10. Littell, R. C., R. J. Freund, and P. C. Spector. 1991. SAS System for Linear Models, 3rd Ed. SAS Institute, Inc., Cary, NC.
11. NC-140. 1987. Growth and production of 'Starkspur Supreme Delicious' on 9 rootstocks in the NC-140 cooperative planting. Fruit Var. J. 41(1):31-39.
12. NC-140. 1990. Early performance of 'Starkspur Supreme Delicious' on 16 rootstocks in the NC-140 cooperative planting. Fruit Var. J. 44(4)225-235.
13. oemoazel. S. A., S. W. Zagaja and A. Czynczyk. 1976. Apple rootstock breeding program in Poland. Compact Fruit Tree 9:15-19.
14. SAS Institute Inc. 1992. SAS/STAT software: Changes and enhancements, release 6.07. Technical Report P-229. SAS Institute, Cary, North Carolina.
15. Seeley, E. J., E. A. Staley and R. Kammereck. 1979. The influence of rootstock and strain on growth and production of 'Delicious' and 'Golden Delicious' apple trees. J. Amer. Soc. Hort. Sci. 104:80-83.
16. Steel, R. G. T. and J. H. Torrie. 1980. Principles and Procedures of Statistics, McGraw Hill, New York.
17. Walker, D. R. and M. Willardson. 1985. The performance of four apple rootstocks. Compact Fruit Tree 18:31-33.
18. Westwood, M. N. 1993. Temperate-zone Pomology, Physiology and Culture, 3rd Ed. Timber Press. Portland, OR.
19. Westwood, M. N., P. B. Lombard, S. Robbins and H. O. Bjornstad. 1986. Tree size and performance of young apple trees of nine cultivars on several growth-controlling rootstocks. Hortscience 21(6):1365-1366.

Fruit Varieties Journal 49(4):235-238 1995

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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before the infected floral buds open. In cases of severe rosette, a fungicide spray program may be warranted. Fungicide applications must coincide with infection periods during the blooming of rosettes. Plantings with severe rosette can also be renovated by cutting canes to ground level after harvest and removing them from the field. However, this practice results in loss of yield the following year.

The most economical control measure for rosette is to plant resistant cultivars. However, resistance to rosette has only been reported in the cultivar 'Humble' (3). Recent blackberry cultivar releases and advanced breeding selections from the University of Arkansas have not been screened for rosette resistance. Our objective was to evaluate blackberry cultivars and breeding selections for resistance to rosette.

Materials and Methods

Sixteen erect blackberry cultivars and breeding selections were evaluated for rosette resistance at the Calhoun Research Station, Calhoun, Louisiana. Thorny cultivars evaluated were: 'Brazos,' 'Cheyenne,' 'Choctaw,' 'Humble,' 'Rosborough,' and 'Shawnee.' Thornless cultivars were 'Arapaho' and 'Navaho.' 'Shawnee' is susceptible to rosette (B. Buckley, III, unpublished data). Eight University of Arkansas breeding selections evaluated were: thorny selections A-1260, A-1374, A-1442, A-1585 and thornless selections A-1560, A-1594, A-1616, A-1617. All selections except A-1260 and A-1374 had either 'Humble' or A-803 as a resistant parent.

Test plots were planted on 19 Sept. 1990 in a randomized complete block design with four replications. A plot consisted of a 3 m hedgerow of blackberry canes. Plots were established by spacing five plants 61 cm apart in rows 3.7 m apart and allowing primocanes to fill in the space between mother plants within a plot. Alleys between plots within a row were 1.5 m. Each row of test plots was bordered on both sides by a row of the rosette susceptible cultivar Shawnee. In February of each year, five random dormant floricanes in each plot were flagged to be used for disease ratings. Plots were rated for incidence and severity of rosette on 30 Apr. 1992, 20 May 1993, and 9 May 1994. Disease incidence was defined as the percentage of plants that exhibited rosette symptoms. Disease severity was defined as the percentage of floricane nodes on a plant with rosettes. Disease severity was rated with a 1-8 modified Horsfall-Barratt scale (2) (1 = 0% floricane nodes with rosettes, 2 = 0-10%, 3 = 10-25%, 4 = 25-50%, 5 = 50-75%, 6 = 75-90%, 7 = 90-100%, 8 = 100%). Data were converted to percentages with the midpoint of the percentage range represented by the scale values. Analysis of variance was performed on the data. Cultivars and selections with 0 values were eliminated from the analysis.

Results and Discussion

Data from three years of evaluating for rosette indicate that there was considerable difference in resistance among the blackberry cultivars and breeding selections tested (Table 1). The cultivars and selections fell into three general groups based on disease ratings: high incidence and severity; moderate-high incidence and low-moderate severity; zero-low incidence and severity. Infection was consistent in the planting as evidenced by uniform infection across replicate plots and border rows of rosette susceptible 'Shawnee.'

Incidence and severity of rosette are usually low the first year the disease appears in a planting and typically increase greatly the next year if control measures are not taken (J. R. Pyzner, personal communication). In the second year after planting (1992), four cultivars in our study had between 60 and 70% incidence and between 40

Table 1. Incidence and severity of rosette disease for sixteen blackberry cultivars and breeding selections evaluated at the Calhoun Research Station, Calhoun, La.[z]

Cultivar or selection	Presence of thorns[y]	1992 Disease incidence (%)	1992 Disease severity[y] (%)	1993 Disease incidence (%)	1993 Disease severity (%)	1994 Disease incidence (%)	1994 Disease severity (%)
Shawnee	+	75[w]	56	100	79	100	73
Rosborough	+	70	50	100	71	---[v]	--
Choctaw	+	65	50	100	42	100	36
Brazos	+	60	44	100	48	---	--
Cheyenne	+	40	10	100	42	100	36
A-1260	+	35	13	80	37	100	40
A-1560	-	5	1	60	4	35	6
A-1585	+	5	1	40	9	70	7
A-1374	+	0	0	25	5	20	1
A-1442	+	0	0	20	3	53	8
A-1594	-	0	0	10	1	5	0
Arapaho	-	0	0	0	0	5	0
Navaho	-	0	0	0	0	0	0
Humble	+	0	0	0	0	45	4
A-1616	-	0	0	0	0	0	0
A-1617	-	0	0	0	0	0	0
LSD (0.05)		26	13	28	18	23	16

[z]Disease incidence is the percentage of plants with rosette, and disease severity is the percentage of floricane nodes on a plant with rosettes.
[y]+ = thorns on canes, - = thorns absent on canes.
[x]Disease severity was rated with a modified Horsfall-Barratt scale (1 = 0% floricane nodes with rosettes, 2 = 0-10%, 3 = 10-25%, 4 = 25-50%, 5 = 50-75%, 6 = 75-90%, 7 = 90-100%, 8 = 100%).
[w]Cultivars and selections with 0 values were eliminated from the analysis.
[v]Ratings were not recorded due to freeze damage.

and 60% severity. In 1993, rosette incidence was 100% for five cultivars. The highest severity in 1993 was recorded for 'Shawnee' and 'Rosborough.' However, the disease affected the two cultivars differently. Rosettes on 'Shawnee' were vigorous and robust and remained green for several weeks after the harvest period. In contrast, rosettes on 'Rosborough' were stunted and shriveled, and the canes died before harvest.

'Humble' is generally recognized as having some resistance to rosette (5). Symptoms may be absent on canes for several years but eventually some rosette occurs. In our study, 'Humble' remained rosette-free until 1994 when incidence was 45%. Rosette severity, however, was very low. Erect thornless cultivars and selections 'Arapaho,' 'Navaho,' A-1594, A-1616, and A-1617 had zero-low incidence and severity in each of the three evaluation years. In Mississippi, rosette symptoms were absent on 'Navaho' canes for several years, but a low-moderate level of rosette was eventually apparent (B. Smith, personal communication). Incidence of rosette in 'Navaho' has also been observed in Louisiana (G. Melcher, personal communication). Much is still unknown about the mechanism and durability of resistance to rosette.

Thorns are considered a major limitation to blackberry production (1). Thornless cultivars and selections identified as having some rosette resistance could prove to be alternatives to 'Humble' for growers and breeders concerned with rosette.

Six breeding selections have either 'Humble' or A-803 as a resistant parent. A-803 was a thornless selection identified as rosette resistant (J. N.Moore and B. Buckley, III, unpublished data). The low incidence and severity of rosette in most of these selections provide encouragement that rapid progress can be made in breeding for rosette resistance.

Literature Cited

1. Clark, J. R. 1992. Blackberry production and cultivars in North America east of the Rocky Mountains. Fruit Var. J. 46:217-222.
2. Horsfall, J. G. and R. W. Barratt. 1945. An improved grading system for measuring plant diseases. Phytopathology 35:655.(Abstr.)
3. Jennings, D. L., H. A. Daubeny, and J. N. Moore. 1990. Blackberries and raspberries (Rubus), pp. 331-389. In: Moore, J. N. and J. R. Ballington (eds.). Genetic resources of temperate fruit and nut crops. Acta Hort. 290.
4. Marroquin, E., F. B. Matta, C. H. Graves, Jr., and B. Smith. 1990. Relationship between flower/fungal development in blackberry infected with *Cercosporella rubi*. HortScience 25:1448.
5. Moore, J. N. 1980. Blackberry production and cultivar situation in North America. Fruit Var. J. 34:36-42.
6. Plakidas, A. G. 1937. The rosette disease of blackberries and dewberries. J. Agr. Res. 54:257-303.
7. Smith, B. J. and J. A. Fox. 1991. Rosette (double blossom), pp. 13-15. In: Ellis, M. A., R. H. Converse, R. N. Williams, and B. Williamson (eds.). Compendium of raspberry and blackberry diseases and insects. APS Press, St. Paul, Minn.