The Effect of Scion and Graft Union on Root Growth Potential (RGP) of Two Seedling Cherry Rootstocks, *Prunus mahaleb* L. and *P. avium* L. "Mazzard"

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Abstract

Root growth potential (RGP), measured as capacity to regenerate new roots following transplanting, was evaluated in two seedling cherry rootstocks, *Prunus mahaleb* L. and *P. avium* L. "Mazzard" at bud swell following 2 growth cycles. Each of these stocks was treated as follows: unbudded, budded with *P. cerasus* cv. 'Montmorency,' and with itself. Mazzard rootstocks displayed a significantly higher RGP than Mahaleb rootstocks. Presence of 'Montmorency' as a scion on Mazzard rootstocks significantly increased new root production compared to unbudded stocks and those budded with Mazzard F12/1. No comparable effect was seen when 'Montmorency' was budded on Mahaleb stocks.

Additional Index Words. Prunus cerasus cv. Montmorency, rooting, transplanting.

Introduction.

The influence of rootstock on the growth and morphology of the scion in a 2-piece tree are well documented (1, 17, 18, 21, 22), but there is relatively little information which describes the effect of the scion or the graft union on the morphology or performance of the rootstock root system, particularly its Root Growth Potential (RGP), defined as the total quantity of new roots produced during a standard test (16).

Scion influence on RGP has been documented in *Quercus* spp. (13) and in *Rosa* spp. (14). The physiological basis of this effect is unknown although there is limited evidence that control is associated with translocatable factors from the scion. Significant differences, in sap dry weight above and below the union of apple cvs. (8) have been noted along with restrictions in acropetal movement of major and secondary nutrients through the graft union (2, 7, 8). A comparison of own rooted peach cvs. with the same cvs. budded to various seedling rootstocks demonstrated a reduction in canopy content of N, Mg and Ca in the budded treatments (3). The impact of these apparent restrictions in nutrient movement on root growth was not determined.

Our objective was to investigate the effects of scion and presence/absence of a graft union on the Root Growth Potential of 2 seedling cherry rootstocks.

Materials and Methods

One year-old seedlings of Mahaleb and Mazzard were planted in early April, 1982, in 7 liter containers using a pasteurized 3:1 (v/v) mineral soil:sand mix. During the first week of June, trees were chip budded 8-9 cm above the soil line in the following combinations:

1. Mahaleb unbudded
2. Montmorency/Mahaleb
3. Mahaleb/Mahaleb (all buds from single source tree)
4. Mazzard unbudded
5. Montmorency/Mahaleb
6. Mazzard F12-1/Mazzard

All stocks were cut-off just above the chip bud a week later and buds forced within 4-5 days. Unbudded stocks were cut-off ca. 8-9 cm above the soil line in order to force a suppressed lateral bud into vigorous growth.

Trees were grown under lathe (ca. 50% shade) and watered regularly. Trees were fertilized in mid-July and mid-August with 400 and 200 ppm N, respectively, from a 20.0N-8.6P-16.6K water soluble fertilizer. Pests were controlled as needed with the following pesticides: plictran, malathion, and benomyl. Trees were allowed to defoliate naturally in the fall and the chilling requirement was satisfied by 10 weeks at 2°C in cold storage after which they were moved to a greenhouse for a second growth cycle under ambient light plus supplemental lighting from overhead mercury vapor lamps (16 hours/day, 100 μmols^{-1}m^{-2} PAR measured at canopy height) from January 21 to March 31. Mean minimum/maximum temperature during this period was 19/27°C (measured at canopy height). At the end of the growth period the trees were defoliated manually and returned to 2°C cold storage for 2 months. In early June, 1983, trees were heeled-in at the nursery. At bud swell (6/27), 6 trees of each budding combination were taken to the greenhouse and prepared for RGP evaluations as follows:

1. Canopy, shoots and stems were sprayed with a fungicide (ferbam-ferric dimethyl dithiocarbamate at 7 g/l) to help protect the canopy from fungal attack while in the Ventilated High Humidity Propagator (Model 520, Agritech, Inc., Raleigh, NC).

2. Trees were depotted and all roots smaller than 2 mm in diameter were removed in order to facilitate later evaluation of RGP. These and all subsequent shoots, leaves, roots, etc. were dried for at least 1 week at 75°C in a forced air oven before weighing.

3. Trees were weighed and repotted in 7 liter containers filled with coarse sand.

Trees were maintained for the entire 31 day regeneration period in the high humidity propagator under a mean minimum/maximum temperature of 20/29°C and a mean % relative humidity of 92% (all measured at canopy height). At the end of the regeneration period the trees were harvested and analyzed in the following manner:

1. Trees were depotted and the root-system gently washed free of sand.

2. All roots arising from the rootstock shank (i.e. vertical axis of the root-system from the first lateral to the soil line) were counted and removed.

3. All remaining roots were counted and removed.

4. Tree was then partitioned into leaves, shoots and stem above the graft union (or its equivalent in unbudded treatments), stem from graft union to soil line, and root scaffold, i.e. vertical axis and laterals left after removal of all the fleshy new roots.

5. Leaf area was measured with a Li-Cor Portable Area Meter, Model LI-3000.

A completely randomized design was used with 6 replications of the 6 treatments during the RGP evaluation. Statistical analysis was in the manner of orthogonal contrasts as described in Table 1. F-tests are reported in Table 2 and means of the different variables measured are displayed in Table 3.

Table 1. Single degree of freedom comparisons and coefficients for analysis of variance (ANOVA).

	Scion/stock combination[z]					
Comparison[y]	MB	MB/MB	MT/MB	MZ	F12/MZ	MT/MZ
C1	1	1	1	-1	-1	-1
C2	1	-1	0	0	0	0
C3	1	1	-2	0	0	0
C4	0	0	0	1	-1	0
C5	0	0	0	1	1	-2

[z]MB = Mahaleb seedling (single source tree when used as scion), MT = Montmorency, MZ = Mazzard seedling, F12 = Mazzard F12/1.
[y]C1 = Mahalab vs Mazzard rootstocks
C2 = Unbudded (MB) vs budded (MB/MB) on Mahaleb rootstocks
C3 = Montmorency (MT/MB) vs Mahaleb scion (MB and MB/MB combined)
C4 = Unbudded (MZ) vs budded (F12/MZ) on Mazzard rootstocks
C5 = Montmorency (MT/MZ) vs Mazzard scion (MZ and F12/MZ combined).

Results

Rootstock effects

Mazzard was superior to Mahaleb in production of total numbers of new roots per tree or per 100 g total plant dry weight (dw). Mean dw per 100 new roots and shoot/root ratio was significantly higher for Mahaleb rootstocks than for Mazzard.

Graft union effects on Mahaleb rootstocks

The presence of a graft union (Mahaleb/Mahaleb) produced a larger loss in rootsystem dw (due to removal of roots less than 2 mm diameter during preparation) and larger shoot/root ratio when compared to unbudded Mahaleb rootstocks.

Scion effects on Mahaleb rootstocks

Total leaf dw was greater when 'Montmorency' was present as scion when compared to unbudded and self-budded Mahaleb rootstocks.

Graft union effects on Mazzard rootstocks

Total plant fresh weight (fw), as measured at start of regeneration period and total plant dw, as measured at end of regeneration period, was greater on self-budded Mazzard rootstocks (Mazzard F12-1/Mazzard) when compared to unbudded Mazzard rootstocks.

Scion effects on Mazzard rootstocks

'Montmorency,' when present as scion, significantly increased total

Table 2. Analysis of variance.

	F value[z]									
					Variable[y]					
Source[x]	1	2	3	4	5[w]	6	7	8	9	10
C1	5.75*	10.16**	3.77	4.65*	0.62	0.31	1.24	2.70	15.76**	10.49**
C2	0.93	0.70	0.66	0.04	7.65*	0.57	0.29	0.78	0.00	9.93**
C3	0.14	0.04	2.63	0.14	0.64	4.38*	0.96	0.94	0.67	0.99
C4	0.22	0.64	2.54	2.48	0.26	1.01	4.74*	7.63*	0.40	0.27
C5	7.75**	9.81**	11.68**	0.20	3.45	2.75	0.96	3.20	0.00	2.22
EMS	1052	18160	33.22	0.699	0.004	0.233	75.26	15.31	3.36	0.37
EMS df[v]	27(3)	26(4)	27(3)	23(7)	26(4)	27(3)	27(3)	26(4)	27(3)	27(3)

[z]Significant at the 5% (*) and 1% (**) levels, otherwise nonsignificant.
[y]For descriptions of variables see Table 3.
[x]C1 = Mahaleb vs Mazzard rootsticks
C2 = Graft union effects on Mahaleb rootstocks (MB vs MB/MB)
C3 = Scion effects on Mahaleb rootstocks (MT/MB vs MB and MB/MB combined)
C4 = Graft union effects on Mazzard rootstocks (MZ vs F12/MZ)
C5 = Scion effects on Mazzard rootstocks (MT/MZ vs MZ and F12/MZ combined).
[w]Analysis performend on transformed data: arcsin(squareroot(Y)).
[v]Planned comparisons (C1-C5) df = 1.

Table 3. Effects of rootstock, scion and presence/absence of graft union on Root Growth Potential, defined as total numbers of new roots produced during a test period, and component dry weights (dw) of 2 seedling cherry rootstocks, Mahaleb and Mazzard, each in 3 budding combinations.

Variable	Scion/stock combination[z]					
	MB	MB/MB	MT/MB	MZ	F12/MZ	MT/MZ
1. Total # roots/tree	14.3	32.4	17.2	36.5	27.8	77.3
2. Total # roots/100 g total dw[y]	51.0	116.0	70.0	183.0	121.0	363.0
3. Total # shank roots/tree	3.5	0.8	6.8	1.5	6.8	14.0
4. Mean dw/100 new roots	0.97	0.87	1.13	0.62	0.26	0.29
5. Percent rootsystem removed[x]	19.9	28.9	26.5	23.9	25.4	30.1
6. Total leaf dw/tree	0.74	0.95	1.35	1.11	0.83	1.37
7. Total fw/tree[w]	48.0	50.7	53.6	43.5	54.4	44.7
8. Total dw/tree[v]	22.87	24.93	25.84	20.45	26.69	20.07
9. Total trunk dw/tree[u]	5.33	5.27	6.05	2.79	3.46	3.11
10. Shoot/root ratio[t]	2.63	3.73	2.88	2.49	2.67	2.13

[z]MB = Mahaleb seedling (single source tree when used as scion), MT = Montmorency, MZ = Mazzard seedling, F12 = Mazzard F12/1.
[y]All dry weights (dw) and fresh weights (fw) expressed in grams.
[x]Calculated as 100 × total dw of roots less than 2 mm diameter removed during preparation for RGP evaluation (root trimmings) divided by total root trimmings dw and total dw of root scaffold after removal of all new roots at end of experiment.
[w]As measured at start of RGP evaluation less total dw of roots less than 2 mm diameter removed during preparation for RGP evaluation.
[v]As measured at end of experiment less new root dw.
[u]Stem tissue from the soil line to bud union (or equivalent in unbudded treatments).
[t]Calculated as leaf + shoot dw + trunk dw divided by root scaffold dw.

numbers of new roots per tree (or 100 g total plant dw) and numbers of shank roots per tree when compared to unbudded and self-budded Mazzard rootstocks.

No significant differences were noted in any comparisons of total new root dw per tree, % rootsystem replaced per tree, total leaf area per tree, specific leaf weight, total shoot dw per tree or total root scaffold dw per tree (data not shown).

Discussion

Mazzard's apparent superiority over Mahaleb in capacity to produce total numbers of new roots per tree or 100 g total tree dw must be viewed cautiously due to the inordinately large production of new roots by the 'Montmorency'/Mazzard combination. Mahaleb budded with 'Montmorency' showed no similar increase in new root production, i.e. a rootstock x scion interaction is present.

Mahaleb produced fewer and larger roots than Mazzard, yet total new root dw was similar. This indicates that Mahaleb may be limited in its capacity

to initiate lateral roots and not in it's ability to increase the mass of a root once initiated.

Root initiation and root elongation are different processes mediated by various factors (11, 15). Auxins appear to be of primary importance in root initiation (19). Zaerr (23) has demonstrated that high auxin concentrations seem to stimulate root initiation while lower concentrations tend to favor root elongation. Relative levels of auxins and auxin inhibitors (apparently originating in buds) have also been implicated as a control mechanism (11, 12).

Highly branched rootsystems have been found to be related to high root regeneration and transplant success in pin and scarlet oaks (13, 20). Pin oak with its more fibrous root system produced far more new roots than the "hard to transplant" scarlet oak which possesses a relatively unbranched rootsystem. Mazzard's rootsystem is generally considered to be rather fibrous and branching compared to that of Mahaleb (20). Our visual observations confirm these descriptions. Prepara-

tion of trees for RGP evaluations often left little more than the vertical root axis on Mahaleb stocks while Mazzard stocks usually retained several short laterals. Zieslin (14) has demonstrated with excised root segments of *Rosa* x *noisettiana* cv. Manetti that the largest numbers of new roots are produced by segments with a diameter of 1-2 mm and the least by segments greater than 4 mm or less than 0.5 mm. Whether this means that Mahaleb's low root regeneration capacity is due to lack of a framework with latent primordia or suitable sites for root initiation is unknown.

In this experiment 'Montmorency' improved RGP of Mazzard stocks when compared to unbudded and self-budded Mazzard rootstocks. No comparable effect was seen on Mahaleb rootstocks. Because 'Montmorency' tended to exaggerate differences in RGP between the 2 rootstocks the most meaningful work on relative performance of these 2 cherry rootstocks will be with grafted material.

The practical importance of work such as this is in explaining differences in rootstock reponses to transplanting, root pruning and expression of physical escape from deleterious soil conditions such as waterlogging or attack by soil borne pathogens.

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