Fruit Varieties Journal 46(2):93-97 1992

Performance of 'Golden Delicious' on Two Rootstocks and Four Dwarfing Interstems Over 10 Years[1]

DAVID C. FERREE[2]

Abstract

In 1981 'Smoothee Golden Delicious' was established on M.9 rootstock trained as a trellis, and as free-standing trees on M.7 rootstock and the following 15 cm interstem combinations: M.9/MM.106, M.9/MM.111, O.3/MM.106 and M.27/MM.111. Trees on M.7 had the largest canopy volume and trunk cross-sectional area (TCA) and lower cumulative yield/ha. Trees on MM.111 with an interstem of M.27 were smaller than trees with an interstem of M.9. Trees on M.9 produced more fruit per TCA than any of the interstems or M.7 trees. The rootstocks and interstems had minimal effects on fruit size or biennial bearing tendency.

As the fruit industry strives to increase orchard efficiency, each component involved in an orchard management system must be evaluated. Rootstocks are the foundation of the newer intensive orchard systems. Past studies (5) have shown the improved production efficiency of trees on M.9 rootstock and M.9/MM.106 interstems compared to the industry standard of trees on MM.106 or M.7. The present study was included as part of a larger systems trial to compare four interstem/rootstock combinations to the same cultivar on M.7 or M.9.

Materials and Methods

In 1981 'Smoothee Golden Delicious' was established on M.9 rootstock trained as a trellis and as free-standing trees on M.7 rootstock and the following 15 cm interstem combinations: M.9/MM.106, M.9/MM.111, O.3/MM.106 and M.27/MM111. There were 3 trees of each combination per replication except the interstems of O.3/MM.106 and M.27/MM.111 which had 5 trees/replication. The trees in north-south rows were spaced as follows: M.9, 2.5 x 3.5 m; M.7, 4.5 x 6 m; and all interstems, 2.5 x 4.5 m. The trees on M.9 were trained as oblique palmettes on a 4-wire trellis with all others trained as central leaders. All trees were minimally pruned and received standard pest management. These trees were part of a large systems trial (3, 6) with whole rows of a rootstock containing 4 cultivars. The rootstocks were arranged as a randomized complete block with 4 replications.

Tree height, spread, trunk circumference and yield were recorded annually. The yield from each tree was graded annually with an FMC weight sizer set to divide the fruit into the following size classes with the number of fruit in each size counted: >80 mm and larger (80-88's); 79-73 mm (100-113's); 72-57 mm (125-138's); and <57 mm and smaller. The fruits were graded according to commercial-standards and culled fruit removed and counted. Biennial bearing was assessed on yields for each pair of years using the index of Hoblyn et al. (7) where i = [(yield year 1) - (yield year 2) ÷ [(yield year 1) + (yield year 2)].

Results and Discussion

Trees on M.7, M.9/MM.106, M.9/MM.111 were taller than trees on O.3/MM.106 or M.27/MM.111 (Table 1). Trees on M.9 were shorter than trees on M.7 and taller than trees on M.27/MM.111. Trees on M.9 and M.7 had not quite filled their allotted in-row space of 2.5 m and 4.5 m, respectively.

[1]Salaries and research support provided by State and Federal funds appropriated to the Ohio Agricultural Research and Development Center, The Ohio State University. Journal Article No. ———.

[2]Department of Horticulture, The Ohio State University/OARDC, Wooster, OH 44691.

Table 1. Tree size, growth and cumulative yield of 'Golden Delicious' on 2 rootstocks and 4 dwarfing interstems over 10 years.

	Tree Size							Cumulative Yield		
Interstem	Height[z] (m)	Spread (m)	Canopy volume (m^3)	TCA (cm^2)	TCA relative to M.7 (%)	Shoot length 1990 (cm)	TCA/ ha (m^2)	Kg/ tree	Kg/ cm^2 TCA	Tons/ ha
M.9	3.1bc	1.8e	13.7b	49.3c	38	29.3a	5.6bc	204.6b	4.74a	233.8a
M.7	3.8a	3.5a	20.9a	128.8a	100	25.5ab	4.5c	289.2a	2.38b	106.9c
M.9/MM.106	3.5ab	3.1ab	11.3bc	84.0b	65	30.0a	7.5a	250.0ab	2.95b	223.3ab
M.9/MM.111	3.5ab	2.9bc	9.0cd	82.5b	64	31.6a	7.3ab	241.6ab	2.94b	214.8ab
O.3/MM.106	2.8cd	2.6cd	7.4cd	68.8bc	53	25.0ab	6.2abc	197.7b	2.85b	173.9ab
M.27/MM.111	2.4d	2.4d	6.7d	57.5c	45	20.2b	5.1c	185.7b	3.24b	165.1b

[z]Means separated by Duncan's New Multiple Range Test, P = 5%.

In a previous study (5), trees on M.9 and M.7 trained similarly had exceeded their allotted space and had the following slightly higher yield efficiencies (yield/trunk area) than reported in this study: M.9, 12%; M.7, 6%; M.9/MM.106, 40%. Thus, the smaller size of the 'Golden Delicious' trees in this study was not likely due to higher production; they may have been smaller because they were planted on a site previously planted to apples, while the earlier study was planted on a site previously planted to cherries. Replant problems in apple orchards have been a worldwide problem (10, 14). Although agronomic crops were produced on this site for 5 years prior to planting back to apples growth could have been affected. However, trees on M.9/MM.106 and M.9/MM.111 exceeded their allotted space of 2.5 m while the other two interstems just filled their space at 10 years of age. Correct spacing is a critical factor contributing to the profitability of an orchard and if the trees do not fill their allotted space, production efficiency and potential economic returns are reduced (5). Trees on M.7 had a larger canopy volume and trunk cross-sectional area (TCA) than on any other rootstock or interstem. Trees on MM.111 with an interstem of M.27 were smaller than trees on MM.111 with an interstem of M.9.

As expected, the large trees on M.7 had higher 10-year cumulative yields per tree than trees on M.9 and the smaller interstems of O.3/MM.106 and M.27/MM.111. However, the large trees on M.7 had lower cumulative yields/ha than any other rootstock or interstem in the trial. Trees on M.9 produced more fruit per unit of trunk area than any of the interstems or M.7. The close association between TCA/ha and cumulative yield/ha shown in other studies (3, 6, 12, 13) was true with 'Golden Delicious' on the rootstocks in this study with highly significant correlation coefficient (r = .78).

Through the first 6 years there was little difference among rootstocks in yield/tree, however, in year 7 interstems of O.3/MM.106 and M.27/MM.111 had larger yields than trees on M.9 (Fig. 1). Generally during the last 3 years yield/tree followed tree size. Beginning in 1985 (age 5) the yield/ha of trees on M.7 began to fall behind the others, although the differences in some years were not significant (Fig. 2).

During the drought year of 1988, fruit size from trees on M.27/MM.111 tended to be smaller than on trees on M.9 (Table 2). However, none of the rootstocks or interstems resulted in a consistent benefit in fruit size. Previous trials (8, 11, 15) have reported small fruit size on trees on M.27 rootstock.

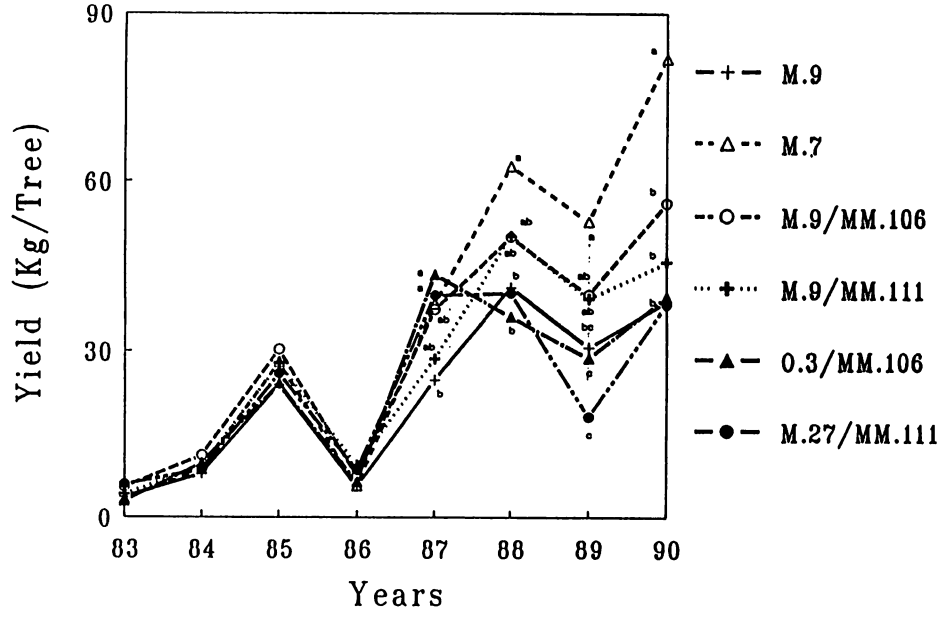

Figure 1. Yields per tree of 'Golden Delicious' apple trees on two rootstocks and four dwarfing interstems over ten years.

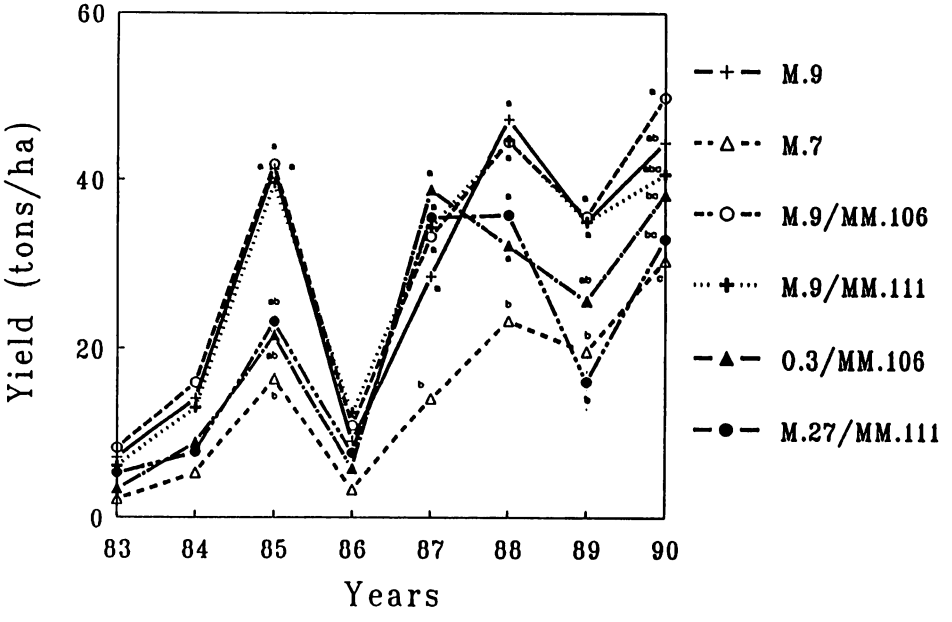

Figure 2. Yields per hectare of 'Golden Delicious' apple trees on two rootstocks and four dwarfing interstems over ten years.

Table 2. Influence of 2 rootstocks and 4 interstems on fruit size distribution of 'Golden Delicious' apples.

	1988 % Size Distribution (mm)					1989 % Size Distribution (mm)					1990 % Size Distribution (mm)				
Interstem	>80[z]	79-73	72-57	culls	Yield Kg/tree	>80[z]	79-73	72-57	culls	Yield Kg/tree	>80[z]	79-73	72-57	culls	Yield Kg/tree
M.9	26.7a	37.7	30.5b	5.0	43.0b	30.4ab	33.6c	16.2	19.8	26.9bc	5.0ab	19.0ab	62.7abc	13.1	38.9b
M.7	18.4ab	33.4	42.6ab	5.4	62.7a	41.9a	35.4bc	8.0	14.8	55.5a	11.7a	26.2a	51.4c	10.5	81.9a
M.9/MM.106	22.0ab	32.2	39.2b	6.5	50.2ab	19.8b	48.3ab	17.0	14.9	40.0b	5.5ab	17.9ab	63.7ab	12.0	56.2b
M.9/MM.111	12.6ab	33.7	47.3ab	6.2	47.6ab	16.6b	53.0a	16.5	13.8	39.4b	11.4a	25.5a	52.3bc	9.4	45.8b
O.3/MM.106	21.9ab	31.7	40.8ab	5.9	36.4b	21.5b	42.1abc	16.8	19.6	28.7bc	6.9ab	18.6ab	60.1bc	14.2	39.8b
M.27/MM.111	5.7b	23.6	64.5a	5.9	40.3b	19.9b	47.5ab	18.4	14.1	18.2c	1.8b	14.9b	71.1a	11.7	38.2b

[z]Means separated by Duncan's New Multiple Range Test, P = 5%.

When M.27 was used as an interstem, a tendency existed for reduced fruit size in some trials (16) with little effect in others (4, 9).

M.9 and M.7 had a similar minimal influence on the tendency toward biennial bearing of 'Golden Delicious' in this study (Table 3). In the comparison 86-87 and 89-90 trees on M.9/M.111 tended to have a lower bienniality index than trees on the other interstem combinations. Trees on M.27/MM.111 tended to have a higher biennality index in some years compared to other interstems, but the differences were not always significant. The average index over all the years was not influenced by rootstock or interstem. Trees in this trial received chemical thinning treatments as considered desirable and this may have masked an effect of rootstock or interstem on biennial tendency. The impact of rootstock on biennial bearing has not been widely examined. Elfving (2) found little influence of the 9 rootstocks (included M.9 and M.7) in the NC-140 trial on biennial production of 'Delicious.'

Although the trees in this trial on M.9 were trained as a trellis and all others trained as free-standing central leaders, tree shape likely had little influence on growth or productivity. Clayton-Greene (1) compared two apple cultivars over a 6-year period on the same rootstock and spacing in 5 widely differing trellis systems and three free-standing systems. He found little difference in yield or growth due to training system. Other trials showing large advantages of one training system over another generally confounded training system influence with changes in tree density (3, 5, 13).

In summary, there was little difference in the 10-year cumulative productivity of the 4 interstems compared in this trial. Trees on O.3/MM.106 and M.27/MM.111 were slightly smaller than M.9 interstem trees and thus, could have been planted slightly closer

Table 3. Influence of 2 rootstocks and 4 interstems on biennialty of 'Golden Delicious' apple trees.

Interstem	Pairs of Years							
	83-84	84-85	85-86	86-87	87-88	88-89	89-90	Average
M.9	.65a[z]	.56	.40	.49bc	.30a	.17b	.19bc	.44
M.7	.61a	.63	.67	.70ab	.25ab	.14b	.21bc	.46
M.9/MM.106	.47ab	.59	.65	.70ab	.16ab	.15b	.17bc	.41
M.9/MM.111	.54ab	.59	.42	.43c	.19ab	.18b	.10c	.39
O.3/MM.111	.44ab	.40	.57	.73a	.17ab	.15b	.27ab	.35
M.27/MM.111	.35b	.52	.55	.66ab	.11b	.39a	.36a	.42

[z]Means separated by Duncan's New Multiple Range Test, P = 5%.

than the 2.5 x 4.5 m spacing used in this trial, although they filled their allotted space at 10 years of age. Since trees on M.27/MM.111 were nearly 30% smaller with correspondingly lower yields than trees on M.9/MM.111 and in 3 years had a higher biennialty index and a tendency, although not significant, for smaller fruit size, the M.9 interstem would be preferred. The productive efficiency of trees on M.9 compared to trees on M.7 was again demonstrated in this study.

Literature Cited

1. Clayton-Greene, K. 1989. Apple production and tree training. Compact Fruit Trees. 22:8-11.
2. Elfving, D. C. and E. D. McKibbon. 1991. Effects of rootstock on productivity and pruning requirements of 'Starkspur Supreme Delicious' apple trees in the NC-140 Cooperative Planting. Fruit Var. J. 45(4):242-246.
3. Ferree, D. C. 1992. Influence of mechanical root pruning and hedging on performance of apple trees in three management systems. Acta Horticulturae (in press).
4. Ferree, D. C. and B. L. Bishop. 1988. Performance of 'Empire' on dwarfing rootstocks and interstems. IN: Fruit Crops 1989. A Sum. of Res. OARDC Res. Circ. 295:7-10.
5. Ferree, D. C., R. C. Funt and B. L. Bishop. 1989. Yield and production efficiency of four apple cultivars in selected orchard management systems. J. Amer. Soc. Hort. Sci. 114:863-868.
6. Ferree, D. C. and T. Rhodus. 1992. Influence of mechanical root pruning or hedging on apple tree growth, production and economic performance. J. Amer. Soc. Hort. Sci. (submitted).
7. Hoblyn, T. J., N. H. Grubb, A. C. Ranter, and B. L. Wates. 1936. Studies in biennial bearing. J. Pomol. and Hort. Sci. 14:39-76.
8. Jackson, J. E. 1986. Malling 20 - A superdwarf rootstock for apples. Acta. Hort. 160:47-48.
9. Lord, W. J., D. W. Greene, R. A. Damon, Jr. and J. H. Baker. 1985. Effects of stempiece and rootstock combinations on growth, leaf mineral concentrations, yield and fruit quality of 'Empire' apple trees. J. Amer. Soc. Hort. Sci. 110:422-425.
10. Merwin, I. A. 1989. Root-lesion nematodes, potassium deficiency, and prior cover crops as factors in apple replant disease. J. Amer. Soc. Hort. Sci. 114(5):724-728.
11. NC-140. 1991. Performance of 'Starkspur Supreme Delicious' apple on 9 rootstocks over 10 years in the NC-140 cooperative planting. Fruit Var. J. 45(4):192-200.
12. Robinson, T. L. and A. N. Lakso. 1991. Bases of yield and production efficiency in apple orchard systems. J. Amer. Soc. Hort. Sci. 116:188-194.
13. Robinson, T. L., A. N. Lakso, and S. G. Carpenter. 1991. Canopy development, yield and fruit quality of 'Empire' and 'Delicious' apple trees grown in four orchard production systems for ten years. J. Amer. Soc. Hort. Sci. 116:179-187.
14. Savory, B. M. 1966. Specific replant diseases. Commonwealth Agricultural Bureau, Farnham Royal.
15. Van Oosten, H. J. 1986. Effects of some new rootstocks on orchard behaviour of apple trees. Acta. Hort. 160:39-46.
16. Wertheim, S. J., S. Morini and F. Loreti. 1989. Effect of M.27 and M.9 used as a rootstock and as interstem on apple tree behaviour in two different growth conditions. Acta Hort. 243:37-44.