Susceptibility of New Apple Cultivars to Common Apple Diseases

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Knowing what to expect from new apple cultivars can help in planning pest control strategies for orchards that contain these cultivars. Although susceptibility to insects and diseases is usually not a limiting factor in cultivar selection, cultivars that are highly susceptible to particular pests may require extra applications of pesticide each year, and the costs associated with those applications should be considered before trees are planted.

The Multistate Research Project, NE-103, was initiated in 1995 to coordinate multi-disciplinary evaluations of new apple cultivars at multiple locations throughout the United States and Canada. Regional research projects such as NE-183 are organized under the auspices of the USDA and are funded using a portion of the Federal Formula Funds that are allocated to land-grant universities each year. The purpose of multistate research programs such as the NE-183 project is to enable cooperation among the State Agricultural Experiment Stations (SAES) in partnership with the Cooperative State Research, Education, and Extension Service (CSREES) of the U.S. Department of Agriculture, to tackle complex problems that are beyond the scope of a single state experiment station.

Currently, 68 scientists from 21 states and three Canadian provinces are listed as participants in the NE-183 multistate project. In the spring of 1995, a series of uniform plantings containing 21 new cultivars and selections was established at 28 locations from Missouri to Maine and from New York to Washington State. In 1999, a second round of uniform plantings of 22 additional cultivars/selections was established at 29 locations. Some of the plantings are being used to assess horticultural qualities of the new cultivars whereas other plantings are being used to evaluate susceptibility to diseases, insects, and mites.

At Cornell's Hudson Valley Lab in Highland, the new apple varieties in both the 1995 (Planting #1) and 1999 (Planting #2) trials are being evaluated for susceptibility to diseases and arthropod pests. Not all pests can be monitored in the same year because severe infestations of one pest can make it impossible to monitor for other pests in that same year. To simplify management of these plantings, disease data has been collected during the early years of the plantings whereas evaluations for insect damage were generally delayed until the trees were older.

This paper presents some of the results of disease evaluations conducted at the Hudson Valley Lab since 1996. Background information on the cultivars has not been included in this paper but is accessible at the NE-183 web site, http://www.ne183.org/cultivars/cultivars.html. Horticultural characteristics for some of these cultivars have also been summarized in a previous *N.Y. Fruit Quarterly* article (Brown and Maloney, 2002).

Experimental Design

Both the 1995 and the 1999 plantings contained five single-tree replicates for each cultivar or selection being evaluated. Within each planting, cultivars were planted in a randomized, complete-block design. Trees evaluated for this report were all on M.9 rootstock and were trained as vertical axe trees. Trees were tied to steel conduit posts, and posts were connected with a single high-tensile wire. Trees were planted approximately 7 ft. apart within the row, and herbicides were used to control weeds and grass beneath trees. Tree rows in the 1995 planting were 20 ft. apart whereas in the 1999 planting they were only 12 ft. apart. Both plantings had trickle irrigation. Golden Delicious (Gibson strain), McIntosh (Pioneer strain in 1995; Rogers strain in 1999), and Mutsu were used as standard cultivars in both plantings, and Cortland was included in the 1999 planting as a known standard for mildew susceptibility.

Disease Evaluations and Data Analysis

No early-season fungicides were applied to the test plots in years when trees were evaluated for apple scab, powdery mildew, or rust diseases. Incidence of various diseases was determined by counting the number of leaves with disease on a specified number of terminals per tree or by evaluating up to 100 fruit per tree. Where similar data were collected for more than one year, a statistical procedure known as repeated measures analysis was used to determine means for the entire multi-year data sets. In all of the data tables, numbers followed by the same small letters do not differ significantly. The arc-sine transformation was used for statistical analyses to determine mean separations, but arithmetic means are shown in the tables.

Because of the transformation used for statistical analyses and the rounding of means to whole numbers, cultivars with the identical means in the data tables sometimes fall into different statistical groupings. Also, the rankings of means may differ slightly from the ranking based on statistical groupings as designated by small letters that follow the means, as occurs, for example, for NJ90, Delblush, and Ambrosia in Table 2.

Apple scab: Only Orin developed as much leaf scab as McIntosh when cultivars were compared over three years in Planting #1 (Table 1). In 1997, the only year that susceptibility to fruit scab was evaluated, McIntosh, Orin, Cameo, Sunrise, Shizuka, Gala, and Golden Supreme all had similar levels of fruit scab. Trees were too young to carry fruit in 1996, and many trees carried no fruit in 1998 because of the severe scab infection that was allowed to develop in 1997.

Pristine, Enterprise, GoldRush, and NY75414-1 are all considered scab-resistant cultivars. The trace of leaf scab reported for these cultivars resulted either from misidentified lesions or from a trace of scab caused by fungal strains that are not completely controlled by the Vf gene for resistance. The scab lesions reported for these cultivars were not examined in the lab to verify that the lesions actually represented apple scab

In Planting #2, only Cortland was as susceptible to leaf scab as McIntosh (Table 2). Rankings for susceptibility to fruit scab varied considerably between 2001 and 2002. In 2002, only NJ 90 and Hampshire developed as much fruit scab as McIntosh. In this planting, Coop 39, Scarlet O'Hara, CQR 10T17, NY 79507-72, CQR 12T50, NY 65707-19, NY 79507-49, and Sundance are considered scab-resistant cultivars. Scab lesions recorded for these cultivars are subject to the same uncertainties as noted for scab-resistant cultivars in Planting #1.

Powdery mildew: None of the cultivars in either planting proved totally resistant to mildew (Tables 3 & 4). However, the more resistant cultivars are likely to develop less mildew in commercial plantings than they did in these randomized plantings

TABLE 1

Apple scab incidence in NE-183 Planting #1, Highland, NY.

Variety	Percent terminal leaves with scab over three years 1996-1997-1998*	% fruit with scab at harvest in 1997
McIntosh (Pioneer)	46 i**	88 h i
Orin	48 i	87 h i
Ginger Gold	31 h	53 d e
Golden Delicious	30 g h	64 e f g
Cameo	29 g h	84 g h i
Sunrise	29 g h	70 e f g h
Braeburn	29 g h	84 g h i
Shizuka	27 f g h	93 i
Mutsu	26 f g h	63 d e f g
Fuji (BC #2)	26 f g h	57 d e
SunCrisp	25 f g h	55 d e
Gala (Fulford)	25 f g h	72 e f g h
Yataka	23 f g	26 b c
Arlet	23 f g	62 d e f
Creston	20 e f	54 d e
Fortune	20 e f	60 d e f
Senshu	15 d e	41 c d
Golden Supreme	15 d e	73 e f g h
Honeycrisp	12 d	no data
Sansa	7 c	0 a
Gala Supreme	2 b	11 b
Pristine	<1 a	0 a
NY75414-1	<1 a	0 a
Enterprise	<1 a	0 a
GoldRush	<1 a	0 a

* All leaves on 5, 15 and 10 terminals per tree were evaluated on the 2 Aug 1996, 14 July 1997 and 11 June 1998 respectively.
**Numbers within columns followed by the same letter do not differ significantly ($P \leq 0.05$).

TABLE 2

Apple scab incidence in NE-183 Planting #2, Highland, NY.

Cultivar	Percent terminal leaves with scab over three years (1999-2000-2001)*	% fruit with scab** 2001	2002
McIntosh (Rogers)	30 j	17 e f	56 f
Cortland	30 i j	9 c d e	no data
Hampshire	28 h i	13 d e f	39 e f
Chinook	25 g h	30 g	30 d e
NJ 90	24 g h	24 f g	48 f
Delblush	24 f g	17 d e f	8 c
Ambrosia	23 g h	30 g	34 e
Zestar	17 e f	0 a	6 b c
Mutsu	16 e	15 d e f	0 a
Jubilee Fuji	14 d e	1 a	14 c
Golden Delicious	11 c d	4 a b c	1 b
Corail (Pinova)	9 c	0 a	3 a b
Runkel	7 c	6 b c d	15 c d
NJ 109	3 b	3 a b c	2 a b
BC 8S-26-50	1 b	0 a	8 c
Coop 39	<1 a	3 a b c	0 a
Scarlet O'Hara	<1 a	2 a b	0 a
CQR 10T17	<1 a	2 a	<1 a b
NY 79507-72	1 a b	0 a	0 a
CQR 12T50	<1 a	0 a	0 a
NY 65707-19	<1 a	0 a	0 a
NY 79507-49	<1 a	0 a	0 a
Sundance	0 a	0 a	0 a

* Presence of scab was evaluated on five terminals/tree on 24 June 1999 and on 10 terminals/tree on 24 July 2000, and 13 June 2002. Numbers within columns followed by the same letter do not differ significantly ($P \leq 0.05$).
** Fruit were harvested near maturity using different dates for different cultivars in 2001, but all cultivars were harvested 24 Jul 2002 because severe rust and scab infections were causing fruit to drop from some trees.

TABLE 3

Powdery mildew incidence in NE-183 Planting #1, Highland, NY

Cultivar	Percent terminal leaves with mildew over three years 1996-1997-1998	
Ginger Gold	44	l
GoldRush	32	k
SunCrisp	26	j k
Gala (Fulford)	23	i j
Braeburn	21	g h i j
Mutsu	21	h i j
Shizuka	20	e f g h i j
BC 8M 15-10	19	f g h i j
Orin	18	e f g h i j
Carousel	17	e f g h i j
Golden Delicious	17	e f g h i j
Sunrise	17	d e f g h
Honeycrisp	17	e f g h i
McIntosh (Pioneer)	15	d e f g h
Golden Supreme	15	d e f g h
Sansa	14	d e f g
Fortune	13	d e f
Arlet	11	c d e
Pristine	9	b c d
Senshu	8	a b c
Fuji (BC #2)	7	a b c
Enterprise	6	a b
NY 75414-1	5	a b
Yataka	4	a
Gala Supreme	4	a

* Ratings were made by evaluating all leaves on five terminals per tree on 28 June 1996 and the eight youngest leaves on 15 terminal per tree on 3 July 1997 and on 10 terminal per tree on 11 June 1998. Numbers followed by the same letter do not differ significantly ($P \leq 0.05$).

TABLE 4

Powdery mildew incidence in NE-183 Planting #2, Highland, NY

Variety	Percent terminals leaves with mildew during two years (2000 & 2002)*	
Delblush	53	j
Coop 39	47	i j
CQR 10T17	47	i j
Cortland	44	h i j
Chinook	42	h i
Sundance	36	g h
Golden Delicious	36	g h
NJ 90	32	f g
Mutsu	31	f g
Scarlett O'Hara	30	f g
Corail (Pinova)	29	e f g
Ambrosia	28	d e f g
BC 8S-26-50	27	c d e f g
NJ 109	24	c d e f
Runkel	23	c d e f
NY 65707-19	21	b c d
Hampshire	19	b c d e
McIntosh (Rogers)	19	b c d
NY 79507-49	18	b c d
CQR 12T50	18	b c
NY 79507-72	16	a b
Zestar	14	a b
Jubilee Fuji	10	a

[1] The eight youngest leaves on 10 terminal shoots per tree were evaluated for powdery mildew on 30 June 2000 and 24 June 2002. Numbers followed by the same letter do not differ significantly ($P \leq 0.05$).

where they were constantly exposed to large amounts of inoculum produced by the adjacent susceptible cultivars.

Rust diseases: Three different rust diseases caused by *Gymnosporangium* species are common on apples in southern New York. Cedar apple rust (CAR), caused by *G. juniperi-virginianae*, infects both leaves and fruit of susceptible cultivars. Leaf infections are far more common than fruit infections for CAR. Hawthorn rust caused by *G. globosum* only infects leaves and is generally less abundant than CAR. Quince rust (*G. clavipes*) infects fruit but does not cause leaf lesions.

On infected leaves, the early symptoms of CAR and hawthorn rust are so similar that the two species cannot be easily differentiated. Therefore, rust evaluations completed during early-summer produced leaf ratings that represented a combination of CAR and hawthorn rust infections. By mid-August, the two species of rust can be differentiated based on the appearance of aecia that form on the bottom sides of infected leaves. Aecia produce the aeciospores that can infect only cedar trees, thereby completing the rust disease cycle. Lesions caused by *G. juniperi-virginianae*, the CAR fungus, develop short aecial tubes that split apart and roll back whereas aecial tubes of *G. globosum* are longer, split open unevenly, and often appear tangled.

In Planting #1, Shizuka, Mutsu, GoldRush, BC8M 15-10, and Golden Delicious all had rust lesions on at least 20 percent of terminal leaves over two years (Table 5). By comparison, NY75414-1, Gala Supreme, Golden Supreme, McIntosh, Fortune, Sunrise, Suncrisp, Enterprise and Sansa all had less than 3 percent of leaves with rust lesions. Susceptibility to quince rust could not be determined for Planting #1 because little quince rust developed in any of the plots during the years when there was sufficient fruit to evaluate.

More detailed data on rust susceptibility was collected in Planting #2. Trees in this planting were surrounded by scattered cedar trees that provided inoculum. The severity of rust infections in this planting was enhanced by spring weather conditions during 2001 and 2002 that favored rust infection. All of the cultivars in Planting #2 were susceptible to rust diseases, with 25-64 percent of terminals leaves affected (Table 6, right-hand column).

The type of rust symptoms that developed in Planting #2 varied among

cultivars. Mutsu, CQR 12T50, and Scarlet O'Hara all had at least 40 percent of leaves with more than 20 lesions per leaf in 2000 and 2001. Of these, 93-99 percent of infected leaves developed aecia typical of CAR lesions (Table 6). By comparison, the last 11 cultivars listed Table 6 had less than 4 percent of leaves with >20 rust lesions per leaf, but eight of these cultivars had more than 10 percent of leaves with >20 leaf spot lesions. Rust-induced leaf spot lesions frequently develop on leaves when CAR spores begin germinating, kill a few leaf cells, then stop growing because of an incompatible host reaction. The killed cells are frequently invaded by other secondary pathogens such as *Alternaria*, *Botryosphaeria*, or *Phomopsis*, and these secondary invaders cause a leaf spot disease that can be nearly as devastating as rust infections.

The 12 cultivars listed in the top half of Table 6 were highly susceptible to cedar apple rust but had relatively few leaves with severe leaf spot (>20 lesions / leaf). The remaining cultivars tended to have a higher incidence of leaf spot, and they usually had more leaves with aecia of hawthorn rust than with aecia of CAR.

TABLE 5

Incidence of rust lesions on leaves (cedar apple rust and hawthorn rust) in NE-183 Planting #1, Highland, NY.

Cultivar	Percent terminal leaves with rust (1996 & 1997)
Shizuka	28 k
Mutsu	28 k
GoldRush	24 j k
BC 8M 15-10	21 i j
Golden Delicious	20 h i j
Ginger Gold	18 g h i
Carousel	17 f g h i
Arlet	17 f g h
Fuji (BC #2)	14 e f g
Senshu	14 e f g
Orin	14 d e f g
Braeburn	14 d e f
Yataka	13 e f g
Pristine	13 d e f
Honeycrisp	11 d e
Gala (Fulford)	9 d
Sansa	2 c
Enterprise	2 b c
SunCrisp	1 b c
Sunrise	1 a b c
Fortune	1 a b c
McIntosh (Pioneer)	<1 a b c
Golden Supreme	<1 a b c
Gala Supreme	<1 a b
NY 75414-1	0 a

*Ratings are from all leaves on 5 terminals per tree on 2 Aug. 1996 and all leaves on 15 terminals per tree on 14 July 1997. Numbers followed by the same letter do not differ significantly ($P \leq 0.05$).

TABLE 6

Incidence of apple rust diseases, rust-induced leaf spot, and rust aecia in NE-183 Planting #2, Highland, NY.

Cultivar	Percent terminal leaves in 2001& 2002 that had >20 lesions per leaf[1]		% infected leaves in Aug 2002 showing[2]			Mean percent terminal leaves affected by rust (including leaves with leaf spot) for 2001 & 2002
	rust lesions	leaf spot	cedar apple rust aecia	no aecia	hawthorn rust aecia	
Mutsu	47 h[3]	1.1 b c[3]	99	1	4	64 j[3]
CQR 12T50	40 g	0.5 a b	99	1	6	53 g h i
Scarlet O'Hara	40 g	0.6 a b	93	8	1	54 h i
Chinook	36 f	0.4 a b	100	0	5	52 f g h i
CQR 10T17	36 f	1.2 b c	100	0	10	49 e f g h
Coop 39	32 e	0.2 a	88	13	3	49 d e f g h
Golden Delicious	32 e	0.3 a b	100	0	4	48 d e f g
Corail (Pinova)	32 e	0.8 a b c	69	31	0	57 i j
Ambrosia	31 d e	1.0 a b c	99	1	3	49 e f g h
BC 8S-26-50	31 d e	0.3 a b	79	20	10	48 d e f g h
NJ 109	28 c d	0.1 a	90	10	1	46 d e f
Jubilee Fuji	26 c	0.5 a b	36	59	5	48 d e f g h
Runkel	3 b	6.1 d	19	53	29	38 b c
Cortland	2 a b	4.1 d	1	80	18	43 c d e
NY 79507-72	0 a	2.8 c	8	21	71	25 a
NJ 90	0 a	5.2 d	6	65	31	34 b
Delblush	<1 a	7.0 d e	6	40	55	42 c d
McIntosh (Rogers)	0 a	10.2 e f	0	95	5	46 d e f
Hampshire	<1 a	12.2 f g	15	64	24	43 c d e
NY 79507-49	0 a	13.0 f g	14	57	30	45 c d e
Sundance	0 a	13.2 g h	32	47	21	46 d e f
Zestar	0 a	15.0 h	0	80	20	48 d e f g h
NY 65707-19	0 a	22.5 i	11	50	39	52 f g h i

[1]All leaves on 5 terminals per tree were evaluated for disease in 2001 and 2002. Missing leaves (empty nodes) were not included in the counts.
[2] Twenty leaves with yellow-orange lesions were collected from each tree in four reps and examined under a dissecting scope for aecial development 21-23 Aug 2002.
[3] Numbers followed by the same letter do not differ significantly ($P \leq 0.05$).

The cultivars with the greatest resistance to foliar rust infections appear in the middle of Table 6. NY79507-72 was the most resistant with only 25 percent of leaves affected by rust and only 2.8 percent of leaves with > 20 lesions.

All of the cutlivars in Planting #2 were susceptible to quince rust, but the incidence of infection ranged from a low of 13 percent for Sundance to a high of 69 percent for Zestar.

Fire blight: Streptomycin sprays were used to protect trees in the Hudson Valley plantings from fire blight, and no blight symptoms developed in any of the trees at this location. However, natural fire blight epidemics developed in NE-183 plantings in several other states. In the 1995 plantings, Arlet, Braeburn, Cameo, Creston, Fortune, Gala Supreme, Ginger Gold, Golden Delicious, Golden Supreme, GoldRush, Honeycrisp, NY 75415-1, Pristine, Sansa, Shizuka, Suncrisp, and Sunrise have all been severely damaged by fire blight in one or two locations. Ambrosia, Autumn Gold, Coop 29, Coop 30, Delblush, Golden Delicious, Hampshire, Jubilee Fuji, NJ 109, NJ 90.NY.75907-72, and Zestar all suffered more than 50 percent mortality from fire blight at one location. Many of the trees killed by fire blight died from rootstock blight after the M.9 rootstocks became infected.

TABLE 7

Quince rust incidence in NE-183 Planting #2, Highland, NY.

Variety	Percent fruit with quince rust in 2001 & 2002*	
Zestar	69	i
Cortland	60	h i
Coop 39	60	h i
Jubilee Fuji	59	g h i
CQR 12T50	57	f g h i
McIntosh (Rogers)	54	e f g h i
NJ 109	52	d e f g h i
NY 79507-72	52	d e f g h
NJ 90	50	d e f g h i
Delblush	49	d e f g h
BC 8S-26-50	45	c d e f g
NY 65707-19	43	c d e f g h
Mutsu	41	c d e f g h
Golden Delicious	41	c d e f g
Chinook	41	c d e f
Ambrosia	39	b c d e
NY 79507-49	39	b c d e f
CQR 10T17	35	b c d e
Scarlet O'Hara	34	b c d e
Corail (Pinova)	32	a b c d
Runkle	28	a b c
Hampshire	25	a b
Sundance	13	a

* In 2001 the mean number of fruit evaluated was 34.0 and ranged from 1 to 150 fruit per tree with three trees having no fruit for evaluation. In 2002 the mean number of fruit evaluated was 30.7 and ranged from 1 to 100 fruit per tree with 13 individual trees having no fruit for evaluation. Numbers followed by the same letter do not differ significantly ($P \leq 0.05$).

Significance of Differences in Susceptibility

Most apple growers decide which apple cultivars to plant based on their perceptions of whether or not the apples from those cultivars can be marketed at a profit. Susceptibility to insects and diseases is usually not a limiting factor in cultivar selection, although organic producers may avoid highly-susceptible cultivars. Cultivars that are highly susceptible to particular pests may require extra applications of pesticide each year, and the costs associated with those applications should be considered before trees are planted. For example, Ginger Gold trees frequently require one or two additional mildewcide sprays per year as compared to less susceptible cultivars such as McIntosh whereas McIntosh may require more sprays to control apple scab. Knowing what to expect from new cultivars can help in planning pest control strategies for orchards that contain these cultivars.

Literature Cited

Brown, S., and K. Maloney. 2002. Apple cultivars: a Geneva perspective. N. Y. Fruit Quarterly 10(2):21-27.

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