Journal American Pomological Society 55(4):197-204 2001

Performance of 'Gala' Apple on Eight Dwarf Rootstocks: Ten-Year Summary of the 1990 NC-140 Rootstock Trial

R.P. MARINI, B.H. BARRITT, J.A. BARDEN, J. CLINE, R.L. GRANGER, M.M. KUSHAD, M. PARKER, R.L. PERRY, T. ROBINSON, S. KHANIZADEH, AND C.R. UNRATH[1]

Abstract

In 1990, trees of 'Gala' apple (*Malus x domestica* Borkh.) on 8 dwarfing rootstocks were planted at 8 locations in North America according to the guidelines established for cooperative testing by the North Central regional cooperative project (NC-140). Rootstocks in this trial included MAC.39, P.1, O.3, M.27, B.9, Mark, M.9 EMLA, and M.26 EMLA. Tree survival was not affected by rootstock. P.1 produced trees with the largest trunk cross-sectional areas, lowest yield and yield efficiency, and smallest fruit. O.3 and M.26 EMLA produced trees with similar TCSA, but M.26 EMLA was the least productive. Mark, MAC.39, B.9 and M.9 EMLA produced trees with similar TCSA, yields and yield efficiencies. M.27 produced trees with the smallest TCSA and relatively low yields.

Introduction

The North American apple industry is moving toward orchard intensification to take advantage of the economic benefits associated with early cropping and management of small trees. Tree size-control and precocity induced by dwarfing rootstocks are necessary for intensive orchards. Unfortunately, all dwarfing rootstocks currently available from commercial nurseries exhibit weakness, such as susceptibility to climatic stresses and diseases, or the production of root suckers that may limit their success in certain regions. Dwarfing rootstocks, possessing greater tolerance to biotic and abiotic stresses, would probably hasten the planting of intensive orchards and should improve the profitability of such orchards.

During the last 25 years several cooperative rootstock trials have been established in North America (4, 11, 12, 13, 14, 15). These multi-site trials, utilizing a common scion cultivar with uniform experimental design, planting material and management protocol, rapidly expose promising new rootstock candidates to a wide range of growing conditions. These trials have greatly shortened the time required to identify rootstocks with superior characteristics and those with weaknesses.

This report summarizes results from 10 years of a uniform rootstock trial involving eight rootstocks at eight North American locations. Seven of the rootstocks chosen for this trial are in the dwarfing category and performed well in earlier NC-140 trials (13, 14). The Polish (P) rootstock, P.1, originated at the Research Institute of Pomology, Skierniewice, Poland, and produced trees about 25% larger than M.26 EMLA in the 1984 NC-140 rootstock trial (14). P.1 was included in this trial because it reportedly tolerates severe winter cold and produces a tree similar in size to M.26 (8).

Materials and Methods

All trees were propagated by TRECO, Inc., Woodburn, OR, with the scion 'Royal Gala'. The one-year-old nursery trees were planted at eight sites during the late winter and spring of 1990. Cooperators and locations are listed in Table 1. The experiment consisted of a randomized complete block design at each site with four blocks (five blocks at NY). Groups of six trees per rootstock were assigned randomly to 10 m-long sections of row. Data were recorded for the four interior trees; the end trees served as guard trees. Therefore, there were 16 data trees per rootstock, and the experimental unit was the four-tree plot. Statistical analyses were conducted on data averaged for the four-tree plot, so there was one observation per block. In-row spacing was 1.6 m. Between-row spacing varied from 3.25 to 4.5 m and differed on each side of the row, because the trees served as the guard rows in the 1990 NC-140 orchard systems trial (3).

Trees were supported with an individual metal conduit or bamboo pole which was attached to a wire 3 m above ground. Trees were trained to the hybrid Tree Cone (HYTEC) system (1, 2). At each site, management practices for irrigation, nutrition, thinning, and pest control were according to local recommendations.

Trunk circumference or diameter of each tree was measured each fall, and trunk cross-sectional area (TCA) was calculated. Some cooperators harvested fruit in 1991, but all cooperators harvested fruit in 1992. The total cumulative number of fruit per plot and cumulative yield (kg/plot) were used to calculate average fruit weight. Crop density (number of fruit(cm^2 TCA) and yield efficiency (kg of fruit(cm^2 TCA) also were calculated. At Quebec the experiment was terminated after the 1997-growing season (8 years). TCA was not recorded at Washington in 1999, so TCA, crop density, and yield efficiency are reported for only nine years.

The cooperator from Washington performed data collection and analyses until 1995, thereafter the cooperator from Virginia served as the planting coordinator. Data were analyzed by analysis of variance using SAS's Mixed procedure and least squares means were compared with the probability of the difference (Pdiff) (P = 0.05) (10). The probability of the difference is the least significant difference, modified for unequal sample size, and has a comparison-wise error rate of 5%. Each site was analyzed separately because sites had unequal variances. Additionally, there were open cells due to O.3 and P.1 not being planted at all locations, and two cooperators did not collect data for all 10 years. Main effect means are presented in the tables to facilitate comparisons of locations and rootstocks. These means should be viewed cautiously because Illinois did not have O.3 and Washington did not have P.1. Had all rootstocks been evaluated at Washington, mean TCA would have been higher, and yield, yield efficiency, and crop density would have been lower. Additionally, means for P.1 would probably have been different: mean TCA would have been smaller, and means for yield, yield efficiency, and crop density would have been higher.

Results and Discussion

Tree survival. Some tree mortality occurred at every location and some mortality occurred on every rootstock Michigan reported the highest tree losses (Table 2). Tree survival was significantly (P=0.05) influenced by rootstock only at North Carolina and Virginia. Rootstocks with the most mortality were MAC.39 at North Carolina (caused by black root rot, *Xylaria ssp.*), M.26 EMLA at Michigan, and M.27 at Virginia. Although not significant at most locations, tree death on M.27 occurred at all locations except Washington. MAC.39 has not been widely tested, and in earlier trials tree survival was inconsistent. In Washington tree survival was at least 90% for three cultivars on MAC.39 (5). In Ohio survival of MAC.39 was 80%, 40%, and 83% for 'Macspur' McIntosh', 'Lawspur Rome', and 'Redchief Delicious', respectively (7). Fire blight was probably the cause of tree death in Ohio. Of the 15 rootstocks evaluated in the NC-140 1984 rootstock trial, survival of MAC.39 ranked 11th and, depending on the location survival varied from 0% to 90% (14). In previous trials, survival of M.27 EMLA and Mark generally was at least equal to that of M.9 (5, 7, 11, 14).

Trunk cross-sectional area. Trunk cross-sectional area (TCA) was highest at Virginia and Illinois and lowest at North Carolina, New York and Ontario (Table 3). Based on TCA, the 8 rootstocks can be grouped into 4 vigor classes (more vigorous than M.26 EMLA, similar to M.26 EMLA, similar to M.9 EMLA, and less vigorous than M.9 EMLA). At 5 of 7 locations, P.1 had TCA significantly larger than M.26 EMLA. In earlier trials at Ohio and

Table 1. Location and cooperators in the 1990 dwarf rootstock trial.

Planting Location and abbreviations	Cooperators	Latitude (°N)	Longitude (°W)
(IL) Urbana, Illinois	Mosbah M. Kushad	40.06	88.12
(MI) Clarksville, Michigan	Ronald L. Perry	42.50	85.14
(NC) Fletcher, North Carolina	Michael Parker, Richard Unrath	35.25	82.30
(NY) Geneva, New York	Terence Robinson	42.52	77.00
(ONT) Simcoe, Ontario	John Cline	42.50	80.18
(QUE) St. Jean, Quebec	Raymond Granger, Shahrokh Khanizadeh	45.19	73.16
(VA) Blacksburg, Virginia	John A. Barden, Richard Marini	37.13	80.24
(WA) Wenatchee, Washington	Bruce H. Barritt	47.25	120.18

Washington, trees on P.1 had TCA similar to trees on M.7 EMLA (5, 7, 14). After five years, the TCA of 'Gala' tress was higher for P.1 than for M.26 EMLA at 7 of 20 locations (12). Averaged over 30 locations, the TCA of 10-yr-old 'Starkspur Supreme Delicious' was 103, 98, and 77 cm^2, respectively for M.7 EMLA, P.1, and M.26 EMLA (14). In Poland, the TCA of trees on P.1 was similar to or less than on Mark (6), but Karychev (8) considered P.1 to be in the same size class as M.26. At most locations, O.3 had TCA similar to M.26 EMLA. These results contradict those of earlier rootstock trials. In previous trials both B.9 and O.3 produced trees with TCA 30 to 80% that of M.26 EMLA (5, 7, 14). After five years, the TCA of 'Gala' trees on B.9 and O.3 was similar to M.9 EMLA and less than that of M.26 EMLA (11). At most locations Mark, B.9, and MAC.39 were in the same vigor class as M.9 EMLA. In earlier trials, Mark and MAC.39 had slightly smaller trunks than M.9 EMLA (5, 7, 12). Although not always significantly smaller than M.9 EMLA, M.27 produced the smallest trunks at all locations. In earlier trials, trees on Mark and MAC.39 usually had slightly smaller trunks than M.9 EMLA, and trees on M.27 had the smallest trunks (5, 7, 12).

Yield. Cumulative yield varied greatly from one location to another (Table 4). Trees on several rootstocks produced more than 200 kg/tree at IL, MI, and VA, whereas all rootstocks produced less than 100 kg/tree at NC. Cumulative yield was influenced by rootstock at all locations, and the performance of a given rootstock varied dramatically from one location to another (Table 4). At most locations yields were relatively low for MAC.39, P.1 and M.27. In general, the highest yielding rootstocks were B.9, Mark, and M.9 EMLA. The interaction between rootstock and location was so strong that no rootstock ranked in

Table 2. Survival (% alive) of 'Royal Gala', trees on 8 dwarfing rootstocks after 10 years. All values are least-squares means, adjusted for missing cells.[Z]

Rootstock	IL	MI	NC	NY	ONT	QUE[Y]	VA	WA	Mean
M.27	75	81	94 a	85	94	90	69 b	100	**86**
MAC.39	81	75	50 b	100	100	95	100 a	100	**88**
M.9 EMLA	88	100	100 a	95	100	80	100 a	100	**95**
Mark	100	88	100 a	90	100	75	81 b	100	**92**
O.3	—	75	81 ab	95	94	85	100 a	100	**90**
B.9	100	75	100 a	95	100	100	100 a	96	**96**
M.26 EMLA	91	50	100 a	100	100	100	100 a	96	**92**
P.1	100	75	100 a	95	100	100	100 a	—	**96**
Mean	**91**	**77**	**91**	**94**	**99**	**91**	**94**	**99**	
P-value	*0.542*	*0.459*	*0.0339*	*0.152*	*0.583*	*0.156*	*0.003*	*0.435*	

[Z]Least-squares means followed by common letters do not differ at the 5% level, by probability of the difference.
[Y]Data for Quebec are for only 8 years.

Table 3. Trunk cross-sectional area (cm²) of surviving 'Royal Gala', trees on 8 dwarfing rootstocks after 10 years. All values are least-squares means, adjusted for missing cells.[Z]

Rootstock	IL	MI	NC	NY	ONT	QUE[Y]	VA	WA[X]	Mean
M.27	41.2 d	33.4 d	20.8 e	31.1 d	24.4 d	7.7 c	37.3 e	20.5 d	**27.0**
MAC.39	53.0 cd	52.6 c	34.2 de	46.5 c	48.4 c	19.3 b	62.3 d	38.2 bc	**44.3**
M.9 EMLA	61.6 c	54.0 c	44.0 d	50.2 c	41.4 c	19.1 b	64.4 d	47.0 b	**47.7**
Mark	53.9 cd	52.5 c	40.9 cd	45.1 c	48.7 c	20.7 ab	54.3 d	36.0 cd	**44.0**
O.3	—	76.9 b	61.2 bc	61.9 b	54.7 bc	18.8 b	77.4 bcd	67.4 a	**59.8**
B.9	57.8 cd	52.1 c	43.2 cd	61.8 b	50.8 c	20.6 ab	65.6 c	45.5 b	**49.7**
M.26 EMLA	85.4 b	82.7 ab	54.2 bcd	68.4 b	67.4 bc	22.0 ab	87.9 b	81.5 a	**68.7**
P.1	115.4 a	98.5 a	78.2 a	88.2 a	96.2 a	26.5 a	109.2 a	—	**87.5**
Mean	**66.9**	**56.1**	**47.1**	**56.6**	**54.0**	**19.3**	**69.8**	**48.0**	
P-value	*0.001*	*0.001*	*0.001*	*0.001*	*0.001*	*0.001*	*0.001*	*0.001*	

[Z]Least-squares means followed by common letters do not differ at the 5% level, by probability of the difference.
[Y]Data for Quebec are for only 8 years.
[X]TCA was not measured in 1999, so data are for 1998.

the top four at all locations. After the first five years of this trial, trees on Mark, B.9 and O.3 tended to have the highest yields at most locations, whereas M.27 had low yields (3). In several other trials P.1 and M.26 had similar cumulative yields (5, 7, 8, 14), but in one trial P.1 produced about 20 to 25% less than M.26 (6). In a semi-dwarf rootstock trial with 'Gala', P.1 was less productive than M.26 EMLA at 8 of 18 locations (12). In an earlier trial in Washington, M.9 EMLA had higher yields than MAC.39 for one of three cultivars (5) but, when averaged over three cultivars, the two rootstocks had similar yields in Ohio (7).

Crop density tended to be highest at NY and lowest at NC and VA (Table 5). Yield efficiency was highest at MI and lowest at NC and QUE (Table 5). Trees on P.1 had the lowest crop density and yield efficiency regardless of location. In other trials P.1 consistently had low yield efficiencies (5, 7, 14) Trees on B.9, O.3 and M.26 had similar TCSA, but both B.9 and O.3 had higher crop densities than M.26, and B.9 had the highest crop density at 3 of 7 locations. Within this group yield efficiency was generally highest for B.9 and lowest for M.26 EMLA. With 'Golden Delicious' and 'Delicious' as scion cultivars, the ranking for yield efficiency was B.9>O.3>M.26 EMLA (5). After five

Table 4. Cumulative yield (kg/tree) of surviving 'Royal Gala' trees on 8 dwarfing rootstocks after 10 years. All values are least-squares means, adjusted for missing cells. [Z]

Rootstock	IL	MI	NC	NY	ONT	QUE[Y]	VA	WA	Mean
M.27	82 d	211 bc	41 c	111 c	74 c	17 c	118 b	71 e	**91**
MAC.39	126 d	148 cd	70 a	152 b	110 b	49 ab	202 a	165 b	**128**
M.9 EMLA	150 bc	242 ab	89 a	177 ab	106 b	45 b	216 a	192 a	**152**
Mark	190 b	292 a	91 a	164 ab	127 ab	46 b	230 a	117 d	**157**
O.3	—	181 bc	85 a	185 a	138 a	50 ab	214 a	187 a	**149**
B.9	200 b	289 a	97 a	167 ab	132 a	60 a	185 a	166 b	**162**
M.26 EMLA	271 a	147 cd	92 a	152 b	117 a	48 ab	189 a	143 c	**145**
P.1	95 d	67 d	49 c	109 c	128 a	44 b	55 c	—	**78**
Mean	**159**	**197**	**77**	**152**	**116**	**45**	**176**	**149**	
P-value	*0.001*	*0.001*	*0.001*	*0.001*	*0.001*	*0.001*	*0.001*	*0.001*	

[Z]Least-squares means followed by common letters do not differ at the 5% level, by probability of the difference.
[Y]Data for Quebec are for only 8 years.

Table 5. Cumulative crop density (fruit·cm²) for surviving trees of 'Royal Gala' on 8 dwarfing rootstocks after 10 years. All values are least-squares means, adjusted for missing cells. [Z]

Rootstock	IL	MI	NC	NY	ONT	QUE[Y]	VA	WA[X]	Mean
M.27	18.1ab	30.7a	18.8ab	26.6a	22.3a	17.1b	20.2b	21.8a	**21.9**
MAC.39	17.1b	15.2d	17.9ab	25.1ab	16.0b	18.6ab	22.3ab	17.4ab	**18.7**
M.9 EMLA	16.0b	20.8c	19.5a	26.5a	19.5ab	19.0ab	22.7a	20.6a	**20.6**
Mark	25.4a	21.8b	19.9a	27.7a	19.0ab	17.3b	27.1a	19.8a	**22.2**
O.3	—	13.6d	13.1b	22.5b	18.4ab	20.9a	19.2bc	14.1b	**17.4**
B.9	23.1ab	25.7b	18.6ab	20.7b	18.7ab	21.7a	19.4bc	20.5a	**21.0**
M.26 EMLA	19.5ab	8.5e	15.2ab	16.6b	12.6bc	16.9bc	14.9c	9.1c	**14.2**
P.1	7.2c	5.6e	5.9c	9.1c	10.4c	13.2c	3.8	—	**7.9**
Mean	**17.0**	**17.7**	**16.1**	**21.8**	**17.1**	**18.1**	**16.2**	**17.6**	
P-value	*0.002*	*0.001*	*0.002*	*0.001*	*0.001*	*0.004*	*0.001*	*0.001*	

[Z]Least-squares means followed by common letters do not differ at the 5% level, by probability of the difference.
[Y]Data for Quebec are for only 8 years.
[X]TCA was not measured in 1999, so data are for 1998.

years of a trial involving four cultivars on five rootstocks, the rootstock x cultivar interaction was significant, but the overall ranking for yield efficiency was B.9>O.3>M.26 EMLA (15). In the present trial Mark, MAC.39 and M.9 EMLA had similar TCAs and they had similar crop densities and yield efficiencies. Within this group Mark had highest crop densities at 2 of the eight locations. In a Washington trial involving three cultivars, the ranking for yield efficiency was Mark>M.9 EMLA>MAC.39 (5). When averaged over three cultivars in Ohio, the ranking for yield efficiency was Mark>MAC.39>M.9 EMLA (7).

Fruit weight. Average fruit weight was influenced by rootstock only at MI, VA, and WA, but the influence of rootstock varied for the three locations (Table 7). At MI, trees on Mark produced larger fruit than trees on P.1 and O.3. At VA, trees on B.9 produced larger fruit than Mark and trees on P.1 produced the smallest fruit. At WA, trees on O.3 and M.9 EMLA produced the largest fruit and trees on M.27 and Mark produced the smallest fruit.

Analyses of covariance were performed for each location to evaluate the potential influence of crop load on fruit weight. Crop density and then cumulative number of fruit per tree was evaluated as a covariate. A requirement for analysis of covari-

Table 6. Cumulative yield efficiency (kg·cm²) for surviving 'Royal Gala' trees on 8 dwarfing rootstocks after 10 years. All values are least-squares means, adjusted for missing cells. [Z]

Rootstock	IL	MI	NC	NY	ONT	QUE[Y]	VA	WA[X]	Mean
M.27	2.6ab	6.2a	2.0a	3.6a	3.1a	2.1b	3.0b	3.6a	**3.3**
MAC.39	2.4b	2.8c	2.0a	3.3ab	2.3b	2.4ab	3.2ab	3.4a	**2.7**
M.9 EMLA	2.4b	4.5b	2.0a	3.5a	2.7ab	2.3ab	3.4ab	4.1a	**3.1**
Mark	3.4a	5.7ab	2.2a	3.6a	2.6ab	2.1b	3.8a	3.2bc	**3.3**
O.3	—	2.4c	1..4b	3.0ab	2.5ab	2.5a	2.8bc	2.8c	**2.5**
B.9	3.1a	5.7ab	2.1ab	2.8b	2.6ab	2.7a	2.9b	3.9ab	**3.2**
M.26 EMLA	2.7a	1.6cd	1.8ab	2.2b	1.7c	2.0b	2.2c	1.8d	**2.0**
P.1	0.9c	0.6d	0.6c	1.2c	1.4c	1.5c	0.6d	—	**1.0**
Mean	**2.5**	**3.7**	**1.7**	**2.9**	**2.4**	**2.2**	**2.7**	**3.2**	
P-value	*0.003*	*0.001*	*0.003*	*0.001*	*0.001*	*0.001*	*0.001*	*0.001*	

[Z]Least-squares means followed by common letters do not differ at the 5% level, by probability of the difference.
[Y]Data for Quebec are for only 8 years.
[X]TCA was not measured in 1999, so data are for 9 years.

Table 7. Average fruit weight (g) of all fruit harvested from surviving 'Royal Gala' trees on 8 dwarfing rootstocks after 10 years. All values are least-squares means, adjusted for missing cells. Z

Rootstock	IL	MI	NC	NY	ONT	QUE[Y]	VA	WA	Mean
M.27	126	131c	107	135	139	120	147ab	165c	**134**
MAC.39	123	150a	110	132	145	128	145ab	197ab	**141**
M.9 EMLA	130	141b	104	134	139	121	148ab	201a	**140**
Mark	123	138b	109	130	137	119	142b	164c	**133**
O.3	—	146a	110	135	138	121	145ab	200a	**142**
B.9	129	147a	112	136	141	125	151a	189b	**141**
M.26 EMLA	132	144ab	119	133	137	117	144ab	197ab	**140**
P.1	128	124c	108	136	131	113	132c	—	**125**
Mean	**127**	**140**	**110**	**134**	**138**	**120**	**144**	**188**	
P-value	*1.452*	*0.001*	*0.136*	*0.765*	*0.257*	*0.059*	*0.002*	*0.001*	

ZLeast-squares means followed by common letters do not differ at the 5% level, by probability of the difference.
YData for Quebec are for only 8 years.

ance is that the relationship between fruit weight and the covariate must be similar for all rootstocks; therefore the slopes must be equal (9, 10). The rootstock x covariate interaction term was included in the model to test homogeneity of slopes. The interaction was significant at IL for number of fruit per tree, so fruit weight could not be adjusted with analysis of covariance. Covariates were significant at only NC, NY, and QUE and least squares means, adjusted for the covariate are presented in Table 8. At NC, fruit weight was influenced by cumulative number of fruit per tree, but not crop density. After accounting for number of fruit per tree, trees on P.1, M.27 and M.26 EMLA produced the largest fruit and trees on M.9 EMLA produced the smallest fruit. At NY, fruit weight was significantly related to both covariates, and after adjusting the means for the covariates, rootstock did not influence average fruit weight. At QUE, after adjusting the means for crop density, trees on O.3, MAC.39, M.9, and B.9 produced the largest fruit and trees on P.1 and M.26 EMLA produced the smallest fruit. When data were analyzed for individual years in the fourth and fifth years of this trial, rootstock did not influence fruit weight at most locations. When means were adjusted for crop load, fruit from trees on P.1 were smaller than on other rootstocks in NY, ONT and QUE in year 4 and QUE in year 5 (4). Small fruit has also been reported for P.1 (5, 16) and for Mark (5, 13). In another NC-140 trial, with four cultivars and five rootstocks, the effects of rootstock on fruit size varied with year and scion cultivar (15). In the third season, regardless of scion cultivar, trees on O.3 produced the smallest fruit. Averaged over four cultivars and three seasons, the ranking for fruit weight adjusted for crop density was M.9 EMLA > B.9 > M.26 EMLA > Mark > O.3 (15).

Conclusions. This was the first NC-140 rootstock trial utilizing sub-sampling, where more than one tree per rootstock was planted in a block. Normally the primary advantage of having more than one observation per plot is that the experiment remains balanced when at least one tree per cell survives. However, this requires that the analysis be performed on the average of surviving trees within a plot. This approach does not allow the evaluation of the within-plot variation. Unfortunately, this experiment was not balanced because IL did not plant O.3 and WA did not plant P.1. In addition, all trees on MAC.39 died in two blocks at NC. Therefore, in this particular instance there was no advantage of planting more than one tree per rootstock in each block. The major disadvantage of planting several trees per block is a loss of replication. In this experiment, there were six trees per rootstock per block, but only the middle four trees were used to collect data. There were 24 trees per rootstock at

Table 8. Average fruit weight (g), adjusted for the covariates crop density (CD) or fruit per tree (FPT) for 'Royal Gala' trees on 8 dwarfing rootstocks after 10 years. All values are least-squares means, adjusted for missing cells.[z] Both covariates were significant for NY, so two analyses of covariance were performed.

Rootstock	NC	NY	NY	QUE[Y]
M.27	116 a	138	130	119 b
MAC.39	112 ab	134	132	128 ab
M.9 EMLA	110 c	137	136	122 ab
Mark	105 bc	134	132	119 b
O.3	108 b	135	138	124 a
B.9	107 bc	135	137	128 a
M.26 EMLA	117 a	128	133	116 bc
P.1	116 a	127	132	108 c
P-value				
Rootstock	*0.033*	*0.502*	*0.576*	*0.020*
CD	—	*0.012*	—	*0.048*
FPT	*0.013*	—	*0.024*	—

[Z]Least-squares means followed by common letters do not differ at the 5% level, by probability of the difference.
[Y]Data for Quebec are for only 8 years.

each location, but there were only four blocks per location, resulting in only 21 degrees-of-freedom in the error term. Had there been only one tree per rootstock per block, the same number of trees could have provided 24 blocks and 161 degrees-of-freedom in the error term. Additional analyses of this data set would be beneficial to evaluate the between-block and within-block variation to determine if subsampling would be beneficial in future rootstock trials.

Most of the rootstocks included in this trial except P.1 and MAC.39 have been tested in several NC-140 trials. Based on our results and those of previous trials, P.1 probably has limited commercial potential. Compared to M.26 EMLA, P.1 produces larger trees, is less productive, and has lower yield efficiency. MAC.39 seems to have no real advantage over M.9 EMLA in terms of size control, productivity, yield efficiency, or tree survival. Therefore, MAC.39 should not be considered for commercial production and should not be included in future rootstock trials. The rootstocks O.3 and B.9 seem comparable to M.9 EMLA in many ways. Decisions concerning the commercial viability of these rootstocks can be made at the completion of the NC-140 1990 cultivar/rootstock trial and the NC-140 1994 dwarf rootstock trial, where they are being compared to M.9 EMLA.

Literature Cited

1. Barritt, B.H. 1992. Management of HYTEC apple orchards. Part I: orchard planning and establishment. Good Fruit Grower. Yakima, WA. 43(19):4, 69, 70, 72, 73.
2. Barritt, B.H. 1992. Management of HYTEC apple orchards. Part II:pruning and training. Good Fruit Grower. Yakima, WA. 43(19):38-42.
3. Barritt, B.H., J.A. Barden, J. Cline, R.L. Granger, E.E. Hoover, M.M. Kushad, R.P. Marini, M. Parker, R.L. Perry, T. Robinson, C.R. Unrath and M.A. Dilley. 1997. North American NC-140 apple orchard systems trial. Acta Hort. 451:443-452.
4. Barritt, B.H., J.A. Barden, J. Cline, R.L. Granger, M.M. Kushad, R.P. Marini, M. Parker, R.L. Perry, T. Robinson, C.R. Unrath and M.A. Dilley. 1997. Performanace of 'Gala' at year 5 with eight apple rootstocks in an 8-location North American NC-140 trial. Acta Hort. 451:129-135.
5. Barritt, B.H., B. S. Konishi, and M.A.Dilley. 1995. Performance of three apple cultivars with 23 dwarfing rootstocks during 8 seasons in Washington. Fruit Var. J. 49:158-170.
6. Czynczyk, A., P. Bielicki, and B. Bartosiewicz. 1999. Performance of three apple cultivars on 17 dwarfing and semi-dwarfing rootstocks during eight seasons. Apple rootstocks for intensive orchards. pp. 21-22. Proc. International Seminar. Warsaw-Ursynów.
7. Ferree, D.C., P.M. Hirst, J.C. Schmid, and P.E. Dotson. 1995. Performance of three apple cultivars with 22 dwarfing rootstocks during 8 seasons in Ohio. Fruit Var. J. 49:171-178.
8. Karychev, K.G. 1999. Low-vigour apple rootstocks for intensive orchards in Kazakhstan. Apple rootstocks for intensive orchards. pp.51-52. Proc. International Seminar..Warsaw-Ursynów.
9. Littell, R.C, R.J. Freund, and P.C. Spector. 1991. SAS system for linear models, 3rd ed. SAS Inst. Inc. Cary, NC.
10. Littell, R.C., G.A. Milliken, W.W. Stroup, and R. D. Wolfinger. 1996. SAS Systems for mixed models. SAS Inst. Inc. Cary, NC.

11. Marini, R.P., J.L. Anderson, W.R. Autio, B.H. Barritt, J. Cline, W.P. Cowgill, Jr., R.M. Crassweller, P.A. Domoto, D.C. Ferree, J. Garner, A. Gaus, G.M. Greene, C. Hampson, P. Hirst, M.M. Kushad, E.Mielke, C.A. Mullins, M. Parker, R.L. Perry, J.P. Privé, G.L. Reighard, T. Robinson, C.R. Rom, T. Roper, J. R. Schupp, E. Stover, and R. Unrath. 2000. Performance of 'Gala' apple on 18 dwarf rootstocks: a five-year summary of the 1994 NC-140 dwarf rootstock trial. J. Amer. Pomol. Soc. 54:92-107.

12. Marini, R.P., J.L. Anderson, B.H. Barritt, G.R. Brown, J. Cline, W.P. Cowgill, Jr., P.A. Domoto, D.C. Ferree, J. Garner, G.M. Greene, C. Hampson, P. Hirst, M.M.Kushad, E.Mielke, C.A. Mullins, M. Parker, R.L. Perry, J.P. Privé, G.L. Reighard, T. Robinson, C.R. Rom, T. Roper, J. R. Schupp, E. Stover, and R. Unrath. 2000. Performance of 'Gala' apple on four semi-dwarf rootstocks: a five-year summary of the 1994 NC-140 semi-dwarf rootstock trial. J. Amer. Pomol. Soc. 54:84-91.

13. 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.

14. NC-140. 1996a. Performance of the NC-140 cooperative apple rootstock planting: I. survival, tree size, yield and fruit size. Fruit Var. J. 50:6-11.

15. NC-140. 1996b. Rootstock and scion cultivar interact to affect apple tree performance: a five-year summary of the 1990 NC-140 cultivar/rootstock trial. Fruit Var. J. 50:175-187.

16. Wertheim, S.J. 1989. Preliminary results of trials with dwarfing apple and pear rootstocks. Acta. Hort. 243:59-70.

Journal American Pomological Society 55(4):204-208 2001

Promising Native Walnut Genotypes (*Juglans regia* L.) of The East Black Sea Region of Turkey

I. BALCI[1], F. BALTA[1], A. KAZANKAYA[1] AND S.M. SEN[1]

Abstract

In order to select promising native walnut genotypes, characteristics of trees situated on the Black Sea Region of Turkey during 1997 to 1999 were examined with regard to fruit properties. The walnut population consisted of 4200 seedling trees. Fifteen native genotypes selected were evaluated as promising. The genotypes exhibited a range of 11.8-18.7 g for inshell fruit weight, 6.25-9.23 g for kernel weight, 48-60% for kernel percentage, 1.02-1.75 mm for shell thickness, 65-100% for terminal fruitfulness and 30-75% for lateral fruitfulness.

Introduction

As the main commercial species *Juglans regia* L. is native to a large area in the world (1, 2, 3). In most parts of Anatolia, this species is cultivated in scattered populations since ancient times (3, 4). Continuous seed propagation for thousands of years has given rise to the occurrence of a great number of seedling walnut trees and valuable walnut genetic resources. Native trees, the numbers of which are estimated to be over 4.5 million, posses large genetic variability which might contribute to breeding programs desiring high yield, good nut and kernel characteristics, high lateral bud fruitfulness, late bud breaking, late flowering, winter hardiness and tolerance to diseases. Selection studies in Turkey were conducted in the Marmara Region

[1]Yüzüncü Yil University, Department of Horticulture, Faculty of Agriculture, 65080-Van-Turkey.