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Stool Layering Ability of Thirty-one Apple Rootstock Cultivars[1]

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Abstract

Twenty-seven apple clonal rootstocks were compared for stool layering ability in a randomized and replicated trial 3, 4 and 5 years after planting. Observations on the rooting of four other apple rootstocks in stool layer beds in adjacent non-replicated plots are also included. The mean number of rooted shoots produced per m of row increased from the third to the fourth year and then leveled off. The change in production of rooted shoots among rootstocks with year was small. Thirteen rootstocks, including V5-38, Malling-Merton (MM.)111, Malling (M.)26, Budagosky (B.)54-118, MM.106, Morden (MO.)56-4, M.4, B.490, B.491, M.27, B.54-233, Alnarp 2, M.7, Jork 9, Robusta 5, P-18, and P-16 were significant by higher than or indistinguishable from M.9 in production of rooted shoots. P-22, B.9, P-2, P-1, Ottawa 3, and MO.56-3 produced significantly fewer rooted shoots than M.9. Antonovka, I48-41, and M.25 produced very few rooted shoots. Production of rooted shoots was closely related to rooting ability but the most productive rootstocks tended also to produce the highest number of shoots per meter. Furthermore, the amount of root formation was greatest on shoots of the most productive rootstocks. In the observation block, MARK, B. 54-146, YP(Mb-4) propagated as well as M.9, whereas M.20 did not. B.54-146 was noteworthy because of the numerous, long roots that developed on its shoots.

Introduction

Stool layering, sometimes referred to as mound layering or stooling, is the most common method of propagating apple rootstock clones. All of the Malling series and many new rootstocks have been selected for their ability to propagate in this way.

The stool layering capability of many new rootstocks have been summarized (2, 3) but few designed experiments have been conducted to compare their stool layering. In this study, we compare the shoot production levels and layer quality of 27 apple rootstock clones in replicated plots and report observations on 4 others in non-replicated plots.

The thirty-one rootstocks included 7 Malling (M.) rootstocks from the East Malling Research Station, U.K.: M.9, M.7, M.20, M.25, M.26, and M.27. Two Malling Merton rootstocks, MM.106 and MM.111 released from East Malling Research Station and John Innes Horticultural Institute were also included. There were four Canadian rootstocks. Two, Ottawa (O).3 and Robusta 5, were selected at the Ottawa Central Experimental Farm, and two, Morden (MO.) 56-3 and MO.56-4, were developed at the Research Station, Morden. Alnarp (A.) 2 was developed at the Swedish University of Agricultural Science, Sweden. Several rootstocks were developed in the USSR, including Budagovsky (B.) 9, B.54-118, B.54-146, B.54-233, B.490, and B.491 developed at the I. V. Michurinsk Experimental Station, Michurinsk, and I48-41 and V5-38 developed at the North-Caucasian Research Institute of Horticulture and Viticulture, Krasnodar. Jork 9 (J9) was developed at Jork Research Station in West Germany. MARK was developed at the Michigan State University, East Lansing. The Polish series, P-1, P-2, P-16, P-18 and P-22, developed at the Fruit Research Station, Skierniewice, was also included. YP(Mb-4) is a *Malus baccata* selec-

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tion from the Agricultural Research Center, Piikiö, Finland. The Antonovka clone that was studied was one that is used as a seed source for seedling rootstocks at Summerland, B.C.

The parentage and horticultural characteristics, pest resistance, and cold hardiness of many of these rootstocks were reviewed by Cummins and Aldwinkle (2) and by Ferree and Carlson (3). The exceptions are MO.56-3, MO.56-4, I48-41 and V5-38. The Morden rootstocks derived from open pollinated Robusta 5 seedlings and were selected for resistance to iron-induced chlorosis.

Materials and Methods

Twenty-eight apple rootstocks were received as scionwood from the Plant Quarantine Station, Agriculture Canada, Sidney, B. C. where they had been virus indexed. MO.56-3 and MO.56-4 were received directly from the Research Station, Morden. They were budded onto Antonovka seedlings. The budded trees were used to establish the stoolbeds by a nurse graft technique. The rootstock of the budded tree was tied off with copper wire and the tree was planted deeply in a trench. Most of the root pieces gradually died, but any that survived and produced suckers were dug out and removed. The scions were bent down and pegged to the ground with small wire hoops. They were grown for one year, and in the second year the new shoots that had developed were cut back to 10 cm stubs and sawdust applied to the level of the cut shoot. In the third year the current season shoots were cut back and the new shoots that develoed on the stubs were mounded with sawdust. In the third to fifth year, the stoolbeds were uncovered in autumn and the rooted shoots were harvested. Sawdust that was removed during harvesting was raked back over the stoolbed after harvest to protect the stoolbed from winter injury. The stools were exposed in the spring and nitrogen fertilizer (200 g N per m) was applied as a band before growth resumed. Foliar applications of 20-20-20 were applied 2 or 3 times (5 kg/ha) per season. Water was applied with overhead micro-sprinkler irrigation. One rootstock, MARK, was received as rooted shoots from Oregon Rootstock Incorporated, and stoolbeds were developed directly from the rooted shoots in a similar way.

Twenty-seven of the rootstocks were planted in a Randomized Complete Block Design with 4 blocks. Each plot consisted of 3 mother plants spaced at 0.5 m. The scion of the rootstock was cut to 0.5 m making the initial plot 1.5 m long. No attempt was made to maintain each mother plant in the plot separately. The total number of shoots and the number of rooted shoots were counted in each plot and expressed on a meter basis. The roots formed on each rooted shoot were also scored based on the number and length of roots. The data were analyzed by analysis of variance and Duncan's new multiple range test was used to separate the means. There were insufficient plant numbers of four other rootstock clones to include in the replicated experiment and these were planted in 3 m plots adjacent to the replicated blocks.

Results and Discussion

Analyses of variance of the number of shoots produced per m, the number of rooted shoots per m, and root quality scores indicated a significant effect of rootstock for all variables (Table 1). There was a significant year effect for number of shoots and number of rooted shoots, but not the root scores. A small effect of rootstock within year was also found for the number of root shoots per m.

The 27 rootstocks are ranked in order of mean number of rooted shoots produced per year (Table 2). The rootstocks were observed to vary in production of rooted shoots from 0.2

Table 1. Analysis of variance for the effect of rootstock and year on the total shoot production (shoots/m), rooted shoot production (rooted shoots/m), and root score (scored 1-5) in stool layer beds.

		Mean square		
Source of variation	df	No. shoots/m	No. rooted shoots/m	Mean root scores (1-5)
Rootstocks	26	1129.29**z	1890.03**	4.641**
Replicates	3	540.59	64.68	0.477
Replicates x rootstocks (Error A)	78	534.89	102.51	0.348
Years	2	8476.06**	6516.08**	0.042
Rootstocks x years	52	489.27	131.92**	0.397**
Error B	161	452.18	64.69	0.225

z** Significant at the 1% level of probability.

rooted shoots per m for Antonovka to 50.8 rooted shoots per m for V5-38. The Malling clones, with the exception of M.25 and M.7, propagated well. Production of these rootstocks varied from an average of 18 shoots per m for M.7 to 44 rooted shoots per m for MM.111. M.9 is an accepted standard for stool layer production. The rootstocks V5-38, B.54-118, MO.56-4. B.490, B.491, B.54-233, A.2, J9, Robusta 5, P-18, and P-16 were significantly higher or indistinguishable from M.9 in production of rooted shoots, whereas the rootstocks P-22, B.9, P-2, P-1, and O.3 were significantly lower than M.9 in production of rooted shoots. The rootstocks I48-41, Antonovka, and M.25 practically failed to root.

Production of rooted shoots in the stool layer beds increased from the the third to the fourth year and then leveled off (Table 2). The small rootstock within year effect indicates production did not increase at the same rate in all rootstocks but this effect was not great and no attempt was made to further explore these differences.

A high, significant correlation (r = 0.94, significant at the 5% level) was found between the percentage rooting and the number of rooted shoots produced per m. The correlation between total number of shoots produced and number of rooted shoots produced per m was low (r = 0.29, not significant at the 5% level). Thus, the production of rooted shoots appeared to be more closely related to the rooting capability to root than to total shoot production. Scoring the rooted shoots for amount of rooting (number and length of roots) indicated that the rootstocks that produced the highest number of rooted shoots also produced shoots with the greatest amount of root formation.

In adjacent observation plots MARK, B.146, and YB(MB-4) appeared to have stool layering ability equal to or better than M.9, whereas M.20 appeared to be deficient in production of rooted shoots. B.54-146 is noteworthy in that it produced many long, well developed roots.

The ease of propagation by stool layering observed for some rootstocks in this study, e.g., M.7, M.25, P-1, P-2 and P-22, appeared to be lower than previously reported (3). It is known that plants lose their rooting capability as they change from the juvenile to the adult growth phase (6). This previously occurred in Robusta 5 (1) and has been proposed as the cause of decline in rooting capability of O.3 (5). It is noteworthy that both of these rootstocks had low propagation capability in this study. Juvenility may possibly have been lost in some of the rootstocks in this study and this may have resulted in low rooting capability.

Table 2. Production of rooted shoots, total number of shoots and root scores on rooted shoots in stool layer beds of twenty-seven clonal rootstocks.

Rootstock	No. of rooted shoots/m 1986	1987	1988	Mean	Mean annual no. of shoots/m	Percentage rooted shoots	Mean root score (1-5)[z]
V5-38	28.9a[y]	54.9a	48.7a	44.2a	50.8ab	86.8	2.5a
MM.111	23.2ab	47.7ab	49.4a	40.1ab	48.2abc	83.2	2.0abcd
M.26	21.9ab	53.4a	36.0abc	37.1ab	46.5bcd	79.8	2.0abc
B.54-118	20.2abc	40.5abc	43.5ab	34.7bc	39.7bcd	87.4	2.2ab
MM.106	22.6ab	37.3bc	34.9abc	31.6bcd	33.9bcd	93.2	2.2ab
MO.56-4	17.1abcd	32.9bcd	30.4bcde	26.8cde	40.1bcd	66.8	1.6bcde
M.4	17.6abc	36.1bc	25.8cde	26.5cde	33.8bcd	79.3	2.0abc
B.490	8.0bcd	23.4cdef	44.2ab	25.2de	35.6bcd	70.8	1.7bcd
B.491	7.1bcd	28.2cde	34.7abcd	23.3def	31.6bcd	73.7	1.7bcde
M.27	9.5bcd	30.5cd	25.1cde	21.7efg	33.0bcd	63.6	1.7bcd
M.9	12.0bcd	26.1cde	24.1cdef	20.7efg	28.9bcd	71.6	1.5bcd
B.54-233	7.2bcd	20.5def	30.2bcde	19.3efg	32.9bcd	58.7	1.8bcd
A.2	4.3cd	24.3cdef	26.3cdef	18.3efg	38.1bcd	48.0	1.4defg
M.7	7.7bcd	25.0cde	19.9cdef	17.5efgh	40.5bcd	43.2	1.6bcde
J.9	8.3bcd	19.6def	18.9defg	15.6fghi	27.1cd	57.6	1.7bcd
Robusta 5	3.4d	13.4ef	24.7cdef	13.8fghi	35.1bcd	39.3	1.3defgh
P.18	3.1d	19.0def	15.4efghi	12.5ghi	35.6bcd	35.1	1.3defgh
P.16	7.3bcd	12.4efg	17.3efg	12.3ghi	23.6d	52.1	1.5cdefg
P.22	3.6d	11.4fg	10.8efg	8.6hij	30.1bcd	28.6	1.5cdef
B.9	1.1d	7.7fg	15.6efghi	8.1hij	24.6d	32.9	1.1efgh
P.2	1.5d	8.1fg	14.6efghi	8.1hij	25.3cd	32.0	1.0fgh
P.1	1.3d	6.3fg	12.2fghi	6.6ij	27.9bcd	23.7	0.8h
O.3	0.7d	8.4fg	8.8ghi	6.0ij	28.6bcd	20.6	0.9gh
MO.56-3	0.0d	4.3fg	2.2hi	2.4j	44.1bcd	5.4	0.8h
I48-41	0.0d	0.5g	0.4gi	0.3j	68.3a	>0.1	0.2i
Antonovka	0.2d	0.0g	0.4gi	0.2j	26.5cd	>0.1	0.2i
M.25	0.0d	0.0g	0.6gi	0.2j	32.7bcd	>0.1	0.2i
	8.9	21.9	22.8	17.9	35.6		1.4
S.E.	±5.1	±5.1	±5.1	±2.9	±6.7		±0.2

Contrast of mean no. of rooted shoots/m by year:
1986 vs. 1987**; 1987 vs. 1988 N.S.[x]

[z]1 = one or two short roots from one point on the shoot, 2 = several short shoots from one point, 3 = several short roots from 2 or more points, 4 = several long roots from 2 or more points, and 5 = long roots from more than two points.
[y]The unlike letters within columns indicate mean separation by Duncan's new multiple range test at the 5% level.
[x]Significantly different at the 1% level; N.S. = non-significant.

Table 3. Production of rooted shoots, percentage of rooted shoots and root score on rooted shoots in unreplicated observation stool layer beds of 4 rootstocks.

Rootstock	No. of rooted shoots/m 1986	1987	1988	Mean	Percentage rooted shoots	Mean root score (1-5)[z]
MARK	12.5	25.7	42.5	26.9	88.7	2.1
B.146[y]	—	11.0	28.7	19.9	98.0	3.5
YP(Mb-4)	—	6.4	25.7	16.0	35.0	1.2
M.20[y]	—	8.0	13.7	10.9	42.0	1.3

[z]The scoring system is indicated in Table 2.
[y]The plot was planted in 1986.

Rooting capability may be maintained by severe pruning (1) and, recently, rooting capability has been recovered in plants of O.3 propagated from the adult phase by meristem culture (H. A. Quamme and E. J. Hogue, unpublished data). Although loss of rooting capability during growth phase transition may be prevented by pruning and may be recovered once lost, it is an undesirable characteristic in rootstocks. A number of rootstocks did propagate well in this study. These may have the best potential for commercial use and may also be useful as parents in future rootstock breeding programs.

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The Interaction Between Fruit Size and Yield in Sweet Cherry

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Abstract

The size of 'Bing' cherries is negatively related to yield where leaf area is relatively constant. Data from three years with light, moderate, and heavy yields and six pruning treatments of varying severity produced a regression line where y = 9.7 - .0062x with r = -.95 where y = grams per cherry, x = kg per tree. Since leaf area was relatively constant, this relationship demonstrates the effect of L:F ratio on fruit size. Cherry cultivar evaluation can be improved by recognizing this relationship. Even crude estimates of L:F, plotted against fruit size, separated cultivars that produced large fruit with heavy yields from those that did not.

Introduction

New cultivars are usually described as having large fruit, or fruit of a particular diameter, weight or volume (1, 2, 3, 4, 8). However, fruit size can vary for many reasons but depends primarily on leaf area per fruit (7, 9). When size and yield data are available, the influence of differences in leaf area per fruit on fruit size usually is ignored or sometimes misinterpreted. A method to compare the size of fruits from different cultivars at the same leaf:fruit ratio (L:F) would be useful, especially when yields vary widely due to environmental conditions. Determining L:F is cumbersome in the field. Yield per tree can be determined readily and can serve as a first approximation of L:F, especially if tree size and vigor are relatively constant. With young bearing trees yield per unit trunk cross-sectional area is a useful representation of relative leaf area. This paper presents data from four

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