

## Influence of Rootstock on 'Delicious' Apple Fruit Shape

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### Abstract.

Differences in scion growth, measured as trunk cross-sectional area (TCA), were observed for trees on 32 apple rootstocks during two seasons. M.27 EMLA (E), P.16, V.3, and P.22 were the least vigorous rootstocks and P.18, A.313, and seedling the most vigorous. Fruit length/diameter (L/D) ratio, a measure of fruit elongation and typiness, for 'Starkspur Supreme' and 'Redchief (Campbell) Delicious' varied with rootstocks and season. Fruit were more elongate during a growing season that was cooler among the two seasons. The relationship between rootstock vigor and fruit L/D ratio was curvilinear with both 'Delicious' strains in both seasons. Trees on the most dwarfing rootstocks M.27E and P.16 had the lowest fruit L/D ratio. As rootstocks increased in vigor from extremely dwarf to semidwarf, e.g., M.7, fruit L/D ratio was higher. Fruit L/D ratio for rootstocks more vigorous than M.7, e.g., P.18 and seedling, was similar to that for semidwarf rootstocks. Rootstock accounted for 40 to 83% of the variation in fruit L/D ratio, depending on the season and 'Delicious' strain.

**Key words.** *Malus domestica*, fruit length/diameter ratio, typey fruit.

'Delicious' apple fruits are easily recognized due to their elongate shape and conspicuous calyx lobes. Elongate 'Delicious' apples with pronounced calyx lobes are said to be 'typey' in comparison with flatter or squat 'Delicious' apples. Typey 'Delicious' fruit often receive a premium price (Westwood and Blaney, 1963; Greenhalgh and Godley, 1976).

Both climatic and nonclimatic factors influence 'Delicious' fruit shape. Generally, 'Delicious' fruit grown in warmer districts are less typey than fruit grown in cooler districts (Greenhalgh and Godley, 1976; McKenzie, 1971). Shaw

(1914) reported that cooler periods shortly after bloom resulted in more elongate apples. Westwood (1962) found that final fruit shape was determined by 100 days after full bloom.

Nonclimatic factors that influence fruit shape include fruit position on the cluster, crop load, canopy shading, growth regulators, and genetic factors such as rootstock and cultivar strain. The terminal fruit on a cluster is more elongate than the lateral fruits, and fruit on trees with a light crop load are more elongate than fruit from trees with a heavy crop load (Webster and Crowe, 1971; Westwood and Blaney, 1963). Shade during the early season or for a full season increases fruit L/D ratio in comparison with full sunlight treatments (Webster and Crowe, 1971). Plant growth regulators including gibberellins and cytokinins increase fruit L/D ratio while others which inhibit gibberellin synthesis, e.g., paclobutrazol, decrease L/D ratio (Curry and Williams, 1983; Greenhalgh et al., 1977; Williams and Stahly, 1969).

Several strains of 'Delicious', e.g., 'Starkrimson', have more elongate fruit than common 'Delicious' (Greenhalgh and Godley, 1976; Westwood and Blaney, 1963). Westwood and Blaney (1963) found that 'Delicious' fruit from trees on non-dwarfing rootstocks (seedling, M.16, M.1, and M.2) were relatively more elongate than fruit from trees on more dwarfing rootstocks (M.4, M.7, and M.9). When semivigorous and vigorous rootstocks were eval-

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uated, Greenhalgh and Godley (1976) found that rootstock did not influence fruit shape.

Many new dwarfing rootstocks, including the Budagovsky (B.), Cornell-Geneva (CG.), Michigan Apple Clone (MAC.), Polish (P), and Vineland (V), are being compared with standard Malling (M.7, M.9 and M.26) rootstocks in North American apple rootstock trials (Barritt, 1992; NC-140, 1990; NC-140, 1991). Several of these new rootstocks are now available from nurseries and are being planted commercially. Orchardists are concerned that new dwarfing rootstocks may alter the typiness of 'Delicious' fruit. This study was undertaken to determine the influence of rootstock on fruit shape during two growing seasons with two strains of 'Delicious' and with 32 rootstocks ranging in tree size from extremely dwarf (M.27) to vigorous (seedling).

### Materials and Methods

Fruit for determination of length/diameter (L/D) ratio was collected in the fall from two adjacent 'Delicious' orchard blocks at the Washington State University Tree Fruit Research and Extension Center, Wenatchee, Washington, USA. A 'Starkspur Supreme Delicious' planting, part of the national NC-140 trial, included 17 rootstocks (Table 1) and was planted in 1984 (NC-140, 1990). Trees were spaced 3.5 x 5.5 m, unsupported, and trained to the central leader system (Heinicke, 1975). A second rootstock trial with 'Redchief (Campbell) Delicious' included 23 rootstocks (Table 1) and was planted in 1986. Trees were spaced 1.8 x 4.9 m, supported with individual poles, and trained to the slender spindle system. In both trials, each rootstock was replicated with 10 individual trees arranged in a randomized complete block design. Fruit L/D ratio was determined from 10 randomly selected fruits from each tree of each rootstock in October 1991 and 1992.

Tree vigor (extent of dwarfing) for each rootstock in each planting was estimated from measurements of trunk cross-sectional area (TCA) 15 cm above the union. Crop density (number of fruit/tree  $\div$  TCA) and mean fruit weight (g) were also determined.

A best fit equation for the relationship of fruit L/D ratio and rootstock vigor (TCA) was determined each season with each 'Delicious' strain, using the SAS PROC NLIN program (SAS Institute, Inc., Cary, North Carolina, USA). This program fits nonlinear regression models using the least-squares method.

### Results and Discussion

Scion growth of both 'Starkspur Supreme' and 'Redchief Delicious' varied from the extremely dwarf M.27E and P.16 through semidwarf M.26E and M.7E to vigorous P.18 and seedling (Table 1). The rootstocks common to both plantings were ranked in approximately the same order for tree vigor in each trial. For previously evaluated rootstocks, tree vigor ranking was generally similar in this study to earlier reports (Ferree and Carlson, 1987; NC-140, 1990; NC-140, 1991; Wertheim, 1989). Neither crop load nor mean fruit weight was correlated with fruit L/D ratio.

Fruit L/D ratios were lowest for trees on the most dwarfing rootstocks and highest with the semivigorous and vigorous rootstocks in 1991 and 1992 with both 'Starkspur Supreme' (Figure 1) and 'Redchief (Figure 2) Delicious'. The relationships were curvilinear with the greatest change in L/D ratio occurring from the most dwarf to the semidwarf rootstocks. Little or no change in fruit L/D ratio occurred as tree vigor increased from the semidwarf to the vigorous rootstocks. The curvilinear relationships were more pronounced in 1992 when the overall L/D ratios were lower (less typey fruit).

Coefficients of determination for the curvilinear relationships of root-

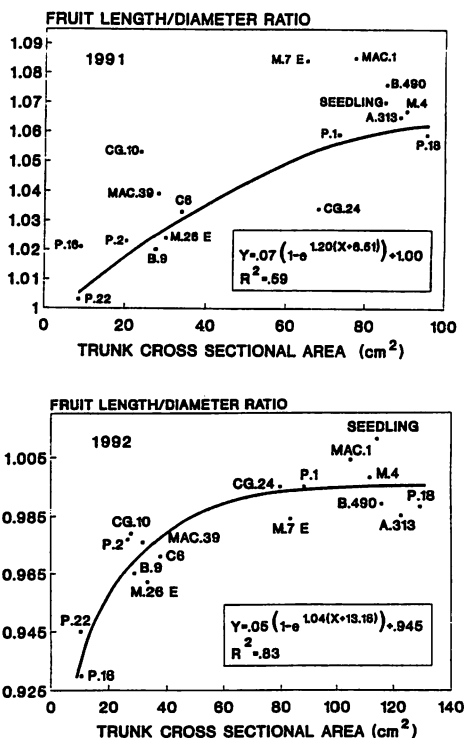
**Table 1. Trunk cross-sectional area as a measure of tree size for two strains of 'Delicious' apple with 32 rootstocks during two seasons at Wenatchee, WA. Rootstocks are listed in estimated order of increasing tree size.**

Rootstock <sup>2</sup>	Trunk cross-sectional area (cm <sup>2</sup> )			
	'Starkspur Supreme'		'Redchief (Campbell)'	
	Year 8 1991	Year 9 1992	Year 6 1991	Year 7 1992
M.27E	--	--	6.1	6.9
P.16	9.0	10.5	8.0	8.5
V.3	--	--	11.6	14.0
P.22	8.5	10.1	--	--
MAC.9	--	--	10.8	11.5
M.9	--	--	10.1	11.7
Mark	--	--	10.2	10.7
B.146	--	--	12.2	12.7
P.2	20.4	26.6	13.5	16.3
CG.10	23.9	27.7	12.1	13.7
M.9E	--	--	15.7	18.2
V.1	--	--	19.7	21.9
B.9	27.1	29.0	21.4	25.2
O.3	--	--	21.0	25.4
MAC.39	28.1	31.8	26.7	30.8
M.26E	29.9	33.5	27.8	36.3
C6	36.9	40.7	19.7	24.3
V.2	--	--	27.9	32.8
M.7A	--	--	29.4	35.9
OAR.1	--	--	35.5	43.8
M.7E	65.3	83.2	--	--
V.4	--	--	40.1	49.9
P.1	76.8	93.5	42.1	52.7
CG.24	68.4	79.6	--	--
MAC.1	81.0	109.5	--	--
MAC.10	--	--	55.5	69.7
MAC.46	--	--	62.1	79.0
M.4	90.6	111.5	--	--
B.490	85.5	115.8	--	--
Seedling	85.2	114.0	--	--
A.313	89.0	122.7	--	--
P.18	95.6	129.3	--	--
LSD P = .05	9.4	13.0	6.5	8.2

<sup>2</sup>The "E" designation refers to virus-free clones released by East Malling-Long Ashton (EMLA).

stock vigor and fruit L/D ratio varied from .40 to .83 (Figure 1 and 2), indicating that there are other factors in addition to rootstock that influence fruit L/D ratio. Light levels within the tree canopy and fruit position on the cluster (terminal vs. lateral) influence L/D ratio (Webster and Crowe, 1971; Westwood and Blaney, 1963). These factors were not controlled in this study. In spite of the unaccounted for variability in fruit L/D ratios, it is clear that dwarfing rootstocks, particularly the most dwarfing, influence fruit shape by reducing the L/D ratio.

Fruit of both 'Delicious' strains had greater L/D ratios in 1991 than in 1992 (Figure 1 and 2). Following bloom (late April), mean daily maximum air



**Figure 1. The influence of apple rootstocks varying in scion vigor control (measured as trunk cross-sectional area) on fruit L/D ratio for eight-year-old (1991, top) and nine-year-old (1992, bottom) 'Starkspur Supreme Delicious' trees.**



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## Early Production of Apple Cultivars on M.9 and Mark Rootstock

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### Abstract

After six years there was little difference in tree size or yield of three apple cultivars on Mark or M.9 rootstocks. Yields of all cultivars in this trial were relatively low and growth was vigorous resulting in large tree size. TCA of both the spur ('Redchief') and standard habit ('Top Red') 'Delicious' strains were larger on Mark than on M.9. 'Melrose' tended to produce larger trees and was more precocious than the other cultivars in this study on M.9. 'Smoothie' / M.9 had equivalent cumulative yield/ha than other cultivars and had the highest production efficiency of all combinations in this study. It is suggested that training techniques to reduce growth and encourage flowering are needed when trees on dwarfing rootstocks are grown on high fertility soils in order to achieve production efficiency.

### Introduction

Economic conditions are forcing orchardists to seek means of getting earlier economic returns by planting trees on small precocious rootstocks. The introduction of Mark rootstock by Michigan State University provided a new candidate to compare to M.9 which is the worldwide standard rootstock for producing small precocious trees (2). Early tests in Ohio comparing 'Empire' and 'Golden Delicious' show-

ed that trees on Mark were not as productive or efficient as trees on M.9 and M.26, but were similar in size to trees on these rootstocks (4). Schupp (9) found that trees on Mark resulted in early flowering and improved yields with 'McIntosh' and 'Empire', but there was little difference with 'Redchief Delicious' or 'Cortland' compared to several other rootstocks. The performance of 'Starkspur Supreme Delicious' on Mark and M.9 was compared over 27 sites in the United States and Canada and there was no difference in tree size or cumulative yield or tree efficiency over 10 years (8).

Fruit production in Ohio is normally on clay and silt loam soils, which result in relatively large tree size. It is clear from past studies that spacing must be correct for intensive plantings to achieve long-term efficiency (3, 6). In order to evaluate early performance in an intensive planting several cultivars on M.9 and Mark were planted as guard trees in an orchard systems trial. A secondary objective was to evaluate the performance of several cultivars in a minimally trained slender spindle system.

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