Genetics and resistance

Resistance to *Entomosporium mespili* among cultivars of saskatoon, *Amelanchier alnifolia*

P.S. Ronald, R.G. St-Pierre, and P.S. Bains

Abstract: Saskatoon (*Amelanchier alnifolia* Nutt.) cultivars were evaluated for their resistance to *Entomosporium* leaf and berry spot disease, caused by the fungal pathogen *Entomosporium mespili* DC. (Sacc.). Leaves and fruit from naturally infected plants of saskatoon cultivars were evaluated for disease incidence and severity. Detached leaves of these cultivars were also evaluated for disease severity after inoculation with a conidiospore suspension under controlled conditions. Leaf age was an important factor in disease response of detached leaves, with older leaves generally displaying reduced susceptibility. Comparisons of disease response for inoculated and naturally infected leaves of various cultivars revealed similar rankings and significant correlation coefficients. Analysis of data from all experiments revealed significant differences ($P \leq 0.05$) in disease response among saskatoon cultivars. Leaf disease response of saskatoon cultivars to *E. mespili* was classed into four groups: (1) those that restricted infection and sporulation, e.g., Success; (2) those that restricted sporulation, e.g., Regent; (3) those that reduced sporulation, e.g., Northline; and (4) those that reduced neither infection or sporulation, e.g., Pearson II. Most cultivars had moderate to high values for the incidence and severity of leaf and fruit infection. Resistant cultivars were distinguished by their ability to restrict fungal sporulation on leaves and fruit. Among the saskatoon cultivars evaluated in this study, Parkhill, Regent, and Success showed consistently lower values for the incidence and severity of fungal sporulation on leaves and fruit.

Key words: *Amelanchier alnifolia*, saskatoon, *Entomosporium mespili*, disease resistance.

Résumé : La résistance à la tache des feuilles et des fruits causée par le champignon pathogène *Entomosporium mespili* DC. (Sacc.) a été évaluée chez des cultivars d'amélanchier à feuilles d'aulne (*Amelanchier alnifolia* Nutt.). La fréquence et l'intensité de la maladie ont été évaluées sur des feuilles et des fruits d'amélanchiers naturellement infectés. L'intensité de la maladie a aussi été évaluée sur des feuilles détachées de ces cultivars après inoculation avec une suspension de conidiospores en conditions contrôlées. L'âge des feuilles fut un facteur important en ce qui concerne la réponse des feuilles détachées à la maladie, les plus vieilles feuilles montrant habituellement une sensibilité moindre. Des comparaisons entre divers cultivars quant à la réponse à la maladie des feuilles inoculées et celle des feuilles infectées naturellement ont révélé des classements similaires et des coefficients de corrélation significatifs. L'analyse des données de toutes les expériences a révélé des différences significatives ($P < 0{,}05$) entre les cultivars d'amélanchier en ce qui a trait à la réponse à la maladie. Les cultivars d'amélanchier furent classés en quatre groupes en fonction de la réponse des feuilles à la maladie : (1) ceux restreignant l'infection et la sporulation, p. ex. Success, (2) ceux restreignant la sporulation, p. ex. Regent, (3) ceux réduisant la sporulation, p. ex. Northline, et (4) ceux ne réduisant ni l'infection, ni la sporulation, p. ex. Pearson II. La plupart des cultivars ont eu des valeurs moyennes à élevées de fréquence et d'intensité de l'infection des feuilles et des fruits. Les cultivars résistants se sont distingués par leur aptitude à restreindre la sporulation du champignon sur les feuilles et les fruits. Parmi les cultivars d'amélanchier évalués dans la présente étude, Parkhill, Regent et Success ont constamment présenté des valeurs plus basses de fréquence et d'intensité de sporulation sur les feuilles et les fruits.

Mots clés : *Amelanchier alnifolia*, amélanchier à feuilles d'aulne, *Entomosporium mespili*, résistance aux maladies.

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Introduction

Entomosporium leaf and berry spot (*Entomosporium mespili* (DC.) Sacc. is a serious and economically important disease of saskatoon (*Amelanchier alnifolia* Nutt.). Typical symptoms include a defoliating leaf spot, as well as spotting, cracking, and deformation of fruit (Davidson 1989). *Entomosporium* leaf and berry spot has been causing significant losses to saskatoon growers since 1990 and destroyed much of the saskatoon fruit crop throughout Alberta in 1994 (Lange and Bains 1994). Fungicidal applications of Tilt® 250 EC (propiconazole) and Bravo® 500 (chlorothalonil) helped to reduce leaf and berry spot on saskatoon (Lange et al. 1998). However, the development of saskatoon cultivars with durable disease resistance would provide a safer and more cost-effective way to control the disease.

A survey of the literature revealed little information regarding *Entomosporium* leaf and berry spot of saskatoon. *Entomosporium mespili* was initially thought to afflict only the foliage of saskatoon (Davidson 1986), causing either leaf spot or leaf blight, depending on the suitability of weather conditions and the susceptibility of the host. However, this pathogen was also identified as the causal agent of spots on saskatoon fruit produced at a test orchard in Alberta in 1988 (Davidson 1989). More recent studies with leaf and berry spot on saskatoon have focused on disease surveys (Davidson et al. 1991; Pesic-Van Esbroeck and Bains 1991; Lange and Bains 1994) and fungicidal control (Lange and Bains 1995; Lange et al. 1998). There has yet to be a comprehensive effort to screen all available saskatoon cultivars for resistance to *Entomosporium* leaf and berry spot.

Screening for resistance to *E. mespili* has been undertaken in several related woody plant genera: *Photinia* (Jacobs et al. 1996), *Pyrus* (Bell and van der Zwet 1988), *Rhaphiolepis* (Corley 1980; Hagan et al. 1996). In the case of ornamental plants such as *Photinia* and *Rhaphiolepis*, it is the foliage that must be protected from disease. Thus, screening techniques have focused on the inoculation and rating of leaves from different host genotypes (Jacobs et al. 1996). For saskatoon, it would be desirable to select genotypes with reduced foliar and fruit susceptibility to *E. mespili*. Davidson (1989) suggested that preventing the disease from attacking early season foliage would help to reduce fruit infection. Saskatoon cultivars that restrict foliar establishment of the fungus should have reduced levels of secondary sporulation and consequently less fruit infection.

Both Davidson (1989) and Lange and Bains (1994) suggested that none of the commercially grown saskatoon cultivars showed resistance to *E. mespili* infection. Howard (1994, 1995) evaluated leaves and fruit of eight saskatoon cultivars (Forestburg, Honeywood, Northline, Parkhill, Pearson II, Pembina, Smoky, and Thiessen) for incidence and severity of infection. All eight cultivars were affected by leaf and berry spot, but Parkhill had lower incidence and severity of leaf infection. The three saskatoon cultivars of American origin (Parkhill, Success, and Regent) have been reported resistant to saskatoon–juniper rust (*Gymnosporangium nelsonii* Arth.) (Chang et al. 1994) and *Entomosporium* leaf and berry spot (St-Pierre 1997).

The objectives of this study were: (1) to develop reliable and meaningful indicators of host disease response for the evaluation of *Entomosporium* leaf and berry spot on saskatoon and (2) to characterize the degree of resistance or susceptibility of saskatoon cultivars to *E. mespili*. This research will facilitate the future development of saskatoon cultivars resistant to leaf and berry spot, resulting in increased yield and fruit quality with minimum use of fungicide.

Materials and methods

Sampling procedure following natural infection

Entomosporium disease symptoms on saskatoon cultivars were assessed following natural infection at replicated cultivar trials in two provinces. In 1997, naturally infected leaves and fruit were sampled from nine-year-old plants of 10 saskatoon cultivars growing in a randomized complete block design (three replications) at a commercial orchard near Edmonton, Alberta. Three consecutive plants of each cultivar were sampled from among the five growing in each replicate. Leaf samples from each plant consisted of five leaves from each of 10 fruit spurs (short, lateral branches) or current-year, terminal shoots. Fruit samples were composed of the fruit from 30 racemes (10 per plant) collected in each plot. The incidence and severity of infection were measured for leaves sampled on 26 June and 10 July and for fruit sampled on 4 July and 18 July.

Naturally infected leaves and fruit were also sampled from saskatoon cultivars growing in randomized complete block designs (three replications) at two experimental sites in Saskatchewan. Samples were collected from eight- and nine-year-old plants of 15 saskatoon cultivars at Hudson Bay, Saskatchewan, in 1998 and 1999 respectively. In 1999, samples were also collected from nine-year-old plants of 16 saskatoon cultivars at Moonlake, Saskatchewan. Three fruiting branches were sampled from single plants of each of the cultivars growing at both sites. For all samples, leaves and fruit were separated and stored in plastic bags at 4°C until evaluated. Fruit set was poor at Hudson Bay in 1998, and samples consisted primarily of leaves. The incidence and severity of sporulation and infection were measured for leaves sampled on 20 July 1998 and 1999 at Hudson Bay. The incidence and severity of sporulation and infection were also measured for fruit sampled at Hudson Bay on 30 June and 20 July 1999, and at Moonlake on 19 July 1999.

Assessment of disease response following natural infection

The incidence and severity of disease was assessed for leaf and fruit samples following natural infection of saskatoon cultivars. At Edmonton, percent leaf area affected (PLAA) and percent fruit area affected (PFAA) were measured using the 1 (0% of surface affected) to 12 (100% of surface affected) Horsfall–Barratt disease severity index (Horsfall and Barratt 1945). Disease severity values were back-transformed to percentages using the midpoint rule (Campbell and Madden 1990). Disease incidence was calculated as the percentage of leaves and fruit assigned a disease severity rating of two or greater.

Leaf samples from Hudson Bay and Moonlake were cleared with a mixture of 95% ethanol and glacial acetic acid (3:1, v/v) to provide adequate contrast for assessment of disease symptoms. Digital images of cleared leaves were produced with a flatbed scanner and evaluated for lesion number, lesion size (cm^2), and PLAA using SigmaScan Pro (SPSS Inc., Chicago, Ill.). Leaves collected at Moonlake in 1999 showed minimal disease symptoms and consequently were not evaluated. The percentage of leaves infected, lesion number, lesion size, and PLAA were determined for 20 leaves per plot. The percentage of leaves infected was defined as the proportion of diseased leaves with at least 1% leaf area affected. The percentage of fruits infected was defined as the proportion of fruits from six racemes with at least one lesion.

Sporulation was measured only on leaf and fruit samples from Hudson Bay and Moonlake. The number of acervuli on naturally infected fruit and leaves was determined by visual inspection under a dissecting microscope. Cultivar means for the percentage of leaves sporulating and leaf acervuli number were determined for plot samples of 40 cleared leaves. The percentage of leaves sporulating was defined as the proportion of leaves with at least 10 acervuli. Values for the number of acervuli per PLAA and per lesion were calculated from replicate means for each cultivar. The percentage of fruits sporulating was defined as the proportion of fruits from six racemes with at least one acervulus. Acervuli number per fruit was determined for 20 fruits, randomly selected from the six racemes.

Inoculum preparation

Conidiospore suspensions of *E. mespili* were prepared directly from acervuli on naturally infected saskatoon fruit. Fruits with sporulating acervuli were sampled from an isolated planting of nine-year-old saskatoon genotypes growing at the field plots of the Department of Plant Sciences, University of Saskatchewan in Saskatoon, Saskatchewan. Conidiospores were scraped from fruit acervuli using a sterile dissecting needle and suspended in distilled water. The mixture was placed on a stir plate at room temperature for 2 h to fully suspend the conidiospores.

Inoculum concentration was measured prior to inoculation and immediately after stirring. Small aliquots of the conidiospore suspension were pipetted into two chambers of the hemacytometer. For both chambers, the number of conidiospores in nine 1-mm squares was counted. Minimal conidiospore dissociation was observed. When the cover slip was in place, each square held approximately 10^{-4} mL of solution. Thus, the number of conidiospores per milliliter of suspension was calculated as the average count per square multiplied by 10^4.

Inoculation of detached leaves with *Entomosporium mespili*

Reaction of detached leaves to *E. mespili* inoculum was used to characterize the susceptibility of saskatoon cultivars to the pathogen. Two experiments, conducted in succession, evaluated the effect of leaf age and host cultivar on susceptibility. Six current-year shoots and their associated leaves were sampled on 29 June and 10 July 1998 from eight-year-old plants of 17 saskatoon cultivars growing in a replicated trial at the field plots of the Department of Plant Sciences, University of Saskatchewan in Saskatoon, Saskatchewan. Sampled foliage was labeled and wrapped in moist paper towels, then placed in a cooler for transport. Using a sharp scalpel, the five uppermost, fully expanded leaves were detached from each shoot directly above the point of attachment. Leaves were classified as leaf 1 (youngest) to leaf 5 (oldest), counting from top to bottom. Excised leaves were washed thoroughly in distilled water. Leaf removal was done underwater to prevent the formation of air pockets in the petiole. Six replicates each consisted of five leaves of each cultivar; each replicate was placed onto a foam sheet (0.6-cm thickness) floating in a separate tank of distilled water. Leaf petioles extended through the foam sheets into the water. The tanks were placed in a growth cabinet for inoculation and incubation.

The concentrations of inoculum for the first and second experiment were 3×10^4 and 8×10^4 conidiospores/mL, respectively. For both experiments, inoculum was applied with an atomizer to four replicates of leaves until runoff. The leaves in the two control treatments were sprayed with distilled water. A 24-h period of darkness followed inoculation, during which time relative humidity in the growth cabinet was maximized with an ultrasonic humidifier. Following the dark period, plastic lids were placed loosely on each tank and the growth cabinet was set for a 14-h day length. Conditions in the growth cabinet were maintained at 20°C and 92% humidity throughout the 9-day incubation period.

Assessment of leaf disease response following artificial inoculation

After 9 days of incubation, leaves of each cultivar were removed in order of age from the four treated tanks and imaged with a flatbed scanner. Leaves were then cleared with a mixture of 95% ethanol and glacial acetic acid (3:1, v/v). Digital images of the cleared leaves were produced as before and individually evaluated for lesion number and PLAA using SigmaScan® Pro (SPSS Inc., Chicago, Ill.). The cleared leaves were arranged in order of age (leaf 1 to leaf 5) based on the previously scanned, uncleared leaves. The number of acervuli present on each leaf was determined by visual inspection under a dissecting microscope. Acervuli number was not determined for detached leaves inoculated in the first experiment because of the deterioration of these samples.

Statistical analysis

All disease incidence and severity data were analyzed using Systat 8.0 (SPSS Inc. 1998). The general linear means (GLM) procedure was used, in combination with a randomized complete block model, to partition the variance in each data set. Disease response data from multiple days or years were analyzed as split plots in time. Mean comparisons were done using Fisher's least significant difference (LSD, $P \leq 0.05$). Pearson's correlation coefficients were used to interrelate measures of leaf disease response.

Hierarchical clustering of standardized data was used to group saskatoon cultivars with similar disease response into discrete categories. Standardization replaced the values of

Table 1. Incidence and severity of leaf and berry spot caused by natural inoculum of *Entomosporium mespili* on 10 saskatoon cultivars at Edmonton, Alberta, in 1997.

	Disease incidence[a]				Disease severity[b]			
	Infected leaves (%)		Infected fruits (%)		PLAA (%)		PFAA (%)	
Cultivar	26 June	10 July	4 July	18 July	26 June	10 July	4 July	18 July
Thiessen	100.0	100.0	100.0	93.3	1.8	1.9	0.9	1.0
Honeywood	100.0	100.0	93.3	100.0	1.2	1.6	0.5	0.9
Northline	100.0	100.0	100.0	78.7	2.3	3.2	0.9	0.8
Pearson II	100.0	100.0	92.0	80.0	1.8	1.5	0.7	0.8
Pembina	100.0	100.0	100.0	100.0	1.8	1.8	1.1	0.7
Smoky	100.0	100.0	73.3	100.0	1.6	1.5	0.4	0.6
Forestburg	93.3	100.0	100.0	93.3	1.7	2.0	0.7	0.5
Parkhill	100.0	100.0	26.7	100.0	1.1	1.6	0.1	0.5
Regent	100.0	94.7	16.0	66.7	1.0	0.8	0.1	0.3
Success	100.0	100.0	40.0	33.3	1.2	0.5	0.3	0.2
LSD ($P \leq 0.05$)	NA	NA	17.7	27.8	0.8	1.0	0.5	0.5

Note: Cultivars are ranked by PFAA on 18 July. NA, not applicable; PFAA percent fruit area affected; PLAA, percent leaf area affected.
[a]Percentage in Horsfall–Barratt severity classes 2 to 12.
[b]Horsfall–Barratt disease severity index back-transformed to percentage.

each specified variable with sample standard scores (*z* score) such that the standardized values had a mean of 0 and a standard deviation of 1. Complete linkage was selected to ensure that clusters were not joined unless their most distant members were relatively close together. The data used for cluster analysis included cultivar means for fungal sporulation on leaves and fruit from multiple years and locations.

Results

Cultivar leaf disease response following natural infection

Leaves sampled from 10 saskatoon cultivars at Edmonton, in 1997, showed high levels of infection on two sampling dates (Table 1). No significant differences in the percentage of leaves infected were observed. However, significant differences in PLAA were observed among cultivars. Percent leaf area affected at Edmonton increased slightly between sampling dates, and differences among cultivars became more noticeable. Leaf samples collected on 10 July showed a range in cultivar means for PLAA from 0.5 to 3.2%; 'Regent' and 'Success' had low values, while Northline had the highest.

Evaluation of naturally infected leaves from saskatoon cultivars sampled at Hudson Bay, in 1998 and 1999, revealed significant differences in disease incidence among cultivars (Table 2). With the exception of Martin in 1998 and PAR90 in 1999, all cultivars showed high values for the percentage of leaves infected, with no significant differences among cultivars. However, significant differences in the percentage of leaves sporulating were observed among cultivars, with means ranging from 17.0 to 88.8% in 1998 and 18.9 to 94.8% in 1999. 'Parkhill' and 'Regent' showed low values (17.0–26.4%), while 'Forestburg,' 'Honeywood,' 'Pearson II,' and 'Smoky' had much higher values (>80%) in both years.

The severity of leaf infection differed significantly among saskatoon cultivars growing at Hudson Bay (Table 3). Cultivar means for lesion number per leaf ranged from 21.4 to 105.4 in 1998 and from 40.2 to 98.2 in 1999; 'Parkhill,' 'Regent,' and 'Success' had the lowest numbers (21.4–52.7) in both years, while 'Buffalo,' 'Pearson II,' and 'Pembina' had high values (>69.4). Cultivar means for PLAA ranged from 1.6 to 8.8% in 1998 and from 3.0 to 9.4% in 1999; 'PAR90' and 'Success' had low values (2.7–3.6%) in both years, while 'Northline' and 'Pearson II' had high values (7.0–9.4%). Cultivar means for lesion size ranged from 6.4×10^{-3} to 13.1×10^{-3} cm^2 in 1998 and from 5.0×10^{-3} to 12.8×10^{-3} cm^2 in 1999. 'PAR90' and 'Pembina' had relatively small lesion sizes (5.0×10^{-3} to 6.7×10^{-3} cm^2) in both years, while 'Northline' and 'Pearson II' had high values (10.5×10^{-3} to 12.8×10^{-3} cm^2).

The severity of sporulation on leaves, measured as acervuli number and number of acervuli per PLAA and per lesion, also differed significantly among cultivars (Table 4). Cultivar means for acervuli number per leaf ranged from 5.3 to 142.7 in 1998 and from 6.8 to 98.8 in 1999; 'Parkhill' and 'Regent' had low values (5.3–7.5) in both years, while 'Pearson II' and 'Smoky' had high values (63.1–142.7). Cultivar means for number of acervuli per PLAA ranged from 1.4 to 16.8 in 1998 and from 1.6 to 15.8 in 1999. Cultivar means for number of acervuli per lesion ranged from 0.2 to 1.4 in 1998 and from 0.1 to 1.4 in 1999. 'Parkhill' and 'Regent' had the lowest values for number of acervuli per PLAA and per lesion, in both years, while 'Pearson II' had the highest values.

Pooled analysis of variance for leaf disease incidence and severity data, collected at Hudson Bay in 1998 and 1999, showed that cultivar was a significant ($P \leq 0.01$) source of variation for six of eight traits, exceptions being the percentage of leaves infected and leaf lesion size (Tables 5 and 6). The effect of year was nonsignificant for all traits examined, with the exception of the percentage of leaves

Table 2. Incidence of infection and sporulation caused by natural inoculum of *Entomosporium mespili* on leaves of 15 saskatoon cultivars at Hudson Bay, Saskatchewan, in July 1998 and 1999.

	Infected leaves (%)[a]			Sporulating leaves (%)[b]		
Cultivar	1998	1999	Mean	1998	1999	Mean
Honeywood	93.0	86.7	89.9	88.0	94.8	91.4
Pearson II	95.0	85.0	90.0	86.8	90.8	88.8
Smoky	90.0	86.7	88.4	88.3	86.4	87.4
Forestburg	96.7	90.0	93.4	88.8	84.0	86.4
Bluff	81.7	88.2	85.0	77.6	86.4	82.0
Thiessen	72.9	88.3	80.6	75.2	88.1	81.7
Buffalo	93.3	81.7	87.5	78.8	76.0	77.4
Northline	85.0	95.0	90.0	65.1	76.3	70.7
Martin	45.0	80.0	62.5	39.2	91.1	65.2
PAR90	71.7	65.0	68.4	55.7	73.4	64.6
Pembina	96.7	76.7	86.7	53.3	72.6	63.0
Nelson[c]	—	77.0	—	—	61.2	—
Success	71.7	80.0	75.9	42.5	37.0	39.8
Regent	73.3	88.3	80.8	26.4	18.9	22.7
Parkhill	73.3	93.3	83.3	17.0	21.2	19.1
LSD ($P \leq 0.05$)	NA	NA	NA	28.9	25.8	34.9

Note: Cultivars are ranked by 2-year mean for percentage of leaves sporulating. NA, not applicable.
[a]Percentage of 20 leaves with at least 1% leaf area affected.
[b]Percentage of 40 leaves with at least 10 acervuli.
[c]The cv. Nelson was not sampled in 1998.

Table 3. Severity of leaf infection caused by natural inoculum of *Entomosporium mespili* on 15 saskatoon cultivars at Hudson Bay, Saskatchewan, in July 1998 and 1999.

	PLAA (%)			Lesion number per leaf			Leaf lesion size ($\times 10^{-3}$ cm^2)		
Cultivar	1998	1999	Mean	1998	1999	Mean	1998	1999	Mean
Pembina	5.5	4.0	4.8	105.4	69.4	87.4	6.4	6.7	6.6
Buffalo	8.8	5.8	7.3	99.2	71.1	85.2	7.8	6.4	7.1
Pearson II	8.6	9.1	8.8	94.1	73.3	83.7	10.8	12.8	11.8
Forestburg	7.2	5.0	6.1	96.4	60.8	78.6	8.2	9.4	8.8
Thiessen	3.8	6.3	5.1	50.9	98.2	74.6	8.9	9.6	9.3
Bluff	4.8	8.2	6.5	60.6	80.2	70.4	7.6	7.9	7.8
Honeywood	4.8	7.7	6.2	57.5	82.8	70.1	6.9	9.4	8.1
Smoky	6.1	5.6	5.9	75.8	62.4	69.1	8.9	8.6	8.8
PAR90	3.6	3.0	3.3	43.0	80.9	62.0	8.0	5.0	6.5
Martin	1.6	4.5	3.1	34.0	89.7	61.9	6.7	8.0	7.4
Northline	7.0	9.4	8.2	46.9	72.1	59.5	13.1	10.5	11.8
Nelson[a]	—	6.0	—	—	54.2	—	—	7.8	—
Parkhill	3.7	4.4	4.0	21.4	52.7	37.0	12.8	6.1	9.4
Regent	3.0	4.8	3.9	26.5	47.1	36.8	7.2	7.4	7.3
Success	2.7	3.3	3.0	26.1	40.2	33.2	9.7	7.8	8.7
LSD ($P \leq 0.05$)	NA	2.9	4.4	43.3	26.5	32.4	NA	NA	NA

Note: Means are for replicate samples of 20 leaves. Cultivars are ranked by 2-year mean for leaf lesion number. NA, not applicable; PLAA, percent leaf area affected.
[a]The cv. Nelson was not sampled in 1998.

sporulating. The interaction between cultivar and year was significant only for lesion number ($P \leq 0.05$).

Cultivar leaf disease response following artificial inoculation

The results of the two detached-leaf assays revealed significant ($P \leq 0.05$) differences in disease response among 17 cultivars of saskatoon (Table 7). Cultivar means for lesion number per leaf ranged from 5.2 to 54.1 and 15.2 to 126.2 for experiments with low and high inoculum concentrations, respectively; 'Parkhill,' 'Regent,' and 'Success' had low numbers, while 'Buffalo,' 'Nelson,' and 'Pearson II' had high numbers in both experiments. Cultivar means for PLAA ranged from 0.1 to 1.7% and from 0.5 to 13.8%

Table 4. Severity of leaf sporulation caused by natural inoculum of *Entomosporium mespili* on 15 saskatoon cultivars at Hudson Bay, Saskatchewan, in July 1998 and 1999.

	Number of acervuli								
	Per leaf			Per PLAA			Per lesion		
Cultivar	1998	1999	Mean	1998	1999	Mean	1998	1999	Mean
Pearson II	142.7	98.8	120.8	16.8	13.5	15.1	1.41	1.38	1.39
Smoky	99.6	63.1	81.3	15.6	11.3	13.4	1.33	1.03	1.18
Forestburg	103.1	57.3	80.2	14.8	12.1	13.4	1.08	0.95	1.02
Honeywood	59.6	90.0	74.8	14.6	12.1	14.8	0.95	1.21	1.08
Bluff	70.0	72.2	71.1	14.4	8.9	11.7	1.15	0.90	1.02
Thiessen	48.1	89.3	68.7	12.8	14.7	13.8	0.95	0.92	0.93
Buffalo	74.7	38.2	56.5	8.7	6.6	7.7	0.74	0.55	0.65
Martin	13.8	68.2	41.0	10.6	15.8	13.2	0.47	0.78	0.62
Northline	30.5	42.4	36.4	4.6	4.8	4.7	0.63	0.64	0.63
PAR90	25.7	34.9	30.3	7.7	11.6	9.7	0.59	0.44	0.51
Nelson[a]	—	30.1	—	—	6.1	—	—	0.60	—
Pembina	16.6	35.4	26.0	3.6	10.5	7.0	0.19	0.54	0.36
Success	15.4	12.1	13.8	5.1	3.2	4.2	0.54	0.27	0.41
Regent	7.5	6.8	7.1	3.0	1.6	2.3	0.33	0.14	0.23
Parkhill	5.3	6.9	6.1	1.4	1.7	1.6	0.24	0.13	0.19
LSD ($P \leq 0.05$)	63.4	24.0	51.2	5.2	5.7	5.3	0.52	0.40	0.50

Note: Means are for replicate samples of 40 leaves. Cultivars are ranked by 2-year mean for acervuli number per leaf. PLAA, percent leaf area affected.

[a]The cv. Nelson was not sampled in 1998.

Table 5. Mean squares from analysis of variance for the incidence and severity of leaf infection caused by natural inoculum of *Entomosporium mespili* on 14 saskatoon cultivars at Hudson Bay, Saskatchewan, in 1998 and 1999.

		Mean square			
Source of variation	Degrees of freedom	Infected leaves (%)[a]	Leaf area affected (%)[b]	Lesion number per leaf[b]	Leaf lesion size[b]
Replicate	2	255.22	9.69	2225.04	0.76
Cultivar	13	449.86 ns	21.18**	1960.93***	0.17 ns
Error a	26	260.39	6.81	371.91	0.10
Year	1	307.78 ns	12.55 ns	2197.56 ns	0.06 ns
Cultivar × year	13	326.96 ns	6.89 ns	1446.77*	0.09 ns
Error b	28	173.18	16.39	860.82	0.22

Note: Error a, cultivar × replicate; error b, cultivar(replicate)(year); ns, not significant; *, **, and ***, significant at $P \leq 0.05$, $P \leq 0.01$, and $P \leq 0.001$, respectively.

[a]Percentage of 20 leaves with at least 1% leaf area affected.

[b]Means are for replicate samples of 20 leaves.

Table 6. Mean squares from analysis of variance for the incidence and severity of leaf sporulation caused by natural inoculum of *Entomosporium mespili* on 14 saskatoon cultivars at Hudson Bay, Saskatchewan in 1998 and 1999.

		Mean square			
			Number of acervuli[b]		
Source of variation	Degrees of freedom	Sporulating leaves (%)[a]	Per leaf	Per PLAA	Per lesion
Replicate	2	319.70	1148.86	62.02	0.17
Cultivar	13	3321.68***	6760.79***	134.12***	0.85***
Error a	26	433.16	929.42	9.95	0.09
Year	1	1707.35*	1.06 ns	2.98 ns	0.06 ns
Cultivar × year	13	360.07 ns	1484.82 ns	20.02 ns	0.07 ns
Error b	28	398.87	2006.06	15.10	0.14

Note: Error a, cultivar × replicate; error b, cultivar(replicate)(year); ns, not significant; PLAA, percent leaf area affected; *, **, and ***, significant at $P \leq 0.05$, $P \leq 0.01$, and $P \leq 0.001$, respectively.

[a]Percentage of 40 leaves with at least 10 acervuli.

[b]Means are for replicate samples of 40 leaves.

Table 7. Severity of disease caused by *Entomosporium mespili* on detached leaves of 17 saskatoon cultivars inoculated with two concentrations of conidiospores in 1998.

	Low inoculum[a]		High inoculum[b]		
Cultivar	Lesion number per leaf	PLAA	Lesion number per leaf	PLAA	Acervuli number per leaf
Martin	26.1	0.5	126.2	4.5	161.6
Pearson II	39.1	0.9	93.7	3.4	160.8
Thiessen	14.5	0.4	60.7	7.1	139.0
Quaker	31.1	0.6	54.7	6.8	112.3
Nelson	54.1	1.5	69.4	10.6	101.3
Honeywood	22.7	0.3	83.0	2.6	93.2
Bluff	25.9	1.7	49.0	11.4	73.8
Northline	17.0	0.6	56.3	13.8	72.6
Pasture	42.3	1.0	61.9	4.5	71.3
Smoky	29.1	0.5	49.2	1.3	66.4
Forestburg	6.9	0.2	48.9	3.4	65.1
Buffalo	44.2	1.1	65.9	9.3	56.5
PAR90	18.2	0.4	47.3	1.1	46.8
Parkhill	9.7	0.2	34.9	4.8	46.7
Pembina	27.4	0.5	56.6	2.5	42.0
Success	5.2	0.1	15.2	0.8	19.4
Regent	14.6	0.3	18.3	0.5	9.7
LSD ($P \leq 0.05$)	11.5	0.5	22.8	5.8	44.9

Note: Means are for replicate samples of five leaves. Cultivars are ranked by acervuli number per leaf. PLAA, percent leaf area affected.

[a]Conidiospore suspension at 3×10^4 spores/mL.

[b]Conidiospore suspension at 8×10^4 spores/mL.

for experiments with low and high inoculum concentrations, respectively; 'PAR90,' 'Regent,' and 'Success' had low values, while 'Bluff,' 'Buffalo,' and 'Nelson' had high values in both experiments. Cultivar means for acervuli number per leaf, counted only for the second experiment, ranged from 9.7 to 161.6 for 'Regent' and 'Martin,' respectively; 'Regent' and 'Success' had the lowest values (<20), while 'Martin' and 'Pearson II' had the highest values (>160). No disease symptoms were observed on noninoculated leaves in either experiment.

Analysis of variance for lesion number and PLAA data from the two experiments suggested that replicate and cultivar were significant sources of variation (data not shown). Significant variation among replicates was not unexpected since the leaves in each cultivar replicate represented different shoots from the same plant. The effect of leaf age was significant ($P \leq 0.01$) for lesion number. Younger leaves had significantly more lesions compared to older leaves. The effect of leaf age on lesion number was consistent across cultivars and experiments. Analysis of variance for acervuli number from the second experiment showed that cultivar, replicate, and leaf age were significant sources of variation. Across cultivars, young leaves typically had significantly more acervuli than older leaves.

Relationships among measures of leaf disease response

In this study, saskatoon leaf disease response to *E. mespili* was assessed by measurements of infection and sporulation. Measures of the severity of infection included PLAA, lesion number, and lesion size. Measures of the severity of sporulation included acervuli number and number of acervuli per PLAA and per lesion. Leaf disease incidence was measured for naturally infected leaf samples as the percentage of leaves infected or sporulating.

Correlation was observed between cultivar means for the incidence and severity of *Entomosporium* leaf spot at Hudson Bay in 1998 and 1999 (Table 8). Measuring the percentage of leaves sporulating was the most rapid method for determining acervuli formation on a sample of diseased leaves. This variable was significantly correlated with more time-consuming measures of disease severity, such as lesion number, acervuli number, and number of acervuli per PLAA and per lesion. The percentage of leaves infected was significantly correlated with PLAA in both years of field data.

Significant relationships ($P \leq 0.05$) were observed among measures of disease severity on leaves after artificial and natural inoculation. A correlation coefficient of 0.78 was observed between cultivar means for acervuli number and lesion number following artificial inoculation. Significant correlation coefficients of 0.69 and 0.75 were observed between acervuli number and lesion number following natural infection at Hudson Bay in 1998 and 1999, respectively. Data for PLAA and acervuli number from Hudson Bay in 1998 and 1999 were also significantly correlated, with coefficients of 0.74 and 0.62, respectively.

Comparison of leaf disease response following artificial inoculation and natural infection

Significant correlation coefficients were observed between leaf disease response data collected following detached-leaf inoculation and natural leaf infection, mea-

Table 8. Correlation coefficients among replicate means per year for measures of leaf disease incidence and severity caused by natural inoculum of *Entomosporium mespili* on 14 saskatoon cultivars sampled at Hudson Bay, Saskatchewan, on 20 July 1998 and 1999.

							Number of acervuli	
Variable	Year	Infected leaves (%)	Sporulating leaves (%)	PLAA	Lesion number per leaf	Leaf lesion size	Per leaf	Per PLAA
Sporulating leaves (%)	1998	0.63*						
	1999	–0.12 ns						
PLAA	1998	0.84**	0.69**					
	1999	0.58*	0.47 ns					
Lesion number per leaf	1998	0.80**	0.73**	0.80**				
	1999	–0.17 ns	0.78**	0.35 ns				
Leaf lesion size	1998	0.08 ns	–0.12 ns	0.25 ns	–0.27 ns			
	1999	0.51 ns	0.46 ns	0.76**	0.20 ns			
Number of acervuli								
Per leaf	1998	0.62*	0.87**	0.74**	0.69**	0.03 ns		
	1999	0.10 ns	0.88**	0.62*	0.75**	0.68**		
Per PLAA	1998	0.25 ns	0.83**	0.33 ns	0.46 ns	–0.25 ns	0.84**	
	1999	–0.30 ns	0.86**	0.14 ns	0.78**	0.35 ns	0.83**	
Per lesion	1998	0.42 ns	0.87**	0.51 ns	0.45 ns	0.03 ns	0.92**	0.92**
	1999	0.15 ns	0.87**	0.63*	0.57*	0.74**	0.96**	0.77**

Note: ns, not significant; PLAA, percent leaf area affected; * and **, significant at $P \leq 0.05$ and $P \leq 0.01$, respectively.

sured in 1998 and 1999. Data for leaf lesion number collected at Hudson Bay in 1998 correlated better with lesion number data from the experiment with low inoculum concentration ($r = 0.60$) than with those from experiment with high inoculum concentration ($r = 0.38$). Data for leaf lesion number collected at Hudson Bay in 1999 correlated better with lesion number data from the experiment with high inoculum concentration ($r = 0.72$) than with those from experiment with low inoculum concentration ($r = 0.27$). Differences in inoculum concentration could explain some of the deviation seen between leaf disease response data collected over 2 years at Hudson Bay.

Cultivar fruit disease response following natural infection

Evaluation of naturally infected fruit from 10 saskatoon cultivars growing at Edmonton in 1997 revealed significant differences in the incidence and severity of infection (Table 1). Cultivar means for the percentage of fruits infected ranged from 16.0 to 100% on 4 July and from 33.3 to 100% on 18 July. On 18 July, 'Success' had the lowest value for the incidence of fruit infection, while the remaining nine cultivars had generally high levels of infection. Cultivar means for PFAA ranged from 0.1 to 1.1% on 4 July and from 0.2 to 1.0% on 18 July. On 18 July, 'Regent' and 'Success' had low values for PFAA (<0.3%), while the remaining cultivars had medium to high values (0.5–1.0%).

Evaluation of naturally infected fruit from Hudson Bay and Moonlake revealed significant differences in disease incidence among 16 cultivars of saskatoon in 1999 (Table 9). The percentage of fruits infected was high for all cultivars sampled at Hudson Bay. Only 'Success' showed significantly lower values for the percentage of fruits infected (82.3% on 30 June and 80.0% on 20 July). Cultivar means for the percentage of fruits sporulating at Hudson Bay ranged from 17.2 to 79.2% on 30 June, and from 31.1 to 92.4% on 20 July, whereas at Moonlake on 19 July they ranged from 0.8 to 76.6%. 'Nelson,' 'Parkhill,' 'Regent,' and 'Success' had consistently lower values for the percentage of fruits sporulating than other cultivars. Buffalo and Pearson II had the highest values for the percentage of fruits sporulating.

Evaluation of naturally infected fruit from Hudson Bay and Moonlake also showed significant differences in fruit acervuli number among 16 cultivars of saskatoon (Table 9). Cultivar means for acervuli number per fruit at Hudson Bay ranged from 0.4 to 6.7 on 30 June and from 0.7 to 8.3 on 20 July, whereas at Moonlake on 19 July, they ranged from 0.0 to 40.9. 'Parkhill,' 'Regent,' and 'Success' had comparatively low values for fruit acervuli number, while 'Martin,' 'PAR90',' and 'Thiessen' had high numbers.

The incidence and severity of *Entomosporium* berry spot increased throughout the growing season at Edmonton and Hudson Bay. At Edmonton, 'Parkhill,' 'Regent,' and 'Smoky' showed increases in fruit disease incidence and severity during the 2 weeks between successive sampling dates (4–18 July 1997). At Hudson Bay, 'Nelson,' 'Northline,' 'Parkhill,' and 'Regent' showed the greatest increases in the percentage of fruits sporulating during the time between sampling dates (30 June – 20 July 1999). 'Bluff,' 'Nelson,' and 'Northline' showed the greatest increases in fruit acervuli number over the same time period.

Analysis of variance for the percentage of fruits infected or sporulating and fruit acervuli number data collected at Hudson Bay in June and July of 1999 showed that cultivar was a significant source of variation (Table 10). The interaction between cultivar and date was nonsignificant for all measures of fruit disease response. Although cultivar means for measures of fruit disease response increased between June and July, cultivar rankings remained similar.

Relative disease resistance or susceptibility of saskatoon cultivars

Leaf disease response of 14 saskatoon cultivars to *E. mespili* was classed into four groups based on cultivar means for PLAA and leaf acervuli number. Leaves of

Table 9. Incidence and severity of berry spot caused by natural inoculum of *Entomosporium mespili* on 16 saskatoon cultivars at Hudson Bay and Moonlake, Saskatchewan, in 1999.

	Disease incidence					Disease severity		
	Infected fruits (%)[a]		Sporulating fruits (%)[b]			Acervuli number per fruit[c]		
Cultivar	Hudson Bay, 30 June	Hudson Bay, 20 July	Hudson Bay, 30 June	Moonlake, 19 July	Hudson Bay, 20 July	Hudson Bay, 30 June	Moonlake, 19 July	Hudson Bay, 20 July
Pearson II	100.0	100.0	70.1	76.6	77.2	2.9	40.9	2.7
PAR90	98.8	98.1	64.6	48.3	70.6	5.0	36.0	4.9
Thiessen	100.0	100.0	77.5	36.3	90.7	6.7	32.1	8.3
Honeywood	99.4	100.0	57.1	46.7	70.6	2.1	28.7	2.5
Martin	98.6	100.0	71.3	45.0	63.9	4.0	28.0	2.9
Smoky	100.0	100.0	61.0	57.3	79.3	1.4	23.3	2.9
Forestburg	99.2	100.0	60.9	44.7	79.0	2.3	19.2	3.9
Buffalo	100.0	100.0	79.2	54.2	92.4	4.5	16.3	5.5
Bluff	96.5	98.6	56.1	25.3	74.9	2.0	10.1	6.1
Quaker[d]	—	—	—	7.4	—	—	5.8	—
Pembina	89.5	95.8	52.6	23.6	58.9	1.9	3.8	2.5
Northline	87.4	97.5	17.8	7.3	62.9	0.7	2.1	4.5
Nelson	91.6	96.7	19.3	7.3	38.1	0.4	1.4	2.4
Parkhill	97.0	100.0	24.6	0.8	39.2	0.9	1.1	0.7
Regent	95.0	98.6	22.0	10.4	48.1	1.5	0.2	1.3
Success	82.3	80.0	17.2	1.6	31.1	0.8	0.0	0.9
LSD ($P \leq 0.05$)	8.8	4.8	20.0	35.2	28.8	2.6	24.8	2.3

Note: Cultivars are ranked by acervuli number per fruit at Moonlake.
[a]Percentage of fruits with at least one lesion in a replicate sample of six racemes.
[b]Percentage of fruits with at least one acervulus in a replicate sample of six racemes.
[c]Means are for replicate subsamples of 20 fruits.
[d]Plants of the cv. Quaker were not included in the Hudson Bay cultivar trial.

Table 10. Mean squares from analysis of variance for the incidence and severity of berry spot caused by natural inoculum of *Entomosporium mespili* on 15 saskatoon cultivars at Hudson Bay, Saskatchewan, on 30 June and 20 July 1999.

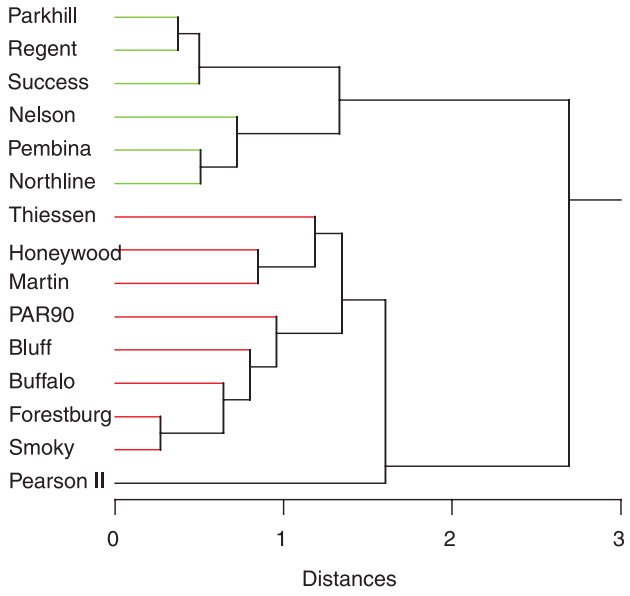
Source of variation	Degrees of freedom	Infected fruits (%)[a]	Sporulating fruits (%)[b]	Acervuli number per fruit[c]
Replicate	2	40.52	52.47	7.61
Cultivar	14	153.09***	2480.21***	19.73***
Error a	28	21.27	256.88	1.86
Date	1	91.66 ns	5100.02**	22.06 ns
Cultivar × date	14	15.46 ns	194.16 ns	3.35 ns
Error b	30	41.50	545.69	6.67

Note: Error a, cultivar × replicate; error b, cultivar(replicate)(year); ns, not significant; *, **, and ***, significant at $P \leq 0.05$, $P \leq 0.01$, and $P \leq 0.001$, respectively.
[a]Percentage of fruits with at least one lesion in a replicate sample of six racemes.
[b]Percentage of fruits with at least one acervulus in a replicate sample of six racemes.
[c]Means are for replicate subsamples of 20 fruits.

'PAR90' and 'Success' restricted infection and sporulation and were characterized by low values for PLAA and leaf acervuli number. Leaves of 'Parkhill,' 'Pembina,' and 'Regent' restricted sporulation and were characterized by medium PLAA and low leaf acervuli number. Leaves of 'Buffalo' and 'Northline' showed reduced sporulation and were characterized by high PLAA and medium leaf acervuli number. The remaining cultivars (Bluff, Forestburg, Honeywood, Martin, Pearson II, Smoky, and Thiessen) were regarded as susceptible with medium to high values for PLAA combined with high leaf acervuli number.

Hierarchical cluster analysis was used to determine which saskatoon cultivars had similar levels of fungal sporulation on leaves and fruit following infection by *E. mespili*. Joint cluster analysis of fungal sporulation data from leaves and fruit of 15 cultivars combined Nelson, Northline, Pembina, Parkhill, Regent, and Success in a large cluster, separate from the other 9 saskatoon cultivars evaluated (Fig. 1). Within this cluster of resistant cultivars, Parkhill, Regent, and Success composed one subgroup, while the other subgroup consisted of Nelson, Northline, and Pembina. Within the cluster of susceptible cultivars, Pearson II composed one subgroup, while the other eight cultivars (Smoky,

Fig. 1. Hierarchical cluster analysis of *Entomosporium* leaf and berry spot disease ratings for 15 saskatoon cultivars. Clustering based on eight sets of data for the incidence and severity of fungal sporulation on leaves and fruit following natural infection by *Entomosporium mespili* in 1998 and 1999. Leaf sporulation data collected following artificial inoculation of detached leaves was also included. Euclidean distance is given below the phenogram.



Forestburg, Buffalo, Bluff, PAR90, Martin, Honeywood, and Thiessen) were grouped together.

Discussion

Past studies of *Entomosporium* leaf spot on saskatoon have focused on measures of infection (PLAA and the percentage of leaves infected) to detect differential disease response among cultivars (Howard et al. 1994, 1995). Leaf and fruit disease response data collected in this study included measures of infection and sporulation. Although measures of infection were useful indicators of cellular damage caused by the pathogen, they may fail to distinguish between a susceptible reaction and a resistant response. There were further limitations associated with measures of infection, particularly with lesion number and size, because of the coalescence of lesions as disease development progressed. In general, the largest and most consistent differences in cultivar disease response were detected by measures of leaf sporulation.

In this study, no saskatoon cultivar showed immunity to the pathogen *E. mespili*. Most cultivars had moderate to high values for the incidence and severity of leaf and fruit infection following inoculation. Resistant cultivars were distinguished by their ability to restrict the incidence and severity of fungal sporulation on leaves and fruit. By measuring the percentage of leaves or fruit sporulating and (or) acervuli number, we obtained an indication of the pathogen's ability to proliferate on foliage and fruit. In this study, the percentage of leaves or fruit sporulating and the number of acervuli per leaf or fruit provided measures of inoculum potential and sporulation capacity of diseased plants. Variables such as number of acervuli per lesion and per PLAA gave an indication of the number of infection loci that developed into sites of sporulation. It is suggested that saskatoon cultivar rankings for resistance to *Entomosporium* leaf and berry spot should be based on measures of fungal sporulation on leaves and fruit.

A comparison of 1998 and 1999 data from Hudson Bay showed similar cultivar rankings for leaf disease response to *E. mespili*. However, the incidence and severity of leaf disease were lower across cultivars in 1998, likely because of an absence of sporulating fruit in that year compared to a relative abundance in 1999. In particular, 'Martin' and 'Thiessen' showed substantially lower values for the incidence and severity of fungal sporulation on leaves in 1998. 'Martin' and 'Thiessen' flower relatively early in the growing season and thus may be more susceptible to fruit loss caused by spring frosts. Fungal sporulation on saskatoon fruit is thought to produce a second wave of inoculum that can further damage already infected leaves. Fruit inoculum appeared to have an equalizing effect on leaf disease response across many cultivars in 1999, masking levels of partial resistance noted in 1998.

Inoculation of detached leaves from 17 saskatoon cultivars with *E. mespili* produced a range of disease response with significant differences among cultivars. Leaf disease severity data (PLAA, lesion number, and acervuli number), obtained following detached-leaf inoculation, showed significant correlation with data collected from naturally infected plants. The similarity in cultivar rankings helped to validate field data and suggested that artificial inoculation of detached leaves is a suitable way to screen saskatoon genotypes for disease response to *E. mespili*. Although the concentration of inoculum had an effect on the level of disease severity, cultivar rankings were similar for both inoculum concentrations. Concentration of *E. mespili* inoculum under orchard conditions is dependent on factors such as weather and plant spacing (Davidson et al. 1991). It is therefore important to validate disease resistance by testing plant response at different levels of inoculum.

Saskatoon leaves of different ages showed differential susceptibility to *Entomosporium* leaf spot. Young leaves often had higher lesion or acervuli number than older leaves. The effect of leaf age on *Entomosporium* disease response has also been reported in *Photinia* ×*fraseri* (Dress.) (Baudoin 1986). Leaves of *Photinia* ×*fraseri* were very susceptible to *E. mespili* as long as they were expanding rapidly; distinct changes in leaf appearance coincided with the onset of resistance. Jacobs (1996) observed that the severity of *Entomosporium* leaf spot on *Photinia* species was directly proportional to leaf age, such that the number of lesions produced on young leaves was 10- to 30-fold greater than that on mature leaves. Kabaluk and St-Pierre (1992) noted that the susceptibility of saskatoon leaves to *Gymnosporangium nelsonii* also decreased with increasing leaf age.

A relationship between leaf age and disease resistance suggests differences in physical and (or) chemical composition among saskatoon leaves of different ages. Wetzstein and Sparks (1983) observed that young leaves of *Carya illinoensis* (Wang.) Koch were less resistant to infection by

Cladosporium caryigenum (Ellis and Langl) Gottwald than older leaves. They noted that the higher level of resistance in older leaves was associated with low trichome density and longevity, high phenolic content in the mesophyll, and thick cuticles. van der Zwet and Stroo (1985) observed that extracts from young leaves of *Pyrus* ×*communis* L. increased *E. mespili* conidiospore germination more than leachates from older leaves. They postulated that a susceptible disease reaction involved the leaching of a stimulatory chemical compound from leaf tissue into spore-containing droplets on the leaf surface. They suggested that the resistance of older leaves was partly due to the lack of leached stimulants.

One would expect a relationship between saskatoon leaf and fruit disease response to *E. mespili*, such that low levels of sporulation on foliage would lead to reduced fruit infection. In general, leaves are thought to be the sites of initial infections in the spring and a source of secondary inoculum throughout the summer. Conidiospores produced in leaf acervuli initiate new leaf and fruit infections. Therefore, the level of infection and sporulation on leaves might influence the development of the disease on fruit. However, as seen at Moonlake in 1999, it is possible to have severe fruit infection even when leaf symptoms are limited. Furthermore, 'PAR90' possessed partial foliar resistance to *E. mespili*, but was highly susceptible to fruit spot caused by the same pathogen. It is apparent that the development of saskatoon cultivars resistant to *Entomosporium* leaf and berry spot will require the consideration of both leaf and fruit disease response.

The incidence and severity of *Entomosporium* berry spot increased throughout the growing season at Edmonton and Hudson Bay. This was consistent with the findings of Davidson (1990), who observed up to 21% fruit infection in late June, rising to 72% at harvest. Increases in fruit disease over time may result from further inoculation and infection of fruit, and (or) changes in fruit structure and composition that increased susceptibility. Stushnoff (1990) reported that saskatoon fruit sugar content increased slowly throughout maturity, but showed a rapid increase just before harvest. Saskatoon fruit disease response may also be related to the thickness and composition of the epicuticular wax found on the exterior of the pome. Knowles et al. (1996) reported that epicuticular wax thickness of saskatoon fruit decreases as the fruit develops and is considerably less at maturity than that reported for most commercially grown small fruits. Furthermore, the space between wax crystals increases as the fruit surface area expands, potentially providing greater opportunity for spore germination and penetration.

This study has provided useful information on the variation in saskatoon cultivar response to *Entomosporium* leaf and berry spot. 'Parkhill,' 'Regent,' and 'Success' showed consistently lower values for the incidence and severity of fungal sporulation on leaves and fruit. These cultivars are thought to be hybrids between *Amelanchier alnifolia* and *Amelanchier stolonifera* Wiegand. (Weir et al. 1997) and may derive their improved disease resistance from *A. stolonifera*. Successful crosses between 'Parkhill' and 'Smoky' (Davidson and Mazza 1991) suggest that it would be possible to transfer resistance to *Entomosporium* leaf and berry spot to Canadian saskatoon genotypes with superior fruit quality. Among existing Canadian saskatoon cultivars selected for fruit yield and quality, Nelson, Northline, and Pembina offered partial resistance to fungal sporulation on foliage and fruit.

Characterization of disease response to *Entomosporium* leaf and berry spot among available saskatoon cultivars provides a valuable informational resource for individuals seeking to establish new orchards. Saskatoon growers would welcome a new cultivar combining disease resistance with other desirable features such as fruit yield and quality. This is especially true for growers interested in producing fruit organically, without synthetic fungicidal disease control. Planting less-susceptible saskatoon cultivars and implementing cultural disease controls, such as drip irrigation and the removal of suckers, may limit the amount of leaf and fruit damage caused by *E. mespili*. Further studies are needed to confirm the cultivar rankings presented here and to understand the possible interrelationship between saskatoon leaf and fruit response to *E. mespili*.

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