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The Influence of Nitrogen Fertilization, Season of Application, and Orchard Floor Management on Fruit Quality and Leaf Mineral Content of 'Golden Delicious' Apple Trees

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Abstract

'Golden Delicious' apple trees were grown under 3 orchard floor management systems (grass sod, vegetation control to July or vegetation control year-round) and 3 rates of nitrogen (30, 60 or 180 kg N ha^{-1}) applied in the spring (1980-83) or the fall (1984-87). Fruit at harvest from grassed plots tended to be firmer, lighter in color, higher in acidity, higher in K and slightly higher in Ca compared to those from non-grassed plots. Leaf N was lower and leaf K was higher from grassed plots than non-grassed plots. High rates of N tended to give greener fruit, higher leaf N and lower leaf K. A lower leaf N content was observed in 1985-87 than in 1981-83 and is assumed to be an effect of time of N application rather than one caused by tree factors.

Introduction

High rates of N fertilization increase leaf N (2, 6, 12, 13) and adversely affect quality of apples (3, 5, 12, 14) but Neilsen et al. (12), however, found a greater influence of orchard floor management on leaf N than rate of N application. Their study showed a lower leaf N content in trees grown on grassed than on non-grassed plots, a result also noted by Haynes (9). Little, however, is known about the effect of time of application of N fertilizer on leaf N and fruit quality. Magness et al. (11) found no difference in leaf N or fruit color for 'York Imperial' and 'Delicious' fertilized in the late fall or early spring. The study by Neilsen et al. (12) involved annual applications of N fertilizer in early spring. A subsequent 4-year study (1984-87) was conducted with annual applications of fertilizer in the late fall. This paper attempts to address the effects of orchard floor management, rate of N application and time of N application on fruit quality and tree nutritional status.

Materials and Methods

The block of 'Golden Delicious' on MM.111 rootstock was planted in 1971 and spaced at 6.1 x 6.1 m. Soil type was a Rutland gravelly sandy loam (10). Three levels of N and 3 levels of orchard floor management were imposed on the block of trees. Each treatment (5 replicates) was represented by 2-tree plots. N fertilizer as NH_4NO_3 was broadcast uniformily in a 10 m^2 (3.0 x 3.35 m) area centered about each tree. The broadcast area approximated the drip-line of each tree within the tree row. Fertilizer was applied annually in mid-April (1980-83) or early November (1984-87) at

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rates of 30, 60 or 180 kg N ha^{-1} (N1, N2, N3, respectively). Orchard floor management was grass mowed once in June (VI), clean cultivation to July by use of herbicides (V2) and clean cultivation by use of herbicides during the growing season (V3).

Thirty leaves per plot were collected in July of each year from the mid-portion of the current season's extension shoots, 30° to 60° to the horizontal and about 1.5 m above ground level. Leaf samples were oven-dried at 65°C and ground in a 40-mesh Wiley mill. 1 g samples of ground leaf tissure dry-ashed at 475°C, were dissolved in 0.5M HCl and analyzed for Ca, Mg, K and Mn content by atomic absorption spectrophotometry. Leaf N was determined on a 100 mg ground sample by the AOAC Kjeldahl method (1965). Leaf P was determined by an auto-analyzer (Technicon Autoanalyzer II Industrial Method No. 334-74 A/A) on a 250 mg ground sample digested at 350°C for 0.5 h in a block digester (12).

Samples of 100 fruit were harvested at commercial maturity (industry recommendations) from each plot and placed in 0°C air at 85-90% R.H. Sub-samples of 15 apples at harvest were evaluated for fruit size, skin color, flesh firmness, soluble solids content and titratable acidity.

Skin color was read on a Golden Delicious Apple Meter (Techwest Industries Ltd., Vancouver, B.C.) and flesh firmness was determined with a Magness-Taylor penetrometer (11.1 cm tip, 2 readings taken on pared surfaces of opposing sides of sample fruit). Soluble solids content in the juice was determined by temperature compensated refractometry and titratable acidity was calculated from titration of the juice to an end point of pH 8.1 with 0.1 N NaOH. Juice was extracted by a commercial blender from slices (2 slices per apple) in each sub-sample.

A 30-apple sample was taken at harvest from each plot for mineral analysis. Two sectors from each apple, free of skin, seeds and carpel tissue, were first air-dried at 20°C for 48-72 h, then oven-dried at 65°C for 24 h and powdered in a 40-mesh Wiley mill. 1 g samples of the powder were ashed and analyzed for Ca, Mg and K by atomic absorption spectrophotometry.

Table 1. Fruit quality and mineral content at harvest in 'Golden Delicious' trees subjected to 3 orchard floor regimes, and 3 levels of nitrogen fertilization applied in the spring (1981-83) or fall (1985-87).[z]

Treatment		Firmness (N)		Skin color (0-10)[y]		Acidity (mg)[x]		Fruit size (g)		Fruit Ca (ug g^{-1}, d.w.)				Fruit K (ug g^{-1}, d.w.)	
		Spring	Fall	Spring	Fall	Spring	Fall	Spring	Fall	Spring	Fall			Spring	Fall
											N1	N2	N3		
Orchard floor management															
Grass sod	(V_1)	77a[w]	82a	3.8a	2.9a	688a	671a	206b	193a	164a	166	158	167	6399a	6173a
Bare until July	(V_2)	75b	81b	3.2b	2.7b	661b	645b	210a	188a	153b	161	155	157	6167b	5839b
Bare year-round	(V_3)	74b	79c	3.0c	2.5b	666b	648b	213a	195a	152b	156	165	154	6085b	5791b
Nitrogen application															
30 kg N ha^{-1}	(N_1)	76	81	3.5	2.8	676	649	209	188	156				6392	6101
60 Kg N ha^{-1}	(N_2)	76	81	3.4	2.7	674	656	206	192	158				6231	5912
180 Kg N ha^{-1}	(N_3)	74	80	3.1	2.6	666	660	214	196	157				6147	5789
Contrast (N)		NS[v]	NS	L	L	NS	NS	NS	NS	NS				NS	L
N • V		NS	NS	NS	NS	NS	NS	NS	NS	NS				NS	NS

[z]Mean values for the periods of 1983-83 and 1985-87, respectively.
[y]Higher values indicate yellower fruit.
[x]Expressed as mg malic acid in 100 ml of juice.
[w]Means separation within columns by Duncan's multiple range test, P = 0.05. Significant at 5% (°) or not significant (NS).
[v]Linear (L).

Table 2. Leaf nutrient concentration at harvest of 'Golden Delicious' trees subjected to 3 orchard floor regimes, and 3 levels of nitrogen fertilization applied in the spring (1981-83) or fall (1985-87).[z]

Treatment	N (%)		Mg (%)		K (%)		Mn (ug g^{-1}, d.w.)						P (%)				Ca (%)	
	Spring	Fall	Spring	Fall	Spring	Fall	Spring			Fall			Spring	Fall			Spring	Fall
							N1	N2	N3	N1	N2	N3		N1	N2	N3		
Orchard floor management																		
Grass sod (V_1)	2.16b[y]	2.01b	0.22a	0.25a	2.20a	2.02a	49	52	55	43	47	52	0.19a	0.16	0.15	0.14	0.80a	0.89a
Bare until July (V_2)	2.39a	2.13a	0.21b	0.25a	2.08b	1.96a	47	49	66	46	48	67	0.18b	0.15	0.14	0.14	0.78a	0.86a
Bare year-round (V_3)	2.42a	2.15a	0.21ab	0.26a	2.02b	1.88b	47	52	57	47	51	64	0.17b	0.14	0.15	0.14	0.78a	0.88a
Nitrogen application																		
30 kg N ha^{-1} (N_1)	2.25	2.04	0.22	0.25	2.17	1.99							0.19				0.78	0.87
60 Kg N ha^{-1} (N_2)	2.31	2.07	0.22	0.25	2.06	1.94							0.18				0.78	0.87
180 Kg N ha^{-1} (N_1)	2.40	2.17	0.22	0.26	2.08	1.92							0.17				0.79	0.88
Contrast (N)	L[w]	L	NS	L	Q	L							L				NS	NS
N*V	NS	NS	NS	NS	NS	NS		**			**		NS		**		NS	NS

[z]Mean values for the periods of 1981-83 and 1985-87, respectively.
[y]Means separation within columns by Duncan's multiple range test, P = 0.05. Significant at 1% (**) or not significant (NS).
[w]Linear (L) or quadratic (Q).

Data for the periods of 1981-83 and 1985-87 were statistically analyzed as a randomized complete block factorial design with 5 replicates for each of the 9 treatments. The transition years of 1980 (first year of spring application) and 1984 (first year of fall application) were excluded as they were not considered representative for each respective period. Nitrogen was partitioned into its linear and quadratic components and orchard management treatment means separated by Duncan's multiple range test if they had a significant F value.

Results and Discussion

Since the two N application periods were not concurrent it will not be possible to compare them directly but only relatively.

Orchard floor management. Fruit grown under grass (V1) was firmer, yellower in color, and higher in acidity and K (Table 1). Fruit size was lower under grass cover during 1981-83 but not during 1985-87 (Table 1). Leaf N was lower and leaf k was higher in trees grown under grass but leaf Ca and Mg were not influenced by orchard floor cover (Table 2).

Rate of N application. Higher rates of N resulted in greener fruit (Table 1) and leaves with higher N and lower concentration (Table 2).

Interactions (N * V). These occurred with fruit Ca during 1985-87 (Table 1), leaf Mn during 1981-83 and 1985-87 (Table 2) and leaf P during 1985-87 (Table 2). However, no consistent features were obvious in the interactions. There was a tendency for vegetation covers (V1 and V2) to increase fruit Ca except at N2 while high rates of N increased leaf Mn especially with some sod removal (V2 and V3). The differences in leaf P during 1985-87 were slight but leaf P decreased with sod removal (V2) at N2.

The higher fruit firmness values observed during 1985-87 (Table 1) may be a consequence of smaller fruit size (192 g vs. 210 g during 1981-83). Smaller fruit may reflect the higher overall yield of 8.7 t ha^{-1} during 1985-87 compared to 5.3 t ha^{-1} during 1981-83. The higher yield may also have been a factor in greener fruit during the same period. That higher rates of N result in greener fruit (Table 1) was reported earlier by Fallahi (4, 5) and Gormley et al. (7). The latter authors also found a higher soluble solids content, higher acidity and yellower fruit when sod covers were utilized. Sod cover gave higher acidity and yellower fruit in this study (Table 1) but had no effect on soluble solids content (data not shown).

Differences between the two periods are higher firmness, greener fruit, lower fruit K (Table 1) and lower leaf N, K and P and higher leaf Mg and Ca (Table 2) during 1985-87, the period for fall application of N. The higher yield during the latter period may have influenced firmness and skin color as well as leaf mineral content. Hansen (8) observed higher leaf Ca and Mg and lower leaf K with cropping trees compared to non-cropping trees. The observed effects on leaf Ca, Mg and K in 1985-87 relative to 1981-83 may be expected if a yield differential (i.e. between high and low yielding trees) was equivalent to the difference between cropping and non-cropping trees. Hansen also (8), reported a higher leaf N content in the trees with fruit than in trees in which the fruit had been removed. However, leaf N in the present study (Table 2) was lower with fall application of fertilizer (higher mean yield) than with spring application of fertilizer (lower mean yield). It is, therefore, possible that the difference in leaf N between the two periods in our study was one of application data. A lower leaf N is desirable because it promotes yellow skin color in 'Golden Delicious' apples (14).

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Sensory Evaluation of Several Scab-Resistant Apple Genotypes[1]

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Abstract

Six scab-resistant and two scab-susceptible apples (*Malus domestica* Borkh.) stored in air at 2°C for 2-3 months were evaluated by descriptive analysis for taste and texture qualities. 'Liberty' was less aromatic but juicier and more acidic than the other genotypes. Crispness was best in 'Liberty,' 'Trent,' and CBR4T29. CBR4T29 and 'Liberty' were judged firmer than others. Mealiness was less obvious in 'Liberty.' FAR-54A48 was the sweetest apple. Electron microscopy studies on the cortical tissue of the soft and firm flesh genotypes did not reveal any differences in cell structure. The eight genotypes could be classified into three groups by similarity coefficients, A) 'Liberty,' 'Trent,' FAR-54A48 and CBR4T29, B) 74-50-13, 'MacSpur McIntosh' and 'Spartan,' C) 75-03-06.

Introduction

Scab is a serious problem in many apple-growing areas and the recent release of several scab-resistant genotypes (2) offers an alternative to the grower. Whether any of these genotypes become commercially acceptable will ultimately depend upon consumer acceptance and grower return. They also partially meet a current awareness for residue-free fruit (1, 13) because they require fewer sprays of fungicides. Insect control, however, is not different from that for scab-susceptible varieties. The purpose of this study was to determine how aroma, flavor and texture in several scab-resistant genotypes compared to those in scab-susceptible varieties. Favorable results would be the first step towards commercial introduction of the scab-resistant genotypes.

Materials and Methods

Apple genotypes. As only the mother tree was available for the St-Jean crosses, it was decided that single trees be used for the other-scab-resistant genotypes and scab-susceptible cultivars. All trees were into their 7th to 9th leaf and considered full bearing. Harvest dates were Sept. 6 for FAR54A48, Sept. 12 for 'McIntosh' and 'Spartan,' Sept. 19 for 75-03-06 and 74-50-13, Sept. 20 'Liberty,' Sept. 28 for CBR4T29, and Oct. 2 for 'Trent.' Maturity for the scab-resistant genotypes was determined by the starch and firmness values for 'McIntosh.'

Genotype description.

74-50-13, a 'McIntosh' x Co-op-11 cross is a late season scab-resistant apple, resembles 'Cortland' in appearance and taste, and has a storage period comparable to 'Cortland' (6). 75-03-06 was developed at Agriculture Canada,

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