Susceptibility of apple scab resistant cultivars to *Gymnosporangium juniper..-virginianae, G. clavipes* n *Botryosphaeria obtusa.*

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Cedar apple rust, quince rust and frogeye leaf spot were evident in 1985 in a fungicide-free second test cultivar evaluation orchard containing scab resistant apple trees. Observations on disease susceptibility were taken for each cultivar and compared to McIntosh and Delicious which were included as standards. The scab resistant cultivars and selections differed in susceptibility to the diseases. There was no evidence that resistance to scab was relatedto cedar apple rust, quince rust or frogeye leaf spot resistance.

Can. Plant Dis. Surv. 66:1.27-30, 1986.

En 1985, la rouille, la rouille du cognassier et la tache ocellée étaient présentes dans un verger ou l'on n'utilisait pas de fongicide afin de faire une deuxième évaluation des cultivars de pommier resistants à la tavelure. L'on a pris des observations sur la susceptibilitb aux maladies de chaque cultivar pour le comparer à McIntosh et Delicious, les deux cultivars etalons. Les cultivars et les sélections resistants a la tavelure différaient dans leur susceptibilitb envers ces maladies. On n'a pas trouvé d'évidence qu'il y ait une relation entre la resistance à la tavelure et celle a la rouille, à la rouille du cognassier et a la tache ocellée.

Introduction

Apple diseases are usually controlled by one or more applications of fungicides. Apple scab caused by ***Venturia inaequalis*** (Cke.) Wint. is the most serious disease affecting apples (***Malus domestica*** Borkh.) in northeastern growing areas and may require 12 or more fungicide sprays for control. Growing cultivars resistant to apple scab may allow a major reduction in fungicide use. When fungicide programs are reduced or eliminated, other diseases may become more prevalent on apple. Little information is available on the susceptibility of scab resistant cultivars and selections to other diseases.

This paper reports on the field susceptibility to cedar apple rust (***Gymnosporangium juniperi-virginianae*** Schw.), quince rust (***G. clavipes*** Cke. and Pk.) and frogeye leaf spot (***Botryosphaeria obtusa*** (Schw. Shoemaker) during 1985 of scab resistant cultivars and selections from crosses including ***Malus floribunda*** Sieb. 821, ***M. atrosanquinea*** Schneid., and ***M. pumila*** Mill parentage. Comparisons included McIntosh and Delicious which were used as standards. Of particular interest are the selections from the Ottawa (O) breeding program and the Co-op selections from the Purdue, Rutgers and Illinois Agricultural Experiment Station Cooperative Apple Breeding Program.

Method

Apple cultivars and selections in a scab resistant second test orchard, planted at the Smithfield Experimental Farm from 1978 to 1983 on M26, 03 and MM106 rootstocks, were used in this study. No fungicides were applied in this orchard during 1985. Insects were controlled using one application each of azinphos-methyl and phosalone, and two applications of phosmet.

A minimum of 100 fruits per cultivar were assessed in late June and early August for cedar apple rust and quince rust. These diseases were identified according to visible host symptoms (13, 17). Only the early August figures were included in this report because they tended to be higher than the late June counts.

The three most severely infected leaves on each of ten terminals per cultivar were rated for rust in late June. The number of rust lesions per leaf was estimated using a scale of 0 to 5 (0 = no lesions; 1 = 1-5; 2 = 6-25; 3 = 26-50; 4 = 51-100; 5 = 101-200 lesions per leaf). The average number of rust lesions per leaf for each cultivar was calculated using the median value for each rating given for each leaf. Size of leaf rust lesions was estimated by comparing the scab resistant cultivars to the standard cultivars, Delicious (small lesion size) and McIntosh (medium lesion size). Rust lesions were checked during August and early September for the presence of pycnia and aecia and the most advanced stage of development was recorded.

Rust infection occurred from naturally occurring sources. Eastern red cedar, ***Juniperus virginiana*** L., the alternate host for all three rust diseases attacking apple, was within 1/2 to 1 km of the orchard. Wetting periods in early May at the tight cluster stage of bud development (37 hr at 8.5°C), late May at the calyx stage (14 hr at 10°C and 56 hr at 13°C) and early June (22.5 hr at 15°C) served as rust infection periods (5).

Frogeye leaf spot caused by B. ***obtusa*** was rated on July 22, using a scale of 0 to 3 (0 = no lesions; 1 = 1-5; 2 = 6-25; 3 = 26-50 lesions per leaf). Since leaf spotting was fairly uniform on the oldest shoot and cluster leaves, an average rating for each cultivar was determined by examining 10 shoots per cultivar. Inoculum likely occurred from overwintering cankers on dead bark and twigs in the orchard. Wetting periods in early May and early June would have provided suitable conditions for B. obtusaleaf infection (11).

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Contribution No. 101

Accepted for publication January 13, 1986

Results and discussion

The scab resistant cultivars and selections differed in their susceptibility to the rust fungi and to *B. obtusa* (Table 1). In this study, as well as previous reports (4, 15) there was no evidence that resistance to scab and cedar apple rust were related. Also there does not appear to be an association between scab resistance and either quince rust or frogeye leaf spot resistance.

Apple leaves are susceptible to both cedar apple rust and hawthorn rust, G *globosum* Farl. (13, 17). Since it is very difficult to distinguish hawthorn rust from cedar apple rust on the basis of leaf symptoms (13), it is possible hawthorn rust was present on the leaves in addition to cedar apple rust. However, Aldwinckle (1) considers hawthorn rust much less frequent in occurrence than cedar apple rust.

Resistance of apple cultivars to cedar apple rust has been characterized as absence of aecia (15) or absence of pycnia and aecia (4, 16). In this study, only four cultivars, Co-op 11, Novamac, 0-6414 and 0-655 had no pycnia or aecia. Co-op 11 and 0-6414 had no cedar apple rust fruit infection. Novamac and 0-655 did not bear fruit. Cultivars with pycnia but no aecia had less than 3% fruit infection. Co-op 1, Co-op 14, Macfree, 0-546, 0-653 and Priscilla had pycnia and also a few aecia, however no fruit infection from cedar apple rust was observed. Trent and HAR13T18 had pycnia and a few aecia but 4 and 8% of the fruit, respectively, was infected with cedar apple rust. Cultivars with numerous aecia had from 12 to 84% fruit infection and were considered very susceptible to cedar apple rust. The cultivars and selections having the most advanced leaf reaction (aecia) tended to have the highest levels of cedar apple rust fruit infection. Cultivar resistance to

Table 1. Susceptibility of scab resistant apple cultivars to cedar apple rust, quince rust and frogeye leaf spot during 1985.

Cultivar	% Fruit infection: Cedar apple rust	% Fruit infection: Quince rust	Average no. rust lesions per leaf	Lesion size *	Most advanced reaction **	Frogeye leaf spot rating ***
Britegold	12	1	78	large	A (v.s.)	1
co-op 1	**0**	2	138	medium	A (v.f.)	1
co-op 3	1	1	85	medium	P	3
Co-op 6	81	5	132	large	A (v.s.)	1
co-op 7	**0**	1	57	medium	P	2
Co-op 8	**0**	0	45	medium	P	2
co-op 9	35	14	32	large	A (v.s.)	1
co-op 10	**0**	4	118	small	**P**	2
co-op 11	**0**	2	6	small	N	1
co-op 12	62	3	94	large	A (v.s.)	1
Co-op 14	**0**	1	51	small	A (v.f.)	2
Co-op 15	38	1	59	large	A (v.s.)	0
Co-op 16	51	6	78	large	A (v.s.)	1
Delicious	0	1	39	small	P (v.f.)	1
HAR4T100	**0**	12	140	medium	**P**	3
HAR13T18	8	**0**	63	small	A (v.f.)	1
Jonafree	22	**0**	93	large	A (v.s.)	0
Macfree	0	9	138	medium	A (v.f.)	2
McIntosh	0	3	39	medium	P	2
Moira	1	14	131	medium	P	3
Murray	1	12	100	small	P	2
Nova Easygro	**0**	2	81	medium	P	2
Novamac	–	–	55	small	N	3
0-533	0	6	**70**	small	P	2
0-546	**0**	1	**99**	small	A (v.f.)	3
0-625	0	17	86	very small	**P**	1
0-634	**0**	2	117	small	P	2
0-637	**0**	2	67	medium	P	3
0-638	**0**	2	57	very small	P (v.f.)	1
0-641	3	4	54	small	P (v.f.)	1
0-644	0	8	79	small	P	3
0-645	**0**	13	77	small	P	3
0-648	12	8	145	large	A (v.s.)	1
0-6410	0	5	124	small	P	3

Table 1. Continued.

Cultivar	% Fruit infection: Cedar apple rust	% Fruit infection: Quince rust	Average no. rust lesions per leaf	Lesion size *	Most advanced reaction **	Frogeye leaf spot rating ***
0-6413	23	6	104	medium	A (v.s.)	2
0-6414	0	2	44	small	N	3
0-6415	2	5	77	small	P	1
0-6416	0	0	77	small	P (v.f.)	1
0-6417	0	5	73	small	P	3
0-653	0	10	106	medium	A (v.f.)	3
0-654	0	0	124	small	P	3
0-655	–	–	58	small	N	1
0-661	27	6	47	large	A (v.s.)	0
0-662	0	0	73	small	P	1
0-663	39	4	48	medium	A (v.s.)	1
0-664	0	0	64	small	P	2
0-669	–	–	129	medium	A (v.f.)	2
Prima	72	2	126	large	A (v.s.)	0
Priscilla	0	10	141	small	A (v.f.)	1
Redfree	1	4	49	small	P	2
Richelieu	22	5	63	large	A (v.s.)	0
Sir Prize	84	15	108	large	A (v.s.)	1
Trent	4	6	83	very small	A (v.f.)	1

*lesion size compared to McIntosh (medium) and Delicious (small).
**A = aecia, P = pycnia, N = nonsporulating lesion, v.s. = very susceptible, v.f. = very few
***0 = no lesions, 1 = 1-5, 2 = 6-25, 3 = 26-50 lesions per leaf.

G. juniperi-virginianae based on the absence of pycnia and aecia would be a more definitive test than based solely on the absence of aecia.

Delicious and McIntosh, when evaluated for cedar apple rust resistance, have been reported to be slightly susceptible (1) or to have a few aecia (9), pycnial lesions, non-sporulating lesions or no macroscopic symptoms (3, 4, 14). In the present study both McIntosh and Delicious had pynical lesions, however, lesion size was larger and pycnia were more plentiful on McIntosh than Delicious. No fruit from either cultivar was infected with cedar apple rust.

Prima was reported susceptible to cedar apple rust (3,6,7) with aecia present (3). The present study agrees with these reports. Sir Prize was very susceptible to cedar apple rust in this study. This agrees with data from New York (6) and Massachusetts (7) but Williams *et al.* (19) report Sir Prize moderately resistant to cedar apple rust. Co-op 16 and Jonafree were also very susceptible to cedar apple rust in this study but Co-op 16 was reported moderately resistant by Williams *et al.* (18). No cedar rust was observed on Jonafree by Dayton *et al.* (10). Priscilla (6,7) and Redfree (20) were reported resistant to cedar apple rust. In this study, 0 and 1%, respectively, of the fruit was infected, although aecial and pycnial leaf lesions did occur. Becker *et al.* (7) reported Macfree leaves were more susceptible to cedar apple rust than were Nova Easygro leaves which agrees with the present study.

Conflicting reports on susceptibility of apple cultivars to cedar apple rust may be due to inoculum concentration and age of apple leaves (2, 5) or confusion with hawthorn rust (13). The present study also reports on the susceptibility of fruit to cedar apple rust. Fruit is not subject to hawthorn rust (13,17).

Leaf rust lesions occurred on all cultivars. There was a trend for the very susceptible cultivars to have larger leaf lesions. The cultivars with non-sporulating lesions had lesions which were small and fewer in numbers than most other cultivars. However, lesion number, by itself, was not a good criteria to identify leaf susceptibility.

Mowry (15) reported that leaves infected with more than five cedar apple rust lesions tended to abscise during the summer. Leaf abscission was noted on many cultivars in this study, however, no attempt was made to correlate leaf abscission with rust infection.

More of the scab resistant cultivars and selections were susceptible to quince rust than to cedar apple rust. However, percent fruit infection for the most susceptible cultivars was higher for cedar apple rust than for quince rust (84% and 17%, respectively). The quince rust infection reported in this study may be low because fruit drop from quince rust was observed. Coulombe (personal communication) also reported fruit drop on the cultivar Quinte. The Delicious cultivar is usally considered susceptible to quince rust (1) although in this study only 1% fruit infection occurred. Many of the scab resistant cultivars were more susceptible to quince rust than was Delicious.

Coulombe (8) reported no fruit infection from quince rust on Trent and 0-546, however, these were susceptible in the pre-

sent study with 6 and 1% infection, respectively. Delicious, Prima and Co-op 1 were susceptible to quince rust in both trials.

Frogeye leaf spot is the foliage symptom of black rot caused by *B. obtusa* (11, 12). Although frogeye leaf spot is not considered an important disease in the northeastern apple growing area (12) it may become more prevalent where fungicide programs are eliminated or reduced. In this study, frogeye leaf spot lesions containing pycnidia were 2 to 4 mm in diameter. Co-op 15, Jonafree, 0-661, Prima and Richelieu appeared resistant to frogeye leaf spot. The other cultivars and selections varied in susceptibility. Where several lesions occurred in close proximity (2 or 3 rating) the spots tended to coalesce forming a larger necrotic area. A rating of 2 or 3 was sufficient to cause leaf abscision.

This report shows the relative susceptibility of the various cultivars and selections to the diseases observed. The cultivars with low disease ratings may have escaped infection or may be susceptible under different conditions or inoculum loads. Cultivars which are resistant to apple scab differ in susceptibility to the apple rust diseases and frogeye leaf spot and may require several fungicide sprays for control of these diseases.

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