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Scion/Rootstock Effects on Tree Size, Cumulative Yield and Yield Efficiency of 'Granny Smith' Apple and Its Sports, 'Granspur' and 'Greenspur'

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Abstract

The influence of 5 rootstocks, seedling, MM.106, MM.111, M.7a and M.26, on tree size and production of 'Granny Smith,' 'Granspur' and 'Greenspur' apple trees planted in 1982 was evaluated over the first 7 years of fruit production (1987-93). For all scions, seedling rootstock produced the largest trees and M.26 produced the smallest. Significant differences among the effects on tree size of the remaining rootstocks depended upon the scion. By the end of the experiment, 'Granny Smith' was the most productive scion; 'Granspur' was least productive. Trees on MM.106 produced the most fruit per tree; trees on M.26 produced the least. For all scions, trees on seedling were least efficient. The most efficient trees depended upon the scion, e.g., M.26 was significantly more efficient than all other rootstocks with 'Granny Smith' but not with 'Greenspur' and 'Granspur.' In this experiment, 'Granny Smith' was the best cultivar, and MM.106 was the best rootstock, for cumulative yield. M.26 was consistently among the best rootstocks for cumulative yield efficiency.

Introduction

Tree and fruit characteristics can be influenced by the apple rootstock (3, 4, 6. 7, 8, 9, 11, 12, 15, 19). Consequently, the introduction of new scion cultivars and rootstocks makes continued rootstock studies essential.

'Granny Smith' and several of its sports are available, and 'Granny Smith' is an important cultivar in the Pacific Northwest. However, reports of the performance of 'Granny Smith' or of its sports on various rootstocks in the region are limited. Barritt (1) studied early production of 'Granny Smith' as part of several orchard systems and found that, within the vertical axis training system, trees on M.9EMLA and Mark rootstocks produced more fruit in the third year than did trees on M.26EMLA.

This research was designed to examine the influence of several common rootstocks on tree size, cumulative yield, and cumulative yield efficiency of 'Granny Smith' apple and two of its sports, 'Granspur' and 'Greenspur,' over an extended period of time.

Materials and Methods

Trees of 'Granny Smith,' 'Granspur' and 'Greenspur' apples on seedling, MM.106, MM.111, M.7a or M.26 rootstocks were planted in 1982 at the Royal Slope Research Unit near Othello, Washington. Each scion/rootstock combination was planted in 10-tree plots, with each plot (except 'Greenspur'/M.7a, which was not available) replicated in each of 3 blocks. Each orchard row was of a given scion, with rootstocks assigned at random to plots within rows. Within-row tree spacing varied according to anticipated final tree size, as follows: 'Granny Smith'—4.3, 3.7, 3.0, 3.0 and 2.4 m on seedling, MM.106, MM.111, M.7a and M.26, respectively; 'Granspur'—2.7, 2.4, 1.8, 1.8 and 1.2 m on seedling, MM.106, MM.111, M.7a and M.26, respectively; 'Greenspur'—2.7, 2.4, 1.8 and 1.2 m on seedling, MM.106, MM.111 and M.26, respectively.

The orchard soil was a fine, loamy sand on a uniform, gentle, south facing slope that was previously planted to alfalfa. Rows were 4.9 m apart in a

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north-south orientation. Pesticide application was based on standard schedules, and, beginning in 1985, standard foliar fertilization schedules were followed for N-P-K, with maintenance-level applications of B and Zn. Chemical thinning was used as necessary. Every fourth row in the orchard was planted to 'Red Chief Delicious'/seedling for pollination. Although trees were trained to be free-standing, central leader trees, the combination of light soil, drip irrigation and wind caused many trees to lean. Therefore, in 1988, all trees requiring support were tied to 10-13 cm diameter posts.

Yield (total fruit weight per plot) and trunk cross-sectional area (20-25 cm from the ground) were collected annually beginning in 1987, the year of the first commercial crop, through 1993. Fruit were hand-picked and weighed in the field using a Hydroway Lift Truck Scale (Model LT 1-12, Filing Scale Company, Macedonia, OH) with a 2000-pound capacity, and graduated in 5-pound increments. Yields were converted to a per tree basis for reporting. Cumulative yield efficiency was calculated as cumulative yield for a given year divided by the trunk cross-sectional area measured before growth commenced the following year.

Statistical Analysis. — The statistical model used is mathematically equivalent to a split split plot model discussed in Cochran and Cox (2). The SAS PROC MIXED procedure was used to accomplish the analysis (14).

For the ANOVA, the test for fixed effects of scion, rootstock, year and their interactions follows the usual tests given in Cochran and Cox (2) or Steel and Torrie (16), with, for example, scion tested with the scion by block interaction mean square (MS); rootstock tested by the rootstock by block within scion MS; and year and its interactions tested by the residual MS.

The analysis was complicated by the presence of a missing scion by rootstock cell ('Greenspur'/M.7a). This was handled by noting that the highest order interaction is estimable (10). Hence, when the three-factor scion by rootstock by year interaction was nonsignificant, the analysis was rerun omitting the three-factor interaction to obtain correct tests for the two-factor interactions. If the three-factor interaction was significant ($P \leq 0.05$), the contrasts among cell means were obtained using procedures specified in Littell et al. (10). Within those effects that ANOVA indicated as significant, appropriate pairwise comparisons were based on single-degree-of-freedom contrasts.

Results

Tree size. — The effect of rootstock on tree size (trunk cross-sectional area) depended upon scion, and this dependence varied from year to year ($P \leq 0.0001$). Because rootstock effects were our main interest, we chose to restrict our analysis to the effect of rootstock within scion over time (rather than scion within rootstock over time).

Within 'Granny Smith,' trees on seedling were significantly larger than all others from year 7 (third year of production) onward (Fig. 1a). Trees on M.26 were smaller than all other 'Granny Smith' from year 6 (the second year of production) onward. 'Granny Smith'/MM.111 or M.7a were similar in size during the entire experiment, but from year 8 on, MM.106 produced larger 'Granny Smith' than MM.111, M.7a or M.26.

Seedling also produced the largest 'Granspur' trees, and M.26 produced the smallest (Fig. 1b). In contrast with 'Granny Smith,' 'Granspur'/MM.106 were never significantly larger than trees on MM.111. By year 9, trees on MM.106 were larger than on M.7a. Trees on M.7a were significantly smaller than those on MM.111 by the last year of the study.

The smallest trees from year 5 (the first year of production) were on M.26 (Fig. 1c). Seedling roots produced the

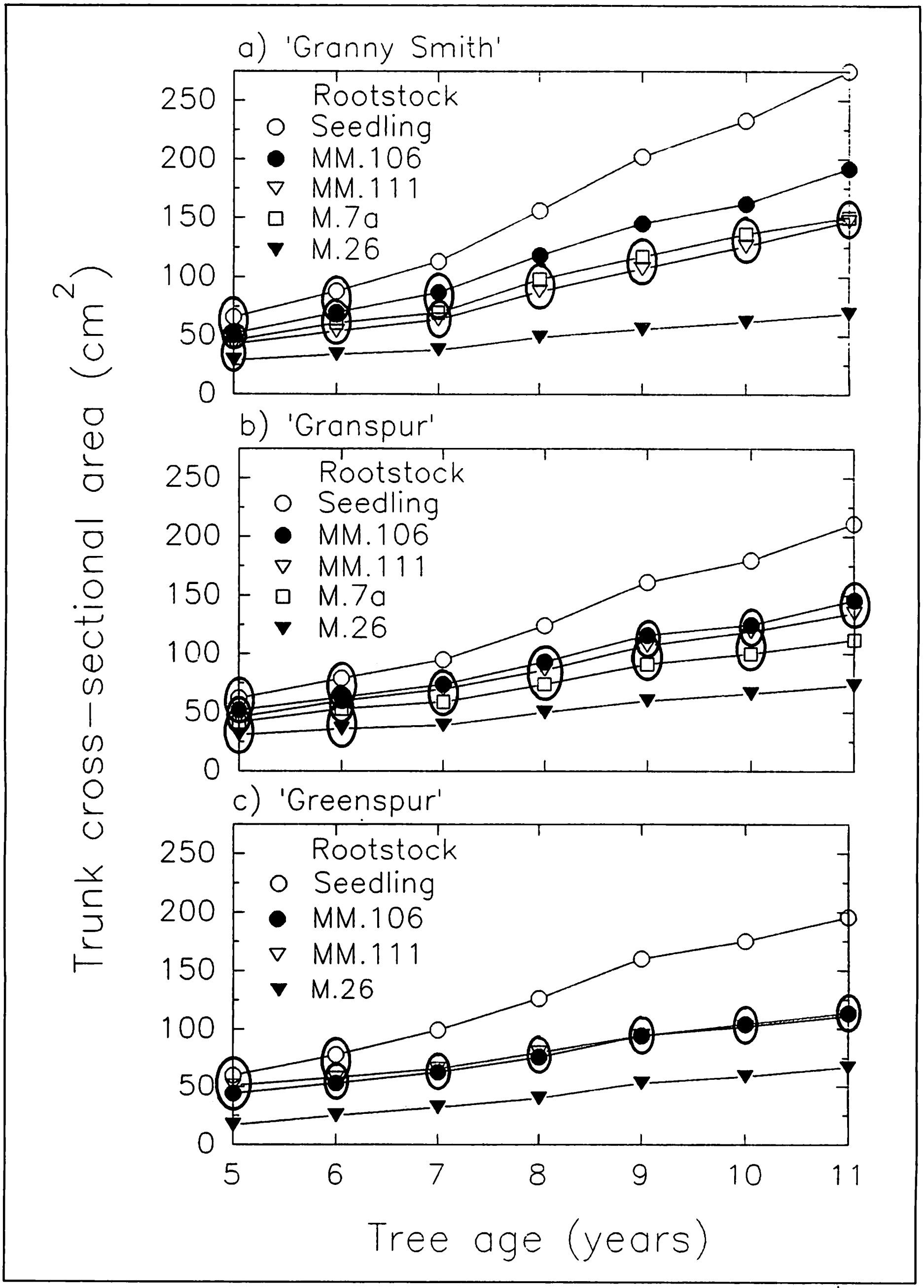

Figure 1. Rootstock effect on trunk cross-sectional area (1987-1993) for: a) 'Granny Smith,' b) 'Granspur,' and c) 'Greenspur' apple trees planted in 1982. Means within a year and enclosed by an ellipse are not significantly different ($P \geq 0.05$). Standard error for a least squares mean for these data was 7.82 cm^2 per tree.

largest 'Greenspur' trees, while there was never a significant difference in size between 'Greenspur'/MM.106 or MM.111.

Cumulative yield. — The effect of rootstock on cumulative yield did not vary among scions. The effect of scion on cumulative yield, however, varied from year to year ($P \leq 0.0001$), as did the effect of rootstock ($P \leq 0.0001$). In year 7 of the experiment, a trend was initiated, suggesting that 'Granny Smith' was more productive than its spurred sports, but it was not until year 9 and later that cumulative yields were consistently and significantly higher than 'Granspur' or 'Greenspur' (Fig. 2a). Cumulative yields of 'Granspur' and 'Greenspur' were not significantly different from each other until the last year of the study, when 'Greenspur' yields were higher than 'Granspur.'

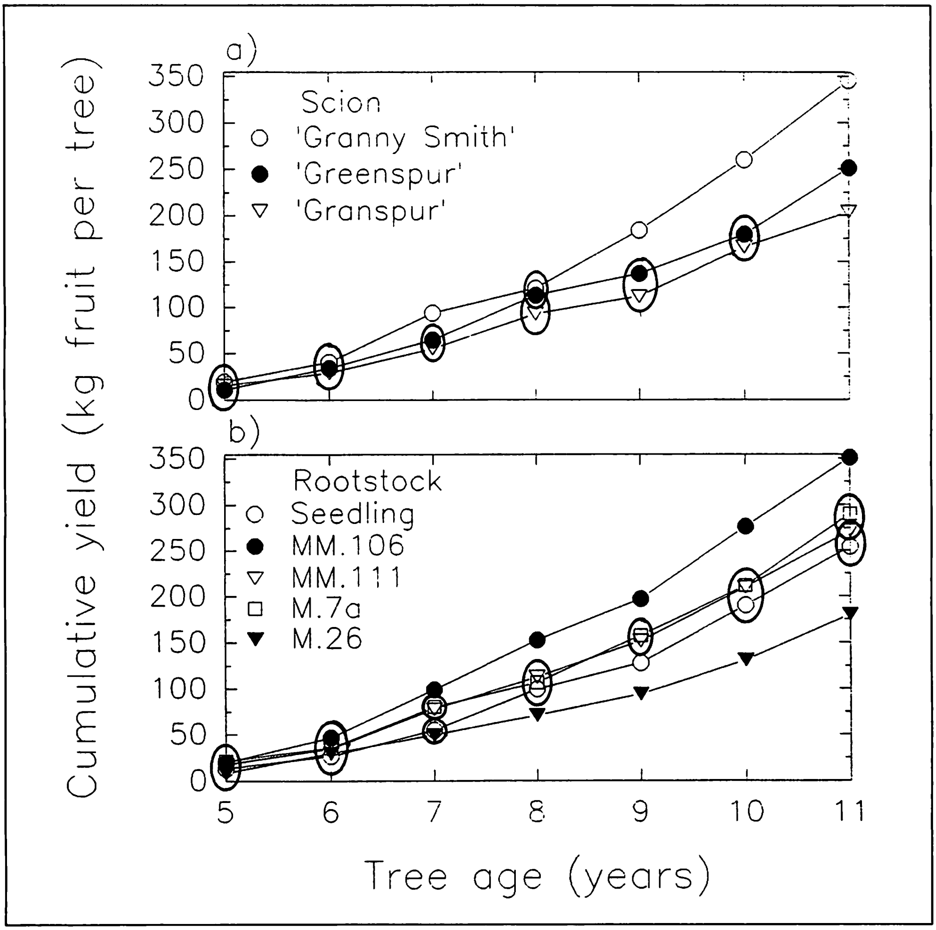

Figure 2. a) Scion effect and b) rootstock effect on cumulative yield (1987-1993) for 'Granny Smith,' 'Granspur' and 'Greenspur' apple trees planted in 1982 on five rootstocks. Means within a year and enclosed by an ellipse are not significantly different ($P \geq 0.05$). Scion effect standard error of the least squares mean for 'Granny Smith' and 'Granspur' was 10.08 kg per tree, and 10.47 kg per tree for 'Greenspur.' Rootstock effect standard error of the least squares mean for trees on seedling, MM.106, MM.111 and M.26 rootstocks Was 8.98 kg per tree, and 10.83 kg per tree for trees on M.7a.

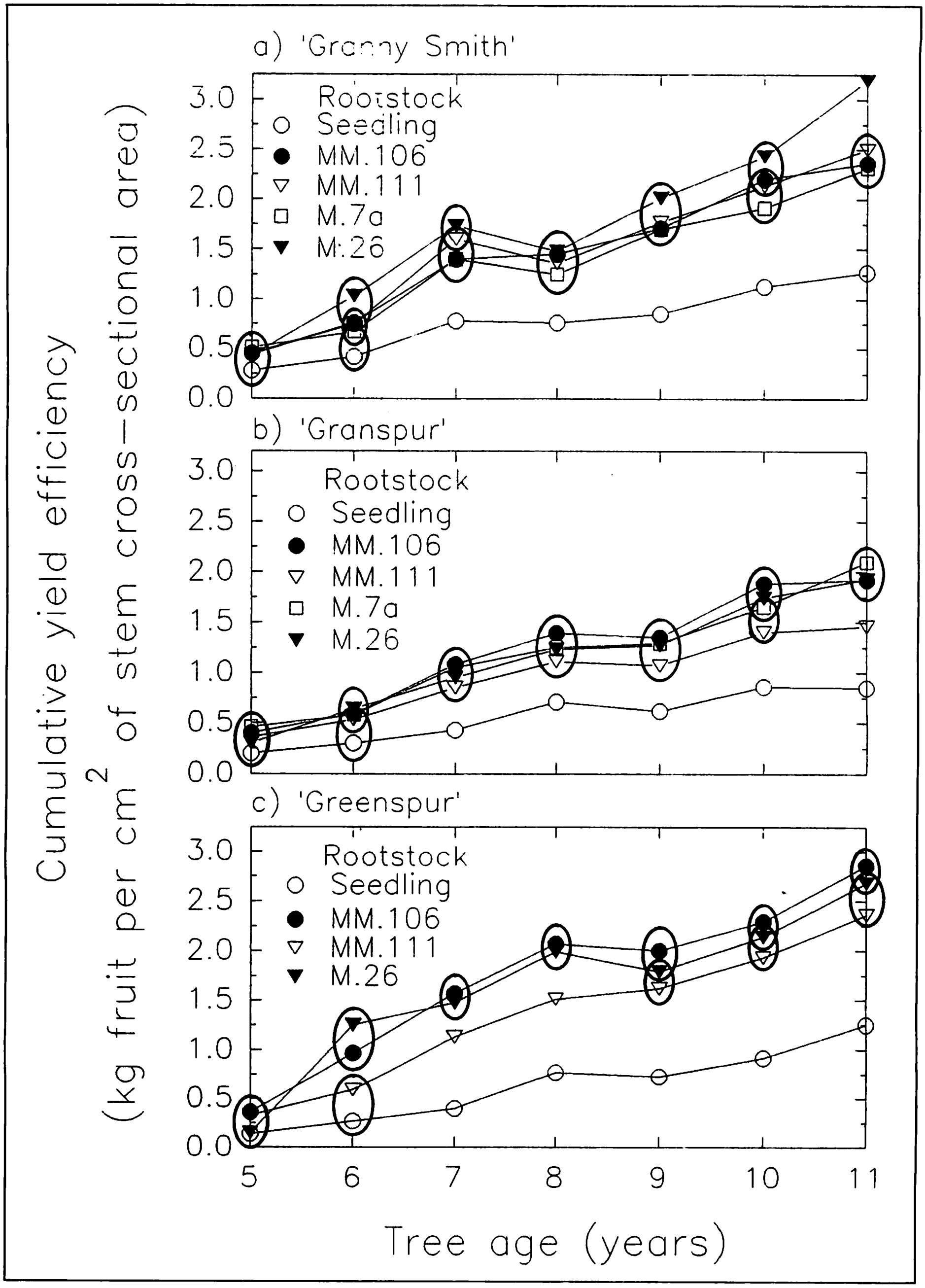

Figure 3. Rootstock effect on cumulative yield efficiency (1987-1993) for: a) 'Granny Smith,' b) 'Granspur' and c) 'Greenspur' apple trees planted in 1982. Means within a year and enclosed by an ellipse are not significantly different ($P \geq 0.05$). Standard error for a least squares mean for these data was 0.132 kg cm^{-2} $tree^{-1}$.

By year 8 of the study, it was apparent that cumulative yield per tree was greatest with MM.106 and least with M.26 (Fig. 2b). Cumulative yields of trees on MM.111 and M.7a were always similar. Within-year comparisons of trees on seedling rootstocks with trees on either MM.111 or M.7a gave ambiguous results, being significantly lower in some years, but not in others.

Cumulative yield efficiency. — As with trunk cross-sectional area, the effect of rootstock on cumulative yield efficiency depended on the scion, and this dependence varied from year to year (P = 0.0448). Again, we chose to focus further analysis on the effect of rootstock within scion over time.

Within 'Granny Smith,' seedling rootstock trees were clearly the least efficient (Fig. 3a). Within-year comparisons indicated that trees on M.26 were significantly more efficient than all other trees only in the last year of the study. We decided that a more powerful test would be to determine whether there was sufficient evidence to indicate that trees on M.26 were more efficient than trees on any other rootstock. The more powerful test was of the null hypothesis that yield efficiency, averaged over the last 4 years of the study, for trees on M.26 was equivalent to the mean yield efficiency of trees on MM.106, MM.111 and M.7a, averaged over the same span of time. This null hypothesis was rejected ($P \leq 0.0001$), indicating a significantly higher yield efficiency for M.26 trees than for trees on MM.106, MM.111 and M.7a. At no time did 'Granny Smith' trees on MM.106, MM.111 or M.7a differ significantly in cumulative yield efficiency.

Within 'Granspur,' as with 'Granny Smith,' trees on seedling were least efficient (Fig. 3b). During the tenth year, trees on MM.111 began to show significantly lower yield efficiency than trees on either MM.106 or M.26. By the last year, 'Granspur'/MM.111 had significantly lower cumulative yield efficiency than the other clonal rootstocks (Fig. 3b). 'Granspur' on MM.106, M.26 and M.7a had similar cumulative yield efficiencies throughout the study.

With 'Greenspur,' trees on MM.106 or M.26 were the most efficient, and trees on seedling were, again, least efficient (Fig. 3c). Although early in the study, trees on MM.111 were less efficient than trees on M.26, this difference disappeared after year 8.

Discussion

As expected. the largest trees were on seedling rootstock. and the smallest were on M.26. Although tree size on seedling depended on scion, with 'Granny Smith'/seedling producing the largest trees, trees on M.26 were of similar size regardless of scion (cf. Figs. 1a, 1b, 1c). 'Granny Smith'/MM.106 was similar in size to the spurred scions on seedling. By the end of the study, 'Granspur'/M.7a was significantly smaller by at least 17% than on MM.106 or MM.111. However, when 'Granny Smith' was the scion, trees on MM.111 were smaller than on MM.106, but essentially the same size as those on M.7a. Even though MM.106 sometimes produces a smaller tree than MM.111 (9). in our research, 'Granny Smith'/MM.106 was larger than on MM.111.

The higher yield of 'Granny Smith' vs. its spurred sports is consistent with recent industry experience. However, we found no research reports of the relative production from these cultivars. Industry observers have noted that spurred types have a tendency toward bitter pit. In our plots, we noted a continuing bitter pit problem in 'Granspur.' Drake et al. (3), however, failed to detect bitter pit in their samples of 'Greenspur' from this orchard. The tendency toward bitter pit and the relatively poor yield should discourage growers from planting these

The high per tree production of trees on MM.106 relative to trees on the other rootstocks is consistent with other reports (5, 7, 9, 13, 17), as is the relatively low production per tree of trees on M.26 (7, 9) because of their smaller size. The remaining three rootstocks produced intermediate yields.

Not surprisingly, seedling was the least efficient rootstock for all scions. However, the relative cumulative yield efficiencies of the most efficient rootstocks varied with the scion. Where direct comparisons are available, e.g., with 'Golden Delicious' and 'Delicious' types (7, 9), efficiencies of M.26 and MM.106 have been comparable. In the present work, however, efficiencies of trees on these two rootstocks were comparable only with spur type scions. With 'Granny Smith' as the scion, trees on M.26 were significantly more efficient. However, to exploit this higher efficiency, trees on M.26 would require planting at higher density than we used. For example, in the last year of this study, 'Granny Smith' produced 454 and 222 kg per tree (data not shown) on MM.106 and M.26, respectively. Therefore, comparable total production would have been obtained from about one-half as many trees on MM.106 as on M.26. At the tree spacing we used, density for 'Granny Smith'/ MM.106 was 551 trees ha^{-1} and was 850 trees ha^{-1} for 'Granny Smith'/M.26. Yield per hectare, then, for these treatments was 250 and 189 metric tons ha^{-1}, respectively. Our 'Granny Smith'/M.26 were, however, sufficiently smaller than 'Granny Smith'/MM.106 that they could have been planted at about 2.5 times the density of 'Granny Smith'/MM.106. This higher density (551 x 2.5 = 1378 trees ha^{-1}), still producing 222 kg $tree^{-1}$, would have produced about 306 metric tons ha^{-1}, giving an overall advantage in total production per hectare to trees on M.26.

Our experience (and apparently that of the fruit industry) is that 'Granny Smith' is preferable to the spur-type 'Granspur' and 'Greenspur,' but Drake et al., (3) found that external greeness for 'Greenspur' was superior to 'Granny Smith.' Selecting the best rootstock from those we tested would depend on local site and soil conditions and production practices. MM.106 and M.26 tended to be the best choices at this site based on cumulative yield and cumulative yield efficiency.

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Blackberry Cultivars Differ in Susceptibility to Rosette Disease[1]

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Abstract

Rosette, incited by *Cercosporella rubi* (G. Wint.) Plakidas, is the most important disease of cultivated blackberries (*Rubus* spp.) in the southern United States. A field test evaluated sixteen blackberry cultivars and breeding selections over a three year period for incidence and severity of rosette. 'Shawnee' and 'Rosborough' had high incidence and severity. Cultivars and selections with moderate-high incidence and low-moderate severity were 'Brazos,' 'Cheyenne,' 'Choctaw,' A-1260, A-1442, A-1560, and A-1585. Cultivars and selections with zero-low incidence and severity were 'Arapaho,' 'Humble,' 'Navaho,' A-1374, A-1594, A-1616, and A-1617.

Introduction

Rosette disease, incited by the fungus *Cercosporella rubi*, is a major factor limiting blackberry production in the southern United States (1, 5, 7). Fungal spores infect axillary buds on primocanes in spring and early summer but disease symptoms do not appear until the following spring. The fungus overwinters in infected buds (4, 7). When infected buds break dormancy in the spring, they develop multiple shoots commonly called a rosette or witches'-broom. Fungal spores are released from open infected flowers on rosettes and new primocanes are infected, thus spreading the disease (6, 7). Infected flowers are sterile and do not produce fruit. Yield can be greatly inhibited in plantings with severe rosette.

Growers can delay the occurrence of rosette in blackberry plantings by destroying wild blackberries near the planting site. In fields where rosette is present but not severe, the disease can be contained by removing rosettes

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