Fruit Varieties Journal 49(4):198-204 1995

Growth and Performance of Four Apple Cultivars on M.26 and Mark Rootstocks, With or Without Preplant Mineral Nutrients

JAMES R. SCHUPP[1]

Abstract

To evaluate the interactions between cultivar and rootstock, four apple (*Malus domestica*, Borkh.) cultivars, 'Pioneer Mac,' 'Marshall McIntosh,' 'Ginger Gold' and 'Empire' on two rootstocks, M.26 and Mark, were planted in a split-plot design. After five years, 'Pioneer Mac' and 'Ginger Gold' had larger trunk cross-sectional area (TCSA) on M.26 than on Mark. 'Marshall McIntosh' and 'Empire' had larger TCSA on Mark than on M.26. Precocity, expressed as both number of flower clusters and yield was greater for trees on Mark for all cultivars except for 'Ginger Gold,' which had greater flower cluster numbers and yield on M.26. Fruit size was variable from year to year, depending on crop load, however 'Pioneer Mac' and 'Ginger Gold' usually produced the largest fruit, while 'Empire' consistently produced the smallest fruit, 'Ginger Gold' appears to be incompatible with Mark. The results of this study demonstrate that cultivar x rootstock interactions can be significant and need to be considered when rootstock and planting density recommendations are made.

Introduction

Dwarfing rootstocks have become widely accepted by the apple industry as a tool for increasing orchard efficiency. Through the efforts of researchers, especially those associated with the regional project NC-140, information on rootstock effects on apple tree performance have been available for making reliable rootstock recommendations. Much of the previous research on rootstock effects on tree survival, tree size, and productivity has been conducted using a single cultivar, often 'Delicious.' Apple cultivars are known to differ widely in vigor, precocity and productivity, which could affect the interpretation of rootstock effects. When evaluating different rootstocks, it also is necessary to consider the possibility of different levels of congeniality between the stock and scion (15).

Cultivar x rootstock interactions are known to occur in apple. Performance of a cultivar can vary and in the worst case, incompatibility can occur (14). Working with the spur-type cultivars 'Redspur' and 'Goldspur' on four rootstocks, Schneider et al. (12) found significant cultivar x rootstock interactions for yield and fruit size, but not for tree size although only main effects of cultivar and rootstock were reported. Denby (4) reported differing performance of six cultivars on three rootstocks, however the experiment lacked adequate randomization to permit assessment of the cultivar x rootstock interaction. Granger et al. (7) acknowledged the existence of cultivar x rootstock interactions in a recent study, but reported only the main effects of rootstocks for each cultivar. As new cultivars, new strains of established cultivars, and new rootstocks become commercially important, the issue of stock x scion interaction needs to be revisited. The objective of this study was to compare the growth and performance of four new cultivars on two popular rootstocks, Mark and M.26, with or without soil-incorporated preplant mineral nutrients.

Maine Agricultural and Forestry Experiment Station External Publication No. 1909. The author would like to acknowledge the assistance of the late Dr. Rollin Glenn in designing this experiment. Thanks are extended to the Maine State Pomological Society for financial support of this research.
[1]Associate Professor, Highmoor Farm, University of Maine, P.O. Box 179, Monmouth, ME 04259.

Materials and Methods

In May 1990, trees of 'Pioneer Mac,' 'Marshall McIntosh,' 'Ginger Gold' and 'Empire' on M.26 or Mark rootstocks were planted in 2m x 48m plots, with 5cm of the rootstock shank above ground. The tree spacing was 2.4m x 8.9m. Half of the plot received preplant mineral nutrients P, K, S, Mg, B, Cu, Zn and Mo incorporated to a depth of 15cm and half was not treated. The soil was a Dixfield fine sandy loam, coarse-loamy, mixed fridgid Typic Haplorthods and soil pH was 5.8 in all plots. The preplant mineral nutrient plots received 600g Urea post-planting and annually thereafter. The untreated plots received 4.5 kg of fertilizer containing 8-0-16, plus 15 S, 7.4 Mg, 0.25 B and 0.2 Cu applied post-planting and thereafter.

The trees were individually staked and trained to a vertical axis system with tree support to a height of 2m. The trees were grown in a 2m-wide herbicide strip and deblossomed in 1991. The experiment was designed as a split-split plot with preplant nutrients as the whole plot, rootstock as the split-plot, and cultivar as the split-split plot, with five replications.

Trunk circumference was measured and trunk cross-sectional area was calculated annually. Tree height and width were measured at the end of the 1994 growing season. The number of flower clusters per tree, and the number of fruit set per tree were counted in 1992 and 1993. Yield and average fruit size were evaluated in 1992, 1993 and 1994.

Results and Discussion

Preplant mineral nutrition had no effect on tree growth, leaf or fruit mineral nutrient content, or fruiting (data not presented). Leaf mineral nutrient concentrations over the first five years were within the recommended range for the control trees, suggesting that mineral nutrient avail-

Table 1. Tree size of four cultivars on M.26 and Mark rootstocks over five years.[z]

Treatment		1990-1994			
Cultivar	Rootstock	TCSA (cm^2)	TCSA Increase	Canopy height(cm)	Canopy width(cm)
Pioneer	M.26	17.8	16.8	280	194
		*	*		NS
Pioneer	Mark	14.1	13.1	237	193
Marshall	M.26	15.6	14.6	265	189
		*	*		*
Marshall	Mark	17.6	16.5	268	237
Ginger Gold	M.26	14.7	13.4	242	210
		*	*		*
Ginger Gold	Mark	7.1	6.6	215	173
Empire	M.26	9.6	8.8	268	181
		*	*		*
Empire	Mark	15.5	14.4	262	228
Main Effects:					
Cultivar		**	**	*	NS
Rootstock		NS	NS	*	NS
Interaction		**	**	NS	**

[z]Means separation between rootstocks within cultivars by Duncan's new multiple range test, P = 0.05.
**, *, NS: Significant at P = 0.01, P = 0.05, or nonsignificant, respectively.

ability was not a limiting factor to tree growth and performance. In a previous study (Glenn, unpublished data) preplant soil preparation including mineral nutrient amendments resulted in improved growth and precocity of 'Macspur McIntosh'/MM.111 trees. In that study, other factors (soil pH and ground cover) were also modified. Based on the present study, it appears that factors other than the addition of mineral nutrients must have accounted for the results observed in the previous experiment.

'Pioneer Mac' and 'Ginger Gold' produced larger TCSA on M.26 than on Mark, while 'Marshall McIntosh' and 'Empire' were larger on Mark than on M.26 (Table 1). Canopy heights appeared to follow a similar trend, however the trees were not supported above 2m and crop-induced leader bending tended to mask differences in leader height. Canopy width of 'Marshall McIntosh' and 'Empire' was greater on Mark while 'Ginger Gold' canopy width was greater on M.26. Canopy width of 'Pioneer Mac' was similar on both M.26 and Mark. The rootstock effect on tree growth varied considerably depending on the scion cultivar. Mark is considered to be smaller than M.26, (3, 9). However, the results of this study suggest that the relative size of apple trees on rootstocks of similar vigor can vary depending on the scion cultivar. The lack of vigor of 'Ginger Gold' on Mark suggests that this is an incompatible combination.

Mark has been shown to be incompatible with some cultivars, particularly triploids (11), however graft union breakage has been the problem, not lack of vigor. To date the graft unions of 'Ginger Gold'/Mark trees appear normal externally. 'Jonagold,' a cultivar that is known to be incompatible with Mark is quite vigorous on Mark (1). Andrews and Rom (1) reported stunted

Table 2. Influence of M.26 and Mark rootstocks on flowering of four cultivars in the third and fourth years of growth.[z]

Treatment		Flowering			
		1992		1993	
Cultivar	Rootstock	Clusters/tree	Clusters/TCSA	Clusters/tree	Clusters/TCSA
Pioneer	M.26	8.3	0.8	69	4.5
		*	*	*	*
Pioneer	Mark	24.6	5.1	107	7.0
Marshall	M.26	6.7	0.6	82	2.5
		*	*	*	*
Marshall	Mark	23.2	2.9	171	5.5
Ginger Gold	M.26	51.1	2.6	175	3.7
		*	*	*	*
Ginger Gold	Mark	9.4	1.4	86	2.0
Empire	M.26	5.9	1.6	62	2.4
		*	*	*	*
Empire	Mark	42.9	6.0	136	5.4
Main Effects:					
Cultivar		NS	*	**	*
Rootstock		NS	**	**	**
Interaction		**	**	**	*

[z]Means separation between rootstocks within cultivars by Duncan's new multiple range test, P = 0.05.
**, *, NS: Significant at $P \leq 0.01$, $P \leq 0.05$, or nonsignificant, respectively.

Table 3. Fruit set of four apple cultivars in the third and fourth years of growth.[z]

Cultivar	Fruit set (No. fruit/100 flower clusters) 1992	1993
Pioneer Mac	103 a	64 a
Marshall McIntosh	73 ab	36 b
Ginger Gold	48 b	18 c
Empire	84 a	34 b

[z]Mean separation by Duncan's new multiple range test, P = 0.05

trees with the normally vigorous cultivar 'Ultragold' on Mark, which they attributed to excessive crop density. In the present study overcropping did not occur. 'Ginger Gold'/Mark trees had low flower density (Table 2) and crop density of 'Ginger Gold' did not differ between rootstocks (Table 4). Mark rootstock has been shown to be sensitive to drought stress (5). This study was conducted in a fine sandy loam soil without irrigation, and the combination of drought stress with partial incompatibility may have aggravated the problem.

Flowering in 1992 and 1993 was greater on trees on Mark than those on M.26 for all cultivars except 'Ginger Gold' (Table 2). 'Ginger Gold' on M.26 had the highest number of flower clusters per tree of any combination but was among the lowest in numbers of flower clusters when on Mark. Mark was previously shown to be very precocious (9, 10, 13) and the same was observed in this study. The low flower numbers reported for the precocious cultivar 'Ginger Gold' when grafted on Mark are further evidence of incompatibility.

Fruit set was unaffected by rootstock and there were no cultivar/rootstock interactions (data not presented). 'Pioneer Mac' had the highest fruit set on relatively low numbers of flowers while 'Ginger Gold' had low fruit set on the highest number of flowers among cultivars (Table 3). 'Ginger Gold' bore flowers both on terminal shoots and spurs, while the other cultivars were primarily spur bearing. Although this growth habit produced higher flower numbers on 3- and 4-year-old trees, these flowers were not as likely to set. These results are opposite to those found in a previous study (13) with the tip-bearing cultivar 'Cortland' which produced low flower numbers and high fruit set in the fourth, fifth and sixth years of growth relative to spur-bearing cultivars. Tip-bearing growth habit, therefore, does not appear to be related to precocity in any consistent way.

Crop density in 1992 was greater for 'Pioneer Mac' and 'Empire' on Mark than on M.26, while the two rootstocks did not affect crop density on 'Marshall McIntosh' or 'Ginger Gold' (Table 4). In 1993 'Marshall McIntosh' and 'Empire' had greater crop density on Mark, while 'Pioneer Mac' and 'Ginger Gold' had similar crop density on both rootstocks.

Table 4. Crop density of four cultivars in M.26 and Mark rootstocks in the third and fourth years of growth.[z]

Treatment		Crop density(Fruit no./TCSA)	
Cultivar	Rtsk	1992	1993
Pioneer	M.26	0.8	4.5
		*	NS
Pioneer	Mark	5.1	7.0
Marshall	M.26	0.6	2.5
		NS	*
Marshall	Mark	2.6	5.5
G. Gold	M.26	2.6	3.7
		NS	NS
G. Gold	Mark	1.4	2.0
Empire	M.26	1.6	2.4
		*	*
Empire	Mark	6.0	5.4
Main effects:			
Cultivar		*	*
Rootstock		**	*
Interaction		**	*

[z]Mean separation between rootstocks within cultivars by Duncan's new multiple range test, P = 0.05.
**, *, NS: Significant at P ≤ 0.01, P ≤ 0.05, or nonsignificant, respectively.

Annual yields were larger for trees on Mark than on M.26 with all cultivars except 'Ginger Gold' (Table 5). Comparing cumulative yields, 'Ginger Gold'/M.26 was the most productive tree in the study and 'Ginger Gold'/Mark was the least productive tree in the study. All other cultivars were much more productive on Mark. Yield efficiency was greater on Mark than on M.26 for 'Pioneer Mac' and 'Marshall McIntosh.' Yield efficiency did not differ among rootstocks for 'Ginger Gold' and 'Empire.'

Fruit size was largest on Mark for all cultivars except 'Ginger Gold' in both 1992 and 1993 (Table 6). In 1994, 'Pioneer Mac' produced larger fruit on M.26 than on Mark and 'Ginger Gold' produced larger fruit on M.26. These differences in 1994 are likely the result of crop load. Differences in fruit size between the two rootstocks became less pronounced each year as yields increased. Autio (2) found no difference in fruit size between Mark and M.26 over 5 years with more mature trees.

The relative tree size of dwarf trees is subject to change over the first 7 years of growth (6), thus it is too early to draw conclusions on the final ranking of tree size from this study. Still it is interesting to note that after 5 years of growth 'Empire' was 61% larger on Mark than on M.26, while 'Ginger Gold' was 107% larger on M.26 than on Mark (Table 1). Variation in tree size among dwarfing rootstocks in the early years after planting is usually attributed to differences in precocity; the trees on more precocious rootstocks allocate more dry matter in the crop, reducing the allocation to vegetative growth (6). This theory would explain the smaller tree size of 'Pioneer Mac'/Mark compared to M.26. However, 'Marshall McIntosh' and 'Empire' were both larger (Table 1) and more productive (Table 5) on Mark than on

Table 5. Influence of M.26 and Mark rootstocks on annual yield, cumulative yield and yield efficiency of four cultivars in the third-fifth years of growth.[z]

Treatment		Yield (kg)				Yield Efficiency
Cultivar	Rootstock	1992	1993	1994	Cumulative	(kg/cm²)
Pioneer	M.26	0.8	4.5	6.4	11.8	0.68
		*	*	*	*	*
Pioneer	Mark	3.1	6.2	8.1	16.5	1.29
Marshall	M.26	0.6	2.5	5.9	8.9	0.52
		*	*	*	*	*
Marshall	Mark	2.4	4.6	10.9	18.0	1.06
Ginger Gold	M.26	1.4	6.4	13.2	21.0	1.50
		NS	*	*	*	NS
Ginger Gold	Mark	0.6	3.1	7.1	10.8	1.35
Empire	M.26	0.5	1.8	8.9	11.2	1.17
		*	*	NS	*	NS
Empire	Mark	3.5	4.9	10.1	18.5	1.25
Main Effects:						
Cultivar		*	*	NS	NS	**
Rootstock		**	**	NS	NS	*
Interaction		**	**	**	**	**

[z]Mean separation between rootstocks within cultivars by Duncan's new multiple range test, P = 0.05.
**, *, NS: Significant at P ≤ 0.01, P ≤ 0.05, or nonsignificant, respectively.

Table 6. Influence of M.26 and Mark rootstocks on average fruit weight of four cultivars.[z]

Treatment		Fruit weight (g)		
Cultivar	Rootstock	1992	1993	1994
Pioneer	M.26	166	163	154
		*	NS	*
Pioneer	Mark	211	145	138
Marshall	M.26	85	108	139
		*	*	NS
Marshall	Mark	173	135	136
Ginger Gold	M.26	143	181	156
		*	*	*
Ginger Gold	Mark	110	145	200
Empire	M.26	69	101	133
		*	*	NS
Empire	Mark	173	146	139
Main Effects:				
Cultivar		**	*	**
Rootstock		**	NS	NS
Interaction		*	*	**

[z]Mean separation between rootstocks within cultivars by Duncan's new multiple range test, P = 0.05.
**, *, NS: Significant at $P \leq 0.01$, $P \leq 0.05$, or nonsignificant, respectively.

M.26. Previous studies (8, 16) that have reported scion x rootstock interactions used rootstocks with a wide range of vigor and correctly concluded that rootstock is the main determinant of tree growth. The present study shows that when comparing rootstocks of very similar size, apple cultivar x rootstock interactions can be highly significant and have practical horticultural importance.

Rootstocks dramatically affected cultivar performance over the first 5 years of this study. 'Pioneer Mac' and 'Ginger Gold' produced larger trees on M.26 than on Mark, while 'Marshall McIntosh' and 'Empire' were larger on Mark than on M.26. All cultivars were more precocious on Mark than on M.26, except for 'Ginger Gold' which appears to be incompatible with Mark. The results of this study suggest that while evaluations with a single cultivar are of value in screening potential rootstocks, it is important to evaluate promising rootstocks with the cultivars that are commercially grown to assure that the best combinations are planted and incompatible combinations are avoided. Studies, such as the 1990 NC-140 cultivar/rootstock planting should provide much needed information for fine-tuning rootstock recommendations.

Literature Cited

1. Andrews, P. K. and C. R. Rom. 1993. Early performance of four apple cultivars, supported or free standing, on Mark rootstock. Fruit Var. J. 47:198-204.
2. Autio, W. R. 1991. Rootstocks affect ripening and other qualities of 'Delicious' apples. J. Amer. Soc. Hort. Sci. 116:378-382.
3. Carlson, R. F. 1980. The Michigan apple clones—an update. Acta Hort. 114:159-169.
4. Denby, L. G. 1982. Performance of six apple cultivars on M.9, M.26 and M.7 rootstocks. J. Amer. Soc. Hort. Sci. 107:14-16.
5. Fernandez, R. T., R. L. Perry, R. M. McLean and A. R. Otero. 1994. Water stress factors and apple rootstock performance. Compact Fruit Tree 27:37-40.
6. Ferree, D. C. and R. F. Carlson. 1987. Apple rootstocks. In: R. C. Rom and R. F. Carlson (eds), Rootstocks For Fruit Crops. John Wiley and Sons, New York.

7. Granger, R. L., G. L. Rousselle, M. Meheriuk, and S. Khanizadeh. 1992. Performance of 'Cortland' and 'McIntosh' on fourteen rootstocks in Quebec. Fruit Var. J. 46:114-118.
8. Hirst, P. M. and D. C. Ferree. 1995. Effect of rootstock and cultivar on the growth and precocity of young apple trees. Fruit Var. J. 49:34-41.
9. NC-140. 1991. Performance of 'Starkspur Supreme Delicious' apple on 9 rootstocks over 10 years in the NC-140 cooperative planting. Fruit Var. J. 45:192-199.
10. NC-140. 1991. Performance of 'Starkspur Supreme Delicious' on 9 rootstocks at 27 sites over 10 years. Fruit Var. J. 45:200-208.
11. Perry, R. L. 1990. Mark in the apple rootstock arsenal. Compact Fruit Tree 23:1-3.
12. 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.
13. Schupp, J. R. 1992. Early performance of four apple cultivars on Mark and other rootstocks in Maine. Fruit Var. J. 46:67-70.
14. Simons, R. K. 1987. Compatibility and stock-scion interactions as related to dwarfing. In: R. C. Rom and R. F. Carlson (eds), Rootstocks For Fruit Crops. John Wiley and Sons, New York.
15. Tukey, H. B. 1964. Dwarf Fruit Trees. MacMillan, New York.
16. Vyvyan, M. C. 1955. Interrelation of scion and rootstock in fruit trees. I. Weights and relative weights of young trees formed by the reciprocal unions, as scion and rootstock, or three apple rootstock varieties: M.IX, M.IV and M.XII. Ann. Bot. 19:401-423.

Fruit Varieties Journal 49(4):204-211 1995

Influence of Nitrogen Fertilization and Orchard Floor Management on Yield, Leaf Nutrition and Fruit Quality of 'Fairhaven' Peach

M. MEHERIUK, G. H. NEILSEN, AND E. J. HOGUE[1]

Abstract

'Fairhaven' peach (*Prunus persica* L. Batsch) trees were subjected to combinations of two rates of nitrogen, single or split application of N, year round or partial annual control of vegetation within the tree row. Yield, leaf nutrient concentration and fruit quality were assessed over six growing seasons. Yield was increased by the higher rate of N in 3 of the 6 years. Vegetation control had little effect on yield. Single applications of N were better for yield than split applications in 2 of 4 years but the reverse was observed in one year. Leaf N tended to increase with higher rates of N application and with split applications of N. Higher rates of N reduced macronutrient concentration, especially leaf P, and tended to increase micronutrient concentration in the leaves. Ground color was greener but fruit firmness was not affected by the higher rates of N application.

Introduction

Peach growers, irrespective of region, strive for a nitrogen fertilization program that promotes good tree vigor, high yields, well-colored fruit and yet does not predispose the trees to winter injury. Higher rates of N fertilization do not always increase yield (1, 2, 11, 12, 13, 20, 22) but can delay harvesting because ground color is too green (2, 6, 10, 15, 20). Nitrogen availability can be influenced by orchard floor management particularly when clean cultivation is practiced. Clean cultivation can increase yield (9, 11) by reducing competition for N between sod and tree roots. High rates of N fertilization can cause excessive vigor which results in shading of the fruit and inadequate color development. Long-term studies are therefore needed to evaluate cultural factors in establishing a fertilization protocol which meets the needs stated above. This paper presents results of a 6-year study on the influence of N fertilization, time of N applica-

[1]Research Scientists, Agriculture and Agri-Food Canada, Research Centre, Summerland, British Columbia, V0H 1Z0 Canada.
Contribution No. 916.