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Effects of Rootstock and Interstock on Seasonal Changes in Foliar Nutrient (N, P, K, Ca) Composition of 'Delicious' and 'Golden Delicious' Apple

STEVE WEST[1] AND ERIC YOUNG[2]

Abstract

Two cultivars of apple (*Malus domestica* Borkh.) propagated on seven different rootstock or rootstock/interstock combinations were evaluated for foliar nutrient composition (N, K, P, and Ca). Two blocks of trees were used, one at a commercial orchard (Barber Orchards[3]) and the other at the Mountain Horticulture Crops Research Station (MHCRS), both in Western NC. Samples were taken in May, June, July and August in 1984. At Barber Orchards the cultivar had a significant effect on nutrient composition with 'Redchief' trees higher in N, P and Ca than 'Smoothee' and lower in K. Rootstock had a significant effect on levels of K and Ca with trees on M.9/MM.106 highest in K and MM.106 highest in Ca. At MHCRS, N and Ca were significantly higher in 'Redchief' than 'Smoothee.' Rootstock had a significant effect on N, P, and K, with M.26 highest for N and P and M.9/MM.111 highest in K. Interactions of cultivar and rootstock were significant for all nutrients at MHCRS, but not Barber. Sampling date had a significant effect on foliar nutrients at both locations with N and K decreasing and Ca increasing over time.

Introduction

With the trend toward higher density plantings apple growers are utilizing more dwarfing rootstocks.

Studies have shown significant rootstock effect on foliar nutrient levels in apple (2, 3). Poling and Oberly (3) showed significant rootstock effect on foliar Mg, Ca, Fe, Mn, and Na levels, but their samples were taken only in mid-August, after vegetative growth had ceased. Awad and Kenworthy (1) found significant seasonal effects on the rootstock influence on foliar composition. Poling and Oberly (3) did not find differences due to rootstock in N, P or K in mid-August, whereas Awad and Kenworthy found significant rootstock effects on N and P levels in mid-July. Additional efforts are needed to develop specific fertility programs for various cultivar/rootstock/interstock combinations and to identify when key elements are affected by rootstock during the growing season. The objective of this study was to determine if rootstock and interstock have an effect on foliar nutrient (N, P, K, Ca) composition over the growing season and if an interaction with cultivar exists.

Materials and Methods

An apple rootstock trial was established April, 1980, at Barber Orchards, Waynesville, NC in a randomized complete block design with three single tree replications of each cultivar/rootstock combination; and April, 1982, at MHCRS, Fletcher, NC, in a randomized complete block design with two three-tree replications of each cultivar/rootstock. Each row contained one cultivar and alternated between cultivars across the orchard. Cultivars used were 'Redchief Delicious' (Cambell strain) and 'Smoothee

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[1]County Extension Director, Federal Bldg., Box 308, Waynesville, NC 28786.

[2]Associate Professor, Department of Horticultural Science, North Carolina State University, Raleigh, NC 27695-7609

[3]The authors wish to express appreciation to Barber Orchards, Waynesville, NC for the use of their trees in this study.

Golden Delicious'; rootstocks were: MM.106, M.7a, MM.111, M.9/MM.106 (Barber's only), M.9/MM.111, M.26, and seedling (MHCRS only). All trees were spaced 4.5 x 9 m and defruited and summer pruned in 1984, the test year. The soil type at Barber Orchards was Tusquitee, 8-15% slope, pH 5.7 5.7, CEC 8.3; MHCRS was Hayesville Loam, 15-25% slope, pH 5.5, CEC 5.5. Soil samples were taken randomly across each orchard and there were no significant differences between samples within an orchard.

Nitrogen was applied at both locations in March, 1984. At Barber's, calcium nitrate was the source at 1.0 kg per tree or 42 kg/ha per acre. At MHCRS ammonium nitrate was the source at 0.5 kg per tree or 41 kg/ha of nitrogen. Phosphorus and potassium were also added at MHCRS at 0.5 kg/tree. No additional fertilizer was applied except boron as solubor 1.2 g/l sprayed dilute at first cover.

At both locations bare strips 1.5 m wide were maintained through the use of herbicides. At Barber's, terbacil (Sinbar) 2.24 kg/ha treated active ingredient plus diuron (Karmex) 2.24 kg/ha active ingredient were band applied March 15, 1984. A one percent solution of glyphosate (Roundup) was used as "touch up" application the first week of August. At MHCRS, 1.12 kg/ha paraquat was band applied June 29, 1984. The middles of both locations were a mixture of Kentucky 31 fescue, orchard grass, and Kentucky blue grass and maintained by mowing.

Table 1. Analysis of variance for main effects and interactions of foliar nutrient levels in two apple cultivars on six rootstocks at Barber Orchard.

	N	P	K	Ca
Cultivar	••[1]	••	••	••
Rootstock	N.S.	N.S.	••	••
Rootstock X Cultivar	N.S.	N.S.	N.S.	N.S.
Date[2]	••	N.S.	••	••

[1] • = P < .05, •• = P < .01.
[2] Interactions with date and three-way interaction were not significant.

Leaf tissue samples (20 leaves/tree) were taken at both locations the first week of May, June, July and August, 1984. Samples were collected from the mid-shoot region of the current year's growth, placed in paper bags and dried for a minimum 24 hr. at 80°C in a drying oven. Samples were ground using a stainless steel Wiley mill with a 20-mesh screen and stored in air tight containers until analysis. Dry ashed samples were analyzed for N by the Kjeldahl method, for K and Ca by flame photometry, and P by colorimeteric analysis.

Results and Discussion

Barber Orchard 'Redchief' trees had significantly higher foliar N, P, and Ca and lower K (Table 1, Fig. 1-4). At MHCRS, 'Redchief' had significantly higher foliar N and Ca, and lower P and K (Table 2, Fig. 1-4). Rootstock had a significant effect on foliar K and Ca at Barber Orchard with M.9/MM.106 highest in K and MM.106 highest in Ca. M.26 was highest in N and P and M.9/MM.111 in K at MHCRS (Table 2, Fig. 1-4). Foliar composition for N, P, K and Ca for each cultivar/rootstock combination averaged over sample dates are shown in Figures 1-4. There were no significant rootstock/cultivar interactions at Barber Orchard (Table 1), but this interaction was significant for all nutrients at MHCRS (Table 2). Generally, the spread between rootstocks in nutrient level was much greater with

Table 2. Analysis of variance for main effects and interactions of foliar nutrient levels in two apple cultivars on six rootstocks at MHCRS.

	N	P	K	Ca
Cultivar	••[1]	N.S.	N.S.	••
Rootstock	••	••	••	N.S.
Rootstock X Cultivar	••	••	••	•
Date[2]	••	••	••	••
Date x Cultivar	••	N.S.	•	••

[1] • = P < .05, •• = P < .01.
[2] Date x Rootstock and three-way interactions were not significant.

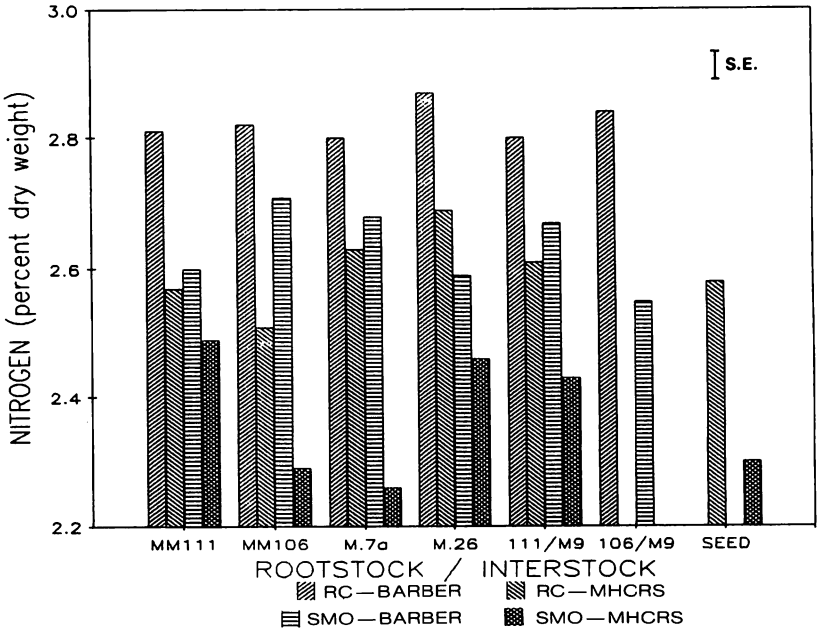

Figure 1. Foliar N level in 2 apple cultivars at 2 locations for 6 rootstocks averaged over 4 sample dates. Vertical bar indicates approximate standard error (S.E.) of the mean. S.E. difference between orchards was N = 0.01.

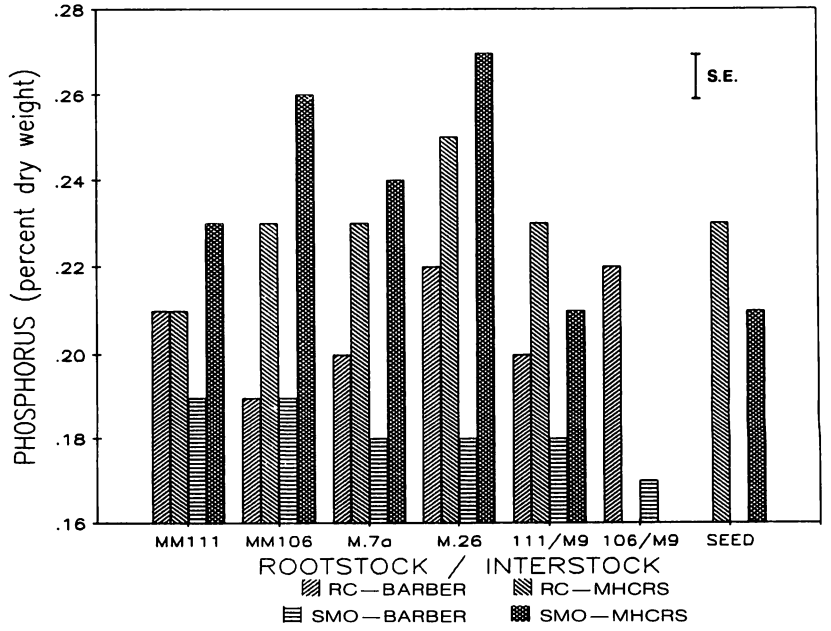

Figure 2. Foliar P level in 2 apple cultivars at 2 locations for 6 rootstocks averaged over 4 sample dates. Vertical bar indicates approximate standard error (S.E.) of the mean. S.E. difference between orchards was P = 0.002.

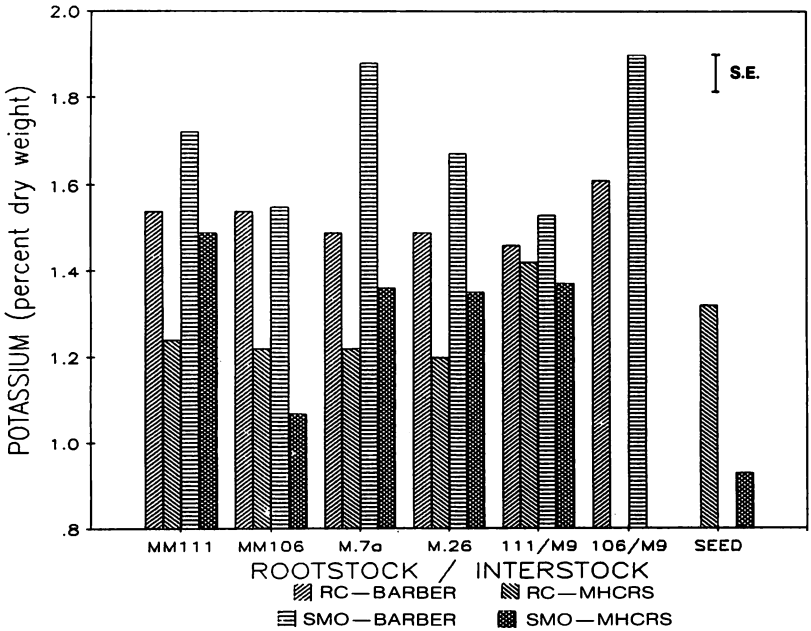

Figure 3. Foliar K level in 2 apple cultivars at 2 locations for 6 rootstocks averaged over 4 sample dates. Vertical bar indicates approximate standard error (S.E.) of the mean. S.E. difference between orchards was K = 0.01.

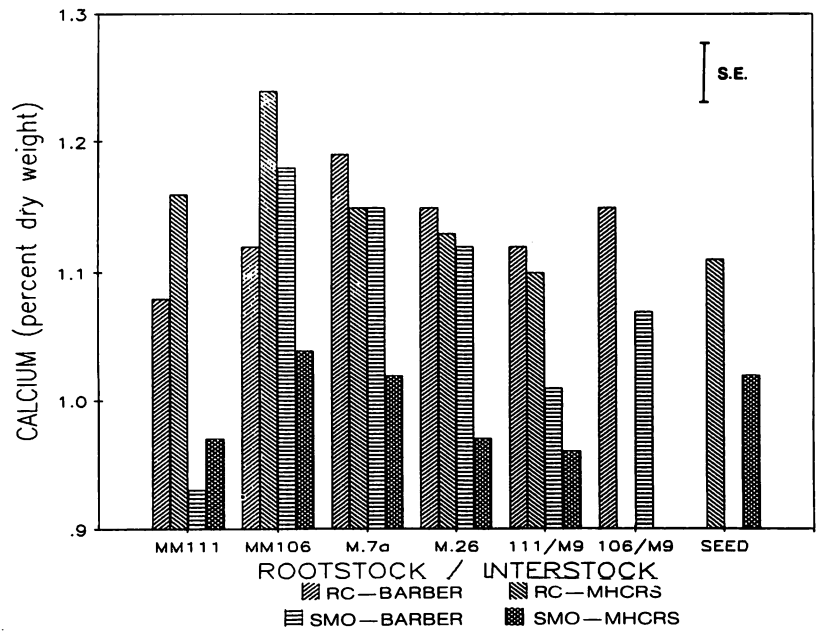

Figure 4. Foliar Ca level in 2 apple cultivars at 2 locations for 6 rootstocks averaged over 4 sample dates. Vertical bar indicates approximate standard error (S.E.) of the mean. S.E. difference between orchards was Ca = 0.01.

'Smoothee' than 'Redchief' at MHCRS, except Ca where the spread between 'Redchief' on different rootstocks was greater (Fig. 4). Ca levels were particularly high in 'Redchief' on MM.106 rootstock with and without the M.9 interstock.

Date had a significant effect on N, K and Ca at each location (Tables 1, 2) with N and K decreasing and Ca increasing with time. The change with date can be seen in Figs. 5 and 6, where the nutrient levels are averaged over all rootstocks. Cultivar differences in N, K and Ca are also shown in these figures. Date x cultivar interactions were significant only for N, K, and Ca at MHCRS (Table 2, Fig. 6). There were no date x rootstock interactions.

Cultivars and rootstock at both locations significantly affected foliar levels of N, P, K and Ca, which would indicate that rates may need to be adjusted for different cultivar/rootstock combinations, Particularly when a cultivar and rootstock are used which both tend toward low levels of a nutrient; for example, 'Redchief' with seedling for K and 'Smoothee' with MM.111 for Ca. Also, the difference in how site affected the cultivar/rootstock interactions, re-emphasizes the need to tailor each orchard's fertilizer program based on specific orchard conditions as well as general recommendations for the cultivar/rootstock combination used.

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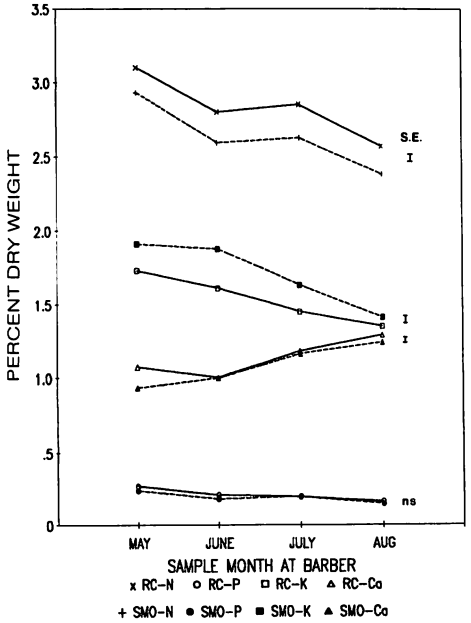

Fig. 5. Foliar nutrient content of two apple cultivars averaged over six rootstock on four sample dates at Barber Orchard. Vertical bar represents standard error (S.E.) of the mean for each nutrient.

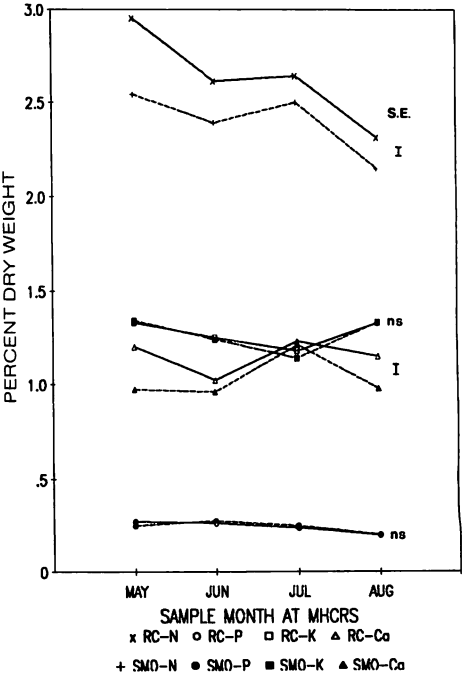

Fig. 6. Foliar nutrient content of two apple cultivars averaged over six rootstocks on four sample dates at MHCRS. Vertical bar represents standard error (S.E.) of the mean for each nutrient.