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Field Susceptibility of 68 Apple Cultivars to Cedar Apple Rust, Quince Rust and Hawthorn Rust

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Abstract

Apple cultivars were evaluated in a field for susceptibility to cedar apple rust (CAR), quince rust (QR) and hawthorn rust (HR). HR lesions on apple leaves were relatively small and few in number compared to CAR lesions. Between 1986 and 1990, percentage fruit infection varied from 0 to 64 for CAR and from 0 to 42 for QR. 'Mutsu' was the most susceptible culitvar to both CAR and QR. Other cultivars highly susceptible to both CAR and QR included 'Burgundy,' 'Gloster 69,' 'Smoothee Golden Delicious,' 'Julyred' and 'Summerred.' Susceptibility of the cultivars to rust infection varied from year to year with 1986 having the highest level of infection.

Introduction

Information on the resistance or susceptibility of apple (*Malus domestica* Borkh.) cultivars to diseases is important to minimize pesticide use for economic and environmental reasons as well as reduce the rate of tolerance development of target organisms to pesticides (1). The application of fungicides could be targeted to susceptible cultivars and control sprays could be avoided on resistant cultivars.

Three rust diseases of apple have been identified in eastern North America (11, 13, 15). Cedar apple rust (CAR) caused by *Gymnosporangium juniperi-virginianae* Schw. occurs on both leaves and fruit of apple, hawthorn rust (HR) caused by *G. globosum* Farl. occurs only on leaves, and quince rust (QR) caused by *G. clavipes* Cke. and Pk. occurs on fruit and appears on leaves as non-discrete spots (14). These diseases are prevalent in areas where the alternate host, eastern red cedar, *Juniperus virginiana* L., is present (9, 13, 15).

The susceptibility of scab-resistant apple cultivars to rust diseases was reported recently (17, 18), but for other cultivars the most recent comprehensive list of cultivar susceptibility was published in 1974 for CAR and QR (2) and in 1981 for QR (7). Since then, many new cultivars have been introduced.

This paper reports the field susceptibility to CAR, QR and HR of 68 apple cultivars. Forty-five cultivars reported here were not included in the previously published lists. In addition, this report shows the relative susceptibility to rust diseases over the five year period from 1986 to 1990.

Materials and Methods

A planting of apple cultivars was established in the spring of 1972 consisting of two trees of each cultivar, one on each of *Malus robusta* Rehd. 5 and Ottawa 3 rootstocks. Some trees were added to the planting in later years. Trees were spaced at 4.6 x 7.6 m without randomization. Apple scab (*Venturia inaequalis* Cke. Wint.) was controlled by using a single application of captafol at 14 kg ai per ha at the 1 cm green tissue stage of bud development in 1986 and 1987. In 1988, 1989 and 1990, apple scab was controlled by following a protective program using 9 to 11 sprays annually of captan at 2.0 to 3.0 kg ai/ha. Insecticide and miticide sprays were applied as necessary to control insects and mites.

A minimum of 100 fruits per cultivar were assessed for CAR and QR infection in late July or early August 1986,

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1988, 1989 and 1990. Some cultivars produced less than 100 fruits and in those cases all fruits on the two trees were evaluated. In 1987, rust infection was very low and therefore was not assessed.

The two most severely infected leaves on each of ten terminal shoots per cultivar were rated for rust infection in late July or early August of 1986, 1988, 1989 and 1990. The number of rust lesions per leaf was estimated using a scale of 0 to 4 (0 = no lesions; 1 = 1 to 5; 2 = 6 to 25; 3 = 26 to 50; 4 = 51 to 100 lesions per leaf) and tr (less than 5 rust lesions per terminal shoot after all leaves on the shoot were examined), and the mean rating for each cultivar was recorded. For each cultivar, the diameter of 10 rust lesions was measured and median lesion diameter was determined. In late August or early September of each year, leaf rust lesions were examined for pycnial or aecial development and the most advanced stage of development was recorded. Based on size of the lesion, number and location of aecia, and shape of the peridium (11, 15), leaf infection was determined to be either CAR or HR. Where aecia were not present or were poorly developed on leaves, no differentiation was made between CAR or HR.

Rust infection occurred from naturally occurring sources. Trees of eastern red cedar, *J. virginiana*, the alternate host for CAR, HR and QR (13, 15) were growing within 500 to 1000 m of the test orchard.

Results and Discussion

CAR was observed on the leaves of 36 of the 68 cultivars evaluated (Table 1). Fruit infection ranged from 0 to 64% for these cultivars. Apple cultivars highly susceptible to CAR and not included on previously published lists (2, 8, 12) were 'Burgundy,' 'Geneva Early,' 'Gloster 69,' 'Kestrel,' 'Loyalist,' 'Sandel' and 'Vista Bella.' HR was observed on two cultivars, 'McIntosh' and 'Delicious.' Both are known to be resistant to CAR (2, 8, 12). Leaf rust was observed on an additional 22 cultivars. However, due to the absence or poor development of aecia, it was not possible to identify the rust species involved. Only three of these cultivars, 'Chieftan,' 'Lord Lambourne' and 'Sinta,' had fruit infected with CAR, and the percentage of fruit infected was low, ranging from 1 to 3%. It is possible that both CAR ;and HR may occur simultaneously on the leaves of some cultivars (13). Aldwinckle reported a low frequency of occurrence of HR in apple orchards (2) and on *J. virginiana* (Aldwinckle, personal communication) compared to CAR. This report agrees that CAR was more prevalent than HR on the apple cultivars.

On eight additional cultivars, no leaf rust lesions were observed, and no fruit infection from CAR occurred. These cultivars were 'Akane,' 'Discovery,' 'Granny Smith,' 'Katja,' 'Redcort,' 'Regent,' 'Shamrock,' and 'Summer Granny.'

Median lesion diameter on leaves infected with HR was 1 mm. CAR median lesion diameter was usually larger, 2 to 8 mm, and only in one case was 1 mm in diameter. Since HR does not attack apple fruits (11, 15) and leaf lesions are few and small in diameter (18) the commercial fruit grower has little reason to be concerned about HR infection.

Percentage fruit infection from QR is shown in Table 1. 'Delicious' is a well known QR susceptible cultivar (11, 14, 18). Other cultivars comparable in susceptibility include 'Burgundy,' 'Empire,' 'Gloster 69,' 'Smoothee Golden Delicious,' 'Julyred,' 'Mutsu,' 'Northern Spy,' 'Paulared,' 'Sinta,' 'Spigold,' 'Summerred,' 'Sungold' and 'Tydeman's Red.'

In this study, both captafol and captan were used for apple scab control. Neither are considered effective for control of rust diseases (16), but captan may reduce fruit infection from

Table 1. Susceptibility of apple cultivars to cedar apple rust, *Gymnosporangium juniperi-virginianae*, Quince rust, *G. clavipes*, and hawthorn rust, *G. globosum*, at the Smithfield Experimental Farm, 1986 to 1990.

	Leaf rust							Fruit infection[u]		
	Rating[v]				Lesion diam.					
Cultivar	1986	1988	1989	1990	(mm)[w]	MAS[x]	Type[y]	CAR	QR	No. of yr.
Akane	-	0	0	0				0	0	3
Belle de Boskoop	2	0	0	1	2	A	U	0	0	3
Blair	1	0	0	0	2	P	U	0	5	4
Bramley's Seedling	4	tr	1	2	4	A	CAR	0	1	3
Burgundy	4	tr	1	2	5	A	CAR	20	10	4
Chieftan	1	0	0	0	1	P	U	1	6	4
Cortland	2	0	0	0	1	A	U	0	0	3
Cox's Orange Pippin	2	tr	tr	1	4	A	CAR	34	2	4
Criterion	-	1	1	2	8	A	CAR	0	0	1
Delicious	2	0	0	tr	1	P	HR	0	19	4
Discovery	-	0	0	0						
Early Cortland	-	0	1	2	5	A	CAR	0	0	1
Empire	2	0	0	0	1	A	U	0	16	4
Fuji	-	1	tr	1	2	A	CAR	0	0	3
Gala	-	tr	0	1	4	A	CAR	0	0	1
Geneva Early	-	2	1	3	7	A	CAR	14	6	2
George	2	0	tr	tr	2	A	U	0	4	4
Gloster 69	3	1	1	2	7	A	CAR	29	18	4
Golden Del., Smoothee	3	tr	1	2	5	A	CAR	37	20	4
Golden Del., Sundale	-	0	1	2	4	A	CAR	0	0	3
Golden Russet	3	tr	1	2	7	A	CAR	9	0	4
Granny Smith	-	0	0	0				0	0	1
Greensleeves	-	1	tr	2	7	A	CAR	1	5	1
Honeygold	3	tr	1	1	3	A	CAR	2	1	4
Idared	3	tr	1	2	5	A	CAR	25	1	4
Jerseymac	1	0	0	0	1	P	U	0	7	4
Jonamac	2	0	0	0	1	P	U	0	0	4
Jonathan	3	1	1	2	6	A	CAR	43	4	4
Jonnee	3	1	1	2	6	A	CAR	33	2	4
Julyred	4	1	1	2	5	A	CAR	40	10	4
Katja	-	0	0	0				0	0	1
Kestrel	3	tr	1	2	1	A	CAR	37	9	4
Liberty (SR)[z]	2	0	0	tr	1	P	U	0	2	4
Lindel	2	0	0	1	1	P	U	0	8	4
Lord Lambourne	-	0	tr	tr	1	P	U	3	1	3
Loyalist	4	tr	1	3	3	A	CAR	28	2	4
Lysgolden	-	1	1	1	5	A	CAR	0	0	3
Macklin	2	tr	1	tr	2	A	U	0	0	3
Magnolia Gold	-	1	1	1	4	A	CAR	1	6	3
Malling Kent	2	tr	1	1	6	A	CAR	4	4	4
McIntosh	2	0	0	tr	1	A	HR	0	1	4
Mutsu	4	1	1	3	4	A	CAR	64	42	4
Northern Spy	3	tr	1	2	2	A	CAR	3	22	4
Paulared	2	0	tr	0	1	P	U	0	10	4
Primegold	3	tr	1	2	5	A	CAR	41	3	4
Puritan	2	0	0	0	1	P	U	0	1	4

Table 1. (Continued).

Cultivar	Leaf rust							Fruit infection[u]		
	Rating[v]				Lesion diam. (mm)[w]	MAS[x]	Type[y]	CAR	QR	No. of yr.
	1986	1988	1989	1990						
Raritan	-	0	0	tr	2	P	U	0	0	2
Red Rome	2	1	1	2	7	A	CAR	3	1	3
Redcort	-	0	0	0				0	3	3
Regent	-	-	0	0				0	4	2
Rhode Island Greening	4	0	1	1	3	A	CAR	5	0	4
Sandel	4	-	1	2	6	A	CAR	33	2	3
Scotia	3	0	0	tr	1	A	U	0	4	4
Shamrock	-	0	0	0				0	2	1
Sinta	3	0	tr	1	2	A	U	1	19	4
Spartan	1	0	0	0	2	A	U	0	3	4
Spigold	4	tr	2	2	2	A	CAR	2	11	4
Spijon	4	tr	1	2	6	A	CAR	2	1	4
Stark Blushing Golden	-	0	tr	0	2	P	U	0	4	3
Stark Pure Gold	-	1	1	1	5	A	CAR	0	4	1
Summer Granny	-	0	0	0				0	2	3
Summerred	4	1	1	2	6	A	CAR	34	15	4
Sungold	2	0	tr	tr	2	A	U	0	19	4
Supergold	-	1	1	2	5	A	CAR	0	0	3
Tydeman's Red	tr	0	0	0	1	P	U	0	19	4
Viking	tr	0	0	0	1	N	U	0	3	4
Vista Bella	4	1	1	3	5	A	CAR	9	1	4
W. V. Red York	3	tr	1	2	4	A	CAR	21	0	3

[u]The figure shown represents the highest percentage fruit infection from 1986 to 1990 and the number of years evaluated for each cultivar.
[v]0 = no lesions, 1 = 1 to 5, 2 = 6 to 25, 3 = 26 to 50, 4 = 51 to 100 rust lesions per leaf, tr = less than 5 rust lesions per terminal shoot and - indicates not evaluated.
[w]Median lesion diameter based on 10 lesions per cultivar per year.
[x]Most advanced symptom: A = aecis, P = pycnia, N = nonsporulating.
[y]Type of leaf rust: CAR = cedar apple rust, HR = hawthorn rust, U = undetermined.
[z]SR = scab resistant.

QR compared to unsprayed trees (19). The same cultivars in unsprayed orchards may have a higher level of infestation from rust diseases, however, this is not the usual situation in commercial orchards.

This report indicates apple cultivars which are susceptible to CAR and QR under our conditions. Cultivars must be compared over several years since the level of infection varies considerably from year to year. In this study, the highest level of infection occurred in 1986, probably due to a 64-hour wetting period that occurred at the calyx stage of bud development. Lower levels of infection occurred in 1988, 1989 and 1990, when shorter duration wet periods occurred. Long wetting periods, from the pink to the calyx stage of bud development, has resulted in a high incidence of fruit infection in susceptible cultivars (5, 18). Resistance is only indicated when rust infection was not present or very low for several years including one year when susceptible cultivars were severely infected (1986).

CAR and QR may cause severe losses to susceptible cultivars in areas where the alternate host, eastern red cedar, occurs. The cultivars may express different levels of disease from those reported here when grown in different geographic areas, under different environmental conditions and/or inoculum loads as well as physiological races of the pathogen (3, 4, 6, 10). This

report should be useful to pomologists for rating the susceptibility to rust diseases of many newer apple cultivars.

Literature Cited

1. Aldwinckle, H. S. 1974. Field susceptibility of 51 apple cultivars to apple scab and apple powdery mildew. Plant Dis. Rep. 58:625-629.
2. Aldwinckle, H. S. 1974. Field susceptibility of 41 apple cultivars to cedar apple rust and quince rust. Plant Dis. Rep. 58:696-699.
3. Aldwinckle, H. S. 1975. Pathogenic races of *Gymnosporangium juniperi-virginianae* on apple. Phytopathology 65:958-961.
4. Aldwinckle, H. S., R. C. Lamb and H. L. Gustafson. 1977. Nature and inheritance of resistance to *Gymnosporangium juniperi-virginianae* in apple cultivars. Phytopathology 67:259-266.
5. Aldwinckle, H. S., R. C. Pearson and R. C. Seem. 1980. Infection periods of *Gymnosporangium juniperi-virginianae* on apple. Phytopathology 70:1070-1073.
6. Chen, H. and S. S. Korban. 1987. Genetic variability and the inheritance of resistance to cedar-apple rust. Plant Pathology 36:168-174.
7. Coulombe, L. J., R. L. Granger, A. Freve and H. Généreux. 1981. Observations sur la rouille du cognassier chez le pommier à La Pocatiere, Puébec. Can. Plant Dis. Surv. 61:25-27.
8. Crowell, I. H. 1934. Compilation of reports on the relative susceptibility of orchard varieties of apples to the cedar-apple rust disease. Proc. Am. Soc. Hort. Sci. 32:261-272.
9. Jones, L. R. and E. T. Bartholomew. 1915. Apple rust and its control in Wisconsin. Agric. Exp. Stn. Univ. of Wisconsin Bull. 257. 30 pp.
10. Korban, S. S., H. Chen and S. M. Ries. 1987. Interaction of apple cultivars with populations of cedar-apple rust. J. Phytopathology 119:272-278.
11. Miller, P. R. 1939. Pathogenicity, symptoms and the causative fungi of three apple rusts compared. Phytopathology 29:801-811.
12. Mitterling, L. A. and A. C. Bobb. 1963. The incidence of *Gymnosporangium juniperi-virginianae* on eleven apple varieties at Storrs, Connecticut. Plant Dis. Rep. 47:136-138.
13. Palmiter, D. H. 1952. Rust diseases of apples and their control in the Hudson Valley,. N.Y. State Agric. Exp. Stn. Bull. 756. 26 pp.
14. Thomas, H. E. 1933. The quince-rust disease caused by *Gymnosporangium germinale*. Phytopathology 23:546-553.
15. Thomas, H. E. and W. D. Mills. 1929. Three rust diseases of the apple. Cornell Univ. Agric. Exp. Stn. Memoir 123. 21 pp.
16. Thomson, W. T. 1988. Agricultural Chemicals, Book IV—Fungicides. 1987-88 revision. Thomson Publications, Fresno, CA. 196 pp.
17. Warner, J. 1986. Susceptibility of apple scab resistant cultivars to *Gymnosporangium juniperi-virginianae*. *G. clavipes* and *Botryosphaeria obtusa*. Can. Plant Dis. Surv. 66:27-30.
18. Warner, J. 1990. Field susceptibility of scab-resistant apple cultivars and selections to cedar apple rust, quince rust and hawthorn rust. Fruit Varieties Journal 44:216-224.
19. Warner, J. and C. Hebert. 1986. Evaluation of fungicide mixes for control of apple scab and quince rust. Page 181 in Pesticide Research Report, compiled by Expert Committee on Pesticide Use in Agriculture, Agriculture Canada, Ottawa, Ontario. pp. 414.

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Micropropagation of Cold Hardy Dwarfing Apple Rootstocks

Micropropagation was achieved readily with P.22 and O.3 with shoot production and rooting increasing to high levels following subculture for 6-9 months. With P.2 shoot production and rooting was low in spite of subculture for 38 months. Nevertheless some improvement in shoot production on culture medium with phloroglucinol (PG) and increased cytokinin, and 80-90% of shoots rooted on medium with PG. With B.9 shoot production was similar to that with O.3 but rooting remained poor in spite of subculture for 39 months. In a line of B.9 subcultured for 4 years, 73% rooting was achieved *in vitro* on medium with PG and 96% by direct transfer of shoots to sand following a dip in IBA.

From Webster and Jones. 1991. *J. Hort. Sci.* 66:1-6.