Crabapple (*Malus* spp. and cultivars) evaluations for resistance to apple scab (*Venturia inaequalis*) infections at Secrest Arboretum in Wooster, Ohio: 2014-2015.

Introduction

The fungus *Venturia inaequalis* causes the foliar and fruit disease apple scab on orchard fruit production trees (*Malus domestica*) and on ornamental, landscape, flowering crabapple trees (*Malus* spp. and cultivars). As with other fungi-caused diseases, the severity of the disease from one season to the next is highly influenced by three factors: environmental conditions, amounts of inoculum and susceptibility of the hosts. These three components make up the legs of the disease triangle (Francl 2001). The apple scab pathogen overwinters in infected leaves on the ground. In the spring, splashing water from rainfall and/or winds carry spores released from the fallen leaves to new leaves and blossoms. These spores produce primary infection. From the primary infections, additional spores are released that produce secondary infections. The optimal conditions for apple scab infection are when temperatures are between 55 and 75 F and the leaves or fruit are continuously wet for 9 or more hours (Giraud et al. 2011)). Under these conditions, the most susceptible hosts suffer heavy and repeated apple scab infections that frequently result in near or total defoliation of the trees. When conditions are not optimal for the spread of apple scab, even the most susceptible hosts will not show a great deal of infection or defoliation until near the end of the growing season.

National Crabapple Evaluation Project (NCEP) plots have been established in several locations in North America, one of which is located at The Ohio State University Secrest Arboretum on the Ohio Agriculture Research and Development Center in Wooster, Ohio. The following report reviews apple scab incidence data from the 2014 and 2015 growing seasons when apple scab pressure was less than severe.

Materials and Methods

Tree Identity. Tree identity is based on the taxonomic and cultivar descriptions provided by the suppliers of the plant materials.

Cultural Care of Plot. Eighty crabapple taxa were planted in 1997-2005 at Secrest Arboretum in Wooster, Ohio, in a completely randomized design. There were five replicate trees planted for most but not all taxa, though fewer replicates exist currently due to a variety of factors, including inadequate original numbers (e.g., 'Hamlet'), death due to bacterial fireblight (e.g., 'Golden Raindrops'), and other attrition such as deer damage.

Plants were irrigated as needed during the year of transplanting and are mulched when needed with composted yard-waste. The soil type in which the trees are planted is a silt loam. Weeds are controlled with spot applications of glyphosate.

Data Collection. Plant evaluations were performed on June 20, July 22, August 26, and September 16, 2014, and June 16, July 20, and September 24, 2015. All trees in the plot were rated on a scale of 0 to 5, with 0 = no scab observed; 1 = less than 5% of leaves affected and no aesthetic impact; 2 = 5 to 20% of leaves affected, with some yellowing but little or no defoliation, moderate aesthetic impact; 3 = 20 to 50% of leaves affected, significant defoliation and/or leaf yellowing, substantial aesthetic impact; 4 = 50 to 80% of leaves affected, severe foliar discoloration and defoliation, severe aesthetic impact; and 5 = 80 to 100% of foliage affected, with 90 to 100% defoliation. Apple scab incidence ratings and observations were conducted by James Chatfield, Erik Draper, and Kenneth Cochran.

Data Analysis. Of the 80 taxa in the plot, 38 taxa in 2014 and 37 taxa in 2015 with five (5) replicates of each were used in the data sets for statistical analysis. CoStat Statistical Software (Version 6.400; Simons, 2008) was used to analyze the data sets. Means were separated using the Student-Newman-Keuls test at $p=0.05$.

Results and Discussion

Results of the 2014 and 2015 evaluations are presented in Table 1 and Table 2, respectively. Significant differences in the mean incidences of apple scab existed between the crabapple taxa each year and for each sampling date (6/20/2014 - $F_{(1,37)}$ = 99.43, $p<0.00001$; 7/22/2014 - $F_{(1,37)}$ = 88.70, $p<0.00001$; 8/26/2014 - $F_{(1,37)}$ = 90.50, $p<0.00001$; 9/16/2014 - $F_{(1,37)}$ = 142.22, $p<0.00001$; 6/26/2015 - $F_{(1,36)}$ = 30.73, $p<0.00001$; 7/20/2015 - $F_{(1,36)}$ = 89.52, $p<0.00001$; and 8/24/2015 - $F_{(1,36)}$ = 107.27, $p<0.00001$).

Apple scab pressure was higher in 2014 than in 2015, was extremely low through most of 2015, and started sooner in 2014 than in 2015 based on the higher mean incidence ratings observed on the July sampling dates. On the June sampling date in 2014, the mean incidences of apple scab infections were 1 or less for 23 of 38 taxa, greater than 1 but not greater than 3 for 13 of 38 taxa, and greater than 3 for 2 of 38 taxa. In June 2015, the mean incidences of apple scab infections were 1 or less for 35 of 37 taxa, greater than 1 but not greater than 3 for 2 of 37 taxa, and greater than 3 for 0 of 37 taxa.

On the July sampling date in 2014, the mean incidences of apple scab infections were 1 or less for 15 of 38 taxa, greater than 1 but not greater than 3 for 13 of 38 taxa, and greater than 3 for 10 of 38 taxa. In July 2015, the mean incidences of apple scab infections were 1 or less for 28 of 37 taxa, greater than 1 but not greater than 3 for 9 of 37 taxa, and greater than 3 for 0 of 37 taxa.

On the August sampling date in 2014, the mean incidences of apple scab infections were 1 or less for 18 of 38 taxa, greater than 1 but not greater than 3 for 12 of 38 taxa, and greater than 3 for 8 of 38 taxa. In August 2015, the mean incidences of apple scab infections were 1 or less for 16 of 37 taxa, greater than 1 but not greater than 3 for 15 of 37 taxa, and greater than 3 for 6 of 37 taxa.

On the September sampling date in 2014, the mean incidences of apple scab infections were 1 or less for 17 of 38 taxa, greater than 1 but not greater than 3 for 6 of 38 taxa, and greater than 3 for 15 of 38 taxa. Data was not collected in September 2015.

Fifteen of the crabapple taxa in 2014 and 16 of the crabapple taxa in 2015 maintained superior scores (1 or less) throughout the entire growing season. These taxa included: 'Adirondack', 'Camelot', 'Candymint', 'Dolgo', 'Excalibur', 'Foxfire', 'Guinevere', 'Holiday Gold', 'Lollipop', 'May's Delight', 'Prairie Maid', 'Red Jewel', 'Sargent', 'Strawberry Parfait', and 'Tina'. 'Lancelot' held in 2015, but exhibited apple scab breakthrough in 2014, a heavier year of apple scab infections. Six of the crabapple taxa consistently scored poorly by the end of the season in both years. These taxa included: 'Adams', 'American Masterpiece', 'Pink Satin', 'Snowdrift', 'Thunderchild', and 'Weeping Candied Apple'. These taxa are referred to as the 'scab dogs' by the evaluators.

Through the 2014 season, there were some variations in the levels of apple scab incidence ratings where it appeared that the conditions of some of the taxa improved between samplings (e.g., 'Sugar Tyme' mean ratings were 1 (6/20), 3 (7/22), 1 (8/26) and 2.8 (9/16)). These perceived improvements were most likely artifacts as a result of leaf drop of the most highly infected leaves between samplings. In

most cases, these perceived improvements in condition disappeared by the last sampling date in September as apple scab infections continue to develop.

The low mean incidences of apple scab in 2015 were most likely not a result of improvements in the resistance of the trees to the apple scab pathogen. Plant host resistance to a pathogen typically declines over time as documented by Becker et al., 2009, seldom does it increase. A review of the disease triangle helps one to deduce the causative agent of the reduction of apple scab incidence. The legs of this triangular relationship are the pathogen, the host and the environment. In this case, the apple scab pathogen appears to be omnipresent occurring at some level every year. The host trees are the same plot of trees examined each year expressing the same level of resistance or less each year. The most unpredictable and changeable factor in this relationship is the environment. Optimal environmental conditions for apple scab disease development do not occur every year. Thus, conditions for disease development must have been poor in 2015.

One take home message from these research results is that one needs to examine multiple years of data to get the clearest picture of what is going on with disease and host plant disease resistance. A single year's data is not enough to reach valid conclusions. These results are also justification for the commitment of research ground to continuous, long-term studies such as the one reported upon here.

Literature Citation
Beckerman, J.L., J.A. Chatfield, and E.A. Draper. 2009. A 33-year evaluation of resistance and pathogenicity in the apple scab - crabapples pathosystem. HortScience 44(3):1-10.

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Table 1. Mean Incidence of the Fungal Disease Apple Scab (*Venturia inaequalis*) Symptoms Assessed on a Scale of 0-5* on Ornamental Crabapple Trees (*Malus* spp. and Cultivars) at Secrest Arboretum, Ohio Agricultural Research and Development Center, Wooster, Ohio in 2014.

Crabapple Taxon	# Reps	6/20/14		7/22/14		8/26/14		9/16/14	
'Adirondack'	5	0	a	0	a	0	a	0	a
'Camelot'	5	0	a	0	a	0	a	0	a
'Dolgo'	5	0	a	0	a	0	a	0	a
'Excalibur'	5	0	a	0	a	0	a	0	a
'Foxfire'	5	0	a	0	a	0	a	0	a
'Guinevere'	5	0	a	0	a	0	a	0	a
'Holiday Gold'	5	0	a	0	a	0	a	0	a
'Lollipop'	5	0	a	0	a	0	a	0	a
M. sargentii 'Sargent'	*5*	0	a	0	a	0	a	0	a
'May's Delight'	5	0	a	0	a	0	a	0	a
'Prairie Maid'	5	0	a	0	a	0	a	0	a
'Strawberry Parfait'	5	0	a	0	a	0	a	0	a
'Tina'	5	0	a	0	a	0	a	0	a
'Candymint'	5	0.8	b	0.6	a	1	bc	1	b
'Coralburst'	5	1	bc	1.6	b	2	de	1.8	c
'Doubloons'	5	1	bc	2.6	cd	4.6	j	4.8	j
'Lancelot'	5	1	bc	1.6	b	1.4	bcd	1	b
'Molten Lava'	5	1	bc	3.2	de	1.6	cd	3.2	defg
'Pink Princess'	5	1	bc	2.8	de	0.8	b	2.6	d
'Red Jewel'	5	1	bc	0	a	0.2	a	0.2	a
'Red Splendor'	5	1	bc	1.8	b	1.6	cd	1	b
'Sentinel'	5	1	bc	3.4	def	1.8	de	3.4	efg
'Sugar Tyme'	5	1	bc	3	de	1	bc	2.8	de
'David'	5	1.2	bc	1.4	b	3.8	hi	3.4	efg
Malus x zumi 'Calocarpa'	5	1.2	bc	2.8	de	1.4	bcd	3.2	defg
'White Cascade'	5	1.2	bc	4.6	gh	3	fg	4.6	ij
'Purple Prince'	5	1.4	c	3	de	1	bc	2.8	de
'Manbeck Weeper'	5	1.8	d	3.2	de	2	de	3.4	efg
'American Salute'	5	2	d	2	bc	2.4	ef	2.6	d
'Mary Potter'	5	2	d	3	de	2	de	3	def
'Royal Raindrops'	5	2	d	4	fg	3	fg	3.8	gh
'Snowdrift'	5	2.6	e	5	h	3.2	gh	4.8	j
'Adams'	5	2.8	ef	2	bc	3.6	ghi	3.6	fg
'American Masterpiece'	5	3	efg	3.6	ef	5	j	5	j
'Thunderchild'	5	3	efg	4.4	gh	3	fg	4.2	hi
'Weeping Candied Apple'	5	3	efg	5	h	4	i	5	j
'Pink Satin'	5	3.2	fg	5	h	3.8	hi	5	j
'Harvest Gold'	5	3.4	g	4.6	gh	3.4	ghi	3.8	gh

* 0 = no scab symptoms observed; 1 = less than 5% of leaves affected and no aesthetic impact; 2 = 5-20% of leaves affected, with some yellowing but little or no defoliation, moderate aesthetic impact; 3 = 21-50% of leaves affected, significant defoliation and/or leaf yellowing, substantial aesthetic impact; 4 = 51-80% of leaves affected, severe foliar discoloration and defoliation, severe aesthetic impact; 5 = 81-100% of foliage affected, with 90-100% defoliation.

** Means with the same letter in a column are not significantly different (Student-Newman-Keuls test, p<0.05).

Table 2. Mean Incidence of the Fungal Disease Apple Scab (*Venturia inaequalis*) Symptoms Assessed on a Scale of 0-5* on Ornamental Crabapple Trees (*Malus* spp. and Cultivars) at Secrest Arboretum, Ohio Agricultural Research and Development Center, Wooster, Ohio in 2015.

Crabapple Taxon	# Reps	6/26/15		7/20/15		8/24/15	
'Adirondack'	5	0	a**	0	a	0	a
'Camelot'	5	0	a	0	a	0	a
'Candymint'	5	0	a	0	a	0.2	a
'Coralburst'	5	0	a	1	bc	2	cd
'Dolgo'	5	0	a	0	a	0	a
'Doubloons'	5	0	a	1.4	c	2.2	cd
'Excalibur'	5	0	a	0	a	0	a
'Foxfire'	5	0	a	0	a	0	a
'Guinevere'	5	0	a	0	a	0	a
'Holiday Gold'	5	0	a	0	a	0	a
'Lancelot'	5	0	a	1	bc	1	b
'Lollipop'	5	0	a	0	a	0	a
M. sargentii 'Sargent'	5	0	a	0	a	0	a
'May's Delight'	5	0	a	0	a	0	a
'Molten Lava'	5	0	a	0.6	b	2	cd
'Pink Princess'	5	0	a	1	bc	2	cd
'Prairie Maid'	5	0	a	0	a	0	a
'Red Jewel'	5	0	a	0	a	0	a
'Red Splendor'	5	0	a	1	bc	2.4	d
'Strawberry Parfait'	5	0	a	0	a	0	a
'Tina'	5	0	a	0	a	0	a
'David'	5	0.2	ab	1	bc	2	cd
'Sentinel'	5	0.2	ab	1	bc	2	cd
'Sugar Tyme'	5	0.2	ab	0.8	b	2.4	d
'Purple Prince'	5	0.4	abc	1	bc	2	cd
Malus x *zumi* 'Calocarpa'	5	0.6	bcd	1	bc	2.4	d
'Adams'	5	0.8	cde	2.2	de	3.2	e
'Pink Satin'	*5*	0.8	cde	1	bc	3.8	f
'Harvest Gold'	5	1	de	2	de	2.2	cd
'Manbeck Weeper'	5	1	de	1	bc	1.6	c
'Mary Potter'	5	1	de	0.8	b	2.4	d
'Royal Raindrops'	5	1	de	2	de	2.4	d
'Snowdrift'	5	1	de	3	f	4.2	f
'Thunderchild'	5	1	de	2	de	3.4	e
'Weeping Candied Apple'	5	1	de	2	de	4	f
'American Salute'	5	1.2	e	1.8	d	2	cd
'American Masterpiece'	5	3	f	2.8	f	4.6	g

* 0 = no scab symptoms observed; 1 = less than 5% of leaves affected and no aesthetic impact; 2 = 5-20% of leaves affected, with some yellowing but little or no defoliation, moderate aesthetic impact; 3 = 21-50% of leaves affected, significant defoliation and/or leaf yellowing, substantial aesthetic impact; 4 = 51-80% of leaves affected, severe foliar discoloration and defoliation, severe aesthetic impact; 5 = 81-100% of foliage affected, with 90-100% defoliation.

** Means with the same letter in a column are not significantly different (Student-Newman-Keuls test, $p < 0.05$).