Fruit Varieties Journal 45(4):242-246 1991

Effects of Rootstock on Productivity and Pruning Requirements of 'Starkspur Supreme Delicious' Apple Trees in the NC-140 Cooperative Planting

D. C. ELFVING[1] AND E. D. MCKIBBON[2]

Abstract

Estimated early yields per ha. (1982-1985) of 'Starkspur Supreme Delicious' apple trees planted on nine rootstock clones in 1980 were directly related to estimated planting-system density except for trees on M.27 EMLA. In contrast, estimated yields per ha. from 1986 through 1989 for all rootstocks were not influenced by estimated planting-system density. Dormant-pruning time requirements from 1982 through 1989 were most influenced by the need for a ladder during pruning. Where ladder use was unnecessary, dormant-pruning time was inversely proportional to tree size, but to a much lesser extent than for trees requiring a ladder. Pruning costs represented a small fraction of estimated crop value. Although cumulative estimated production per ha. did not differ significantly among rootstocks, there was a significant, positive relationship between estimated net crop value (crop value minus pruning costs) and estimated planting density.

Pruning costs constitute a significant fraction of preharvest apple production costs (5, 10), as much as half in some cases (3). The nine rootstocks included in the 1980-81 NC-140 cooperative rootstock planting produced very large differences in tree size, precocity and yield efficiency (11, 12). Many reports describe rootstock effects on tree growth and yield (1, 2, 9, 11, 13, 14, 17). Information is lacking on pruning requirements of trees on different rootstocks grown with uniform training and spacing. This report describes rootstock effects on productivity and pruning requirements of the trees planted at Simcoe, Ontario in 1980 for the NC-140 trial described elsewhere (11, 12).

Materials and Methods

Five trees of 'Starkspur Supreme Delicious' on each of nine different rootstock clones were planted in a randomized complete-block design in 1980 at the Horticultural Experiment Station, Simcoe, Ontario as a part of the NC-140 program (11). The trees were spaced at 3.7 x 5.5 m on a Tavistock soil consisting of 40-100 cm of sandy, loamy material over glaciolacustrine clays. All trees were trained to the conventional central-leader system (15). Trunks of trees on the rootstocks M.9 EMLA, M.9 and M.27 EMLA were supported with stakes in 1983 to prevent excessive leaning or tree loss, but all canopies remained self-supporting. One tree on M.9 EMLA and one on O.3 died during the study.

The time required to dormant-prune each tree was recorded in early spring each year, beginning in 1982, the year the first yields were produced. Where a ladder was required to complete pruning of a tree, this fact was noted. Fruit numbers and yield were collected from each tree each year, beginning in 1982. Canopy spread was measured at the widest portion of the canopy in the fall of each year.

All data were evaluated by analysis of variance and/or regression using the General Linear Models (GLM) procedure of the Statistical Analysis System (SAS) program package (SAS Institute, Cary, NC). Means were separated using Duncan's multiple-range

[1]Research Scientist, Horticultural Research Institute of Ontario, Simcoe, Ontario N2Y 4N5.
[2]Economist, Economics and Policy Coordination Branch, Ontario Ministry of Agriculture and Food, Vineland, Ontario L0R 2E0.

test for unbalanced data when the overall F-test was significant (4). Year-to-year variation in yield was calculated according to the bienniality index (i) of Hoblyn, et al. (7). An estimated planting-system density was established for each rootstock based on canopy width measurements at the end of the 10th year. An appropriate between-row spacing was included for equipment passage. Because single-row systems for small trees allocate an increasing proportion of land area to non-productive alleyway space (16), this between-row spacing was not held constant to reduce bias against the smallest trees. The estimated tree densities used to calculate orchard performance were chosen to represent realistic spacings minimizing unnecessary waste of land as alleyway area. All costs and revenues were calculated on an annual basis using average annual Ontario labor wage rates and 'Delicious' apple prices provided by the Economics and Policy Coordination Branch of the Ontario Ministry of Agriculture and Food. All monetary values in this report were adjusted to 1989 Canadian-dollar equivalents using an annual discount rate of 10%.

Results and Discussion

Estimated yield per ha. in the early years (1982-1985) was directly related to estimated tree density, which was in turn inversely related to tree size (Fig. 1). In young orchards where yield per tree has not yet reached its maximum, the number of producing units per unit land area is a principal factor determining overall production. M.27 EMLA did not follow the same relationship as the other rootstocks, but still exhibited high, early production. Interestingly, trees on the rootstock OAR 1 displayed reasonably good, early per-ha. production despite being the second least precocious rootstock in the trial. This fact emphasizes the importance of density in influencing early orchard production.

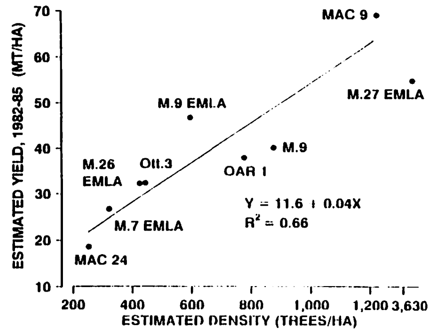

Figure 1. Relationship between estimated density and estimated early yield for 'Starkspur Supreme Delicious' trees on 9 rootstocks. Trees on M.27 EMLA did not fit the relationship for the other rootstocks.

In contrast to the early-production years, density (inversely related to tree size) had no influence on the estimated yield per ha. of any rootstock over the last four years of the trial (Fig. 2), despite significant differences among rootstocks in yield per tree (11, 12). In older trees, yield becomes more closely related to individual rootstock characteristics, environmental factors, and orchard-management practices.

While estimated cumulative yield per ha. was not significantly different among rootstocks, cumulative yield

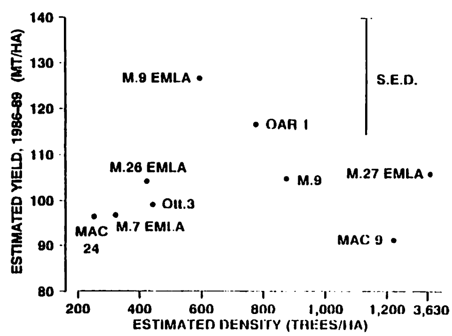

Figure 2. Absence of relationship of estimated density to later yield of 'Starkspur Supreme Delicious' trees on 9 rootstocks. S.E.D. = standard error of the difference between two means.

Table 1. Effects of rootstock on yield, bienniality, and dormant pruning of 'Starkspur Supreme Delicious' apple trees from 1982 to 1989.

Rootstock	Spread (m)^z	Estimated between-row spacing (m)^y	Estimated planting density (trees/ha)^y	Cumulative yield (kg/tree)^z	Estimated cumulative yield (mt/ha)^z	Mean bienniality index i°100)^z	Estimated total crop value (1989 $/ha)^y	Estimated total pruning cost (1989 $/ha)^y
MAC.24	5.2a	7.6	253	456a	115a	53ab	39,130	1960
M.7 EMLA	4.5b	6.9	322	384ab	124a	46abc	42,130	1150
M.26 EMLA	3.8c	6.2	424	323bc	137a	42bcd	47,820	780
O.3	3.7c	6.1	443	297c	132a	46abc	45,820	930
M.9 EMLA	3.3cd	5.1	594	292c	174a	37cd	60,920	1030
OAR 1	2.8de	4.6	776	200d	155a	56a	53,690	720
M.9	2.6e	4.4	874	166d	145a	42bcd	52,050	830
MAC.9	2.1f	3.9	1221	132d	161a	34d	58,680	1070
M.27 EMLA	1.1g	2.5	3636	44e	161a	55a	58,600	1450

^zMean separation in columns by Duncan's multiple-range test (P = 0.05).
^yCalculated from rootstock mean values; not analyzed.

per tree and year-to-year variation in yield differed substantially (Table 1). Bienniality was not clearly related to tree vigor; instead it appeared to be a unique characteristic of each rootstock. Dormant-pruning costs reflected both tree size and specific rootstock effects on pruning requirements. Trees on OAR 1 required little pruning throughout the trial, accounting for their estimated total pruning costs. Trees on MAC.9 and M.27 EMLA required extensive spur pruning at various times during the trial, increasing their estimated total pruning cost (6). Trees on MAC.24 were very large and produced substantial amounts of watersprout growth each year, thereby increasing total pruning cost.

Estimated total crop value was closely related to estimated cumulative per ha. yield for all rootstocks (Table 1). Trees on OAR 1 consistently produced small apples, despite carrying low to moderate crop loads. Since crop-value estimates in this study did not take fruit size into account, the total crop value for OAR 1 was overestimated.

Dormant-pruning time requirements on a per-tree basis could be separated into two groups based on the need for a ladder during the trial (MAC.24, M.7 EMLA, M.26 EMLA), there was a large reduction in pruning time as density increased (tree size decreased). Where most or all pruning could be carried out from the ground, pruning time per tree was also inversely related

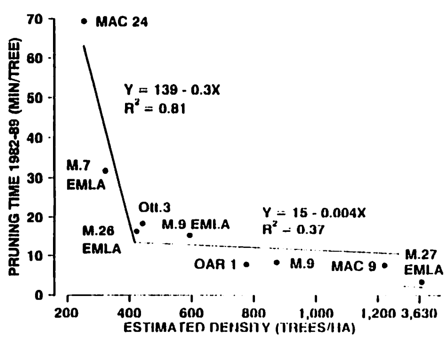

Figure 3. Relationships between cumulative pruning time per tree and estimated density for 'Starkspur Supreme Delicious' trees requiring a ladder during pruning (MAC.24, M.7 EMLA, M.26 EMLA) and those not requiring a ladder. Trees on M.27 EMLA fits the same relationship for other trees not requiring a ladder.

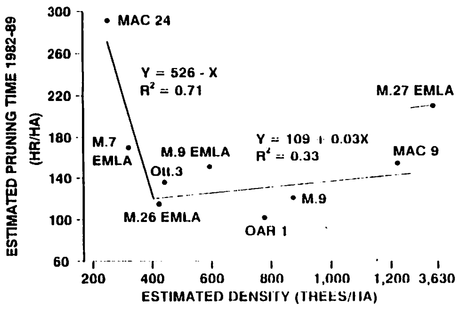

Figure 4. Relationships between estimated cumulative pruning time per ha and estimated density for 'Starkspur Supreme Delicious' trees requiring a ladder during pruning (MAC.24, M.7 EMLA, M.26 EMLA) and those not requiring a ladder. Trees on M.27 EMLA fit the same relationship for other trees not requiring a ladder.

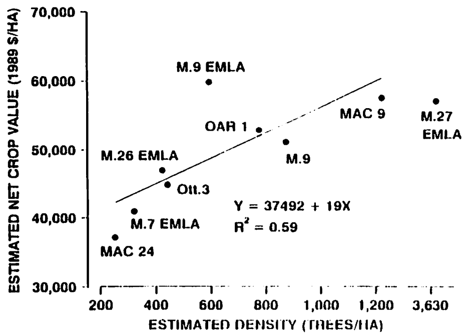

Figure 5. Relationship between estimated net crop value (total crop value minus total pruning costs) and estimated density for 'Starkspur Supreme Delicious' trees on 9 rootstocks. Trees on M.27 EMLA did not fit the relationship for the other rootstocks.

to tree density, but to a much lesser extent.

When pruning time was estimated on a per-ha. basis (Fig. 4), there was a similar decline in estimated pruning time with increasing density for those rootstocks where ladder use was required. Again, there was only a small effect of density on pruning time for rootstocks requiring little or no ladder use. These results clearly document the inefficiency and added cost associated with the use of a ladder during dormant pruning.

Although the yield in later years and the cumulative yield estimated on a per-ha. basis were not significantly different among rootstocks, there was a significant positive relationship between estimated net crop value (total crop value minus total pruning costs) and estimated density (Fig. 5), largely a consequence of improved yield in the early years from the less vigorous rootstocks. These results illustrate the economic benefit derived from good early production. Trees on M.27 EMLA did not show an increase in estimated net crop value proportional to their estimated density. Instead, their performance was similar to M.9 and MAC.9, and would not justify the added cost associated with increased tree numbers for a conventional single-row planting system.

M.9 EMLA and MAC.9 had the highest estimated net crop value among the rootstocks in this trial, with trees on more vigorous rootstocks showing a progressively less favorable balance between production and pruning costs. The largest trees in this trial, on MAC.24 and M.7 EMLA rootstocks, had the lowest estimated net crop values, due to delayed onset of production combined with greater pruning requirements. Had all costs of production, including initial tree and planting costs, been available, the economic advantages of the less vigorous rootstocks might have been somewhat reduced (8). Nonetheless, the results reported here indicate that even with variable rootstock genotypes, smaller trees demonstrate potential economic advantages in terms of early production and dormant-pruning costs.

Literature Cited

1. Archbold, D. D., G. R. Brown and P. L. Cornelius. 1987. Rootstock and in-row spacing effects on growth and yield of spur-type 'Delicious' and 'Golden Delicious' apple. J. Amer. Soc. Hort. Sci. 112:219-222.
2. Autio, W. R. and F. W. Southwick. 1986. The effects of rootstock and root-interstem combination on the growth, productivity, and

anchorage of a spur and standard strain of Delicious apple tree. Fruit Var. J. 40:128-133.
3. Castaldi, M. 1989. A survey of the cost of growing and harvesting apples in eastern New York in 1988. Cooperative Extension, Cornell Univ., Bul. XB015.
4. Damon, R. A., Jr. and W. R. Harvey. 1987. Experimental design, ANOVA, and regression. Harper and Row, New York.
5. Downy, R., L. Good, R. L. Norton and C. D. Kearl. 1974. An economic evaluation of high density apple planting systems in western New York. Cornell Univ. Dept. of Agr. Econ. A.E. Res. 73-26.
6. Ferree, D. C. and C. G. Forshey. 1988. Influence of pruning and urea sprays on growth and fruiting of spur-bound 'Delicious' apple trees. J. Amer. Soc. Hort. Sci. 113:699-703.
7. Hoblyn, T. N., N. H. Grubb, A. C. Painter and B. L. Wates. 1936. Studies in biennial bearing. I. J. Pomol. and Hort. Sci. 14:39-76.
8. Jackson, J. E., G. C. White and C. Duncan. 1986. Economic appraisal of orchards of Cox's Orange Pippin apple on M.9 and MM.106 rootstocks. Acta Hort. 160:383-390.
9. Larsen, F. E. and R. Fritts, Jr. 1982. Sixteen-year summary of apple rootstock influence on yield, yield efficiency and trunk growth. J. Amer. Soc. 107:23-27.
10. McKibbon, E. D. 1989. Fruit crops: Estimated production costs, Ontario, 1989. Ont. Min. Agr. and Food Econ. Info. Rept. 89-04.
11. NC-140. 1987. Growth and production of 'Starkspur Supreme Delicious' on 9 rootstocks in the NC-140 cooperative planting. Fruit Var. J. 41:31-39.
12. NC140. 1991. Performance of 'Starkspur Supreme Delicious' on 9 rootstocks at 27 sites over 10 years. Fruit Var. J. 45(4):192-199.
13. Schneider, G. W., C. E. Chaplin and D. C. Martin. 1978. Effects of apple rootstock, tree spacing, and cultivar on fruit and tree size, yield and foliar mineral composition. J. Amer. Soc. Hort. Sci. 103:230-232.
14. Seeley, E. J., E. A. Stahly and R. Kammereck. 1979. The influence of rootstock and strain on growth and production of 'Delicious' and 'Golden Delicious' apple trees. J. Amer. Soc. Hort. Sci. 104:80-83.
15. Tehrani, G., N. W. Miles and D. C. Elfving. 1988. Training and pruning fruit trees. Ont. Min. Agr. and Food Pub. 392.
16. Wertheim, S. J. 1980. High-density planting: Development and current achievements in the Netherlands, Belgium, and West Germany. Acta Hort. 114:318-327.
17. Westwood, M. N., P. B. Lombard, S. Robbins and H. O. Bjornstad. 1986. Tree size and performance of young apple trees of nine cultivars on several growth-controlling rootstocks. HortScience 21:1365-1367.

Growth Dynamic Influenced by Apple Scion and Rootstock Vigour

Potted apple trees of 'Classic Delicious' (nonspur) or 'Redchief Delicious' (spur-type) on seedling or M.26 were grown three seasons. Across rootstocks, spur-type 'Delicious' characteristics included lower whole-tree and shoot-wood dry weights resulting in higher root/shoot ratios. Across scions, rootstock had little effect in dry weight of tree parts above the graft union, whole tree dry wt. or spur density. Trees on M.26 had higher root shank and lower fibrous-root dry weight. The spur scion on M.26 had the most spurs and flowers per meter of scion.

From Lehman et al. 1990. *J. Hort. Sci.* 65:123-127.

Response of Apple Rootstocks to Irrigation

At East Malling in England trees on M.9, M.26, MM.106, and MM.111 were evaluated over 5 years. Irrigation increased growth and cropping similarly for trees on all rootstocks. The rate of soil moisture depletion in the absence of irrigation increases with rootstock vigor, though that of M.9 tended to increase to the level of the intermediate rootstocks toward the end of the study. The highest leaf conductances were observed in the more invigorating rootstocks for example MM.111 up to 19% more than the others indicating that these rootstocks had the largest stem hydraulic conductances.

From Higgs and Jones. 1990. *J. Hort. Sci.* 65:129-141.