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Influence of Rootstock on Fruit and Tree Characteristics of 'Macspur McIntosh'[1]

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Abstract

Macspur McIntosh apples grown on 4 rootstocks (M.9 EMLA, Ottawa 3, M.26 and M.4) were harvested at weekly intervals over a 5-6 week period and assessed for internal ethylene content (IEC), red skin colour, average fruit weight, flesh firmness, starch index (SI), soluble solids concentration (SSC), and titratable acidity. Data from the 4-year study showed no significant effect of rootstock on the proportion of fruit with an IEC of 1 ppm or more, a level indicative of fruit in the climacteric stage. Red skin colour, firmness, SSC, SI, and average fruit weight showed some differences in 1 or 2 years of the study but no trends were evident. Cumulative yield was not significantly different with rootstock but tree canopies on M.9 EMLA and Ottawa 3 were smaller and more yield efficient than canopies on M.26 or M.4.

Recent studies have shown an influence of rootstock on maturity of apples. Using ripening date as an index of maturity, Drake et al. (4) observed a delay in maturity for Goldspur Golden Delicious apples on MM.111 compared to fruit on M.26 or seedling rootstock. The delay in maturity was evident in the first two harvests but not in the third one. Fallahi et al. (5) observed a delay in ripening of Starkspur Golden Delicious apples on OAR 1 compared to fruit on seedling, MM.111, MM.106, M.7 and M.26 rootstocks. Autio et al. (2) noted a tendency for M.27 to advance maturity in Starkspur Supreme Delicious and for OAR 1 to delay maturity in the cultivar. They also found a slight advancement in maturity of McIntosh on Ottawa 3 compared to M.26, EMLA 7 or M.7a (1). M.9 EMLA and other clones of M.9 are widely used in high-density orchards throughout the world as well as in British Columbia. Ottawa 3 is comparable to M.9 EMLA for tree size control but is more cold hardy (Cummins and Ald

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winkle 3). Since high density orchards rely on size-controlling rootstocks, growers must know how the rootstocks affect fruit maturity, fruit quality and tree performance. Our objective in this study was to evaluate the influence of M.9 EMLA, Ottawa 3, M.26, and M.4 on fruit maturity, fruit quality, tree size, cumulative yield and tree efficiency for young Macspur McIntosh trees.

Materials and Methods

A block of Macspur McIntosh on M.26, M.4, M.9 EMLA, and Ottawa 3 rootstocks was established at the Summerland Research Station in 1985. Spacing was 3.0 x 4.9 m in a completely randomized block design of 8 replicates of single-tree plots. Cultural practices for the block were the same as for commercial orchards. Herbicides provided complete control of vegetation within tree rows. The first crop was harvested in 1987.

All trees were trained as a vertical axis according to principles outlined by Lespinasse (8). The central leader, tied to a central support, was pruned at planting and left intact thereafter. Shortly after bud break in the spring, several new shoots just below the leader were removed to maintain leader dominance. Only large branches in direct competition with the central leader were removed during dormant pruning in subsequent years.

Five fruit per tree were taken at weekly intervals and assessed for average fruit weight, internal ethylene content (IEC), percent red skin colour, flesh firmness, soluble solids concentration (SSC), titratable acidity (TA), and starch index (SI). The first harvest commenced in the third week of August and the last harvest was completed about Sept. 20. Commercial harvest of McIntosh commences in the 2nd week of September. Fruit sample size was limited to five apples in order to minimize any effect of fruit removal on maturity of fruit remaining on the young trees. Ethylene in a 1 ml gas sample taken from the core of each apple was quantified by flame-ionization gas chromatography (model 5700A, Hewlett-Packard Co., Avondale, Penn.). Chromatographic conditions were 250C for the detector and 130C for the oven. Separation of ethylene was obtained with a 1.8m x 3mm stainless-steel column packed with 40/60 mesh alumina. The proportion of skin with red colour was estimated visually. Flesh firmness was measured with a Magness-Taylor penetrometer (11.1 mm tip) on opposite and pared sides of each apple within a sample. Two slices from each apple within a sample were juiced in a commercial blender. TA and SSC of the juice was determined by titration (end point of pH 8.1) and refractometry, respectively. SI was assessed from a McIntosh starch chart (Courtesy of Dr. Lau, Okanagan Federated Shippers, Kelowna, B.C.) on the stem half of each apple dipped in an iodine solution. The chart has a scale of 1 to 9 where 1 = no loss of starch and 9 = no starch present.

Trunk diameter was measured annually at 5 cm above the graft union. Tree height and spread were measured in 1990. Cumulative yield included fruit from all harvests and any windfalls under the tree for the years of 1987, 1988, 1989 and 1990. Yield efficiency was calculated from the total cumulative yield over the 4-year period and the trunk cross-sectional area (TCSA) in 1990.

Data were analyzed by ANOVA (SAS Inc., Carey, N.C.) as a split-plot design with rootstock and block as the main effects and harvest date as the sub-effect. Proportional data (e.g. red skin colour) were transformed into arcsine values before statistical analysis. Significant treatment means were separated by Duncan's multiple range test.

Results and Discussion

The proportion of fruit with an internal ethylene content (IEC) of 1 ppm or more was not significantly different among the rootstocks in any year (Table 1). The starch index was not influenced by rootstock except in 1988 when apples on M.4 had less starch (higher starch rating) than fruit on Ottawa 3. There was less red colour in fruit from trees on M.4 than from those on M.9 or Ottawa 3 in 1987 and 1988. No significant differences for red skin colour were evident in 1989 or 1990.

Flesh firmness did not differ with rootstock except in 1988 where small differences were present. SSC was lower in fruit on M.4 than on the other rootstocks in 1988. The subsequent years of 1989 and 1990 showed no significant differences. Average fruit weight was higher in fruit on M.26 and M.4 than on M.9 or Ottawa 3 in 1989 but values in other years were not affected by rootstock. TA was not influenced by rootstock (data not shown). No significant harvest date X rootstock interactions were found for IEC, SI, SSC, or TA. Harvest date X rootstock interactions for red colour in 1987 and for average fruit weight in 1989 had no commercial importance.

Autio (1) noted a delay in maturity for Summerland Red McIntosh on M.7 relative to M.26 or Ottawa 3 rootstocks but not with the latter two rootstocks. Maturity in Starkspur Supreme Delicious fruit did not appear to be different from trees on M.26, M.9, or Ottawa

Table 1. Influence of rootstock on internal ethylene content, starch index, red skin colour, flesh firmness and soluble solids concentration for 'Macspur McIntosh' apples.

Variable	Rootstock	1987	1988	1989	1990
a) Internal ethylene (% fruit with 1 ppm or more)	M.26	21.9 a[z]	37.6 a	33.0 a	28.4 a
	M.4	15.2 a	45.4 a	42.2 a	24.2 a
	M.9 EMLA	26.8 a	45.2 a	30.3 a	24.2 a
	Ottawa 3	20.9 a	28.9 a	2.7 a	21.5 a
b) Starch index (1-9)[y]	M.26	2.7 a	4.4 ab	4.6 a	3.8 a
	M.4	2.7 a	4.7 a	4.8 a	3.6 a
	M.9 EMLA	2.8 a	4.5 ab	4.7 a	3.5 a
	Ottawa 3	2.8 a	3.9 b	4.7 a	3.8 a
c) Red skin colour (%)	M.26	46.4 bc	61.9 ab	74.7 a	79.6 a
	M.4	37.8 c	54.4 b	72.1 a	77.8 a
	M.9 EMLA	60.7 a	70.2 a	81.9 a	84.6 a
	Ottawa 3	55.3 ab	65.8 a	80.5 a	79.2 a
d) Flesh firmness (N)	M.26	65.7 a	62.5 bc	67.4 a	69.0 a
	M.4	65.5 a	61.4 c	67.8 a	71.0 a
	M.9 EMLA	66.7 a	64.2 ab	67.9 a	72.2 a
	Ottawa 3	66.9 a	64.6 a	68.7 a	69.0 a
e) Soluble solids concentration (%)	M.26	-[x]	12.0 b	12.8 a	12.3 a
	M.4	-	11.2 c	12.3 a	11.8 a
	M.9 EMLA	-	12.9 a	12.6 a	12.6 a
	Ottawa 3	-	12.6 a	12.6 a	12.4 a
f) Average fruit weight (g)	M.26	206 a	226 a	271 a	209 a
	M.4	206 a	228 a	266 a	208 a
	M.9 EMLA	190 a	227 a	237 b	207 a
	Ottawa 3	220 a	226 a	231 b	221 a

[z]Means separation with a column and variable by Duncan's multiple range test at $P \leq 0.05$.
[y]Higher values indicate less starch.
[x]Data not collected.

3 when ethylene and starch values were considered (2). However, neither internal ethylene nor starch index suggested any influence of M.26, M.4, M.9 EMLA or Ottawa 3 rootstocks on fruit maturity of Macspur McIntosh apples in our study. A difference in the proportion of fruit in the climacteric phase would have been strong evidence for a rootstock effect. Consistent differences in SSC and SI over the 4-year period would have been additional evidence for a rootstock effect on maturity but none were found (Table 1). Crop loads which can influence fruit maturity were not significantly different among the four rootstocks in any year of our study (data not shown).

Fruit weight in Starkspur Supreme Delicious apples was not different among M.26, M.9 or Ottawa 3 rootstocks (2). The proportion of larger fruit for McIntosh and Cortland was higher on M.26 than on Ottawa 3 or M.4 in a study by Granger et al. (7). The Macspur McIntosh apples in our study showed larger fruit on M.26 and M.4 than on Ottawa 3 only in 1989 (Table 1).

Trunk cross-sectional area (TCSA) in 1990 was smaller for trees on M.9 EMLA and Ottawa 3 than on M.26 or M.4 (Table 2). Tree height showed the same trend but tree spread was narrower on M.9 EMLA and Ottawa 3 than on M.4. Cumulative yield over the 4-year period was not significantly different among the four rootstocks. However, yield efficiency was superior for trees on M.9 EMLA and Ottawa 3 than on M.4 or M.26.

Tree size on the 4 rootstocks in terms of TCSA, height, and spread (Table 2) are consistent with the findings of Cummins and Aldwinkle (3). In our study, Macspur McIntosh trees on Ottawa 3 produced trees that were the same size as those on M.9 EMLA, but in other studies with Cortland and McIntosh (7) and Starkspur Supreme Delicious(9) they were 10 to 20% larger. Ferree and Schmid (G), on the other hand, could find no differences in TCSA for McIntosh trees on M.26, M.9 and Ottawa 3.

Tree age, climate and soil may explain the differences in tree size seen with M.9 EMLA, M.26, and Ottawa 3 as rootstocks common to all studies. The greater yield efficiency of M.9 EMLA and Ottawa 3 at this early stage of growth was probably a reflection of precocity as measured by flowering intensity (Table 2). Flowering intensity, determined in 1989, showed values of 14.4, 10.7, 5.9, and 3.1 flower clusters/cm^2 for M.9 EMLA, Ottawa 3, M.26, and M.4 respectively. The greater yield efficiency of Macspur McIntosh on M.9 EMLA and Ottawa 3 compared to M.26 is in agreement with observations of Starkspur Supreme Delicious on these rootstocks (9). With Cortland and McIntosh, yield efficiency of Ottawa 3 was higher than that of M.26 and M.4 (7).

In summary, we found no evidence that the rootstocks, Ottawa 3, M.9 EMLA, M.26 or M.4, while differing in size controlling potential, exerted any consistent influence on fruit maturity, colour, or average fruit weight

Table 2. Influence of rootstock on trunk-cross sectional area (TCSA), tree size, cumulative yield, and yield efficiency of 'Macspur McIntosh' trees[z]

Rootstock	TCSA[z] (cm^2)	Height (m)	Spread (m)	Cumulative yield (1978-90, kg/tree	Yield efficiency (kg/cm^2)
M.4	80.2 a[y]	5.02 a	4.45 a	137.8 a	1.75 b
M.26	73.0 a	4.84 a	4.24 ab	129.2 a	1.85 b
M.9 EMLA	40.5 b	3.86 b	3.56 b	105.3 a	2.88 a
Ottawa 3	38.9 b	3.93 b	3.65 b	107.1 a	2.79 a

[z]Data for 1990 except where indicated.
[y]Means separation within a column by Duncan's multiple range test at $P \leq 0.05$.

of Macspur McIntosh apples in their first 4 years of production. The long-term influence of these rootstocks could not be assessed because the block was removed in 1991.

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Susceptibility of 15 Apple Cultivars to Apple Scab, Powdery Mildew, Canker and Mites

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Abstract

Field resistance of 15 apple cultivars to diseases and pests was evaluated by not treating with pesticides during the observation period. The level of apple scab, powdery mildew, canker and fruit tree spider mites was assessed.

The cultivars 'Discovery,' 'Filippa,' and 'Bramleys Seedling' showed low susceptibility to scab. 'Mutsu,' 'Summerred,' 'Gravenstein' and in some cases 'Cox's Orange,' 'Guldborg' and 'Red Ananas' were very susceptible to scab. 'Belle de Boskoop,' 'Bramleys Seedling,' 'Discovery,' 'Filippa,' Ingrid Marie' and 'Mutsu' had low susceptibility to powdery mildew, whereas 'Ildrod Pigeon' was sensitive to powdery mildew. 'Belle de Boskoop,' 'Bramleys Seedling,' 'Filippa' and 'Red Ananas' were not sensitive to canker. 'Discovery' and 'Transparente Blanche' were most susceptible to canker. 'Belle de Boskoop,' 'Cox's Orange,' 'Gravenstein,' 'Mutsu' and 'Skovfoged' had low susceptibility to spider mites. 'Red Ananas,' 'Filippa,' 'Discovery,' 'Guldborg' and 'Ildrod Pigeon' were attacked by spider mites.

Introduction

Efforts to avoid or reduce the use of pesticides are stressed in organic and integrated pest management production systems.

Growing less susceptible cultivars appears to be one of the important factors. Knowledge about the susceptibility of different cultivars is mostly based on grower experience, where the conditions vary, or on research where only one or two pathogens were investigated. The present study was conducted to obtain more complete information about the susceptibility of important cultivars in Denmark under field conditions.

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