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

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Abstract

The growth, productivity, and fruit characteristics of four summer ripening disease-resistant apple (*Malus domestica,* Borkh.) cultivars, (DRCs), 'NY 66305-139,' 'Williams' Pride,' 'Redfree,' and 'Dayton' on M.26 EMLA, M.27 EMLA, or Mark rootstocks were compared. 'NY 66305-139' was the earliest ripening cultivar, with the smallest tree size, lowest yield, and the smallest, softest fruit. 'Williams' Pride' trees were vigorous, productive, and produced large fruit with the highest percentage of red skin color compared to the other cultivars in this trial. The presence of moldy core and bitter pit in 1996, raise concerns about its commercial potential. 'Redfree' trees were intermediate among the four cultivars in vigor and precocity, and produced high yields of medium sized fruit. 'Dayton' trees were vigorous, high yielding, and produced the largest, firmest, sweetest fruit, however the September 10 ripening date was late for a summer cultivar. Mark and M.26 EMLA produced similar sized trees, while M.27 EMLA produced very small trees. A significant cultivar x rootstock interaction resulted from 'Dayton' trees being larger than 'Williams' Pride' when both were on M.26, while both cultivars produced similar sized trees on M.27 or Mark. Of the four cultivars in this trial, we consider 'Redfree' to be the best summer DRC for commercial orchards, based upon ripening date, yield, and fruit quality. Mark rootstock was preferable to M.26 or M.27 for the cultivars in this trial, with the best tree growth and precocity.

Introduction

Comparisons of the growth and productivity of DRCs are not well documented (3, 6). How DRCs perform with different rootstocks has not been reported. The present study was initiated to compare the growth and fruiting of three new DRCs with 'Redfree,' an older DRC with acknowledged fruit quality attributes (2, 3). A second objective was to determine which of three dwarfing rootstocks was most desirable for high density plantings of summer ripening DRCs.

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 'Redfree' (9), 'Dayton' (5), and 'Williams' Pride' (4), was obtained from Purdue University and scion wood for 'NY 66305-139' (6) was obtained from the New York State Agricultural Experiment Station. The trees were grown in the nursery in 1989, then headed at a height of 45 cm in the spring of 1990, as described for the "knip boom" method (1). A single shoot was allowed to grow to form a feathered tree, and the 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. The trees were individually staked and trained using slender spindle methods with tree support to a height of two m. 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, with four replications.

Trunk circumference 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. Bloom density and

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Table 1. Tree size of four summer ripening disease-resistant apple cultivars on M.27 EMLA, M.26 EMLA and Mark rootstocks.

	1991-1996			
Cultivar	TCSA (cm^2)	TCSA increase	Canopy ht (cm)	Canopy width (cm)
Redfree	17.7 b[z]	16.0 b	243 b	268 a
Dayton	33.0 a	30.9 a	301 a	285 a
Williams' Pride	27.0 a	25.2 a	241 b	281 a
NY 66305-139	10.5 c	9.3 c	242 b	231 b
Rootstock				
M.27 EMLA	7.5 b	6.3 b	207 b	161 b
M.26 EMLA	29.7 a	27.6 a	287 a	319 a
Mark	28.9 a	27.1 a	276 a	319 a

[z]Mean separation within columns for main effects of cultivars or rootstocks by Duncan's new multiple range test, $P \leq 0.05$.

fruit set were counted in 1993 and 1994. Yield was weighed annually from 1993 to 1996, and average fruit weight, fruit size, percent blush, fruit flesh firmness and soluble solids content were evaluated from a 15-fruit sample in 1994, 1995 and 1996.

Results

'Dayton' and 'Williams' Pride' had the largest TCSA, followed by 'Redfree' then 'NY 66305-139' (Table 1). Mark and M.26 EMLA produced similar sized trees, while M.27 EMLA produced very small trees. A significant cultivar x rootstock interaction resulted from 'Dayton' trees being larger than 'Williams' Pride' when both were on M.26 EMLA, but not when both cultivars were on M.27 EMLA or Mark (data not presented).

Although there was some seasonal variation, cumulative yield for 'Redfree,' 'Dayton,' and 'Williams' Pride' was similar, and greater than that of 'NY 66305-139' (Table 2). Yield efficiency was greatest for 'Redfree.' Trees on Mark produced higher cumulative yield than trees on M.26 EMLA, while trees on M.27 EMLA produced the least.

Table 2. Yield and yield efficiency of four summer ripening disease-resistant apple cultivars on M.27 EMLA, M.26 EMLA and Mark rootstocks.

	Yield (kg)				Yield Efficiency (kg/cm^2)
Cultivar	1994	1995	1996	cumul.	
Redfree	3.9 bc[z]	10.6 a	12.4 b	27.0 a	1.8 a
Dayton	6.9 a	5.1 b	16.2 a	27.8 a	1.1 c
Williams' Pride	4.4 b	11.2 a	8.9 c	24.7 a	1.2 bc
NY 66305-139	1.9 c	3.5 b	7.1 c	12.6 b	1.4 b
M.27 EMLA	2.6 b	3.1 c	4.8 b	10.1 c	1.7 a
M.26 EMLA	4.9 a	7.9 b	13.6 a	26.5 b	1.1 c
Mark	5.4 a	11.8 a	15.1 a	32.4 a	1.4 b

[z]Mean separation within columns for main effects of cultivar or rootstock by Duncan's new multiple range test, $P \leq 0.05$.

Table 3. Early fruit set of four summer ripening disease-resistant apple cultivars on M.27 EMLA, M.26 EMLA and Mark rootstocks.

Cultivar	Fruit set (%)		Fruit no./TCSA	
	1993	1994	1993	1994
Redfree	82 bc[z]	68 a	2.1 b	5.3 a
Dayton	153 a	40 b	0.8 c	2.8 b
Williams' Pride	124 ab	65 a	2.5 a	3.1 b
NY 66305-139	37 c	71 a	1.6 b	5.5 a
M.27 EMLA	74 b	64 a	2.1 a	5.4 a
M.26 EMLA	75 b	57 a	1.2 b	3.7 ab
Mark	148 a	62 a	1.9 a	3.5 b

[z]Mean separation within columns for main effects of cultivar or rootstock by Duncan's new multiple range test, $P \leq 0.05$.

'Dayton' and 'Williams' Pride' had the highest fruit set in 1993, although fruit number per unit of TCSA was low for 'Dayton,' owing to large tree size (Table 3). 'NY 66305-139' had the lowest fruit set in 1993, but was among the highest in 1994. Trees on Mark were the most precocious in 1993, but not in 1994.

'Dayton' produced the largest, firmest fruit with the highest soluble solids (Table 4). 'NY 66305-139' fruit were the smallest, least red, and softest fruit. Fruit from trees on M. 27 EMLA were consistently smaller and had higher soluble solids content than trees on M. 26 EMLA or Mark.

Discussion

Apple is both blessed and cursed with strong cultivar recognition by consumers. This recognition builds loyalty for established cultivars and makes the introduction of new cultivars time consuming and difficult. The existing summer cultivars have less consumer loyalty, due in part to the brief season of availability as well as the general mediocrity of fruit quality to

Table 4. Fruit size, fruit color, fruit firmness and soluble solids content of four summer ripening disease-resistant apple cultivars on M.27 EMLA, M.26 EMLA and Mark rootstocks.

Cultivar	Fruit weight (g)	Fruit diameter (mm)	Red surface (%)	Fruit firmness (N)	Soluble solids (%)
Redfree	135 c[z]	66 c	71 b	83 b	11.3c
Dayton	214 a	77 a	75 b	85 a	12.8 a
Williams' Pride	158 b	73 b	81 a	80 c	11.2 c
NY 66305-139	109 d	66 c	55 c	61 d	12.0 b
M.27 EMLA	138 b	69 b	73 a	78 a	12.2 a
M.26 EMLA	160 a	72 a	70 ab	77 a	11.5 c
Mark	164 a	72 a	68 b	77 a	11.8 b

[z]Mean separation within columns for main effects of cultivar or rootstock by Duncan's new multiple range test, $P \leq 0.05$.

be found among the summer cultivars. This would seem to create a niche for summer ripening DRCs. Unfortunately, each of the three new DRCs in this trial had shortcomings.

When comparing these cultivars, it is important to note that, although all were described as summer cultivars, ripening date spanned 30 days from the earliest to the latest cultivar. 'NY 66305-139' ripened unevenly between August 10 to August 19, 'Williams' Pride' between August 21 and August 27, 'Redfree' from August 28 to Sept. 5, and 'Dayton' ripened between Sept. 9 and Sept. 11.

Although 'Dayton' was the most precocious, produced high yields and the largest, firmest, sweetest fruit in this trial, it is more properly compared with fall-ripening cultivars, as the ripening dates fall between those of 'Paulared' and 'McIntosh' in Maine. Although milder in flavor, 'Dayton' would be a superior cultivar to 'Prima' for this harvest period.

'NY 66305-139' was a small, weak growing tree with low precocity and productivity, small fruit size and soft fruit flesh. Although it would be highly desirable to have DRCs with early summer ripening dates, this cultivar would seem to have low potential for commercial success.

'Williams' Pride' trees were vigorous and productive, and produced large, highly colored fruit in this trial. The ripening dates recorded in Maine for 'Williams' Pride' were one to two weeks later than those reported in the cultivar release (4). The fruit from this cultivar were subjectively rated as excellent, with at least six weeks of storage potential in refrigeration. In 1996, we observed a large number of prematurely ripened fruit, which were subsequently found to have moldy core. Nine percent of the 1996 yield of 'Williams' Pride' had moldy core, and an additional 10% had bitter pit symptoms. The trees in this study received foliar calcium sprays in 1996, and a composite leaf sample from this cultivar taken for foliar analysis revealed no mineral nutrient deficiencies. Watercore and bitter pit have been previously reported as problems with this cultivar (2).The loss of marketable yield resulting from these disorders diminishes the commercial potential for 'Williams' Pride.'

'Redfree' trees had moderate vigor and precocity, that produced a high yield of medium sized, firm red fruit. The flavor of 'Redfree' fruit is mild, but pleasant. 'Redfree' was free of physiological disorders and it kept for at least six weeks in refrigerated storage. Of the four cultivars, we consider 'Redfree' to be the best summer DRC for commercial orchards.

Survival in this study was 100% on all three rootstocks. Trees on Mark were as large as those on M.26, in agreement with previous studies (7, 8). Trees on Mark were the most precocious and produced the highest cumulative yields, therefore this rootstock would be preferable over M.26 EMLA or M.27 EMLA for use with any of the cultivars in this trial.

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