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Impact of Apple Rootstock/Cultivar on Processing Market Profitability

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Abstract.

Four apple cultivars suitable for processing ('York Imperial', 'Rome Beauty', 'Stayman', and 'Smoothee Golden Delicious') and four rootstocks (M.26 EMLA, M.9 EMLA, O.3 and B.9) used in a ten-year experiment at Rock Springs, PA were evaluated for relative profitability. Based on cash flow measures, 'Rome Beauty' out performed the other three cultivars by a wide margin because of early yields of large sized fruit. M.26 EMLA was found to be the best rootstock for 'Rome Beauty' because of its high expected cash flow and low variability of income. O.3 was found to be the best rootstock for 'York Imperial', 'Stayman', and 'Smoothee Golden Delicious' based on the same measures. B.9 was found to have the lowest average cash flow and highest income variability for all four cultivars at the experiment's density of 961 trees/ha. However, at higher densities which would be possible given tree cross sectional area measurement, B.9 was found to be the best rootstock in terms of cash flow for 'York Imperial', 'Rome Beauty', and 'Smoothee Golden Delicious', while O.3 remained the best rootstock for 'Stayman'. To overcome the cash flow differential between 'Rome Beauty' and the other cultivars, prices would need to be 23-94% higher depending on the rootstock used.

Introduction.

Selection of a profitable cultivar/rootstock combination is a critical aspect in the production of any tree fruit. The cost of establishing an apple orchard makes it imperative that a fruit producer have the most complete information available when selecting cultivars and rootstocks. The choice of cultivar and rootstock will affect the future profitability of the orchard through its impact on yield and fruit quality. Evaluating the economic feasibility of alternative cultivar/rootstock combinations is vital to preserving and improving the competitive position of Mid-Atlantic apple growers.

In recent years there has been considerable research looking at the impacts of apple rootstocks on tree yield and growth (6, 7, 8). Studies by Harper and Greene (4) and Harper, Greene, and Swaminathan (5) have evaluated the impact of rootstocks on profitability for single fresh-market peach and apple cultivars in the NC-140 trials at Biglerville, PA. This analysis will expand on these earlier studies by evaluating the relative profitability of four processing cultivars and four rootstocks.

Materials and Methods.

As part of the NC-140 apple rootstock trial, four processing cultivars ('Smoothee

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Golden Delicious', 'York Imperial', 'Stayman' and 'Rome Beauty') were planted in the spring of 1990 at Rock Springs, PA. Each cultivar was propagated on M.26 EMLA (M.26), M.9 EMLA (M.9), Ottawa 3 (O.3), and Budagovsky 9 (B.9) (with the exception of 'Stayman' on M.9). Specific details regarding the establishment and maintenance of the trees used in this study has been presented previously (8).

Fruit were harvested from 1993-99 from each replicate tree. The number of fruit per tree was counted and total yield per tree was weighed. Fruit were kept separately by tree and transported to the Product Evaluation Lab at the Horticulture Research Farm. Fruits were graded mechanically utilizing a Greefa™ rotary grading machine that separated the fruit based on fruit diameter. Fruit was separated into 3 size categories that corresponded to size classifications established by local processing companies, < 63.5 mm, 63.5 - 70.0 mm, and >70.0 mm. After the fruit from each individual tree was run through the grader the number of fruit per size class was counted and the percent of fruit in the three categories was determined. In order to evaluate the effect of yield and fruit size on profitability, net return streams were projected for each cultivar/rootstock combination. Cost of production for each combination was estimated by adjusting budgets found in Harper (3) to the proper tree densities. Support system costs were based on staked conduit and wire systems estimated by Crassweller (1). Pruning labor costs were based on an hourly wage of $10/hour and the estimated pruning and training times from Funt et al. (2). Estimated tree density for the experiment was 961 trees/ha. Harvest cost depends on yield and was charged at 6.2¢/kg. Annual yields per hectare were calculated by multiplying the estimated tree density by the average yield for each cultivar/rootstock combination. Fruit size data was used to apportion total yield into the three price categories used by processors. The seven-year (1993-1999) averages of processing prices offered by Knouse Foods Cooperative (the largest apple processor in Pennsylvania) are listed in Table 1 for each of the cultivars and size categories. Using the yield and the size data and yearly processing prices, gross returns were calculated for each cultivar and rootstock annually. Net returns were then calculated by subtracting the appropriate production, planting, pruning, and harvest costs from gross returns. There was no tree mortality in the experiment.

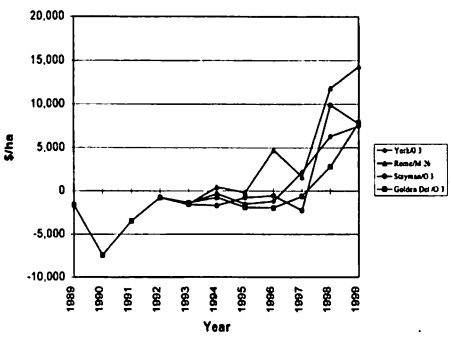

Figure 1. Annual cash flow for most profitable rootstock by cultivar based on 961 trees/ha.

Results and Discussion

Yields per hectare varied considerably for the four processing cultivars and the four rootstock treatments (Table 2). Average yield was highest for 'Rome Beauty' on M.26 and lowest for 'Smoothee Golden Delicious' on B.9. 'Rome Beauty' had the highest average yield for each of the rootstocks and the lowest relative yield variability as measured by the coefficient of variation (c.v.; the standard deviation divided by the mean, expressed as a per-

Table 1. average procesing apple prices ($/metric ton), Knouse Food Cooperative, Biglerville, PA, 1993-1999.

	Fruit Size		
Cultivar	<63.5 mm	63.5-70.0 mm	>70.0 mm
'Rome Beauty'	$101	$166	$198
'Stayman'	$101	$188	$230
'Golden Delicious'	$101	$188	$230
'York Imperial'	$101	$199	$246

Table 2. Average yield (metric tons/ha) for four processing cultivars on four rootstocks, Rock Springs, PA 1993-1999.

Cultivar	Rootstock M.26	M.9	O.3	B.9
'York Imperial'				
average	25.28	28.26	27.87	24.64
coefficient of variation (%)	116.1	117.0	92.6	109.6
'Rome Beauty'				
average	50.29	44.98	42.63	36.38
coefficient of variation (%)	85.2	78.5	74.6	77.7
'Stayman'				
average	23.16	--	27.63	18.29
coefficient of variation (%)	142.1	--	122.0	123.8
'Smoothee Golden Delicious'				
average	20.02	20.45	22.21	16.65
coefficient of variation (%)	113.7	110.2	107.9	114.7

centage). 'Smoothee Golden Delicious' had the lowest average yields and 'Stayman' had the highest coefficients of variation. Cultivars on B.9 had the lowest yields and cultivars on M.26 tended to have more relative yield variability.

Fruit size also varied considerably across cultivars and rootstocks (Table 3). 'Rome Beauty' had the most fruit in the >70.0 mm category for each of the four rootstocks. 'York Imperial' had the most fruit in the 63.5-70.0 mm category for all rootstocks except 'Smoothee Golden Delicious' on B.9. 'York Imperial' also had the most fruit in the <63.5 mm category for all rootstocks except 'Smoothee Golden Delicious' on O.3. The relative variability of the percentage of fruit falling into each size category tended to decline as fruit size increased. In general, M.26 had the most fruit in the >70.0 mm fruit category and the least relative variability in size for all four cultivars.

The average processing price received is given for each cultivar and rootstock in Table 4. The average price received is a function of the proportion of fruit in each size category and the prices offered for each size in a given year. 'York Imperial' had the highest average price received across all rootstocks. M.26 had the highest average price received across cultivars and the lowest relative variability (with the exception of 'Smoothee Golden Delicious' on B.9). Despite the highest proportion of fruit in the >70.0 mm size class, 'Rome Beauty' had the lowest average price received.

Estimates of total and average cash flow for each cultivar and rootstock is given in Table 5. Cash flow is the difference between cash coming into a business from sales and cash paid out for expenses. Negative cash flows for the period from 1989 (year of land preparation) to 1992 represents the preproductive years before any apples are available for sale. Cash flows starting in 1993 reflect the difference between cash outflows and inflows. Of the four cultivars, only 'Rome Beauty' has positive total cash flow for the period from 1989 to 1999. Total cash flow changed from negative to positive in 1998 for M.26 and M.9 and in 1999 for O.3 and B.9. The change from negative to positive is of in-

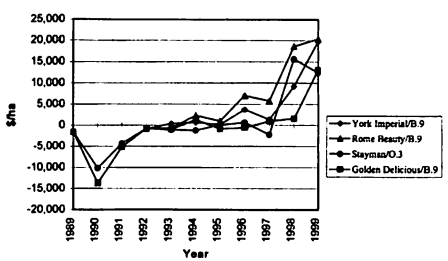

Figure 2. Annual cash flow for most profitable rootstock by cultivar based on hypothetical densities.

Table 3. Percentage of fruit in three processing size categories for four processing cultivars and four rootstocks, Rock Springs, PA, 1993-1999.

Cultivar	Rootstock M.26	M.9	O.3	B.9
'York Imperial'	Average Percent			
<63.5 mm	8.7%	10.4%	10.2%	10.1%
63.5-70.0mm	25.8%	27.7%	32.1%	25.3%
>70.0 mm	65.5%	61.9%	57.7%	64.6%
	Coefficient of Variation (%)			
<63.5 mm	41.4	76.4	46.5	68.6
63.5-70.0mm	34.9	30.4	18.8	26.3
>70.0 mm	12.3	25.0	15.1	20.7
'Rome Beauty'	Average Percent			
<63.5 mm	2.0%	2.5%	4.7%	3.1%
63.5-70.0mm	7.6%	11.0%	18.0%	10.2%
>70.0 mm	90.4%	86.5%	77.4%	86.6%
	Coefficient of Variation (%)			
<63.5 mm	50.3	78.1	83.3	47.7
63.5-70.0mm	23.7	73.8	81.7	36.0
>70.0 mm	2.8	11.4	23.7	5.8
'Stayman'	Average Percent			
<63.5 mm	3.2%	--	5.7%	8.9%
63.5-70.0mm	19.6%	--	25.4%	23.4%
>70.0 mm	77.2%	--	69.0%	67.7%
	Coefficient of variation (%)			
<63.5 mm	114.5	--	122.3	154.5
63.5-70.0mm	71.9	--	78.8	85.6
>70.0 mm	22.1	--	38.7	48.8
'Smoothee Golden Delicious'	Average Percent			
<63.5 mm	5.5%	6.1%	11.2%	9.8%
63.5-70.0mm	25.4%	25.5%	31.4%	27.7%
>70.0 mm	69.0%	68.5%	57.4%	62.5%
	Coefficient of Variation (%)			
<63.5 mm	94.8	95.0	116.8	82.2
63.5-70.0mm	53.5	58.1	38.8	52.4
>70.0 mm	26.5	29.0	41.0	35.7

terest to growers because it represents the amount of time required to recoup preproductive costs. The high early yields of 'Rome Beauty' more than compensate for the lower average price received (Table 4). Total cash flows for the productive period (1993 to 1999) are also given; all cultivars and rootstocks except 'Stayman' on B.9 had positive total cash flows during this time. Cash flows for each cultivar and rootstock were estimated to be the same during the preproductive period. This was because the same practices would be used for land preparation, trees were planted at the same density, pruning costs were assumed to be the same (because overall tree height and spread was not statistically different), and the same conduit and wire support system was budgeted for all cultivar/rootstock combinations. 'Rome Beauty' had the highest average cash flow during this period, around 2-3 times higher than for 'York Imperial' depending on the rootstock.

Rootstock had a large impact on cash flow (Figure 1). M.26 has the highest cash flow for 'Rome Beauty', while O.3 had the highest cash flow for 'York Imperial', 'Stayman', and 'Smoothee Golden Delicious'. In this study the rootstock with the highest average cash flow for each cultivar also had the lowest income variability. This is unlike the findings of previous economic evaluations by Harper and Greene (2) and Harper, Greene, and Swaminathan (3) which found clear opportunities for decision makers with different risk prefer-

Table 4. Average price recieved ($/metric ton) for four processing cultivars based on fruit size measurements, Rock Springs, PA 1993-1999.

Cultivar	Rootstock M.26	M.9	O.3	B.9
'York Imperial'				
average	221.70	219.99	216.02	220.70
coefficient of variation (%)	11.6	12.4	12.0	12.5
'Rome Beauty'				
average	194.07	191.73	186.36	191.94
coefficient of variation (%)	11.1	12.7	15.0	11.2
'Stayman'				
average	220.52	--	215.96	214.83
coefficient of variation (%)	11.7	--	14.5	15.1
'Smoothee Golden Delicious'				
average	212.18	211.46	202.92	207.76
coefficient of variation (%)	13.7	13.9	14.5	11.6

Table 5. Total and average cash flow ($/ha) for four processing cultivars on four rootstocks planted at 961 trees/ha, Rock Springs, PA 1989-1999.

Cultivar	Rootstock M.26	M.9	O.3	B.9
'York Imperial'				
total, 1989-99	-3,321	-2,586	-1,756	-5,607
total, 1993-99	9,935	10,670	11,500	7,649
average, 1993-99	1,419	1,254	1,643	1,093
coefficient of variation (%)	312.2	283.3	231.8	319.5
'Rome Beauty'				
total, 1989-99	17,932	12,030	7,809	3,448
total, 1993-99	31,188	25,286	21,065	16,744
average, 1993-99	4,455	3,612	3,009	2,392
coefficient of variation (%)	139.9	143.0	151.0	169.4
'Stayman'				
total, 1989-99	-6,447	--	-2,461	-13,936
total, 1993-99	6,809	--	10,795	-680
average, 1993-99	973	--	1,542	-97
coefficient of variation (%)	505.0	--	326.3	-2,894.8
'Smoothee Golden Delicious'				
total, 1989-99	-10,380	-9,937	-9,101	-15,448
total, 1993-99	2,876	3,319	4,155	-2,192
average, 1993-99	411	474	594	-313
coefficient of variation (%)	867.1	718.2	606.4	-768.8

ences to make tradeoffs between the expected value (average cash flow) of an alternative rootstock and its variability (risk). The difference may be due to the fact that the rootstocks in the present study were as a group closer in size to each other than the rootstocks in the previous study. The results also indicate that the second best rootstock in terms of average cash flow and variability is M.9 for 'Rome Beauty', 'York Imperial', and 'Smoothee Golden Delicious'. The second best rootstock for 'Stayman' (which was not evaluated on M.9) was M.26. At the end of the study cultivars on B.9 were the smallest while those on M.26 were the largest as measured by TCSA (Table 6). However, tree height and spread were not different. The trees had filled the allotted row space.

Table 6. Tree size as measured by trunk cross-sectional area (1999) and hypothetical desitites/ha compared to M.26.

Rootstock	TCSA	%of M.26	Hypothetical density
M.26	97.1	100.0	961
M.9	71.8	73.9	1,297
O.3	65.5	67.5	1,426
B.9	46.1	47.5	2,026

The effect of a closer tree spacing on cash flow is estimated in Table 7. Assuming that the tree density used in the experiment reflects the proper density for the largest trees (M.26), the relative density of the other rootstocks were adjusted on the basis of their TCSA compared to M.26 (Table 6). Cash flows were adjusted to reflect higher costs for M.9, O.3, and B.9 because of higher planting, pruning, and support system costs. Based on the higher yields per hectare reflected by these hypothetical densities, B.9 and O.3 become the most profitable rootstocks and M.26 becomes the least profitable (Figure 2). B.9 has the highest cash flow for three of the cultivars, with the exception of O.3 on 'Stayman'. 'Rome Beauty' was the only cultivar where all four rootstocks had positive total cash flows for the period 1989-99. 'Rome Beauty' also had the highest cash flows of the four cultivars for each of the rootstocks. In addition, it exhibited the least cash flow variability.

Although these estimates do not necessarily reflect the proper density for these rootstocks, it does indicate that profitability is very sensitive to tree density. It also indicates that the high yield of 'Rome Beau-

Table 7. Total and average cash flow ($/ha) for four processing cultivars on M.26 at 961 trees/ha, M.9 at 1,297 trees/ha, O.3 at 1,426 trees/ha, and B.9 at 2,026 trees/ha, Rock springs, PA, 1989-1999.

	Rootstock			
Cultivar	M.26	M.9	O.3	B.9
'York Imperial'				
total, 1989-99	-3,321	4,158	8,381	13,996
total, 1993-99	9,935	20,178	25,320	35,297
average, 1993-99	1,419	2,883	3,617	5,042
coefficient of variation (%)	312.2	196.7	152.2	143.7
'Rome Beauty'				
total, 1989-99	17,932	23,884	22,568	33,138
total, 1993-99	31,188	39,904	39,507	54,469
average, 1993-99	4,455	5,701	5,644	7.781
coefficient of variation (%)	139.9	119.9	117.4	108.5
'Stayman'				
total, 1989-99	-6,447	--	7,335	-3,591
total, 1993-99	6,809	--	24,274	17,740
average, 1993-99	973	--	3,468	2,534
coefficient of variation (%)	505.0	--	211.8	229.5
'Smoothee Golden Delicious'				
total, 1989-99	-10,380	-5,763	-2,514	-6.778
total, 1993-99	2,876	10,257	14,425	14,553
average, 1993-99	411	1,465	2,061	2,079
coefficient of variation (%)	867.1	303.3	252.8	238.6

Table 8. Price increase required for cash flows to be equal to 'Rome Beauty' on the same rootstock, 1989-1999.

	Rootstock			
Cultivar	M.26	M.9	O.3	B.9
'York Imperial'	54%	35%	23%	24%
'Stayman'	69%	--	25%	67%
'Golden Delicious'	94%	71%	52%	80%

ty' compared to higher value cultivars like 'York Imperial', 'Stayman', and 'Golden Delicious' made it more profitable to grow. To overcome the cash flow differential between 'Rome Beauty' and the other cultivars, prices would need to be 23-94% higher depending on the rootstock used (Table 8). Even with higher prices, 'Rome Beauty' would continue to have the least cash flow variability, an important consideration for growers trying to manage financial risk.

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