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Growth and Productivity of Disease-Resistant Apple Cultivars on M. 27 EMLA, M. 26 EMLA, and Mark Rootstocks

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Abstract

The growth, precocity, yield, and fruit size of 'Liberty,' 'NY 75414-1,' 'NY 74828-12,' and 'NY 65707-19' on M. 27 EMLA, M. 26 EMLA and Mark rootstocks, with 'McShay' on M. 26 EMLA and Mark, were compared. 'Liberty,' 'McShay,' and 'NY 74828-12' trees were larger than 'NY 75414-1,' while 'NY 65707-19' trees were the smallest. Among rootstocks, trees on Mark were larger than trees on M. 26, while trees on M. 27 were the smallest. There were no interactions between cultivar and rootstock on tree growth in this study. 'NY 74828-12' produced the most flower clusters in the third and fourth years of the study, and 'NY 65707-19' the least. In 1993, trees on Mark had more flowers than those on M. 26, while trees on M. 27 had the fewest flower clusters. 'Liberty,' 'NY 75414-1' and 'NY 74828-12' produced higher cumulative yield than 'McShay' and 'NY 65707-19.' Trees on Mark had higher cumulative yield than M. 26, while trees on M. 27 produced the smallest yields. Fruit size was greatest for 'NY 65707-19' and smallest for 'NY 74828-12.' Trees on M. 27 produced smaller sized fruit than trees on M. 26 or Mark. 'NY 75414-1' had moderate vigor, high precocity, yield, and yield efficiency, with acceptable fruit size. 'NY 74828-12' also performed very well in this trial, but possesses Vm resistance to apple scab, not Vf, and is unlikely to be named. Among the disease-resistant apple cultivars (DRC) in this trial, 'Liberty' and 'NY 75414-1,' based upon precocity, vigor, yield, and fruit size, have the best potential for commercial production. Mark rootstock produced the largest trees with the highest yields, and was superior to M. 26 as a rootstock for the DRCs in this study.

Introduction

It has been over 50 years since apple breeding programs specifically aimed at developing new varieties with resistance to scab and other diseases were started, and over 25 years since the first disease-resistant apple cultivar was released (4), yet few, if any of these varieties have become commercially important.

Consumer recognition of varietal traits leads to a certain kind of "brand loyalty" for apple cultivars and makes introduction of new varieties both time consuming and expensive. Introducing a new apple variety requires a large promotional effort. Ultimately, consumer acceptance and grower returns determine whether a new variety becomes established (5).

The objective of this study was to compare the growth and fruiting of four new DRCs with 'Liberty,' a DRC with high productivity (7), and high consumer preference ratings (5, 12). A second objective was to compare the growth and performance of DRCs on three dwarfing rootstocks.

Materials and Methods

In 1988, a nursery was established at Highmoor Farm, Monmouth, ME, with M.27 EMLA, M.26 EMLA, and Mark rootstocks (Treco Nursery, Woodburn, OR). Scion wood for 'Liberty'(7), 'NY 75414-1'(8), 'NY 74828-12'(8), and 'NY 65707-19'(8) was obtained from the New York State Agricultural Experiment Station. Scion wood for 'McShay'(9) was obtained from Oregon State University. The trees were T- budded in July, 1988, then grown in the nursery for two years. In the spring of 1990, the trees were headed at a height of 45 cm, as described for the "knip boom" method (1). A single shoot was allowed to grow to form a

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feathered tree, and the dormant trees were dug in November, 1990 and stored in refrigerated storage.

The trees were planted in 1991 at 2.4 x 4.8 m spacing, with the bud union two cm above the soil line. The soil was a Dixfield fine sandy loam, coarse-loamy, mixed frigid Typic Haplorthods. The trees were individually staked and trained using slender spindle methods with tree support to a height of two meters. The trees received standard horticultural and pest management practices, except that no fungicides were applied for control of scab. The experiment utilized a split plot design with cultivar as the main plot, rootstock as the sub-plot, and four replications.

Circumference of the trunk 50 cm above the soil line was measured annually and trunk cross-sectional area (TCSA) was calculated. Tree height and tree width were measured at the end of the 1996 growing season. The number of flower clusters and the number of fruit that set were counted in 1993 and 1994 and fruit set was calculated. Yield was weighed annually from 1993 to 1996, and average fruit weight and fruit diameter were evaluated from a 20-fruit sample in 1994, 1995 and 1996.

Results

There were no significant interactions between cultivar and rootstock in this study (data not presented). Since there were no trees of 'McShay'/M.27, the comparisons among cultivars are presented as the pooled means on Mark and M.26. Rootstock effects were compared across all cultivars, except 'McShay.'

Table 1. Tree size of five disease-resistant apple cultivars after six growing seasons.[z]

Cultivar	TCSA (cm^2)	TCSA increase	Canopy Ht. (cm)	Canopy width (cm)
'Liberty'	18.3 a[y]	16.2 a	245 b	233 a
'McShay'	17.2 a	16.0 a	325 a	278 a
NY 754414-1	13.2 b	11.6 b	292 a	267 a
NY 74828-12	18.8 a	16.6 a	247 b	247 a
NY 65707-19	8.2 c	6.9 c	236 b	183 b

[z]Means are pooled averages for each cultivar on M.26 EMLA and Mark rootstocks.
[y]Mean separation by Duncan's new multiple range test, P = 0.05.

Table 2. Effect of M.27, M.26 and Mark rootstocks on the growth of four disease-resistant cultivars.[z]

	1991-1996			
Rootstock	TCSA (cm^2)	TCSA increase	Canopy Ht. (cm)	Canopy width (cm)
M.27 EMLA	3.8 c[y]	2.4 c	160 c	106 b
M.26 EMLA	13.1 b	11.3 b	242 b	227 a
Mark	16.1 a	14.3 a	268 a	237 a

[z]Means are pooled averages for all cultivars, except 'McShay.'
[y]Mean separation by Duncan's new multiple range test, P = 0.05.

Tree survival through 1996 was 100% in this planting. 'Liberty,' 'McShay,' and 'NY 74828-12' had the largest TCSA on Mark and M.26 rootstocks (Table 1). 'NY 65707-19' trees were the smallest, while 'NY 75414-1' trees were intermediate in size. 'McShay' and 'NY 75414-1' produced the tallest trees, and 'NY 65707-19' trees had the narrowest canopies.

Mark rootstock produced the largest, tallest trees in this study, and M.27 produced the smallest, shortest, and narrowest trees (Table 2). Trees on M.26 were intermediate in TCSA and tree height.

In 1992 there were no differences among cultivars or rootstocks in flower number or fruit set (data not presented). 'NY 74828-12' produced the most flower clusters per tree in 1993, and among the highest number of flower clusters in 1994 (Table 3). 'Liberty' and 'NY 75414-1' ranked next in flowering in 1993, and 'Liberty' remained among the highest in flowering in 1994. 'McShay' had the least flower numbers in 1993, but ranked near the top in 1994, while 'NY 65707-19' produced among the fewest flower clusters in both years. 'Liberty' and 'NY 74828-12' set higher numbers of fruit per unit of TCSA than 'McShay or 'NY 65707-19' in both 1993 and 1994. Fruit set of 'NY 75414-1' was intermediate, and not significantly different from the highest or lowest fruiting cultivars in 1993. In 1994,

Table 3. Flowering and fruit density of five disease-resistant apple cultivars in the third and fourth years of growth.[z]

	Flowering					
	1993		1994		No. fruit/TCSA	
Cultivar	Clusters/tree	Clusters/TCSA	Clusters/tree	Clusters/TCSA	1993	1994
'Liberty'	31 b[y]	4.2 ab	80 a	9.2 ab	4.5 a	4.8 a
'McShay'	11 c	2.1 b	74 ab	8.9 ab	1.2 b	1.8 c
NY 75414-1	28 b	6.0 a	46 bc	6.5 bc	3.2 ab	4.0 ab
NY 74828-12	48 a	6.8 a	90 a	10.5 a	5.6 a	5.5 a
NY 65707-19	17 bc	4.9 b	24 c	4.5 c	3.7 b	2.5 bc

[z]Means are pooled averages for each cultivar on M.26 and Mark rootstocks.
[y]Mean separation by Duncan's new multiple range test, P = 0.05.

'NY 75414-1' set more fruits per unit of TCSA than 'McShay.'

Trees on Mark rootstock produced more flowers and set more fruit than trees on M.26 or M.27 in 1993 (Table 4). In 1994, trees on M.26 produced more flower clusters than trees on Mark, while M.27 produced the fewest flowers per tree. Trees on Mark set more fruit per unit of TCSA than those on either Malling stock in 1993, while there were no differences in fruit set attributable to rootstock in 1994.

Yields were generally low, with no significant differences among cultivars in 1993 and 1994 (data not presented). In 1995, 'Liberty,' 'NY 75414-1,' and 'NY 74828-12' produced higher yield than 'McShay' or 'NY 65707-19' (Table 5). Trees on Mark produced the largest yields from 1994 on, while trees on M.27 produced the least (Table 6).

'NY 65707-19' produced the largest diameter fruits, with no differences among the other four cultivars (Table 7). Fruit of 'NY 65707-19' also had the greatest individual fruit weight, while 'NY 74828-12' produced the smallest fruits. Among rootstocks, M.27 produced the smallest fruit, while there was no difference in fruit size between Mark and M.26 (Table 8).

Discussion

'McShay' produced 53% of the cumulative yield of 'Liberty' in this trial, suggesting that this selection is not productive enough for commercial planting. 'NY 65707-19' trees had high yield efficiency, but were very small trees on the rootstocks we tested, indicating that this cultivar would need to be planted on more vigorous semi-dwarf rootstocks in order to be productive on a land use basis. 'NY 74828-12' was vigorous and productive, but produced small-sized fruit, as previously reported (10). Additionally, it has been reported that 'NY 74828-12' has Vm resistance to scab, not Vf, and that it is therefore susceptible to race 5 of the scab fungus (2). In view of these shortcomings, it is unlikely that this selection will be named.

Table 4. Effect of M.27 EMLA, M.26 EMLA and Mark rootstocks on flowering and fruit density of four disease-resistant apple cultivars in the third and fourth years of growth.[z]

	Flowering					
	1993		1994		Fruit No./TCSA	
Rootstock	Clusters/tree	Clusters/TCSA	Clusters/tree	Clusters/TCSA	1993	1994
M.27 EMLA	13 b[y]	6.1	26 c	9.3 a	3.2 b	4.3
M.26 EMLA	21 b	4.6	70 a	10.2 a	2.3 b	4.7
Mark	41 a	6.3	50 b	5.1 b	6.2 a	3.8

[z]Means are pooled averages for all cultivars, except 'McShay.'
[y]Mean separation by Duncan's new multiple range test, P = 0.05.

Table 5. Yield and cumulative yield efficiency of five disease-resistant apple cultivars.[z]

Cultivar	Yield (kg) 1995	1996	Cumulative	Yield efficiency (kg/cm^2)
'Liberty'	12.9 a	14.6 a	30.4 a	1.8 b
'McShay'	8.4 bc	5.6 c	16.1 b	1.0 c
NY 75414-1	12.2 ab	12.4 ab	28.0 a	2.3 a
NY 74828-12	11.6 ab	15.3 a	31.3 a	1.9 b
NY 65707-19	6.7 c	7.8 bc	16.8 b	2.4 a

[z]Means are pooled averages for each cultivar on M.26 and Mark rootstocks.
[y]Mean separation by Duncan's new multiple range test, P = 0.05.

Table 6. Effect of M.27, M.26 and Mark rootstocks on yield and cumulative yield efficiency of four disease-resistant apple cultivars.[z]

Rootstock	Yield (kg/cm) 1993	1994	1995	1996	Cumulative	Yield efficiency (kg/cm^2)
M.27 EMLA	0.1 b[y]	0.5 c	3.5 c	2.5 c	6.8 c	2.6 a
M.26 EMLA	0.9 a	1.4 b	8.0 b	10.3 b	20.6 b	1.9 b
Mark	1.0 a	2.9 a	13.7 a	14.8 a	32.3 a	2.3 ab

[z]Means are pooled averages for all cultivars, except 'McShay.'
[y]Mean separation by Duncan's new multiple range test, P = 0.05.

Table 7. Average fruit size of five disease-resistant apple cultivars, 1994-1996.[z]

Cultivar	Fruit dia (mm)	Fruit wt. (g)
'Liberty'	72 b[y]	162 b
'McShay'	72 b	154 b
NY 75414-1	73 b	159 b
NY 74828-12	71 b	130 c
NY 65707-19	80 a	175 a

[z]Means are pooled averages for each cultivar on M.26 and Mark rootstocks.
[y]Mean separation by Duncan's new multiple range test, P = 0.05.

'NY 75414-1' produced trees of moderate vigor with good precocity and productivity, resulting in high yield efficiency (Table 5). The fruit size of 'NY 75414-1' was acceptable for commercial markets and this cultivar received high consumer acceptance scores, both at harvest and after storage (13). We think that this selection has potential for introduction as a cultivar for growers seeking a DRC with fruit characteristics similar to 'McIntosh.'

'Liberty' trees were vigorous, precocious, and productive, in agreement with previous studies (7, 10). 'Liberty' is one of the most popular DRCs introduced (4). On the basis of its productivity, as shown in this study and other reports (7, 10), as well as consumer acceptance (3, 5, 6, 12, 13), it appears likely that 'Liberty' will likely remain prominent among DRCs for the immediate future.

After six seasons growth, trees on Mark were 23% larger than trees on M.26, with 57% greater cumulative yield. Although most previous reports place Mark closer to M. 9 in tree size, a study in Maine showed that 'Marshall McIntosh' and 'Empire' trees were larger and more productive on Mark than on M.26 (11). Mark was superior to M.26 as a rootstock for the DRCs we tested, while M.27 lacked adequate vigor for commercial plantation.

Table 8. Effect of M.27, M.26 and Mark rootstocks on average fruit size of four disease-resistant apple cultivars, 1994-1996.[z]

Rootstock	Fruit dia. (mm)	Fruit wt. (g)
M.27 EMLA	67 b[y]	119 b
M.26 EMLA	73 a	156 a
Mark	75 a	157 a

[z]Means are pooled averages for all cultivars, except 'McShay'.
[y]Mean separation by Duncan's new multiple range test, P = 0.05.

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Winter Hardiness and Plant Vigor of 24 Strawberry Cultivars Grown in Denmark

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Abstract

The winter hardiness of 24 strawberry (*Fragaria x ananassa* Duch.) cultivars in a field trial planted in August 1996 was evaluated following 1996/97 winter temperatures of –12 °C with no snow cover. Significant differences among cultivars for winter hardiness were expressed by the number of dead or damaged plants. 'Senga Sengana,' 'Korona,' 'Polka,' 'Petrina' and 'Honeoye' were the most winter-hardy cultivars, whereas 'Burlington,' 'Hapil' and 'Evita' showed very low winter hardiness. A significant positive correlation was shown between winter hardiness and general plant vigor.

Introduction

Cultivated strawberries (*Fragaria x ananassa* Duch) often suffer from severe winter damage, particularly during winters with temperatures below the freezing point and no snow cover, a situation not uncommon in a number of strawberry-growing countries. Strawberry plants usually cannot endure temperatures below –12 to –15 °C (6), depending on acclimation period, weather conditions, cultivar and cultural practices (3, 10, 13, 14). Due to this relatively limited winter tolerance, artificial winter covering is commonly

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