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Vegetative Growth and Fruiting of 'Red Fuji' Apple on M.9 Clones and Other Dwarfing Rootstocks

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Abstract

In 1993, trees of 'Red Fuji' (T.A.C. 114) apple (*Malus x domestica* Borkh.) on 16 dwarfing rootstocks were planted in New Franklin, Missouri to evaluate tree growth and productivity in a Midwestern climate. Rootstocks included 11 M.9 clones, as well as B.9, M.27 EMLA, Mark, V.1, and V.3. Tree mortality was primarily a result of high winds during thunderstorms in June 1998 and 2000. By 2002, trees on V.1, M.9 NAKB T340 and M.9 EMLA had greater trunk cross-sectional areas (TCAs) than those on M.9L (infected with latent viruses), M.9 Janssen 337, V.3, B.9, and M.27 EMLA. All M.9 clones produced trees that were relatively more vigorous than M.9L, except M.9 Janssen 337 when relative size was calculated. The shortest trees at the end of the trial were those on B.9 and M.27 EMLA. After ten years, trees on Mark, M.9 Burgmer 751, and M.9 NAKB T340 had greater cumulative yield (CY) than those on M.9 NAKB T338, M.9L, M.9 Janssen 337, M.9 Burgmer 984 and M.27 EMLA. The less vigorous rootstocks, M.27 EMLA and B.9 had greater yield efficiency (YE) than V.1, M.9 NAKB T340, and M.9 EMLA. Mean fruit weight was statistically similar among all rootstocks, except M.27 EMLA. However, average weight of fruit harvested from M.9 NAKB T340 and M.9 Burgmer 751 averaged $\geq$ 26 g more than that from M.9L trees.

Introduction

The release of M.9 rootstock in 1917 by the East Malling Research Station profoundly influenced apple production. Today, M.9 is the most commonly planted dwarfing rootstock worldwide (18). Currently, there are more than 25 clones of M.9 available and it has been used as a parent in several rootstock breeding programs (6, 10, 18). For example, 28 clones were selected in Poland from an Antonovka x M.9 cross, resulting in the release of P.1, P.2, P.16, P.18, and P.22 (6). Additionally, the JM series (JM.1, 2, 5, 7 and 8) from the Apple Research Center, Morioka, Japan was a cross of Marubakaido (Seishi) x M.9 (15). Other progeny of M.9 rootstock include Ottawa 3 (Canada), G30 and CG7707 (Cornell-Geneva/ ARS breeding program, United States), Jork 9 (Germany), Mark (United States), J-TE (Czech republic), and Supporter 1, 2, 3, and 4 (Pillnitz breeding program, Germany) (7, 9, 17, 18).

Where apples are produced in high density orchards, the preferred rootstock is often derived from M.9. While some European researchers have reported minimal differences in productivity among M.9 clones (4, 8, 19), generally a particular clone or rootstock derived from M.9 has been selected for an apple-growing region because it is readily propagated and available from a local nursery or because it is adapted to local site conditions (4, 8 10, 19). In 1993, a rootstock trial including M.9 clones and other dwarfing rootstocks was established in Missouri to evaluate vegetative growth and productivity of these trees in a Midwestern climate. This report summarizes growth responses that occurred since regular cropping was achieved.

Materials and Methods

'Red Fuji' (T.A.C. 114) trees on 11 clones of M.9 rootstock and B.9, M. 27 EMLA,

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Mark, V.1, and V.3 were obtained from a commercial nursery (TRECO, INC., Woodburn, OR). Trees were planted in a Menfro silt loam soil at the University of Missouri Horticulture and Agroforestry Research Center near New Franklin on May 20, 1993. Although the site had been fallow for two years preceding this experiment, it had been planted previously with apples for 40 years. Trees were spaced 1.8 x 4.9 m with the bud union ≈ 5 cm above the soil surface. Ten single-tree replications of each rootstock were planted in a randomized complete block design. Thirty pollenizer trees of 'Stark UltraGold'/Mark were included throughout the planting. Trees were headed at 76 cm and trained in a vertical axis system (1). Immediately after planting, a 3-cm-diameter conduit pipe was placed adjacent to each tree for leader training and support. Stakes extended 2.7 m above the soil surface. A wire connecting the stakes at 1.3 m was used for additional support. Pruning cuts on the central leader were minimized, allowing leaders to grow above the 2.7 m stakes used for support. Thinning, drip irrigation scheduling and pest, weed, and fertility management followed local recommendations (3).

Data collected annually included tree survival, trunk circumference at 30 cm above the soil surface, tree height and spread, yield, and fruit weight of 50 apples randomly sampled from each tree. TCA was calculated from trunk circumference measurements. Cumulative yield efficiency (fruit yield/TCA) was derived from data collected from 1993-2002. Data were subjected to analysis of variance using the GLM procedure of SAS (SAS Institute, Cary, N.C.). Means were separated by Fisher's protected LSD test, $P \leq 0.05$.

Results and Discussion

Changes in tree mortality, vigor, and productivity occurred since the earlier report on this trial which summarized the growth of trees from 1993 through 1997 (16). During the first five years of this experiment, one tree each on 'Mark' and on M.9 NAKB T338 died as a result of vole damage (16). By 2002, 30% of the trees on M.9 Burgmer 756 and 984, M.9 Janssen 337, V.3, and B.9 were lost (Table 1). However, no mortality was recorded for trees on M.9 NAKB T340 or M.9 Burgmer 751. Nearly all losses occurred at one side of the trial after severe weather episodes, with wind speeds > 74 km per hour (45 mph) in June 1998 and 2000. Although low temperatures were recorded in January 1997 (-28°C), 1999 (-25°C), and 2001 (-26°C), visual symptoms of winter injury were not apparent.

In the earlier report, trees on Mark, as well as V.1, NAKB T340, V.1, and EMLA 9 had greater TCA than B.9, M.9L, Janssen 337, V.3, and M.27 trees in 1997 (16). By 2002, when more regular cropping was achieved, trees on Mark dropped in the ranking of TCA (Table 1). When relative size of trees was calculated, all the rootstocks except M.9 Janssen 337, V.3, B.9 and M.27 EMLA produced trees larger than those on M.9L (Table 1). Of the M.9 clones released by the Dutch Inspection Service for Woody Nursery Stock (NAKB), trees on NAKB T340 were substantially larger relative to those on NAKB T337 or T338. In similar trials planted in Washington, M.9 NAKB T337 rootstock produced weak trees (2). At the Rocky Reach, WA location, which was also a replant site, M.9 RN 29, M.9 Burgmer 756, and M.9 EMLA trees had the greatest TCAs among the M.9 clones. Additionally, TCAs of NAKB T340, B.9, and M.9 Burgmer 984, and Mark trees were similar after nine years at Rocky Reach. In contrast, TCAs of NAKB T340 trees were larger than those of B.9, M.9 Burgmer 984, and Mark after ten years in Missouri. Konishi and Barritt (11) reported that in other rootstock trials conducted around the world, M.9L and M.9 Fleuren 56 produced smaller trees than M.9 T337, M.9 Pajam 1, M.9 RN 29, and M.9 EMLA. V.1 rootstocks tend to produce a vigorous tree in many North American locations (2, 12). While the Missouri trial did not include M.26 as a standard of comparison because of its large size and susceptibility to fire blight, it has been reported that V.1 trees are equal or greater in TCA than M.26 trees (2, 12).

In 2002, trees on V.1 and M.9 Burgmer 756 were taller than those on M.9L rootstock and five other M.9 clones (Table 1). In contrast, B.9 and EMLA 27 rootstocks produced trees shorter than those on M.9L rootstock. While

Table 1. Tree loss, tree size, cumulative yield, yield efficiency, and average fruit size of 'Red Fuji' on M.9 clones and other dwarfing rootstocks.

Rootstock	1993-2002 Cumulative tree loss %	2002 TCA (cm^2)	2002 Relative size (%)[z]	2002 Tree height (cm)	1993-2002 Tree spread (cm)	1993-2002 Cumulative yield (kg/tree)	Cumulative yield efficiency (kg/cm^2)	Ave. fruit weight (g)
V.1	10	112.9 a[y]	175	444 a	217 a	147.9 abcd	1.34 c	167 a
M.9 NAKB T340	0	90.8 b	141	431abc	210 ab	167.8 abc	1.90 c	182 a
M.9 EMLA	20	83.8 bc	130	411abcd	213 ab	144.1 abcd	1.98 c	177 a
M.9 Burgmer 756	30	79.8 bcd	124	442 ab	213 ab	138.9 abcd	2.09 bc	164 a
M.9 RN 29	10	73.2 cd	113	399 cd	206 ab	154.0 abcd	2.40 bc	162 a
Mark	10	72.0 cd	111	391d	202 bc	177.3 a	2.84 bc	173 a
M.9 Burgmer 984	30	70.0 cd	108	414 abcd	208 ab	112.0 d	2.28 bc	165 a
M.9 NAKB T337	10	68.9 cd	107	401 bcd	205 b	134.0 abcd	2.38 bc	168 a
M.9 NAKB T338	20	68.6 cde	106	415 abcd	208 ab	119.4 d	2.53 bc	164 a
M.9 Burgmer 751	0	68.1 cde	105	401cd	206 ab	172.4 ab	2.69 bc	180 a
M.9 Pajam 1	20	66.1 cde	102	400 cd	206 ab	131.9 bcd	2.51 bc	161 a
M.9L	10	64.6 de	100	397 cd	205 b	119.2 d	2.22 bc	154 a
M.9 Janssen 337	30	63.4 de	98	397 cd	206 ab	115.5 d	2.48 bc	159 a
V.3	30	60.5 de	94	379 d	202 bc	128.0 cd	2.97 bc	165 a
B.9	30	49.0 e	76	331 e	191 c	136.8 abcd	3.31 b	159 a
M.27 EMLA	10	16.1 f	25	243 f	143 d	63.0 e	5.86 a	115 b

[z] Relative size = TCA of rootstock ÷TCA of M.9 x 100.

[y] Mean separation within columns by Fisher=s protected LSD test, $P \leq 0.05$.

trees on V.1 generally had the greatest spread, those on EMLA.27 had the smallest spread and could have been spaced more closely within the row for more efficient land use.

In the early years of the trial, cumulative yield among rootstocks was similar due to adverse weather conditions in 1995 and 1996 (16). Thereafter, fruit was harvested annually and trees on M.9 NAKB T340, Mark, and M.9 Burgmer 751 had greater cumulative yield than those on M.9 Burgmer 984, M.9 NAKB T338, M.9L, M.9 Janssen 337, and EMLA 27 (Table 1). In 1997, M.27 EMLA was the only rootstock that differed from M.9L in yield efficiency (16). Five years later, trees on B.9 and M.27 EMLA were more efficient than the more vigorous trees on M.9 EMLA, M.9 NAKB 340, and V.1 rootstocks.

Trees on M.27 EMLA produced smaller fruit than trees on all other rootstocks (Table 1). The small fruit on M.27 EMLA and small TCA reflects the weak growth of these trees. At the Washington sites, M.27 EMLA trees also produced the lowest average fruit weight (2). In Missouri, mean fruit weight was statistically similar among all M.9 clones. However, fruit weight of M.9L trees ranked the lowest (with the exception of EMLA 27 fruit). Fruit harvested from M.9 NAKB T340 averaged nearly 30 g more than that from M.9L trees. The two M.9 clones that tended to produce the largest fruit (Burgmer 751, NAKB T340) also ranked among rootstocks with the greatest cumulative yield. Thus, these rootstocks were productive with large fruit size even without adjustment for crop load.

In summary, results from this trial showed that V.1, M.9 NAKB T340, and M.9 EMLA produce vigorous trees in terms of TCA, while trees on M.9 EMLA Janssen 337, V.3, B.9, and M.27 EMLA are weaker. While M.9 Burgmer 751 and Mark are weaker trees than M.9 NAKB T340, all three rootstocks tend to be very productive. This report also confirms that Mark is well-adapted to a Midwestern climate in spite of its poor performance in more arid regions and its susceptibility to soil-line swelling (5, 13, 14).

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Yield, Quality Attributes, and Degree Day Requirements of Various Wine Grapes under Climatic Conditions of Intermountain West Region

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Abstract

Adaptability, yield, quality attributes, and growing degree day (GDD) requirements of 15 wine grape cultivar clones planted in 1997 under climatic conditions of southwest Idaho (Intermountain West Region) were evaluated during 1999-2001. 'Viognier 01' was an excellent white wine grape and 'Valdepenase 03' an outstanding red wine grape. Wines of 'Carignane 06', 'Grenache 03', and 'Meunier 01' were not satisfactory. Relatively low wine quality of 'Carignane 06' and 'Grenache 03' grapes could in part be related to their high yield. Wine of 'Petite Verdot 01' was excellent; however, its very low yields do not economically justify growing this grape under southwest Idaho conditions. Cumulative growing degree days were sufficient to mature all wine grapes tested in this study.

Introduction

Vine adaptability and fruit quality attributes of wine grape cultivars to a geographical region need to be evaluated before they are widely planted on a commercial scale. Interest in production of wine grapes has increased throughout the world, and this interest is partially due to the medical reports implying certain health benefits associated with wine consumption. California is the major producer of wine grapes in the U.S., and thus, numerous research projects are conducted on various viticultural aspects of wine grapes, including breeding and cultivar evaluations in that state. Adaptability and quality of wine grapes in different regions of the United States have been reported (1, 2, 3, 5, 8, 10).

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