

The Effect of Eight Dwarf Rootstocks on Burrknot Development on 'Gala' Apple Trees at Two Locations

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Abstract

Burrknot development was evaluated on 10-year-old 'Gala' scions growing in North Carolina and Virginia on eight dwarfing rootstocks. The effect of rootstock on burrknot development was similar for both locations. In general, trees on P.1 and O.3 produced the most burrknots and trees on M.27 produced the fewest burrknots. The number of burrknots per tree was not related to trunk cross-sectional area (TCA), but burrknot density (burrknots/TCA) was highest for O.3 and lowest for M.27.

Introduction

Burrknots are areas of partially developed adventitious root initials originating in stem tissue in apple trees (7). Root primordia form from nondifferentiated parenchymatous tissue in the bud and leaf gap areas at each node (9). Burrknots form on the above-ground portion of many apple rootstocks and on some scion cultivars such as 'Gala' and 'Empire'. These areas can enlarge as the tree grows and cause trunk fluting or partial girdling, which can interfere with vascular transport and stunt the tree (8).

Burrknots can also be feeding sites for dogwood borer (*Synanthedon scitula* Harris) larvae (2) and ambrosia beetles (*Xylosandrus germanus* Blandford), and entry sites for fireblight (*Erwinia amylovora* Burrill) (6). Because burrknots are undesirable, it would be useful to identify cultural practices, such as rootstock selection, that may reduce burrknot development. In this report we present evidence that burrknot development on 'Gala' scions is influenced by rootstock.

Materials and Methods

Data for this study were from the 1990 NC-140 Dwarf Rootstock Trial with 'Gala' as the scion cultivar, and details

concerning the trial were published previously (5). Data were obtained from cooperators in North Carolina and Virginia. The experiment was a replicated randomized complete block design (RCBD) (1), because there was a RCBD at each location. Eight dwarf rootstocks (MAC.39, P.1, O.3, M.27 EMLA, B.9, M.26 EMLA, Mark, and M.9 EMLA) were compared at each location, where groups of six trees per rootstock were assigned randomly to 10-m-long sections of row within each of four blocks. Burrknot data were recorded for two representative trees per block, so at each location there were 8 data trees per rootstock and the experimental unit was the two-tree plot. In the fall of 1999 trunk cross-sectional area (TCA) was recorded for each tree measured 20 cm above the graft union. The number of burrknots in each of three size categories (<2 cm, 2 to 6 cm, and >6 cm in diameter along the longest axis), present on the entire scion, was recorded for each tree. Most of the burrknots were located on the undersides of scaffold branches, especially where the branch originated from the trunk. The proportion of burrknots in each size category and the burrknot density (total number of burrknots/cm² TCA) were also calculated for each tree.

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Data for each location were analyzed separately because variances differed and because the data indicated that there was an interaction between rootstock and location. Data were analyzed with analysis of variance using SAS's Mixed Procedure (3), where block and trees in blocks were declared as random effects. Least squares means were compared with Tukey's test at the 5% level of significance.

Results

Averaged over all rootstocks, trees in North Carolina had about 45% more burrknots than trees in Virginia (22.1 vs 15.2 burrknots per tree). In North Carolina rootstocks separated into three fairly distinct groups for total number of burrknots (Table 1). Trees with the most burrknots

were those on O.3, P.1, and M.26, whereas trees on Mark, B.9, and M.27 had the fewest and the others were intermediate. Trees on O.3 and P.1 had the most burrknots in all three size categories and trees on Mark, B.9, and M.27 had the fewest in all sizes. The proportion of burrknots in a given size category was not significantly affected by rootstock except for the smallest size. For trees on M.27, M.9, and MAC.39, more than 55% of the total burrknots were < 2 cm in diameter and for trees on O.3 and P.1 less than 33% were small (data not shown). Analysis of covariance was performed to determine if total number of burrknots per tree was related to TCA, where TCA was included in the model as a covariate and rootstock was included as a class indicator variable. TCA

Table 1. Trunk cross-sectional area (TCA), burrknots per tree and burrknot density (total burrknots/cm²TCA) on 10-yr-old 'Gala' scions as influenced by eight dwarf rootstocks at two locations.

Rootstock	TCA (cm ²)	Burrknots per tree				Burrknot density (no./cm ² TCA)
		Total	<2 cm	2-6 cm	>6 cm	
North Carolina						
P.1	76.4 a ^Z	43.4 a	14.0 a	24.9 a	4.5 ab	0.58 b
M.26 EMLA	55.3 b	30.1 ab	13.9 ab	13.2 b	3.5 ab	0.59 b
O.3	59.8 b	48.8 a	14.8 a	26.0 a	8.0 a	0.83 a
M.9 EMLA	44.2 b	13.2 bc	7.6 ab	4.9 bc	0.8 b	0.30 bc
MAC.39	31.1 bc	19.1 bc	12.0 ab	6.2 bc	1.9 b	0.62 ab
Mark	39.7 bc	10.5 c	4.8 b	5.5 bc	0.2 b	0.25 bc
B.9	44.1 b	8.6 c	4.2 b	3.5 bc	0.9 b	0.20 c
M.27 EMLA	18.1 c	3.1 c	2.4 b	0.5 c	0.2 b	0.18 c
<i>P-Value</i>	0.001	0.001	0.001	0.001	0.001	0.001
Virginia						
P.1	39.0 a	27.4 ab	5.6 ab	18.2 ab	2.6 ab	0.69 b
M.26 EMLA	34.6 ab	14.1 bc	4.1 ab	8.1 c	1.8 ab	0.45 bc
O.3	32.9 bc	34.4 a	9.9 a	21.9 a	3.5 a	1.10 a
M.9 EMLA	31.1 bcd	6.9 cd	7.1 b	3.6 c	0.5 b	0.31 cd
MAC.39	30.1 bcd	9.6 cd	2.4 b	6.9 c	0.6 b	0.39 c
Mark	28.6 cd	15.5 bc	5.4 ab	9.6 bc	1.8 ab	0.48 bc
B.9	28.0 d	11.8 cd	2.8 b	7.6 c	1.1 ab	0.23 cd
M.27 EMLA	21.8 e	1.5 d	0.5 b	0.9 c	0.1 b	0.06 d
<i>P-Value</i>	0.001	0.001	0.002	0.001	0.004	0.001

^ZValues are least square means of 8 trees per rootstock. Mean separation within location by Tukey's test at 5% level of significance.

was not significant and the interaction between TCA and rootstock was not significant; therefore burrknot development was affected by rootstock, but it was independent of TCA. Burrknot density was greatest for O.3, which was higher than for all other rootstocks except MAC.39 (Table 1). Burrknot density was lowest for B.9, Mark, M.9, and M.27.

In Virginia, trees on O.3 and P.1 had more total burrknots than trees on B.9, MAC.39, and M.9; M.27 had the fewest burrknots (Table 1). Similar trends were apparent for all three size categories; trees on O.3 consistently had more burrknots than trees on B.9, MAC.39, M.9 and M.27. The proportion of burrknots within a given size category was not significantly affected by rootstock at the 5% level (data not shown). Analysis of covariance indicated that total number of burrknots per tree was not related to TCA and the interaction between TCA and rootstock was not significant. Trees on O.3 had the highest burrknot density (Table 1). Trees on P.1 had a higher burrknot density than trees on MAC.39, M.9, B.9, and M.27, whereas values for trees on M.27 were lower than for all rootstocks except B.9 and M.9.

Discussion

Clonal apple rootstocks differ in their tendency to form burrknots (6). Liners of MM.111 produced more total burrknots and more large (>20 mm diam.) burrknots than liners of M.26, M.7, and MM.106. In a multi-location rootstock trial, the proportion of the rootstock circumference of 5-yr-old 'Gala' trees that was covered with burrknots was influenced by the interaction of location and rootstock (4). Burrknot severity was influenced by rootstock at 11 of 20 locations. Trees at Massachusetts, Tennessee, and New Brunswick, Canada produced few burrknots, whereas burrknot development was high at Colorado, Iowa, New York, Pennsylvania, and Wisconsin. At most locations burrknot development was high for Mark and M.27.

We are unaware of other reports where burrknot severity was quantified on apple scion tissue. In the 1994 NC-140 multi-lo-

cation rootstock trial where 18 dwarf rootstocks were compared, the average proportion of rootstock circumference covered with burrknots was 5.9% in North Carolina and 2.6% in Virginia, but rootstock means were significantly different in only Virginia (4). Interestingly, burrknot severity was at least 45% greater in North Carolina than in Virginia for the 1994 trial and for the present study. We have no explanation for the observed differences, but burrknot development may be influenced by environmental factors such as temperature and moisture, and possibly by cultural practices such as orchard nutrient management or pruning severity. In North Carolina burrknot severity on the rootstock was greatest for O.3 and P.2 and lowest for M.9 NAKBT337 and B.469, whereas in Virginia burrknot severity was highest for M.26, M.27, and B.491 and lowest for Mark and V.3 (4). The severity of burrknot development on the rootstock may not correspond to burrknot development on the scion of a rootstock/scion combination. In the 1994 NC-140 trial (4), burrknot development on the rootstock was consistently high for M.27, but in the present trial scion tissue on M.27 consistently had the fewest burrknots.

In the present study burrknot development on the scion was similar at both locations. When the rootstocks were ranked for burrknot severity, the ranking for all rootstocks except B.9 and Mark were similar at both locations, and only trees on B.9 and Mark had more burrknots in Virginia than in North Carolina. The ranking of burrknot density was the same for all rootstocks except for Mark, M.26, and MAC.39. Unlike total number of burrknots per tree, burrknot density was higher in North Carolina for only M.26, MAC.39 and M.27. Although burrknot development was influenced by rootstock, it was not related to rootstock vigor because the two rootstocks with the most burrknots (O.3 and P.1) had different TCA. These data clearly show that rootstock can influence burrknot development on apple scions and this characteristic, as well as burrknot development on the root-

stock, should be evaluated in future rootstock trials.

Literature Cited

1. Hinkelman, K. and O. Kempthorne. 1994. Design and analysis of experiments. Wiley, New York, N.Y.
2. Kain, D. 2000. Borer problems and their control in dwarf apple trees. http://www.nysaes.cornell.edu/ent/documents/aa_Borer_Report_2000.pdf
3. Littell, R.C., G.A. Milliken, W.W. Stroup, and R.D. Wolfinger. 1996. SAS system for mixed models. SAS Institute Inc., Cary, N.C.
4. Marini, R.P., J.L. Anderson, W.R. Autio, B.H. Barritt, J. Cline, W.P. Cowgill, Jr., R.M. Crassweller, P.A. Domoto, D.C. Ferree, J. Garner, A.Gaus, G.M. Greene, C. Hampson, P. Hirst, M.M. Kushad, E. Mielke, C.A. Mullins, M. Parker, R.L. Perry, J.P. Privé, G.L. Reighard, T. Robinson, C.R. Rom, T. Roper, J.R. Schupp, E. Stover, and R. Unrath. 2000. Performance of 'Gala' apple on 18 dwarf rootstocks: a five-year summary of the 1994 NC-140 dwarf rootstock trial. J. Amer. Pomol. Soc. 54:92-107.
5. Marini, R.P., B.H. Barritt, J.A. Barden, J. Cline, R.L. Granger, M.M. Kushad, M. Parker, R.L. Perry, T. Robinson, S. Khanizadeh, and C.R. Unrath. 2001. Performance of 'Gala' apple on eight dwarf rootstocks: ten-year summary of the 1990 NC-140 rootstock trial. J. Amer. Pomol. Soc. 55:197-204.
6. Rom, R.C. 1973. Burrknot characteristics of six clonal apple rootstocks. Fruit Var. J. 27:84-86.
7. Rom, R.C. and S.A. Brown. 1979. Factors affecting burrknot formation on clonal *Malus* rootstocks. HortScience 14:231-232.
8. Rom, R.C. and R.F. Carlson. 1987. Rootstocks for fruit crops. Wiley, New York, N.Y.
9. Swingle, C.F. 1927. Burrknot formations in relation to vascular system of the apple stem. J. Agr. Res. 34:533-544.



Reflective Film and Ethephon to Improve Red Color of Apples

The influence of a metalized reflective film (RF) on red color development of apples was studied over four years. Film was applied to the orchard floor in the row middle or under the trees beginning 5-7 weeks before harvest. Compared to a standard orchard sod, a killed sod, or various polyethylene films, RF increased the level of photosynthetic photon flux (PPF) reflected into the canopy. This increased level of PPF resulted in darker, redder 'Delicious', 'Empire', and 'Fuji' apples, with a greater % of surface red. The effect of RF was greatest in the lower 2.4 m of the canopy. A high density RF may be a cost effective method to enhance red color of apples in the mid-Atlantic region. Comparisons between RF and ethephon varied with cultivar. Ethephon advanced maturity, but RF did not. From: Miller, S.S., and G. M. Greene. 2003. HortTechnology 13: 90-99.



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