The breeding program at the HRIO has provided a selection of cultivars which ripen in August and September with good fruit size and yield. Except for 'Veeblue' winter hardiness is less than that of 'Stanley' and 'Italian.'

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Shank Tissue Proliferations in Apple Rootstocks: Effects on Tree Growth and Correlation with Site Factors

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Abstract

A factorial planting of three scion varieties ('Gala,' 'Fuji,' and 'Braeburn') on each of four rootstocks (Mark, M.26, M.7a, and MM.111) was established at two locations in Maryland in 1990. In 1993, trees were scored for trunk circumference (TC), extension growth, leaf color, burrknots (BK) and root mass proliferations (RMP) both above and below ground, and presence of pests on the shanks. Mark was the only rootstock with RMP; 75% of the trees examined had these tissue proliferations. The % of TC composed of RMP below ground was 2-3X higher in Mark grafted with 'Fuji' than was observed with other scion varieties. Across rootstocks, % TC composed of BK below ground was significantly affected by location. In each rootstock, regressions between growth parameters and % of TC with BK or RMP were almost all negative and many had significant correlations. In Mark, % of TC with RMP below ground (but not above) was significantly correlated with reduced TC at 25 cm. The occurrence of RMP was much greater below ground than above. Orchard surveys of trees on Mark were also conducted at several commercial sites in MD and NY. The percentage of trees showing RMP ranged from 0 to 90%. There was a significant reduction in TC at 25 cm with increasing levels of RMP. The percentage of trees with RMP and mean % of TC with RMP significantly correlated with percentage of trees having visible woolly apple aphids or their distinctive galls.

Introduction

Proliferation of several tissue types on the shanks of apple rootstocks have been anecdotally associated with poor tree performance. Burrknots, areas of concentrated root initials, develop on many root-

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stocks (8) and when present are reported to result in greater variability in tree size within an orchard (4). Distinctive tissue proliferations at or below the soil surface, designated root mass proliferations (RMP), have been noted on Mark rootstock in many orchards (5). Greatly reduced tree growth, small fruit size, and frequent yellowing of leaves have been reported coincident with appearance of RMP (10). Researchers at Michigan State have reported RMP are principally composed of abnormally developed xylem parenchyma (7) and postulated a deleterious effect on water relations. Mark is a dwarfing rootstock and is notable for inducing early high yields and having high yield efficiency (6). These characteristics resulted in extensive plantings on Mark. Despite many reported problems with Mark, it continues to perform well in some orchard blocks. The purpose of the work reported here is to determine how RMP and burrknots affect tree performance and to determine what factors may be implicated in their development.

Materials and methods

Factorial Planting

Three scion varieties ('Gala,' 'Fuji,' and 'Braeburn') on each of four rootstocks (Mark, M.26, M.7a, and MM.111) were established at two locations in MD in 1990. Four replicates of each rootstock and scion combination were planted at each site but loss of five trees to fireblight resulted in an incomplete factorial. In the fall of 1993, trees were scored for trunk circumference (TC), extension growth, leaf color, burrknots (BK) and RMP both above and below ground, and presence of pests on the shanks. Trunk circumference was measured 25 cm above the soil surface. Current season growth of the leader was measured on each tree. Trunk circumference at the site of the tissue proliferation was measured and the length of circumference comprised by the proliferation itself was recorded. Measurements below ground were made to 10 cm in depth in the same quadrant for each tree and the sampled area was assumed to represent the entire tree circumference below ground. The proportion of tree circumference comprised of BK or RMP was calculated for each tree above and below ground. Burrknots were visually distinguished as rough masses of root initials. RMP was identified as distorted and irregular swelling. Galls caused by woolly apple aphid were observed as smooth hemispherical swellings occurring either individually or in small clusters.

Commercial Orchard Survey

In the fall of 1993, similar measurements were made in commercial orchards in Maryland and the Hudson Valley of New York. Twenty trees were evaluated for each scion variety at each site. Measurements were made at these sites without disturbing the soil. During the autumn each tree was evaluated for: season's extension growth of the leader; the trunk circumference (TC) at 25 cm above the soil; percent of trunk circumference comprised by and size of burrknots; percent of trunk circumference comprised by and size of RMP; leaf color; and presence of insect pests at the crown.

Statistical Analysis

Data were evaluated through ANOVA and correlation analysis using SuperAnova and StatView (Abacus Concepts, Berkeley, CA). Unless otherwise indicated statistical significance was indicated at the $p = 0.05$ level.

Results and Discussion

Factorial Planting

Mark was the only rootstock observed to have RMP; 75% of the trees on Mark examined had these tissue proliferations (Table 1). The % of TC composed of RMP below ground was 2-3X higher in Mark grafted with 'Fuji' than was observed with other scion varieties, but it was only statistically greater than 'Braeburn' (Table 2). Across all scion varieties, % of TC with RMP below ground (but not above) was significantly correlated with reduced trunk cross sectional area (TCA) at 25 cm (Table 3). The occur-

Table 1. Effect of rootstock on percent trees with burrknots or root mass proliferation (RMP) in factorial experiment using three scion varieties at two locations in Maryland. Extension growth and trunk circumference are also indicated for each rootstock.

Rootstock	Mean % of trees with burrknots	Mean % of trees with RMP above ground	Mean % of trees with burrknots above ground	Mean % of trees with RMP below ground	Mean % of trees with burrknots below ground	Mean % of trees with RMP	Mean extension growth (cm)[z]	Mean trunk circum at 25 cm (cm)[z]
M.7a	95.8	0.0	82.5	0.0	50.0	0.0	53.4a	19.1a
M.26	77.3	0.0	59.1	0.0	31.8	0.0	44.8b	15.6b
MM.111	87.5	0.0	75.0	0.0	54.1	0.0	57.2a	18.3a
Mark	52.0	34.8	43.5	65.2	17.4	75.0	32.8c	14.1c

[z]means followed by the same letter are not significantly different at the 0.05 level

rence of RMP was much greater below ground than above (Table 1). Percent trunk circumference comprised of RMP below ground (but not above) was significantly correlated with reduced TCA (Table 3) The percentage of trunk circumference comprised of BK and RMP combined did not significantly improve the correlation with growth parameters.

Incidence of BK also correlated negatively with tree growth in most cases although these correlations were seldom statistically significant (Table 3). MM.111 had a significantly higher proportion of trunk circumference comprised of BK above ground than other rootstocks and was significantly higher than all rootstocks except M.7a below ground (Table 3). In both Mark and MM.111 there was a significant correlation between percent of trunk circumference comprised of burrknots above ground and reduced trunk circumference (Table 3). Percent of trunk circumference covered by burrknots was also significantly affected by location, with values three times higher in the western Maryland piedmont site compared to the site on the Delmarva peninsula (data not shown).

Table 2. Effect of scion variety on % of trunk circumference (TC) covered by RMP on Mark rootstock.

Scion Variety	Above ground % of TC covered by RMP[z]	Below ground % of TC covered by RMP[z]
Braeburn	5.5a	26.4a
Gala	11.0a	41.7ab
Fuji	22.3a	77.5b

[z]means followed by the same letter are not significantly different at the 0.05 level.

Commercial Orchard Survey

Trees examined were in their third, fourth, or fifth leaf. The percentage of trees observed to have above ground RMP in each block ranged from 0 to 90% (Table 4). In the most severely affected plantings, the RMP tissue encompassed an average of more than 50% of the trunk circumference at the soil, and some trees were completely encircled with RMP. When data on all trees on Mark were analyzed together there was a highly significant (0.001 level) reduction in TCA correlated with increasing levels of RMP but there was no significant overall effect on extension growth or leaf color. Within individual plantings, four of the eight blocks sampled had significant correlations between extent of RMP and reduction in extension growth and/or smaller TCA. Two of the blocks had significant positive correlations between RMP and either TCA or extension growth. This may indicate a greater tolerance for RMP in these scion varieties or may reflect an earlier stage in the development of RMP at these sites, with RMP growth initially associated with greater tree growth and reduced growth likely in coming years. In two blocks, there was a significant correlation between leaf chlorosis and RMP. One block had no evidence of RMP above ground.

Too few plantings have been examined to draw firm conclusions concerning the influence of horticultural factors on RMP. The correlation between RMP and presence of woolly apple aphid suggests that this pest may enhance the formation of

Table 3. Percent of trunk circumference (TC) covered by root mass proliferation (RMP) and burrknots (BK) above and below ground level correlated with parameters of tree growth in four rootstocks.

	Data A	Corr. Data A		Data B	Corr. Data B		Data C	Corr. Data C		Data D	Corr. Data D	
Rootstock	% TC with BK above ground[z]	shoot growth[y]	trunk cross area[y]	% TC with RMP above ground[z]	shoot growth	trunk cross area	% TC with BK below ground[z]	shoot growth	trunk cross area[y]	% TC with RMP below ground	shoot growth	trunk cross area[y]
M.7a	16.9a	+.166	−.358*	0.0a	na	na	11.0ab	−.187	−.209	0.0a	na	na
M.26	16.3a	−.241	−.170	0.0a	na	na	6.2a	−.132	−.359	0.0a	na	na
MM.111	31.4b	−.358*	−.528***	0.0a	na	na	19.3b	+.138	−350*	0.0a	na	na
Mark	12.5a	−.263	−.475**	13.5b	−.151	−.235	2.6a	+.192	+.057	50.2b	−.265	−.495**

[z]means followed by the same letter are not significantly different at the 0.05 level.
[y]significant correlation at: * = 0.10 level, ** = 0.05 level, *** = 0.01 level.

Table 4. Evaluation of trees on Mark rootstock in commercial orchards for severity of root mass proliferation (RMP) and correlation with vegetative factors.

Location	Scion	Year planted	% of trees with above ground RMP	Mean % of trunk circumference with RMP	% of trees with visible woolly apple aphid	Corr. Coeff. of % Trunk RMP with extension growth[z]	TCA @25 cm[z]	leaf color[z]
NY	Jonagold	1987	35	8.0	5.0	−0.454**	−0.377	−0.401*
NY	Mutsu	1987	0	0.0	0.0	—	—	—
NY	Redcort	1988	70	34.9	15.0	−0.582***	−0.366	−0.271
NY	Smoothee	1988	60	18.0	15.0	+0.461**	−0.107	+0.073
MD	Delicious	1989	80	40.7	5.0	−0.215	−0.424*	+0.015
MD	Jonathan	1990	85	43.0	30.0	+0.111	+0.619***	−0.255
MD	Redcort	1990	90	56.2	30.3	−0.450*	−0.623***	−0.464**
ALL	ALL	ALL	60	28.3	12.5	−0.022	−0.467***	−0.175

[z]significant correlation at: * = 0.10 level, ** = 0.05 level, *** = 0.01 level

RMP, but it is known that these aphids are strongly attracted to such warty structures (2) and this may be responsible for the observed relationship. The percentage of trees displaying RMP and the mean proportion of trunk circumference composed of RMP significantly correlated (r = 0.76 and 0.78 respectively) with the percentage of trees with visible woolly apple aphids or their distinctive galls. In this small sample of orchards, the incidence of RMP was lower in the NY plantings compared to those examined in MD. In our observations of orchards on Mark where no data were taken, it appears that the regional difference in RMP development is even greater than these data suggest. Many orchards on Mark rootstock in NY have little or no above ground evidence of RMP while orchards in MD typically develop very visible swellings. However many NY orchards planted on Mark rootstock are declining, and when trees are removed, RMP is observed below ground level (data not shown).

Both burrknots and RMP produce effects consistent with partial girdling of trunks through disruption of normal phloem continuity. Small fruit size, weak growth and yellow leaf color reported for trees on Mark with severe RMP (10) are also reported following severe girdling (1, 3). Interestingly, the positive attributes of Mark rootstock, early cropping and high yield efficiency (6) are also consistent with a girdling response. We hypothesize that both positive and negative attributes of Mark result from vascular disruption (essentially girdling) from RMP development. Unfortunatcly, with continued development over time, the girdling by RMP becomes more severe with each passing year. A partial girdling effect of some rootstock/scion combinations was sug-

gested by Tukey (9) to explain the effect of some rootstocks.

Widespread reports of poor tree development on Mark rootstock have resulted in removal of Mark stoolbeds from nurseries and virtually complete cessation of its use in new commercial plantings. We had initially planned a broader survey of orchards planted on Mark but concluded that this was unwarranted because of its apparent commercial eclipse. Our data indicate that the root mass proliferations on Mark rootstock develop early in orchard life and are significantly correlated with decline in tree growth. Presence of RMP below ground influences tree growth before it becomes apparent on the soil surface. Anecdotal reports from numerous researchers and orchardists suggest that RMP growth continues through five or more years of tree development, and in most cases reaches a threshold where tree vigor and productivity declines after two to five years of promising growth and production.

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Hand and Mechanical Pruning of Thorny, Erect-Type Blackberries in Alabama

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Abstract

Two thorny, erect blackberry cultivars were subjected to four pruning methods and evaluated for yield, berry characteristics and plant vigor in 1991 and 1992. The pruning treatments consisted of: (1) hand pruning spent floricanes immediately after harvest in the summer, summer topping primocanes to 120 cm, and pruning lateral branches to 45 cm during the dormant period (standard hand pruning); (2) hand pruning dead floricanes during the dormant period, summer topping primocanes to 120 cm, and pruning lateral branches to 45 cm during the dormant period (dormant hand pruning); (3) mechanically pruning dead floricanes and primocanes to 30 cm immediately after harvest in the summer; (4) mechanically pruning dead floricanes and primocanes to 15 cm immediately after harvest in the summer. Standard and dormant hand pruning resulted in the highest yields and simulated mowing to 15 cm resulted in the lowest yields for both cultivars tested. The amount of yield reduction from mowing due to reduced primocane vigor indicated that one year of profitable production will probably be lost. Berry characteristics were not affected by pruning method. Dormant hand pruning of dead floricanes appears to be the most economically viable alternative pruning method relative to removing the dead floricanes in the summer.

Pruning is one of the most important practices involved in blackberry culture, yet few studies have examined the effect of different pruning methods on yield, berry characteristics and plant vigor. While second-year floricanes are flower-

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