing did not affect N, Fe, Zn or Cu content of the leaves. However, leaves from the widest spaced trees had more P and K than those from the closest trees, suggesting more competition for these elements among the more closely spaced trees. However, Ca, Mg and Mn were present in greater concentration in leaves from the closely spaced trees. One year's data from another younger planting with closer spacing (0.6, 1.2, 1.8 m) show a similar trend in leaf Mg and Mn content (data not presented). These data raise the question of desirability of high density plantings in soils high in available Mn.

Rootstock effect on mineral composition of scion leaves was observed with N, P, Ca, Mn, Zn and Cu though none were found to be at deficient or toxic levels in the foliage (Table 1). Trees on M 7 had the highest N, P, and Cu; those on MM 106 were highest in Ca as previously reported (4) and higher in Cu than those on MM 111 as previously reported (6). Leaves from trees on MM 111 were highest in Mn and Zn, and seedling rootstock were also highest in P. Leaves from seedling trees were lowest in N and Cu, those on MM 111 were lowest in P, and those on M 7 were lowest in Ca, Mn, and Zn. Rootstock did not affect Mg levels in leaves though those from M 7 have been reported (1) to be low in foliar Mg. Only in respect to Ca and Mn was there a significant interaction between rootstock and scion cultivar indicating that the stock effects on foliar mineral composition reported here may be expected to occur with other scion cultivars (9). Thus, in marginal cases it may be possible to alleviate some nutritional problems by proper selection of rootstock.

Tree size was affected by rootstock; those on seedling rootstocks were largest and those on MM 106 were smallest. Trees on the other 2 stocks were intermediate in tree size. The differences however were small at the end of 6 years. Tree size may be related to production; trees on seedling rootstocks produced the least fruit and those on MM 106 produced the most with the other trees intermediate. 'Goldspur' trees produced the highest yield on MM 111 rootstock while 'Redspur' produced the most on MM 106. Both produced the least on seedling rootstock. Even though yield on seedling trees was only 60% of that on MM 106 (Table 1) there was essentially no effect on fruit size. This lack of rootstock effect on fruit size is probably due to a significant interaction between rootstock and cultivar since 'Goldspur' fruit on seedling stock were largest whereas the 'Redspur' fruit were smallest on the same stock (data not presented). The higher average yield of trees on MM 106 apparently did not adversely affect nutrient composition of scion foliage, for MM 106 was usually among the highest where rootstock effect on foliar composition was significant.

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Chemical Thinning of Peach Fruits with CGA 15281 and CGA 17856[1]

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Abstract. **Beta-chloroethyl-methyl-bis-benzyloxy-silane (CGA 15281) was applied to 6 Eastern U.S. grown peach (*Prunus persica* (L.) Batsch) cultivars. Thinning response varied considerably with cultivar, timing, concentration and year. Unpredictable and commercially unacceptable leaf abscission occurred with most cultivars during the three-year period. Adequate thinning was achieved without excessive leaf abscission (10% or less) with only one treatment on 3 cultivars ('Redhaven', 'Loring', and 'Sunhigh') during the 3-year period. Reproducibility between years was not good. Unpruned trees or long 2-year-old limbs lost a greater portion of fruit at the base of shoots and on the interior of the trees than trees pruned to a uniform shoot length. The thinning response to CGA 17856 (an analogue of CGA 15281) was compared to the same rate of CGA 15281 on 5 cultivars. A tendency to greater leaf abscission was observed with CGA 17856.**

The search for an effective chemical peach thinning agent has not resulted in a commercially acceptable method of fruit removal. Numerous materials have been tried (2, 3, 4, 7, 8, 10, 11) and most have been discarded due to inconsistent results, leaf abscission, fruit deformation, or unacceptable timing in relation to bloom and the frost period. The timing of N-1-naphthylphthalamic acid (NPA) near bloom (1) and naphthaleneacetic acid (NAA) and 3-chlorophenoxy-α-propionamide (3-CPA) during cytokinesis (5, 6, 8) has been more critical than for ethylene-releasing compounds such as ethephon (9). Since CGA 15281 and CGA 17856 are known to release ethylene when applied to plants, the applications were timed when weather conditions were 20-27°C and ovule length was 8-16 mm and not necessarily according to the time of cytokinesis.

Materials and Methods

All treatments within an experiment were applied to 4 single tree replicates in a randomized complete block design. Percentage fruit remaining and fruit size were determined on 4 pre-selected limbs (each with 75 fruit or more) per tree. Ten fruit per limb were sized at 2 dates prior to harvest with a band-type hand sizer. The controls for each experiment were unthinned; however, to prevent tree breakage the controls and underthinned treatments were hand thinned about 14 days after treatment, except for the tagged limbs on each tree.

In 1974 and 1975, treatments were applied with a high-pressure gun-type sprayer at about 35 kg/cm^2 (500 psi). In 1976 a commercial 3-point hitch airblast sprayer was used at 27 kg/cm^2 (380 psi) and nozzled to deliver approx 2, 620 liters/ha (280 gal/acre) at about 2.4 km/hr (1.5 mph). Temp were higher and wind calmer in 1974 and 1975 than in 1976. Ovule length of 50 randomly selected fruits from at least 10 border row trees was measured on each spray date with a hand caliper.

Commercial peach orchards in the vicinity of Winchester, Virginia used for these experiments were: in 1974, 15-year-old 'Redhaven' and 18-year-old 'Elberta'; in 1975, 9-year-old 'Redhaven', 'Loring', and 'Sunhigh' and 15-year-old 'Madison'; in 1976, 10-year-old 'Redhaven', 'Loring', and 'Sunhigh' and 18-year-old 'Madison', 'Redhaven', and 'Jefferson'.

Results and Discussion

The desired percentage fruit remaining after the thinner applications ranged from 25 to 35% in most of these experiments; however, this figure was dependent on original crop load. Fruit-size measurements reflected effective thinning; however, if serious foliage injury had occurred fruit size could have been adversely affected. In addition, since these compounds release ethylene, the fruit growth rates and/or maturity may also affect fruit size measurements. The thinners did not appear to affect maturity when applied at this stage of fruit development.

'Redhaven'. In 1974, CGA 15281 slightly over-thinned at 500 ppm and caused some leaf abscission (about 10% removal) when applied at an ovule length of 8.6 mm (Table 1A). The 1000 ppm treatment caused excessive fruit and leaf abscission

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