Seasonal Dynamics of Alfalfa Foliar Pathogens in Iowa

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ABSTRACT

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The frequency of occurrence of 11 foliar pathogens of alfalfa was monitored at four locations in Iowa over a 2-yr period. At each location, disease severity and percent defoliation were assessed weekly beginning in early May and continuing until late September or early October. For each sampling period and for all four locations, 100 lesions or blotches were incubated in moisture chambers (12 hr of light per day) for 48 hr at 23 C to facilitate pathogen sporulation and identification. Percentage of the total lesions or blotches caused by each pathogen was plotted vs. time to identify seasonal patterns. Correlation analyses were performed between the percentages of lesions or blotches caused by each pathogen sampled and the date of sampling (day of year). Correlations were also determined between frequency of pathogen occurrence and mean rainfall and mean maximum and minimum temperatures occurring 1, 2, and 3 wk before each sampling date. Ten fungal pathogens (*Cercospora medicaginis, Colletotrichum dematium, Colletotrichum trifolii, Leptosphaerulina trifolii, Leptotrochila medicaginis, Phoma medicaginis, Pseudopeziza medicaginis, Stagonospora meliloti, Stemphylium botryosum*, and *Uromyces striatus*) and one bacterial pathogen (*Xanthomonas campestris*) were identified. Of these, *Phoma medicaginis, Leptosphaerulina trifolii, Pseudopeziza medicaginis*, and *Cercospora medicaginis* occurred in the highest frequencies. Occurrences of *Phoma medicaginis, Colletotrichum dematium*, and *Xanthomonas campestris* were negatively correlated with date of sampling (early-season pathogens), whereas occurrences of *Cercospora medicaginis, Leptotrochila medicaginis, Stagonospora meliloti, Pseudopeziza medicaginis* (in most location years), and *Uromyces striatus* were positively correlated with date of sampling (late-season pathogens). Disease severity and defoliation at harvests varied among locations and years. Defoliation ranged from as little as 3% at Knoxville in 1992 to as high as 71% at Ames in 1991, and disease severity at the time of harvests ranged from 3% at Knoxville in 1992 to 73% at Ames in 1991.

Alfalfa (*Medicago sativa* L.) occupies the third largest hectarage in Iowa, after corn and soybean. Although diseases of alfalfa reduce hay quality, quantity of yield, stand establishment, and life span (3,11,14), little is known about alfalfa pathogens in Iowa and their effects on alfalfa production. The most recent work on foliar pathogens of alfalfa has been done in North Carolina (4,5,9,12,13). Leaf spots of alfalfa were caused by at least four fungi: *Leptosphaerulina trifolii* (Rostr.) Petr., *Stemphylium botryosum* Wallr., *Cercospora medicaginis* Ellis & Everh., and *Phoma medicaginis* Malbr. & Roum. in Roum. var. *medicaginis* Boerema. The seasonal occurrence of these pathogens was determined at three locations over a 2-yr period. In Wyoming, Gray (6) found that common leaf spot caused by *Pseudopeziza medicaginis* (Lib.) Sacc., downy mildew caused by *Peronospora trifoliorum* de Bary, and spring black stem and leaf spot caused by *Phoma medicaginis* were the major diseases of irrigated alfalfa, whereas yellow leaf blotch caused by *Leptotrochila medicaginis* (Fuckel) H. Schüepp predominated on dryland alfalfa. In a 3-yr survey of alfalfa fields in Alabama, Gray et al (7) recorded the presence of anthracnose caused by *Colletotrichum trifolii* Bain & Essary, Sclerotinia crown and stem rot caused by *Sclerotinia trifoliorum* Eriks., Rhizoctonia crown rot caused by *Thanatephorus cucumeris* (A.B. Frank) Donk, summer black stem and leaf spot caused by *Cercospora medicaginis*, charcoal rot caused by *Macrophomina phaseolina* (Tassi) Goidanich, and rust caused by *Uromyces striatus* J. Schröt. (6).

Alfalfa in Iowa is susceptible to a number of plant pathogens, as evidenced by the prevalence of leaf spots and premature defoliation. However, the pathogens causing these injuries and their relative importance in Iowa have not been determined. Reliable information concerning the relative importance of alfalfa foliar pathogens and the injury they cause would facilitate prioritization of research needs and the development of cost-efficient disease management programs. To date, no comprehensive studies on the seasonality of foliar pathogens and the injury they cause on alfalfa in Iowa have been conducted. The objectives of this study were to determine the seasonal occurrence and prevalence of alfalfa diseases at four locations in Iowa, determine the seasonal severity and defoliation caused by foliar pathogens, and examine the correlations between seasonal patterns of occurrence and weather. A preliminary report has been published (8).

MATERIALS AND METHODS

Sampling procedure. Field plot experiments were established in existing alfalfa stands in a north-south transect at four locations in Iowa: 1) the Johnston (1991) and Idens (1992) research farms, both located in Ames; 2) the Ankeny Research Station, Ankeny; 3) the Chariton Research Station on the McNay Farm, Chariton; and 4) a grower's field in Knoxville.

Occurrences and relative frequencies of alfalfa foliar pathogens were recorded weekly beginning on day 122 (2 May) of 1991 and day 123 (3 May) of 1992. Weekly sampling continued through day 270 (27 September) in 1991 and day 275 (3 October) in 1992. The alfalfa cultivar Ranger, which is susceptible to all alfalfa foliar pathogens, was monitored at Ames, Ankeny, and Chariton, and cv. PA-80 (Pioneer Hybrid International, Inc.), a mixture of 80% alfalfa, 15% orchardgrass, and 5% timothy, was monitored at Knoxville. At Ames and Knoxville in 1991 and at Ankeny and Knoxville in 1992, 2- to 4-ha alfalfa stands were divided into quadrants, and 25 stems were selected from each quadrant by arbitrarily sampling six or seven stems from each arm of a W-shaped sampling pattern. The stems were clipped at the soil line, placed in plastic bags, and transported in an ice cooler to the laboratory for disease assessment. At Ankeny and Chariton in 1991 and at Ames and Chariton in 1992, 0.91 × 7.62 m plots were established by using a sickle bar cutter to clip a 0.91- to 1.52-m border around each plot. Four replicate plots were established and maintained within each field. Field sizes ranged from 2 to 10 ha. Ten stems per plot were sampled arbitrarily each week from each plot and assessed for disease severity and percent defoliation in the laboratory.

Disease assessment. Percent defoliation was determined by counting the number of leaflets missing from the primary trifoliolate at each node of each stem sample, dividing by the number of

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nodes × 3 (since there are three leaflets per trifoliolate leaf), and then multiplying by 100. Disease severity for each stem sample was calculated using the equation $Y = [(100 - D)X] + D$, where Y represents total percent disease severity due to foliar pathogens, X is the percentage of necrotic leaf area occupied by lesions or blotches, and D is the percentage of leaflets defoliated. The disease severity value was a reflection of all foliar pathogens present and causing injury. A computerized disease-assessment training program was used to train raters to estimate disease severity (Alfalfa.Pro; F. W. Nutter, Jr., and D. Littwiller, *unpublished*). Several different raters were employed in 1991, and a single rater

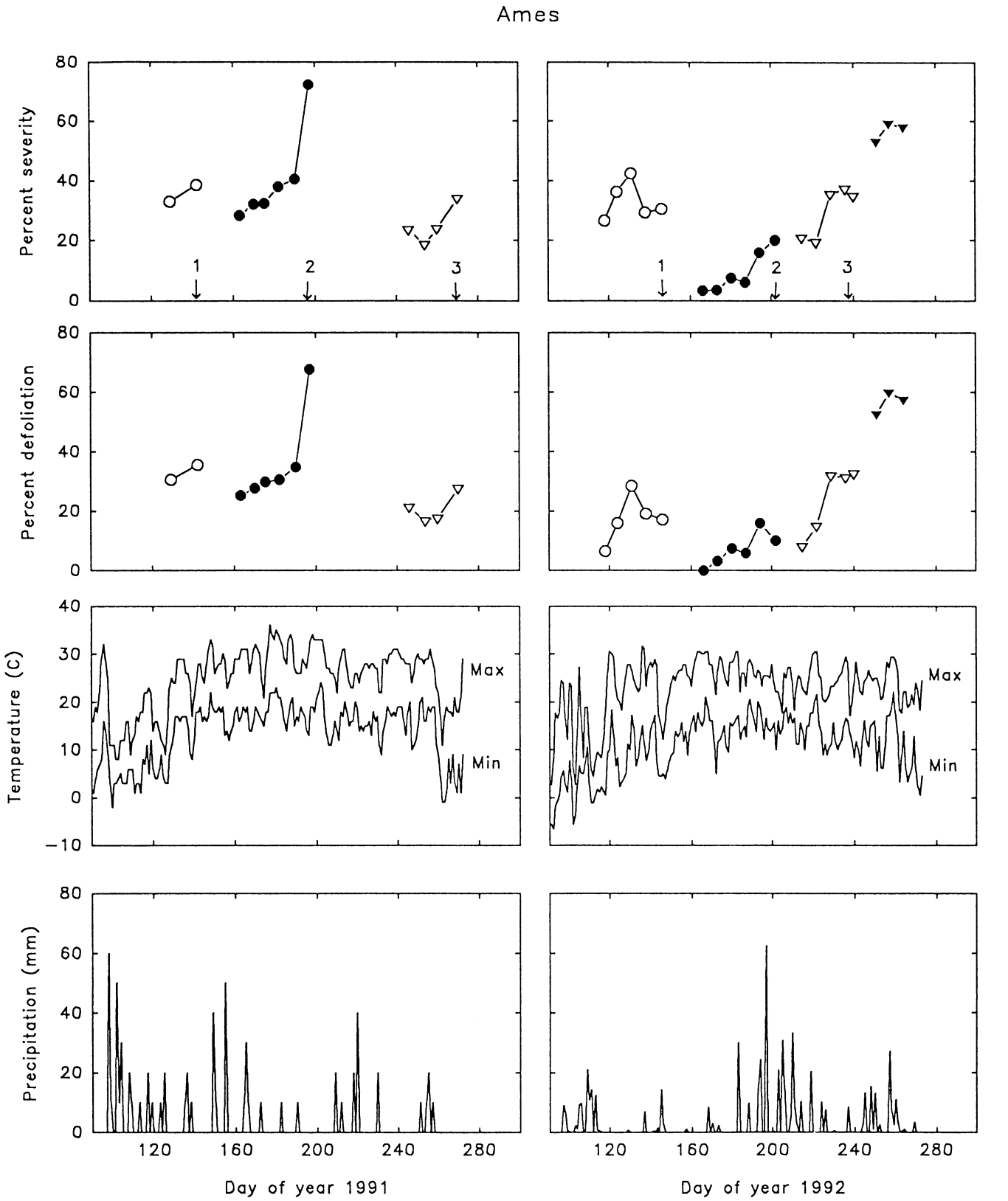

Fig. 1. Disease severity, percent defoliation, maximum and minimum daily temperatures, and daily rainfall for Ames, Iowa, in 1991 and 1992. Closed circles, open circles, and open triangles indicate samples assessed until the first, second, and third harvests, respectively. Numbers above arrows indicate harvest dates.

assessed samples from Ames, Ankeny, and Chariton in 1992. A different rater was responsible for evaluating all samples from Knoxville in 1992.

Determination of frequency and occurrence of foliar pathogens. From each replication, seven or eight leaves, containing at least 25 lesions or blotches (100 per field), were incubated in petri dish moisture chambers to facilitate pathogen sporulation and identification. Leaves or leaflets were incubated at 23 C for 48 hr, and lesions or blotches were observed under a stereoscopic microscope. Asexual and sexual fruiting structures of fungal pathogens were aseptically transferred to V8 or acidified PDA, and plates were incubated in a lighted

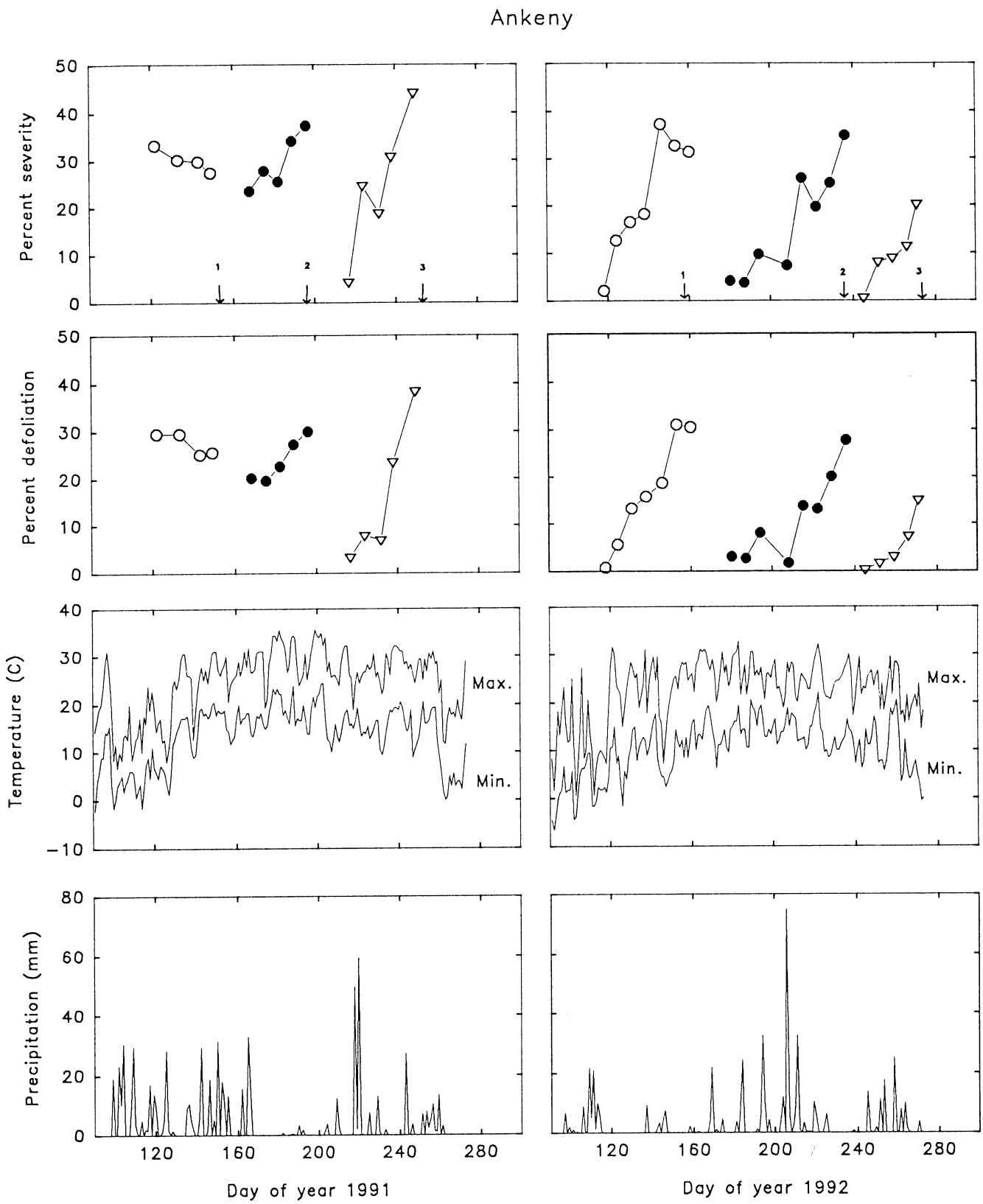

Fig. 2. Disease severity, percent defoliation, maximum and minimum daily temperatures, and daily rainfall for Ankeny, Iowa, in 1991 and 1992. Closed circles, open circles, and open triangles indicate samples assessed until the first, second, and third harvests, respectively. Numbers above arrows indicate harvest dates.

growth chamber (12 hr of light per day) at 23 C to further ensure accurate identification of the foliar pathogens involved (2,13,14). The frequency of each pathogen causing a lesion or blotch was recorded and expressed as a percentage of the total number of lesions or blotches observed.

Data analysis. Weather data for the four locations were acquired from the State Climatological Office, Iowa Department of Agriculture and Land Stewardship, Des Moines. Variables examined were mean rainfall (mm), and mean maximum and minimum air temperatures for periods occurring 1, 2, and 3 wk before each sampling date. Correlation analyses were performed to

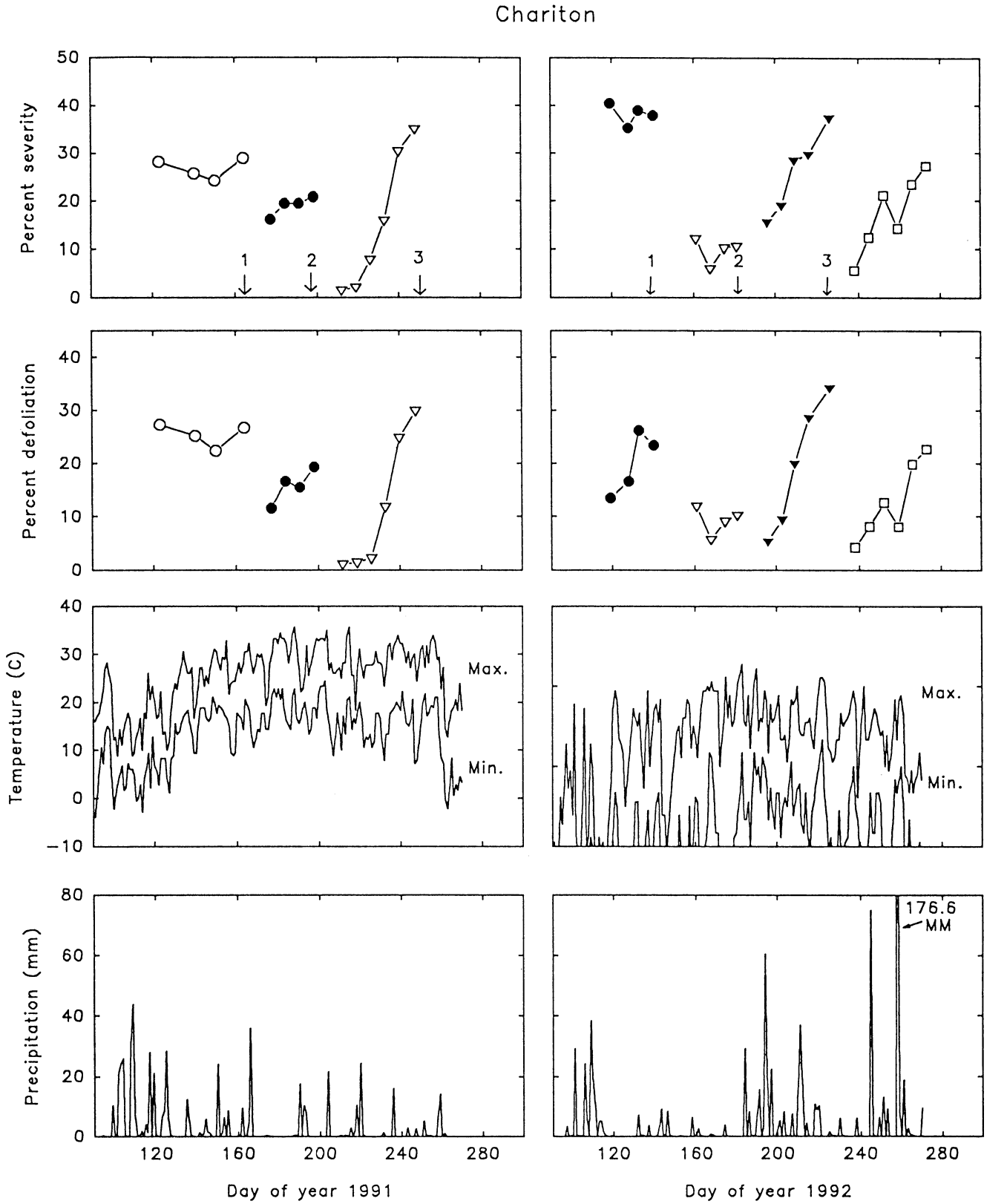

Fig. 3. Disease severity, percent defoliation, maximum and minimum daily temperatures, and daily rainfall for Chariton, Iowa, in 1991 and 1992. Closed circles, open circles, and open triangles indicate samples assessed until the first, second, and third harvests, respectively. Numbers above arrows indicate harvest dates.

relate relative frequencies (occurrence) of pathogens from each sampling date (day of year) to changes in mean maximum and minimum weekly temperatures and precipitation. Correlations were also performed between day of year and frequency of occurrence for all 11 pathogens.

RESULTS AND DISCUSSION

Disease severity and defoliation varied among locations and years but were quite high by most harvest dates (Figs. 1–4). In 1991, defoliation values prior to harvests ranged from 28 to 70% in Ames (Fig. 1), from 25 to 38% in Ankeny (Fig. 2), and from 20 to 28% in Chariton (Fig. 3). In Knoxville, percent defoliation was 60% by the first 1991 harvest date (Fig. 4); data for the second and third harvests were not obtained in 1991. In 1992, percent defoliation values at the time of harvests were again highest at Ames,

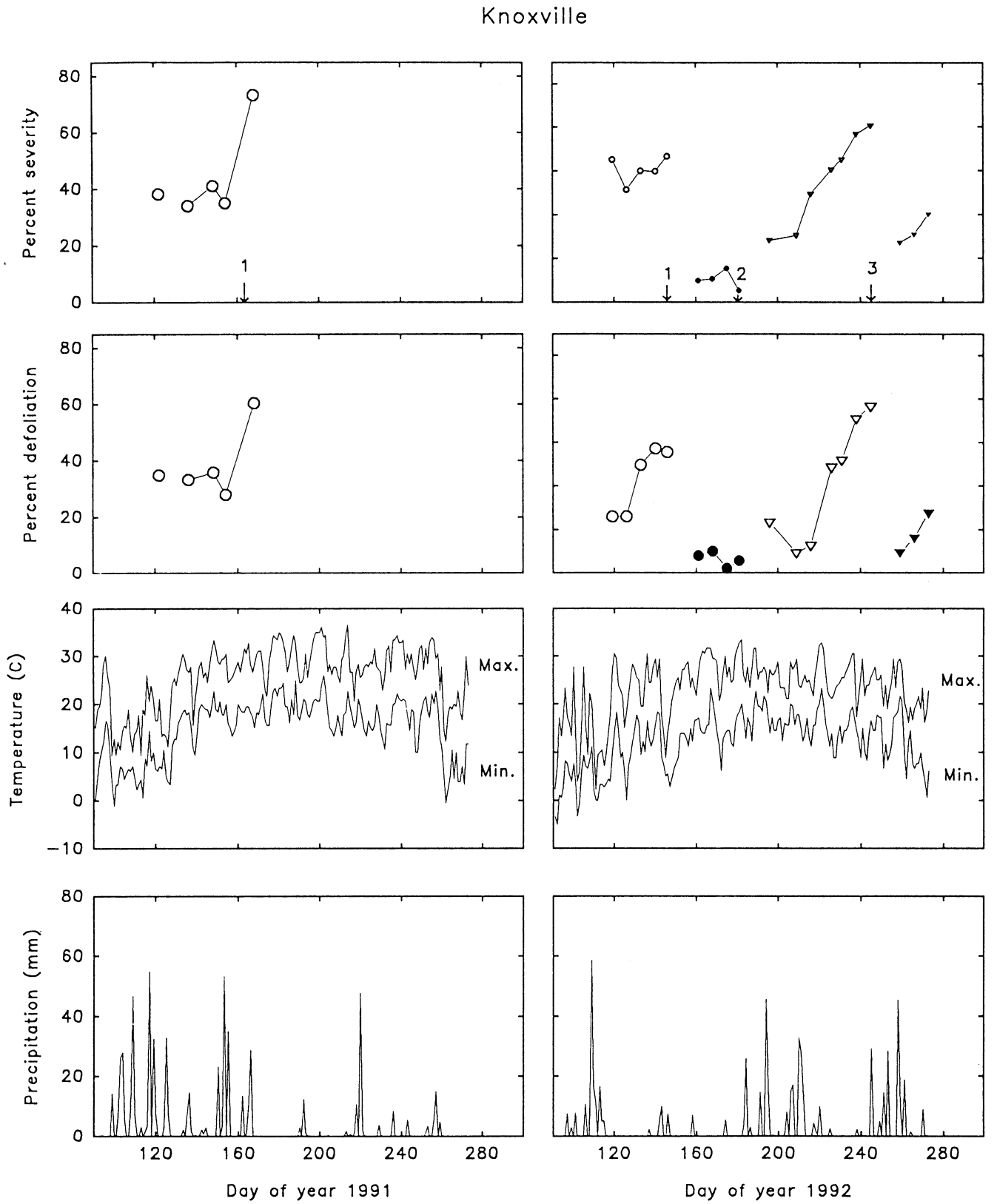

Fig. 4. Disease severity, percent defoliation, maximum and minimum daily temperatures, and daily rainfall for Knoxville, Iowa, in 1991 and 1992. Closed circles, open circles, and open triangles indicate samples assessed until the first, second, and third harvests, respectively. Numbers above arrows indicate harvest dates. In 1991, disease severity and defoliation data were collected only until the first alfalfa harvest.

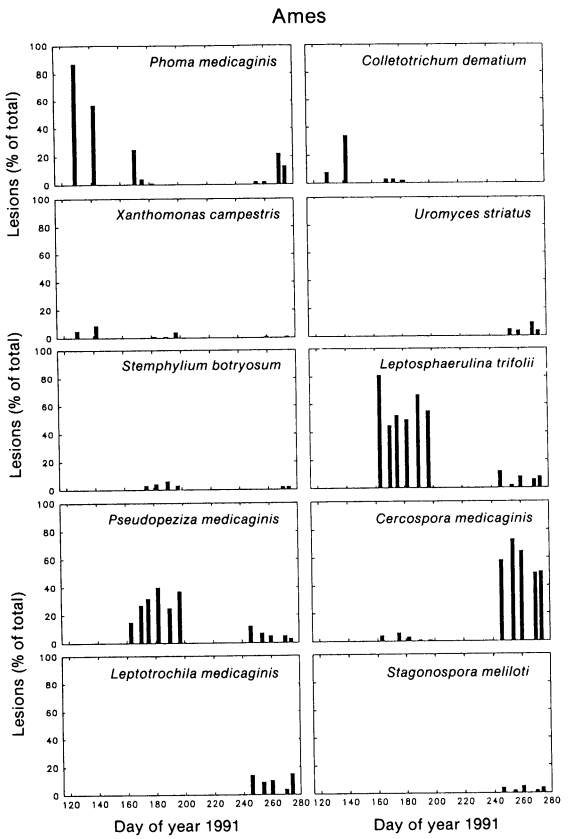

Fig. 5. Relative percentages of the frequencies for foliar pathogens monitored at Ames, Iowa, in 1991.

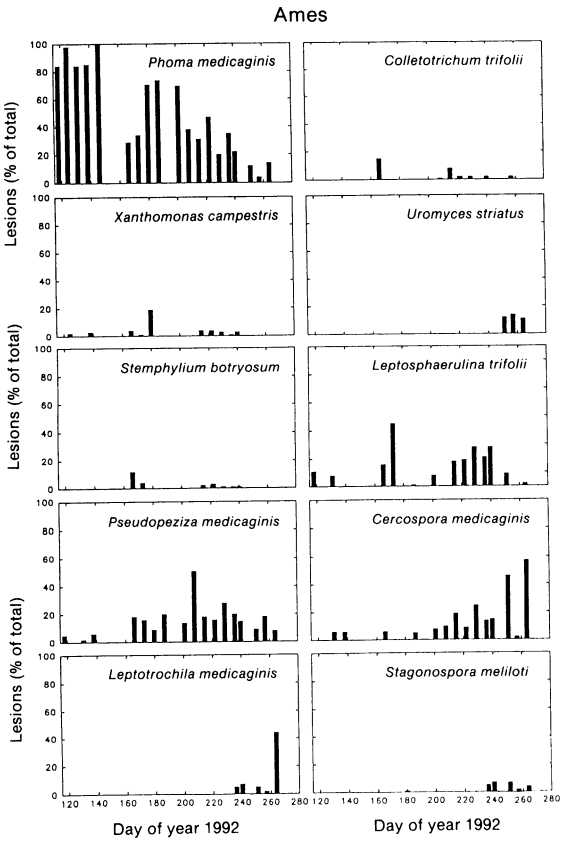

Fig. 6. Relative percentages of the frequencies for foliar pathogens monitored at Ames, Iowa, in 1992.

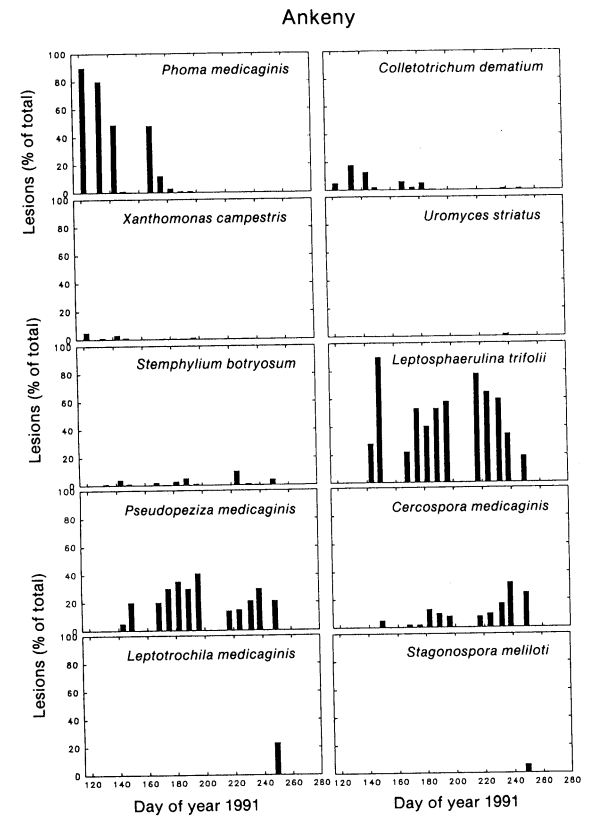

Fig. 7. Relative percentages of the frequencies for foliar pathogens monitored at Ankeny, Iowa, in 1991.

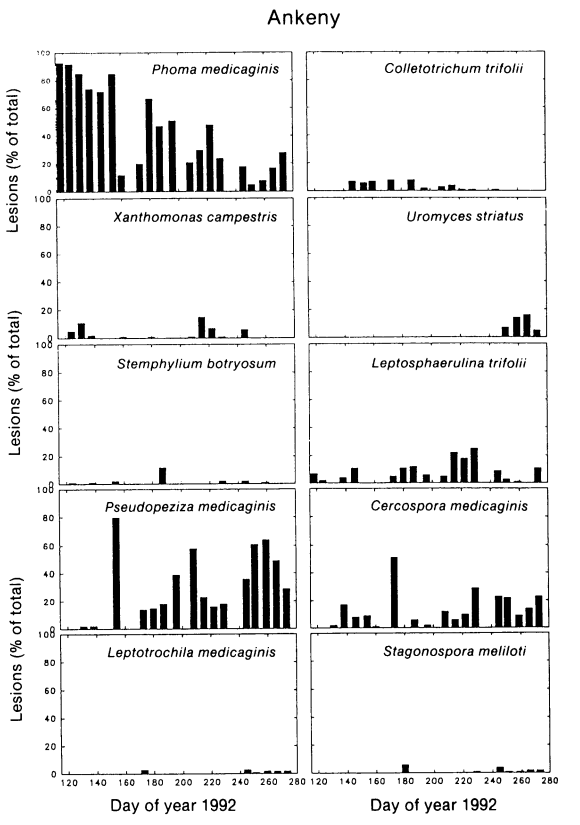

Fig. 8. Relative percentages of the frequencies for foliar pathogens monitored at Ankeny, Iowa, in 1992.

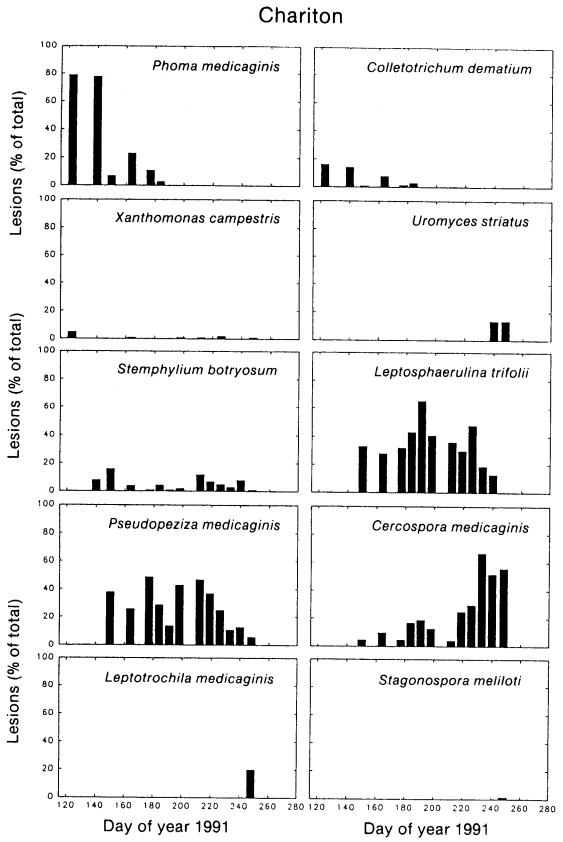

Fig. 9. Relative percentages of the frequencies for foliar pathogens monitored at Chariton, Iowa, in 1991.

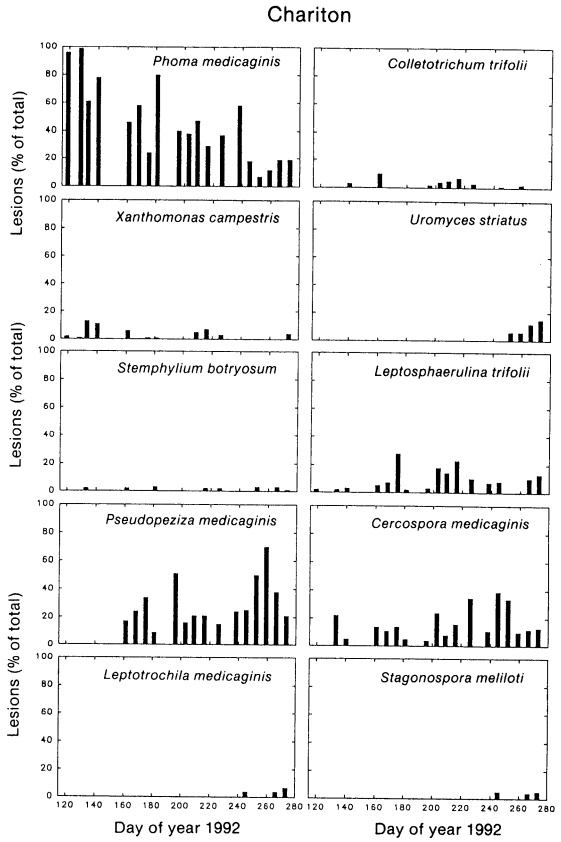

Fig. 10. Relative percentages of the frequencies for foliar pathogens monitored at Chariton, Iowa, in 1992.

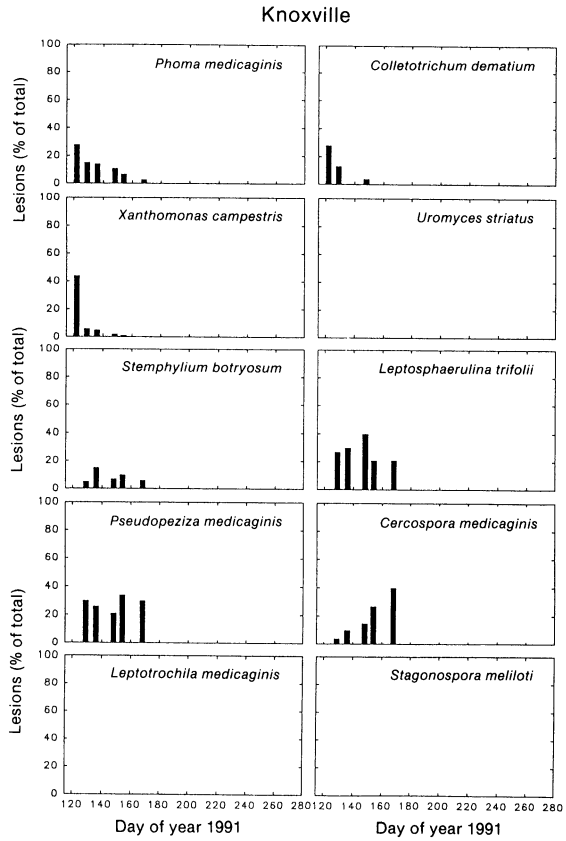

Fig. 11. Relative percentages of the frequencies for foliar pathogens monitored at Knoxville, Iowa, in 1991.

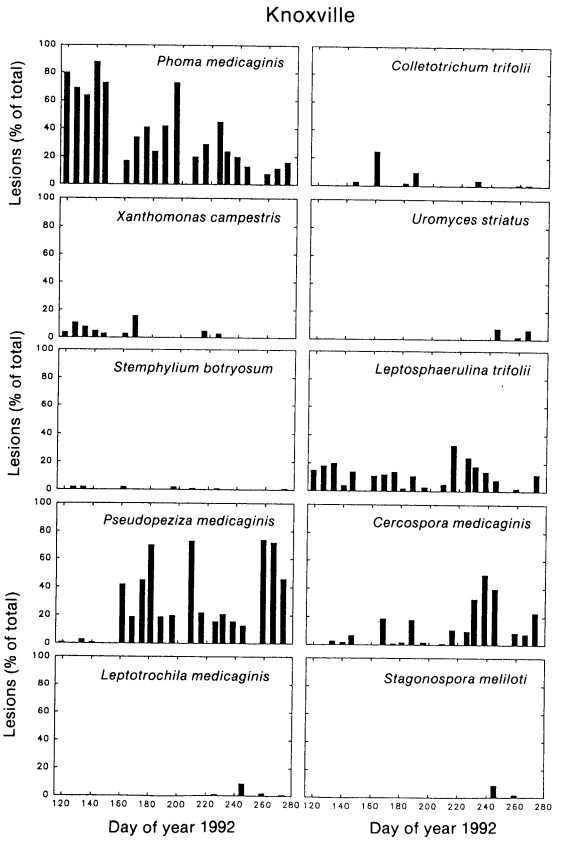

Fig. 12. Relative percentages of the frequencies for foliar pathogens monitored at Knoxville, Iowa, in 1992.

ranging from 10 to 58%; values ranged from 16 to 30% in Ankeny, from 22 to 34% in Chariton, and from 3 to 38% in Knoxville (Figs. 1–4). Disease severity, which included defoliation, was slightly greater than defoliation values for all samplings but in general followed a similar pattern (Figs. 1–4). The PA-80 mixture of 80% alfalfa, 15% orchardgrass, and 5% timothy grown at the Knoxville location did not appear to reduce disease levels when compared with the pure stands of alfalfa monitored in Ames, Ankeny, and Chariton.

Ten fungal pathogens and one bacterial pathogen occurred at all four locations in both years with the exceptions of *Colletotrichum dematium* (Pers.) Grove f. *truncatum* (Schwein) Arx, which was detected at all four locations in 1991 but not in 1992, and *Colletotrichum trifolii*, which was detected at all four locations in 1992 but not in 1991 (Figs. 5–12). The other eight fungal pathogens were *Cercospora medicaginis, Leptosphaerulina trifolii, Leptotrochila medicaginis, Phoma medicaginis, Pseudopeziza medicaginis, Stagonospora meliloti* (Lasch) Petr., *Stemphylium botryosum*, and *Uromyces striatus*, and the bacterial pathogen was *Xanthomonas campestris* pv. *alfalfae* (Riker et al) Dye. Seasonal patterns for specific pathogens at Ames, Ankeny, Chariton, and Knoxville were very similar in 1991 and 1992 (Figs. 5–12). *Phoma medicaginis, Leptosphaerulina trifolii, Pseudopeziza medicaginis*, and *Cercospora medicaginis* occurred most frequently and were probably the pathogens most responsible for the high levels of disease severity and defoliation recorded at all sites.

Phoma medicaginis showed a consistent seasonal pattern; it was most frequently present in the spring before the first harvest and decreased in frequency as the summer progressed. *Phoma medicaginis* was correlated negatively with date of sampling for all eight location years examined and was found to be the pathogen causing nearly all of the injury to alfalfa prior to the first harvest (Table 1). *Phoma medicaginis* was also negatively correlated with mean weekly maximum and mean weekly minimum temperatures (Table 2), indicating that relatively higher frequencies of *Phoma medicaginis* were associated with lower weekly maximum and minimum mean temperatures. These results differ from seasonal patterns observed for *Phoma medicaginis* in North Carolina, where no consistent pattern of seasonal occurrence for that pathogen was detected (13); however, our results parallel the seasonal patterns observed in Wyoming (6).

Cercospora medicaginis exhibited a different seasonal pattern than *Phoma medicaginis* in that sampling date was positively correlated with *Cercospora medicaginis* in all location years (Table 1). Levels of disease caused by this pathogen were initially low beginning in midsummer, then gradually increased as the summer season progressed (Figs. 5–12). However, because *Cercospora medicaginis* was infrequently and positively correlated with weekly maximum and minimum temperatures (Table 2), it is more likely that a buildup of inoculum over time, rather than warmer seasonal temperatures, was responsible for increased occurrence of this pathogen as the season progressed. *Cercospora medicaginis* was present at low levels as early as day 129 (9 May). Baxter (1) reported that *Cercospora medicaginis* was an important pathogen in Iowa in the mid-1950s and that the leaf spot phase of the disease commonly appeared in mid-June. Over the eight location years examined, we found that *Cercospora medicaginis* appeared by day 140 ± 11 days (between 9 May and 31 May), 2–5 wk earlier than the date reported by Baxter (1).

In a 2-yr study, Von Chong and Campbell (13), reported that *Leptosphaerulina trifolii* was present continuously for all sampling dates in North Carolina. We also found that *Leptosphaerulina trifolii* and *Pseudopeziza medicaginis* were generally present throughout the growing season for all eight location years investigated in Iowa. The frequency of *Leptosphaerulina trifolii* lesions relative to other foliar pathogens was highest in midseason. The lack of a significant correlation between occurrence of *Leptosphaerulina trifolii* and day of sampling for all eight location years supports the observation that *Leptosphaerulina trifolii* exhibited no clear seasonal pattern in Iowa. *Pseudopeziza medicaginis* was also present throughout the growing seasons at all eight location years. However, day of sampling was positively correlated with occurrence of *Pseudopeziza medicaginis* in five of the eight location years, indicating a buildup of inoculum over time and/or the presence of more favorable weather conditions for this pathogen from midseason on (Tables 1 and 2).

In North Carolina (13), frequency of *Leptosphaerulina trifolii* decreased from day 160 to day 220, whereas in Iowa, this was often the period in which that pathogen attained peak frequencies. Unlike the results reported for North Carolina (13), there did not seem to be a negative effect of mean maximum temperatures ≥30 C on the occurrence of *Leptosphaerulina trifolii* (Figs. 5–12, Table 2), which may indicate the presence of ecotypes for this pathogen. Mean maximum daily temperatures were positively correlated with *Leptosphaerulina trifolii* at all four locations in 1991 but not in 1992, which was one of the coolest

Table 1. Correlation coefficient between day of year samples were collected and occurrence of 11 alfalfa foliar pathogens in Iowa

Pathogen / Year	Location			
	Ames	Ankeny	Chariton	Knoxville
Phoma medicaginis				
1991	−0.56++[a]	−0.78**	−0.86**	−0.90**
1992	−0.87**	−0.81**	−0.83**	−0.76**
Pseudopeziza medicaginis				
1991	0.49++	NS	NS	NS
1992	0.42++	0.58**	0.67**	0.51*
Leptosphaerulina trifolii				
1991	NS	NS	NS	NS
1992	NS	NS	NS	NS
Cercospora medicaginis				
1991	0.89**	0.84**	0.79**	0.97**
1992	0.67**	0.38+	0.46*	0.55*
Xanthomonas campestris				
1991	−0.55++	−0.70**	−0.49+	−0.75+
1992	NS	NS	−0.42++	−0.57*
Colletotrichum dematium				
1991	−0.52++	−0.68**	−0.90**	−0.82++
Colletotrichum trifolii				
1992	NS	NS	NS	NS
Stemphylium botryosum				
1991	NS	NS	NS	NS
1992	NS	NS	NS	NS
Leptotrochila medicaginis				
1991	0.78**	0.44+	NT	NT
1992	0.47*	0.56**	0.55*	0.40+
Stagonospora meliloti				
1991	0.81**	0.44+	NT	NT
1992	0.64**	0.38++	0.55*	0.40+
Uromyces striatus				
1991	0.56++	0.49++	NS	NT
1992	0.59**	0.63**	0.65**	0.56*

[a]NS = not significant, ** = $P \leq 0.01$, * = $P \leq 0.05$, ++ = $P \leq 0.10$, + = $P \leq 0.15$, NT = not tested because pathogen detected on insufficient dates.

summers on record in Iowa (Table 2).

Xanthomonas campestris occurred in low frequencies at all locations for both years (Figs. 5–12) and was correlated negatively with day of year for all four locations in 1991 and for two of the four locations in 1992 (Table 1). Occurrence of *Xanthomonas campestris* was correlated with precipitation occurring 1 wk prior to sampling in three of the four locations in 1991 and two of the four locations in 1992 (Table 2). Although, *Xanthomonas campestris* is reported to be favored by warm, wet weather (11), the pathogen was detected on more sampling dates in 1992 (cooler year) than in 1991 at all four locations. *Xanthomonas campestris* was also found to be negatively correlated with maximum and minimum temperatures in both years, indicating that cooler temperatures in Iowa favor disease development.

Leptotrochila medicaginis, Stagonospora meliloti, and *Uromyces striatus* tended to occur in low frequencies late in the season, and frequencies of these three pathogens were positively correlated with day of year. *Stemphylium botryosum* occurred sporadically in low frequencies for all location years, and occurrence of this pathogen was not correlated with day of year. Because of low frequencies of occurrence, there were no significant correlations between weather variables and the occurrence of these four pathogens, and therefore these data are not included in Table 2.

There appeared to be an environment × pathogen frequency interaction for *Colletotrichum* spp. because *Colletotrichum dematium* was detected only in 1991 and was negatively correlated with day of sampling and temperature, whereas only *Colletotrichum trifolii* was detected in 1992 and its occurrence was not correlated with day of sampling or temperature (Table 1). Although *Colletotrichum trifolii* is considered to be an important foliar pathogen in much of the United States (11), it accounted for more than 20% of the lesions on only one occasion in our study (Fig. 12). *Colletotrichum dematium* accounted for more than 20% of the lesions at single locations on two sampling dates in 1991 (Figs. 5 and 11).

Several studies have reported that two or more alfalfa foliar pathogens can be present simultaneously in diseased stands of alfalfa (3,5–7,10–12,14). Our findings agree with those of Von Chong and Campbell (13) that alfalfa foliar pathogens are not mutually exclusive in the ecological (leaf, petiole, stem) or seasonal (temporal) niches they occupy. We often observed the presence of two or more

Table 2. Correlation coefficients between occurrence of seven alfalfa foliar pathogens and mean weather parameters in four locations in Iowa

Pathogen Year	Weeks prior to sampling	Maximum temperature				Minimum temperature				Rainfall (mm)			
		Ames	Ankeny	Chariton	Knoxville	Ames	Ankeny	Chariton	Knoxville	Ames	Ankeny	Chariton	Knoxville
Phoma medicaginis													
1991	1	−0.77**[a]	−0.75**	−0.75**	−0.80*	−0.65*	−0.73**	−0.63*	−0.84+	0.48+	NS	0.63*	NS
	2	−0.72**	−0.82**	−0.85**	−0.97**	−0.72**	−0.80**	−0.77**	−0.89*	NS	NS	NS	NS
	3	−0.88**	−0.80**	−0.94**	−0.90*	−0.89**	−0.77**	−0.86**	NS	NS	NS	NS	NS
1992	1	NS	−0.34+	NS	NS	−0.43++	−0.42++	−0.41++	NS	NS	0.37+	−0.47*	NS
	2	NS	−0.52*	−0.54*	NS	−0.54*	−0.52*	−0.59**	−0.41++	NS	NS	NS	NS
	3	−0.40++	−0.57**	−0.46*	−0.40++	−0.56*	−0.60**	−0.46*	−0.43++	NS	NS	NS	NS
Pseudopeziza medicaginis													
1991	1	0.72**	0.78**	NS	NS	0.68*	0.75**	NS	NS	NS	NS	−0.60*	NS
	2	0.55+	0.74**	0.61*	0.85++	0.55++	0.74**	0.58++	NS	NS	NS	NS	NS
	3	0.59*	0.72**	0.65*	0.85++	0.57++	0.76**	0.62*	NS	NS	NS	−0.57++	NS
1992	1	NS	NS	NS	NS	0.42++	NS	0.47*	NS	0.53*	0.36+	0.71**	NS
	2	0.42++	NS	0.43++	NS	0.69**	0.38++	0.44++	NS	NS	NS	NS	NS
	3	0.45*	0.47*	NS	0.44++	0.55*	0.44++	NS	0.50*	NS	NS	NS	NS
Leptosphaerulina trifolii													
1991	1	0.58*	0.50++	0.56++	0.73+	0.54++	0.51++	0.78+	NS	NS	NS	NS	−0.91*
	2	0.53++	0.51++	0.76**	NS	0.58*	0.48++	0.81**	NS	0.47+	NS	NS	NS
	3	0.50+	0.69**	0.62*	0.93*	0.54++	0.66**	0.62*	NS	NS	0.54*	−0.60*	0.93*
1992	1	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	2	NS	NS	0.43++	NS	NS	0.52*	0.58**	NS	NS	0.42++	NS	NS
	3	NS	NS	0.46*	NS	NS	0.42++	0.46*	NS	NS	0.44*	NS	NS
Cercospora medicaginis													
1991	1	NS	NS	0.47+	0.77+	NS	NS	NS	0.80+	NS	NS	NS	NS
	2	NS	0.48+	NS	0.93*	NS	0.41+	NS	0.94*	NS	NS	NS	NS
	3	NS	NS	0.48+	NS	NS	NS	NS	NS	NS	NS	NS	NS
1992	1	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	2	NS	0.43++	0.38+	NS	NS	0.34+	0.35+	0.35+	NS	0.34+	NS	NS
	3	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Colletotrichum dematium													
1991	1	NS	−0.49++	−0.70*	−0.93*	NS	NS	−0.59++	−0.89*	NS	NS	0.61*	0.78+
	2	NS	−0.59*	−0.85**	−0.94*	NS	NS	−0.75**	−0.93*	NS	NS	NS	NS
	3	−0.79**	−0.67**	−0.88**	−0.94*	−0.75**	−0.52++	−0.78**	NS	NS	NS	NS	NS
Colletotrichum trifolii													
1992	1	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	2	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	3	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Xanthomonas campestris													
1991	1	−0.77**	−0.74**	−0.75**	−0.80++	−0.65*	−0.73**	−0.63*	−0.84++	0.48+	NS	0.63*	0.71+
	2	−0.72**	−0.82**	−0.84**	−0.96*	−0.72*	−0.80**	−0.77*	−0.89*	NS	NS	NS	NS
	3	−0.88**	−0.80**	−0.94**	−0.90*	−0.89**	−0.77**	−0.86**	NS	NS	NS	NS	NS
1992	1	NS	−0.34+	NS	NS	−0.43++	−0.42++	−0.41++	NS	NS	−0.37+	−0.47*	NS
	2	NS	−0.52*	−0.54*	NS	−0.53*	−0.52*	−0.59**	−0.41+	NS	NS	NS	NS
	3	0.40++	−0.57**	−0.46*	NS	−0.56*	−0.60**	−0.46*	−0.43*	NS	NS	NS	NS

[a] NS = not significant, ** = $P \leq 0.01$, * = $P \leq 0.05$, ++ = $P \leq 0.10$, + = $P \leq 0.15$.

pathogens on the same leaf. Unlike the results from North Carolina (5,13), however, there were clear seasonal distributions for several pathogens in Iowa. In addition, the injury to alfalfa stands in Iowa was caused by a pathogen complex different from the North Carolina complex (*Phoma medicaginis, Leptosphaerulina trifolii, Stemphylium botryosum*, and *Cercospora medicaginis*). The complex of foliar pathogens in Iowa also differs from the pathogen complex reported for Illinois (3). The Illinois complex consists primarily of *Phoma medicaginis* and *Stemphylium botryosum* and, to a lesser extent, of *Colletotrichum* and *Leptosphaerulina* spp. Therefore, the Iowa leaf spot complex, which consists primarily of *Phoma medicaginis, Leptosphaerulina trifolii, Pseudopeziza medicaginis*, and *Cercospora medicaginis*, may require different management tactics to minimize losses than those utilized in other regions.

One new approach of how information from the present study might be applied is through the development and use of mixtures of alfalfa germ plasms in which cultivars are selected on the basis of their resistance to one or more of the pathogens present in the Iowa complex. This approach would be most useful in systems in which resistance to multiple foliar pathogens in one background is not available, yet some cultivars have resistance to individual diseases. One drawback to this approach is the lack of acceptable resistance to *Phoma medicaginis* in currently grown cultivars. *Phoma medicaginis* is an important pathogen that is present in several regions of the United States (4,6,10, 11,13). To properly assess the usefulness and impact of alfalfa mixtures in Iowa, additional information will be needed concerning the relationship between disease intensity and reduction in yield and quality. We are presently working on quantifying the yield losses caused by alfalfa foliar pathogens in Iowa.

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