The Effect of Interstock on the Mineral Nutrition of Young Trees of Four Apple Cultivars\(^1, 2\)

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Abstract. One-year whips of 4 apple cultivars of known virus status on 'M 9' rootstock were grafted, rearranging the tops to give 16 combinations of scion and interstock, from which growth, leaf mineral status, and an uptake index were determined. Numerous components of scion and interstock effects and interactions were identified; there were no general effects of self-grafting or cross-grafting. Mineral uptake, mineral concn, and growth were influenced by specific combinations of scion and interstock.

Differences in leaf tissue composition due to sampling date, rootstock and scion cultivars were found to vary with element (1). Several rootstock x scion interactions were also found, Warne and Wallace (8) studying nine Malling rootstocks found that rootstock influenced the chemical composition of the scions. Transport of \( 32\text{P} \) and \( 45\text{Ca} \) varied in rootstocks of 'M 9', 'M 17', 'M 16' and 'Delicious' seedling all in relation to 'Mcintosh' tops (3).

There are very few studies of the effect of interstock on scion nutrition. In a 6 year study of 'M 9' and 'M 16' as reciprocal interstock/rootstock combinations, effects of different lengths and positions of the interstock on the growth and flowering of 'Starking Delicious' scions were examined (6). Effects of interstocks on the growth of 'Golden Delicious' trees have also been studied (5). Neither of these studies reported leaf nutrient status.

The influence of rootstock, bodystock and interstock upon the leaf nutrient composition of apples grown in the field was studied (7) using leaf samples collected from trees of 80 combinations of 4 rootstocks, 5 interstocks and 4 scion cultivars and analyzed for N, P, K, Ca and Mg. Rootstock, interstock and scion cultivar markedly influenced leaf nutrient composition. While certain interactions of interstock and scion resulted in greater differences in K and Mg than would be anticipated by either the interstocks or the scions alone, the authors do not show which specific combinations of interstock and scion were responsible for the interactions observed, nor do they state whether K

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and Mg were separately or jointly increased or decreased, and their experimental design is not fully described. The virus status of their trees was not known, and may not have been constant for all their experimental material. Growth and nutrition of young apple trees may be affected by virus infection (2, 4). The purposes of the present experiment were to study the effect of various combinations of interstock and scion cultivars on leaf nutrient composition, under uniform growing conditions and virus status, and to measure the ability of stems of certain cultivars to transport nutrients differently.

One-year whips, 1.0—1.2 m long, of 'Golden Delicious', 'Mcintosh-Summerland Red', 'Red Delicious-Harold's Red', and 'Spartan' all budded on 'M 9' in 1969 were purchased from a commercial nursery in February, 1971. As the common 'M 9' rootstock was believed to be infected with all viruses present in any one of the scion cultivars, the trees in the present experiment were considered to be uniformly virus infected. Initially 'Mcintosh' had stem pitting, 'Spy' decline and chlorotic leaf spot virus; 'Red Delicious' had stem pitting, 'Spy' decline and mild rubberty wood viruses; 'Golden Delicious' had chlorotic leaf spot and mild rubberty wood viruses; 'Spartan' was virus free, and 'M 9' carried all of these viruses plus brown line decline virus (M. F. Welch, personal communication). A whip-and-tongue graft was made 10 cm above the bud union, and each of the cultivars was used as a scion on all 4 of the resulting interstock cultivars, thus providing 16 distinct combinations of scion and interstock. There were 16 trees of each combination. The trees were immediately planted in 9-liter plastic pails in a potting soil and arranged in a randomized blocks of 64 trees in the greenhouse. For each tree the length of new shoot growth was determined on April 30, 1971 and leaf samples from each tree were taken on May 3, 1971. For chemical analyses, the leaf samples from the 4 identical pots within a block were pooled. The analysis of variance was that for a \( 4 \times 4 \) factorial in each of 4 complete blocks. Main effects and interactions were subdivided into individual degrees of freedom to identify any effects of specific combinations of interstocks and to identify specific combinations of those which might be individual components of interaction. This experiment was terminated after collection of leaf samples, but the trees were saved and were transplanted to a field location in June, 1971, maintaining the same experimental design as in the greenhouse.

Leaf samples were analyzed for N by semi-micro Kjeldahl, for P by phosphomolydate colorimetry, for K and Na by flame emission photometry, and for Ca, Mg, Fe, Mn and Zn by atomic absorption spectrophotometry. On the assumption (not tested) that dry matter of new growth was highly correlated with shoot extension, an "uptake index" was computed by multiplying the concn (ppm) by the mean growth measurement (m), for the 4 identical trees sampled.

Statistical analyses of growth, leaf nutrient concn, and "uptake index" were carried out as described above by using a multiple step-wise regression program on an IBM 360/67 computer under MTS. For convenience in discussing the results we have used the term "self-graft" when scion and stem are of the same cultivar, "cross-graft" when they differ and "reciprocal" to designate 2 combinations of the same cultivars in different arrangement.

In summarizing the results (Tables 1-2), the adjusted means presented were fitted from a final stepwise multiple regression equation. Most differences shown are significant at the 5% level, and only differences known to be significant at this level are discussed in the text.

Growth measurements. Certain combinations of scion and interstock had more growth than others (Table 1). When 'Golden Delicious', 'Mcintosh', or 'Red Delicious' were used as scions, 'Spartan' interstock increased growth of the scion in comparison with other cultivars used as interstocks. When 'Spartan' was used as a scion the greatest growth was obtained on 'Mcintosh' interstock, and the least growth on 'Golden Delicious' interstock. Only with 'Spartan' scions did self-grafts have superior growth over any cross-grafts. Except for leaf P content, growth measurements were statistically independent of leaf mineral composition. There was some tendency for increasing tissue P levels to be associated with decreased growth (\( R^2 = 8.4\% \)).

Mineral composition. Self- and cross-grafts of most combinations had similar N composition (Table 1). The 2 reciprocals involving 'Mcintosh' and 'Red Delicious' decreased N levels in the tissue. With 'Golden Delicious', 'Mcintosh' and 'Red Delicious' scions, there were no differences in P concn due to interstock. For 'Spartan' scions the self-graft had higher P concn.

Increases in nutrient concn in
self-grafts were also noted in K for 'McIntosh' and Mn for 'Golden Delicious'. Decreases in leaf nutrient concn of self-grafts were noted in Ca for 'Golden Delicious', in Mg for 'Red Delicious' and 'Golden Delicious' and in Mn for 'Red Delicious'. Although there was higher Mg concn in 'Spartan' self-grafts than in 2 cross-graft combinations, the greatest Mg content in 'Spartan' scions were found where 'Golden Delicious' was used as an interstock. 'Spartan' scions had higher K levels with 'Red Delicious' interstock than with other interstocks.

'Golden Delicious' scions had greatest Mg content when cross-grafted with 'McIntosh' and 'Spartan'. In 'McIntosh' scions Mg levels were lower when cross-grafted with 'Red Delicious' and 'Spartan'. Mg levels were least in 'Spartan' scions cross-grafted with 'McIntosh' and greatest in cross-grafts with 'Golden Delicious'. With reciprocal grafts involving 'Golden Delicious' and 'Red Delicious' and cross-grafts with 'Spartan' were least in cross-grafts with 'Red Delicious'.

### Table 2. Adjusted means for index of mineral uptake for 16 scion-interstock combinations.

<table>
<thead>
<tr>
<th>Scion</th>
<th>Interstock</th>
<th>N (%)</th>
<th>P (%)</th>
<th>Ca (%)</th>
<th>Mg (%)</th>
<th>Fe (ppm)</th>
<th>Mn (ppm)</th>
<th>Zn (ppm)</th>
<th>Na (ppm)</th>
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<td></td>
<td>McIntosh</td>
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<td>134</td>
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<tr>
<td></td>
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<td>.180</td>
<td>.200</td>
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<td>134</td>
<td>46</td>
<td>40</td>
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<tr>
<td></td>
<td>Spartan</td>
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<td>.208</td>
<td>.200</td>
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<td>134</td>
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<td>1.04</td>
<td>.73</td>
<td>.270</td>
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- **Multiple R² (%)**: 28.2
- **F-probability**: .0002
- **Standard error of estimate**: 0.58

2There were 4 trees of each combination in each of 4 complete blocks of the experiment. Adjusted means were fitted from a multiple regression equation.

7There were 4 trees of each combination in each of 4 complete blocks of the experiment. Adjusted means were fitted from a multiple regression equation.
levels of 'Golden Delicious' self-grafts.

In 'Golden Delicious' scions the uptake index was greatest for P in cross-grafts on 'Spartan', least for Mg and Mn in cross-grafts on 'Red Delicious', and greatest for Zn in cross-grafts on 'Red Delicious'. The uptake index in 'McIntosh' scions was greatest for P in cross-grafts on 'Spartan', least for Mg in cross-grafts on 'Red Delicious', and least for Mn in self-grafts and in cross-grafts on 'Red Delicious'. In 'Red Delicious' scions, the uptake index was least for N in cross-grafts on 'McIntosh', greatest for P, K and Mn in cross-grafts on 'Spartan'. In 'Spartan', the uptake index for N was greatest in the self-graft and the cross-graft on 'McIntosh', less in the cross-graft on 'Red Delicious' and least in the cross-graft on 'Golden Delicious'. In 'Spartan' scions the index for P was least in the cross-graft on 'Golden Delicious', greater in the cross-graft on 'Red Delicious', greater still in the cross-graft on 'McIntosh', and greatest of all in the self-graft. For K, Ca, Mg and Fe in 'Spartan' scions, the indices were least in the cross-grafts on 'Golden Delicious'. In 'Spartan' scions the index for Mn was least in the self-graft.

Many components of main scion and interstock effects and of interactions of these were identified as to their influence on growth, mineral uptake indices and leaf element content, so many in fact that no simple generalities can be made. This agrees with the conclusions of Tukey et al. (7) although they do not state that they tested individual contributions to interaction. We find no general effects of self-grafting, cross-grafting or reciprocals in our results. As measured by our methods it appears that for certain scions, mineral uptake, content and growth may be influenced by cross-grafting on interstocks of specific cultivars. From the lack of correlation between growth and mineral composition we infer that all unions were able to supply adequate nutrients to support growth and that the unions were uniformly well healed at the time of sampling.

The results with 'Spartan' are of particular interest at the present time because it is believed that many young trees of this cultivar will be topworked to other cultivars by both nurserymen and orchardists since 'Spartan' production is being discouraged in British Columbia pending a comprehensive solution to a disorder leading to breakdown of its fruit in storage. Growers who might wish to topwork 'Spartan' to another cultivar can derive little advice on the choice of the optimum cultivar for use as scions. At the same time, our data do not give any general contraindication to topworking that cultivar, since from the point of view of growth, 'Spartan' was generally the best interstock in the experiment and cross-grafting on 'Spartan' interstock did not materially alter the nutrient status of the scion cultivars.

A Nutrient Solution-Sand Culture System for Studying the Influence of N Form on Highbush Blueberries

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Abstract. Blueberry plants (Vaccinium corymbosum L. cv. Wolcott) under a constant-flow gravity system in the greenhouse were able to utilize either NO₃⁻N or NH₄⁺N and maintained a healthy growth status for 2 growing seasons.

The N nutrition of the blueberry has been controversial since commercial production began. Numerous authors have recommended the use of NaNO₃ in place of (NH₄)₂SO₄ (1, 2, 5). Currie (3) concluded that NO₃⁻N may be harmful to plant growth. Townsend (10, 11) and Herath and Eaton (7) applied NO₃⁻N and/or NH₄⁺N to rooted cuttings in sand and peat culture with moderate control of the rooting media pH. Plants supplied NO₃⁻N developed marginal necrosis and leaf abscission. Plants supplied NH₄⁺N were more vigorous and had significantly greater shoot growth. Nutrient solutions have been applied to blueberry plants by different methods ranging from sub-irrigation to drip culture; the formulations have varied in composition (1, 2, 5).

The purpose of this investigation was to design a nutrient solution system for commercial production size 'Wolcott' blueberry plants capable of maintaining an agreeable pH around the root zone by constantly replacing nutrient solution in contact with the roots and to determine if 'Wolcott' blueberry plants could utilize either NO₃⁻N and/or NH₄⁺N under such conditions.

Twenty-five dormant 5-year old 'Wolcott' highbush blueberry plants were removed from a commercial farm with approx 0.25 m² of soil around the intact root system in each bush. The plants were transported to the greenhouse, held outside at -4.0°C for 24 hr, and carefully washed to remove all soil from the roots. The containers for the plants were half sections of 208 liter drums cut parallel to the heads. Five 1.3 cm drain holes were drilled in the bottom of each container before the internal surfaces were painted with 3 coats of liquid asphalt roof coating containing asbestos fibre. Glass wool plugs were placed over each drain-hole and approx 5.1 cm of washed crushed gravel was placed evenly in the bottom of each container followed by 23 cm of washed white construction-grade sand of 0.4 cm or smaller mesh. The plants were centered in the containers. Additional washed sand was added with water and gently tamped to obtain max contact of the sand with the roots and to barely cover the roots. The plant-container units were sorted into 5 replications of 5 similar sized plants and placed by replication in a 9.14 x 7.32 m greenhouse. Random assignment of treatments was made within each replication. A 16-hr photoperiod was maintained with 3 incandescent 100-watt lamps with reflectors centered 60 cm above the plants in each replication. The greenhouse temp were maintained at 18°C (night) and 24°C (day). On Feb. 1, 1968, daily applications

Literature Cited