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Performance of Three Apple Cultivars on 19 Standard and Semi-Standard Rootstocks Over 10 Years

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Abstract

In 1986 'Macspur McIntosh,' 'Lawspur Rome Beauty,' and 'Redchief Delicious' apple trees on 19 standard and semi-standard rootstocks were planted at Ripley, OH. 'Macspur' produced the largest trees after 10 years, followed by 'Lawspur' and 'Redchief,' and the interaction between cultivar and rootstock for all factors measured was significant. MAC.24, B.490, MAC.4 and MAC.1 resulted in trees with larger TCA's than 'Macspur' on seedling rootstock, while 8 other rootstocks were similar in size to M.7 EMLA. Trees on MM.106 EMLA had larger TCA than 'Macspur'/MM.106, but EMLA status had no effect with M.7 or both rootstocks with the other cultivars. Trees of 'Lawspur' and 'Redchief' on MM.106 EMLA were much smaller than 'Macspur' on MM.106 EMLA. B.118 was precocious with all 3 cultivars and 'Lawspur' was particularly precocious on P.13 and MM.106. The following rootstocks had higher cumulative yields/tree than 'Macspur'/seedling, while being similar in size: MAC.4, B.118, P.18, M.4 and MM.106 EMLA. The following had higher cumulative yields/tree than 'Lawspur'/seedling, while being equivalent in size: MAC.24, MAC.4, B.118, M.4, P.13. None of the rootstocks were superior to M.7, while several of the larger rootstocks, P.13, B.118, MM.106 and MM.111 were superior to seedling.

Although most new orchards of apples are being planted on dwarfing rootstocks, some fruit growers are interested in larger, free-standing trees. A collection of promising standard and semi-standard rootstocks from around the world were gathered by TRECO and propagated to 5 cultivars. Three of these ('Redchief,' 'Golden Delicious,' and 'Granny Smith') were planted in Washington (1, 2) and 'Macspur' and 'Lawspur' planted in Ohio. A partial planting of 'Redchief' trees was included in Ohio.

Materials and Methods

In 1985, TRECO made available 'Macspur McIntosh,' 'Lawspur Rome Beauty,' and 'Redchief Delicious' trees on 19 standard or semi-standard rootstocks (listed in Table 2). The trees were planted at the Southern Branch of the Ohio Agricultural Research and Development Center near Ripley, Ohio, on a Ross moyne bonnell soil. The trees were spaced 2.75 m in row with 5.5 m between rows and trained as free-standing central leaders with minimal pruning. Soil management was a 2 m herbicide strip with mowed sod alleyways. Trees were fertilized uniformly with ammonium nitrate and received no special sprays to control fireblight. Cultivars were planted in rows with rootstocks randomized in blocks across the planting, with 10 single-tree replicates of 'Macspur' and 'Lawspur' and 5 single-tree replicates of 'Redchief.' The following rootstocks were unavailable with 'Redchief': seedling, MM.106, Ant.306, MM.104 EMLA.

Annually, trunk circumference and yield were recorded. In 1989 and 1990, a severe outbreak of fireblight occurred that resulted in significant tree loss in an adjacent planting on this farm (5). Fireblight was rated using a scale of 0 = none to 10 = whole-tree covered in strikes. After 10 years in the orchard, tree height and spread were measured and yield per hectare cal-

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Table 1. Tree size and yield of three cultivars averaged over 20 rootstocks at the end of 10 years.

							Cumulative		
Cultivar	Tree Loss (%)	Fireblight[z]	TCA cm²	Height m	Spread m	Trees/ ha[x]	Yield/ tree kg	Efficiency Kg/cm²	Yield/ Ha[x] t
Macspur	8.5	.10b	271.3a	4.9a	4.7a	317c	329.9b	1.45c	44.1c
Lawspur	3.5	.63a	119.3b	3.7c	3.5b	517b	493.7a	4.27a	103.5a
Redchief	12.5	.02b	106.5b	4.0b	3.3b	596a	298.9c	2.99b	68.6b
F-Significance[y]									
Rootstock (RS)		**	**	**	**	**	**	**	**
Cultivar (C)		**	**	**	**	**	**	**	**
RS X C		**	**	**	**	**	**	**	**

[z]Fireblight rating: 0 = no strikes to 10 = whole-tree covered in strikes.
[x]Calculated using spacing based on (actual spread at 10 yrs) x (spread + 2.5 m).
[y]NS, *, ** = nonsignificant, P = 0.05, p = 0.01, respectively.

culated using actual tree spread at 10 years as the in-row spacing and this figure plus 2.5 m as between row distance.

Results and Discussion

Tree loss over 10 years in this planting was minimal and although 'Lawspur' had the greatest amount of fireblight, the infection did not result in tree loss (Table 1). In an adjacent planting (5) of 'Lawspur' on a series of dwarfing rootstocks, 28% of the trees died mostly due to fireblight infection. 'Macspur' resulted in the largest trees of the three cultivars in TCA, height and spread and most trees exceeded their allotted space at 10 years of age. 'Lawspur' trees had the greatest cumulative yield, yield efficiency and yield/ha based on tree size at 10 years of age. Generally, the interaction of cultivar and rootstock was significant and subsequent data will present the interaction means.

Trees on MAC.24, B.490, MAC.4 and MAC.1 rootstocks had larger TCA's than 'Macspur' on seedling rootstocks; however, TCA was similar to 'Lawspur' on seedling for these rootstocks (Table 2). Eight of the rootstocks (M.2 EMLA and more dwarfing in Table 2) had smaller TCA's than seedling and were similar in size to trees on M.7 EMLA. Rootstocks MM.106 and M.7 were compared to the same clone with EMLA status and with 'Macspur' MM.106 EMLA was larger than the original clone, but the difference was not significant for M.7, even though the EMLA status trees tended to have a larger TCA. EMLA status made no difference in tree size with 'Lawspur' or the M.7 comparison with 'Redchief.' The order of rootstocks listed in Table 2 is based on TCA of 'Macspur' from largest to smallest and it is obvious that trees on 'Lawspur' or 'Redchief' do not follow that pattern. Rootstocks that stand out as differing among cultivars are MM.106 EMLA being relatively small with both 'Lawspur' and 'Redchief' and M.2 EMLA being much smaller with 'Redchief' compared to the order with 'Macspur.' P.16 was included in this planting due to the availability of extra trees, but due to its extremely small size was always different from the other rootstocks. It was included in the tables to give a contrast and to link this planting to the dwarf planting at the same location (5).

Judged by tree height and spread 'Macspur' trees on all rootstocks except P.16 greatly exceeded their allotted in-row space of 2.5 m and significant containment pruning was required for the last 5 years to hold the trees, likely resulting in reduced yield and yield efficiency (Table 2). Several studies have shown that pruning delays fruiting and decreases tree yield efficiency (3,6). Although trees of 'Lawspur' and 'Redchief' slightly exceeded their allotted space, containment pruning was minimal and would have had minimal effect on tree performance. Based on actual tree size at 10 years of age tree spacing projections for 'Macspur' ranged from 246 trees/ha on

Table 2. Tree size of three apple cultivars on 20 rootstocks at 10 years of age in Southern Ohio.

	Trunk Cross-Sectional Area (cm2)			Tree Height (m)			Tree Spread (m)		
Rootstocks	'Macspur'	'Lawspur'	'Redchief'	'Macspur'	'Lawspur'	'Redchief'	'Macspur'	'Lawspur'	'Redchief'
MAC.24	401.6	202.1	166.7	5.1	4.5	4.8	5.3	4.2	3.9
B.490	361.5	133.8	115.4	5.0	3.9	4.5	4.8	3.5	3.6
MAC.4	349.7	171.9	145.1	5.1	4.1	4.2	4.9	3.9	3.8
MAC.1	336.7	134.8	106.3	5.3	4.1	4.0	4.9	3.6	2.6
B.118	317.4	124.2	150.3	5.2	3.6	4.4	5.0	3.4	4.0
P.18	302.9	133.1	135.3	4.9	4.0	4.3	5.0	3.7	4.1
MAC.16	295.5	148.6	94.9	5.3	4.0	4.2	4.7	3.7	2.7
Seedling	288.0	164.0	—	4.9	4.1	—	4.6	3.7	—
Ant.313	285.6	114.4	112.4	5.0	3.9	4.1	4.9	3.5	3.6
M.4	275.9	127.1	117.7	4.8	3.8	4.0	4.9	3.8	3.1
MM.106EMLA	263.3	72.9	55.1	5.1	2.8	3.2	5.0	3.0	2.7
M.2EMLA	241.7	114.4	81.8	5.0	3.7	3.5	4.7	3.2	3.1
P.13	236.2	131.5	117.1	4.7	3.6	4.2	4.4	3.6	4.2
M.7EMLA	222.4	83.3	99.5	4.8	3.6	4.4	4.5	3.3	3.4
MM.111EMLA	221.2	73.9	74.7	4.8	3.3	3.6	4.5	3.0	2.7
MM.106	216.1	84.5	—	4.9	3.3	—	4.6	3.3	—
Ant.306	211.9	123.2	—	4.4	4.0	—	4.2	3.7	—
MM.104EMLA	193.5	91.2	—	4.1	3.4	—	4.4	3.2	—
M.7A	189.1	88.7	93.8	4.7	3.3	4.3	4.6	3.3	2.9
P.16	38.4	32.1	23.4	2.9	2.4	2.1	2.5	2.4	2.0
LSD .05	41.6	41.6	55.3	.54	.54	.76	.43	.43	.69

MAC.24 to 370 trees/ha on Ant.306. The smaller trees of 'Lawspur' resulted in higher projected densities ranging from 353 trees/ha on MAC.24 to 616 trees/ha on MM.111 EMLA. The upright habit of 'Redchief' would have permitted even higher tree densities ranging from 373 trees/ha on P.13 to 838 trees/ha on MM.106 EMLA. Of course, P.16 would have permitted very high densities for the cultivars as follows: 'Macspur,' 805 trees/ha; 'Lawspur,' 846 trees/ha; and 'Redchief,' 1145 trees/ha.

The fireblight infection that caused significant tree loss in an adjacent planting of these cultivars on dwarfing rootstocks (5) had no effect on tree loss in this planting and the degree of infection was slight (Table 3). Generally, 'Lawspur' had more fireblight than the other cultivars and trees on B.118, MAC.4, P.13 and MM.106 had slightly more than some other rootstocks, but generally there were only a few strikes per tree on the most severely infected. These trees had their first small crop in 1988 and combined with the next two crops, provide an estimator of precocity. Of the seedling size or larger rootstocks, B.118 stands out as being precocious with all three cultivars. P.13 and MM.106 were particularly non-precocious with 'Macspur.' It is interesting that although 'Macspur' trees on MM.106 EMLA were significantly larger than on MM.106, there was no difference in early yield/tree or yield efficiency.

A comparison of the cumulative yield/tree over 10 years shows that 'Macspur' trees on the following rootstocks that produced large trees had a higher yield than similar sized trees on seedling: MAC.4, B.118, P.18, M.4 and MM.106 EMLA. Of the 'Macspur' trees similar to M.7A in size, Ant.306 had much lower yields, while the others were similar to yields on M.7A. Of the rootstocks that produced trees similar in size (TCA) to 'Lawspur'/Seedling, the following were more productive than seedling: MAC.24, MAC.4, B.118, M.4, P.13. Of the smaller rootstocks producing trees similar in size (TCA) to 'Lawspur'/M.7A, the following

Table 3. Fireblight rating and cumulative yield and yield efficiency through the first 5 years of three cultivars on 20 rootstocks.

	Fireblight*			Cumulative yield/tree '86-'90 (kg)			Cumulative efficiency '86-'90 (kg/cm^2)		
Cultivar	'Macspur'	'Lawspur'	'Redchief'	'Macspur'	'Lawspur'	'Redchief'	'Macspur'	'Lawspur'	'Redchief'
MAC.24	.40	1.30	.00	12.0	77.8	8.4	.14	1.35	.18
B.490	.10	.50	.00	20.4	42.7	7.8	.22	1.25	.17
MAC.4	.20	1.60	.00	22.4	63.2	6.1	.24	1.18	.13
MAC.1	.00	.40	.20	9.9	40.8	7.9	.12	1.03	.21
B.118	.00	2.00	.00	30.9	60.9	17.3	.35	1.55	.22
P.18	.20	.40	.00	21.3	43.6	10.1	.26	1.21	.10
MAC.16	.14	.70	.20	13.8	39.6	9.3	.15	.88	.27
Seedling	.10	.20		6.4	34.7		.09	.88	
Ant.313	.00	.10	.00	12.0	29.8	11.4	.16	1.00	.25
M.4	.00	.30	.00	13.9	39.2	8.4	.21	1.08	.21
MM.106EMLA	.20	.40	.00	27.7	43.9	6.3	.40	1.82	.30
M.2EMLA	.20	.60	.00	27.2	36.2	7.9	.38	1.21	.24
P.13	.10	1.20	.00	20.7	63.8	7.4	.32	1.47	.28
M.7EMLA	.00	.50		23.7	29.6		.43	1.18	
MM.111EMLA	.00	.00	.00	15.3	37.7	5.7	.23	1.50	.22
MM.106	.10	1.10		30.8	55.2		.50	1.78	
Ant.306	.00	.20		6.3	40.9		.08	1.04	
MM.104EMLA	.00	.20		11.0	21.4		.14	1.07	
M.7A	.22	.60	.00	27.4	35.6	8.9	.52	1.36	.19
P.16	.20	.33	.00	6.1	18.9	4.7	.46	1.86	.37
LSD .05	.67	.67	.77	11.2	11.2	14.9	.27	.27	.41

*Fireblight rating of 0 = none to 10 = strikes over entire tree.

were more productive: MM.106, Ant.306 and B.118.

Due to their generally larger tree size, none of the large rootstocks resulted in improved yield efficiency (yield/TCA) over 'Macspur'/seedling (Table 4). 'Macspur' on the following semidwarf rootstocks had improved yield efficiency compared to seedling, but had no advantage over M.7A, the most widely planted rootstock of this group: M.4, MM.106, MM.106 EMLA, M.2 EMLA, P.13, M.7 EMLA, MM.104 EMLA. All rootstocks with 'Lawspur' resulted in improved yield efficiency compared to 'Lawspur'/ seedling. MM.106 and MM.106 EMLA had greater yield efficiency than the 'Lawspur'/M.7A. We didn't have 'Redchief'/seedling as a standard, but none of the rootstocks improved yield efficiency compared to 'Redchief'/M.7A and the following resulted in lower efficiency: MAC.24, B.490, MAC.4, MAC.1 and MAC.16.

Evaluating rootstock efficiency by calculating tree spacing based on actual tree size at 10 years of age, and projecting cumulative yield/ha emphasize the productive efficiency and smaller tree size of 'Lawspur.' Compared to 'Macspur,' 'Lawspur' was particularly efficient on the following rootstocks: MAC.24, B.490, MAC.4, MAC.1, B.118, MAC.16, P.13 and MM.106.

A companion planting to this one was set in Washington with 'Redchief' as the cultivar common to both trials (1, 2). Comparing cumulative yields of several rootstocks common to both sites, yields for the first 9 years were slightly higher in Ohio for M.7A for example, and slightly lower for B.118 and MM.106 EMLA, but overall very comparable. For the cultivars they evaluated ('Redchief,' 'Golden Delicious,' and 'Granny Smith') they found little yield increase with increase in tree size for the very vigorous rootstocks. This agrees quite well with the data for 'Macspur' and 'Lawspur' in this trial. This failure of vigorous rootstocks to promote high yields may be due to increased shad-

Table 4. Cumulative yield and yield efficiency over 10 years for three apple cultivars on 20 rootstocks in Southern Ohio.

	Yield/tree (kg)			Yield/TCA (kg/cm^2)			Yield/ha* (t)		
Rootstocks	'Macspur'	'Lawspur'	'Redchief'	'Macspur'	'Lawspur'	'Redchief'	'Macspur'	'Lawspur'	'Redchief'
MAC.24	145.5	412.2	144.9	.36	2.03	.85	35.2	145.2	57.4
B.490	125.2	226.8	139.0	.33	1.66	1.19	34.2	105.0	60.5
MAC.4	155.0	299.1	159.4	.45	1.74	1.07	42.2	120.9	63.9
MAC.1	111.9	224.6	97.7	.34	1.65	.96	30.5	101.2	72.3
B.118	168.1	258.5	220.2	.52	2.07	1.44	43.7	126.8	84.6
P.18	164.0	216.9	192.9	.55	1.61	1.42	43.4	90.1	71.2
MAC.16	121.8	246.4	68.7	.43	1.71	.72	32.2	107.1	50.0
Seedling	99.5	195.1		.34	1.22		30.7	79.7	
Ant.313	122.8	180.8	169.5	.43	1.61	1.47	32.3	85.5	76.1
M.4	189.9	259.2	144.1	.70	1.94	1.22	53.4	105.6	89.4
MM.106EMLA	205.0	187.2	92.2	.80	2.61	1.97	54.3	111.9	67.6
M.2EMLA	201.7	175.1	101.8	.83	1.58	1.22	58.9	94.2	57.5
P.13	167.3	302.0	178.3	.73	2.26	1.52	53.9	136.8	64.7
M.7EMLA	153.2	173.8	119.4	.70	2.06	1.21	49.6	89.3	59.7
MM.111EMLA	144.7	161.0	99.0	.66	2.20	1.36	45.9	94.3	68.3
MM.106	215.3	239.4		1.01	2.77		67.7	120.1	
Ant.306	93.4	227.6		.50	1.81		33.6	97.8	
MM.104EMLA	154.0	141.6		.88	1.55		51.1	75.6	
M.7A	166.3	186.6	152.3	.90	2.01	1.62	50.5	92.4	95.2
P.16	70.8	87.4	54.7	2.64	3.15	2.39	50.3	69.9	57.7
LSD .05	53.7	53.7	72.6	.31	.31	.42	58.5	58.5	79.0

*Calculated with spacing based on (actual spread at 10 yrs) x (spread + 2.5 m).

ing into the interior of the canopy of large trees (4, 9, 11).

Although none of the standard and semi-standard rootstocks in this trial were consistently better than the widely planted M.7A, several were far superior to seedling in precocity, yield/tree and yield/ha. Thus, if a large tree is desired, P.13, B.118, MM.106, or MM.111 would be preferred over seedling. This confirms previous studies showing that seedling has undesirable characteristics that recommend against planting it (7, 8, 10).

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Sensory Characteristics of Four Strains of 'Fuji' Apples

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Abstract

Four strains of 'Fuji' apples were profiled over two growing seasons for their visual and flavour/texture characteristics using descriptive analysis techniques. Trees had similar yield (number and weight of fruit) and were grown in a randomized plot at Agriculture and Agri-Food Canada, Summerland, British Columbia. Twelve judges evaluated five visual attributes (ground color, percent red, red-color saturation, stripe density and lenticels), and six flavor/texture attributes (crispness, firmness, juiciness, fruitiness, sweetness and sourness). In both years (1994, 1995), 'Fuji' strains differed in all visual attributes and crispness and sourness. There were instrumental color differences (L, a, and b measurements), but no pH, soluble solids, titratable acidity (TA) and pressure differences. In general, apples harvested in 1995 were less mature than those from 1994. This was reflected by higher TA and pressure values and lower sweetness, fruitiness and juiciness scores.

Introduction

There is interest in establishing plantings of new apple cultivars where the fruit have a high return, good storage capability and superior eating quality (9, 12). 'Fuji' ('Rails Janet' X 'Delicious') (14) is one such cultivar (12). Numerous red-striped and solid-red color strains are available (9). While mutant strains of 'Gala' (8), 'Jonagold' (8, 5) and 'Delicious' (3) have been evaluated, limited information is available (9) about the flavor and texture of 'Fuji' strains. Therefore, the purpose of this research was to document the nature and magnitude of the visual and flavor/texture differences among four 'Fuji' strains.

Materials and Methods

Apples: Four strains of 'Fuji' apples ('Fuji,' 'Redsport #1,' 'Redsport #2,' and 'Nagano #1') were grown on M.26 rootstock in a randomized plot at Agriculture and Agri-Food Canada, Research Station Summerland. Trees were established in 1991 and trained as slender spindles. Trees were cropped in 1993. Fruit from the 1994 and 1995 growing seasons were obtained from spur buds and harvested, at the same time, on the last possible commercial harvest date (limited by local weather conditions). In 1994, full bloom and harvest occurred on April 27 and Oct 14. In 1995, full bloom and harvest occurred on May 6 and Oct 16.

In 1994, apples from four trees were evaluated for each strain; in 1995, only two trees of each were available. The yield and number of apples per tree were recorded. Apples were stored for four months in air storage at 0 C until sensory evaluation.

From each tree, 12 defect-free apples of a similar size and shape were selected. Six of these apples were polished and used for the visual evaluation; the rest were used for the flavor/texture and analytical evaluations.

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