Evaluation of Resistance to Ergot, Caused by *Claviceps purpurea*, in Kentucky Bluegrass, Based on Incidence and Severity Estimates

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ABSTRACT

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Ergot, caused by *Claviceps purpurea*, is an important disease of Kentucky bluegrass grown for seed. Resistance is a preferred means of disease control, although approaches to evaluating ergot resistance in Kentucky bluegrass are not well established. A large scale disease assessment trial was established to compare within-year and year-to-year variability among measures of ergot incidence or severity in Kentucky bluegrass and to determine the most efficient approaches for cultivar evaluation. The susceptibility of 104 Kentucky bluegrass cultivars (78 commercial and 26 experimental) to ergot was assessed, based on percentage of panicles with sclerotia (incidence), sclerotia per panicle (severity), percentage of seeds replaced by sclerotia, or percentage of sclerotia among seed by weight. Cultivar ranking for susceptibility within years was similar for all methods of ergot assessment. Yearly mean incidence of ergot among cultivars ranged from 1.0 to 97.5% for susceptible cv. HV102 to 0.0 to 2.5% for resistant cv. Huntsville, with remaining cultivars distributed between the extremes. Yearly mean values of ergot incidence and severity differed among years. Much of this variability was due to days with rain during the period from flower initiation to maturity (period of susceptibility). Disease incidence was correlated ($P \leq 0.05$) with days with rain in 22 of the cultivars. Duration of flowering was correlated ($P \leq 0.05$) with ergot incidence in 11 cultivars. Results from this study suggest that variability in host and environment would likely offset any gain in precision of severity data. In large trials in particular, collection of incidence data (percentage of panicles with ergot) would provide the most timely and efficient means for ergot assessment.

Additional keywords: *Poa pratensis*

Ergot, caused by *Claviceps purpurea* (Fr.:Fr.) Tul., is an important disease of grasses grown for seed. Ergot can be especially severe in Kentucky bluegrass (*Poa pratensis* L.) seed production, with yield losses estimated as high as 25% (2). *Claviceps purpurea* invades the ovary, replacing the potential seed with a hard black sclerotium. Sclerotia are typically one to several times longer than the host seed and black in color, making visual detection relatively easy. Spread of conidia of *C. purpurea*, which ooze from infected florets in a mixture of conidia and a sugary syrup derived from the plant sap (honeydew), can occur through seed head to seed head contact, rain splashing, or insect movements. The flower is the only organ infected (3).

Ergot control through fungicide application at flowering is possible but expensive.

Host resistance is the preferred approach to disease control. However, few quantitative studies of resistance to ergot in Kentucky bluegrass are available, and there is little information concerning variability associated with different methods of ergot assessment. In the cereal grains, ergot has been assessed preharvest, as percentage of spikes with sclerotia (13), or percentage of florets with sclerotia (4,7,10) or as post-harvest estimates of percent sclerotia among seed by weight (9).

Expression of ergot in Kentucky bluegrass as percentage of flowers infected is difficult, since individual flowers are small and clustered into numerous tightly packed spikelets on panicles. Methods of disease assessment have included number of sclerotia per panicle (6) or per spikelet (5), sclerotial weight per panicle (6), percent seed replaced by sclerotia (2), or disease ratings of sclerotia or honeydew production (12). Cultivars vary in number of flowers per panicle and in timing and duration of flowering, potentially confounding disease resistance trials. Considerable year-to-year variation can occur, with wet conditions during flowering favoring disease development (1), although quantitative measures of variability are lacking. Information on year-to-year variability and

within-year variability is needed for effective evaluation of commercial or experimental cultivars for resistance to ergot. In addition, an understanding of advantages and disadvantages of the various assessment methods appropriate for determining host resistance to ergot would facilitate selection of assessment methods for both reliability and efficiency. The objectives of this study were to determine if ranking of cultivars or experimental selections in terms of susceptibility to ergot varies depending on methods of disease assessment, to determine to what extent year-to-year variability can be accounted for by rainfall data, and to evaluate resistance among cultivars of Kentucky bluegrass to *C. purpurea*.

MATERIALS AND METHODS

Field plots. Cultivars of Kentucky bluegrass (78 commercial and 26 experimental, 104 total) were obtained from U.S. and European grass breeders. Cultivars were sown in germination boxes, and individual seedlings were transplanted to 4.0 × 20.5-cm plastic cone pots (Cone-tainers) filled with commercial potting soil mix. After about 2 months, two plants per block of each cultivar were transplanted to field plots in the fall of 1993 in a randomized complete block experiment with five replications. The field plot was established at the Hyslop experimental research farm near Corvallis, OR (44°38' N, 123°12' W). The soil type was a Woodburn silt loam, a fine-silty, mixed, mesic; Aquultic Argixerolls, on 0 to 3% slopes. The plot area was fertilized by soil incorporation of 35.8 kg N, 15.4 kg P, 29.7 kg K, and 15.7 kg S ha⁻¹ applied as a complete blend prior to transplanting in 1993. Thereafter, fertilizer was applied in split applications: 33.1 kg N, 17.8 kg P, and 31.1 kg S ha⁻¹ as a blend of ammonium phosphate (16-20-0) and ammonium sulfate (20-0-0-24) in fall (mid-November 1994, 1995, 1996, and 1997) and two applications of 61.6 kg N ha⁻¹ as urea in spring (early March and mid-April 1995, 1996, 1997, and 1998). Irrigation was applied immediately after transplanting and at short intervals thereafter in 1993 for establishment. Irrigation was not applied after 1993. Weeds were controlled with applications of 0.28 kg a.i. ha⁻¹ of bromoxynil (3,5-dibromo-4-hydroxybenzonitrile) plus 0.28 kg a.i. ha⁻¹ MCPA [(4-chloro-2-methylphenoxy) acetic acid] after emergence and 2.24 kg a.i. ha⁻¹ of diuron

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Table 1. Incidence percentage of seed heads with sclerotia of *Claviceps purpurea* among registered or experimental cultivars during 1994 through 1998

Cultivar	% seeds heads with sclerotia				4-year mean	Days with rain ^a		Susceptible period ^b	
	1994	1996	1997	1998		<i>r</i>	<i>P</i>	<i>r</i>	<i>P</i>
HV 102	51.5	48.0	1.0	97.5	49.5	0.70	0.29	0.98	0.02
Adelphi	40.7	7.5	17	76	35.3	0.84	0.15	0.97	0.03
Eclipse	43.7	0.5	44.0	50.0	34.6	0.99	0.01	0.51	0.49
Bristol	37.0	2.0	22.5	70.0	32.9	0.95	0.05	0.80	0.20
Re 88	31.5	3.0	2.5	73.0	27.5	0.98	0.01	0.93	0.07
84-777	34.5	1.0	4.5	69.5	27.4	0.90	0.10	0.96	0.01
Unique	25.5	0	33.5	45.0	26.0	0.96	0.04	0.61	0.39
Touchdown	22.7	3.5	1.5	72.0	24.9	0.93	0.07	0.92	0.08
Destiny	25.3	0	16.5	55.0	24.2	0.90	0.10	0.73	0.27
Able 1	34.7	2.0	8.0	51.0	23.9	0.96	0.04	0.62	0.37
B8-13	22.5	1.0	5.7	65.5	23.7	0.83	0.17	0.66	0.34
Monopoly	22.6	0	23.1	47.5	23.3	0.30	0.70	0.85	0.15
Chateau	17.1	12.5	4.0	58.5	23.0	0.97	0.03	0.56	0.44
Asset	14.4	0	50.1	27.5	23.0	0.77	0.23	0.23	0.77
Majestic	48.2	3.0	1.0	38.5	22.7	0.71	0.29	0.99	0.01
C 74	18.7	0	22.5	48.0	22.3	0.87	0.13	0.84	0.15
Aspen	21.0	2.5	27.5	38.1	22.3	0.85	0.15	0.64	0.36
A7-187	22.5	2.1	3.0	61.5	22.3	0.98	0.02	0.89	0.11
Plush	38.9	2.5	4.0	42.0	21.8	0.72	0.28	0.96	0.04
Julia	32.5	0	6.0	47.5	21.5	0.85	0.14	0.97	0.03
Estate	17.5	5.0	0	63.0	21.4	0.98	0.02	0.89	0.11
B8-106	23.0	1.5	2.0	58.4	21.2	0.98	0.02	0.85	0.15
America	32.4	2.0	16.9	32.5	20.9	0.86	0.14	0.93	0.07
Minstrel	9.5	4.5	10.5	58.5	20.8	0.88	0.12	0.76	0.24
Midnight	12.7	0	38.0	28.0	19.7	0.47	0.53	0.96	0.03
Glade	24.5	1.5	18.0	34.5	19.6	0.91	0.09	0.57	0.43
Sydsport	37.5	3.6	2.0	33.5	19.1	0.74	0.26	0.90	0.10
Barzan	18.4	0.5	1.0	54.5	18.6	0.94	0.06	0.84	0.16
Baron	13.0	0.5	1.9	58.5	18.5	0.95	0.06	0.92	0.07
Engrapp 03-6-49-1	24.8	0	6.0	42.5	18.3	0.91	0.09	0.91	0.08
BA-13	11.3	0.5	7.0	53.5	18.1	0.99	0.001	0.77	0.23
Classic	15.0	0.5	5.9	50.6	18.0	0.90	0.10	0.57	0.43
A 34	15.0	0	12.5	44.4	18.0	0.57	0.43	0.61	0.39
Cheri	18.0	2.0	6.5	44.0	17.6	0.99	0.01	0.79	0.21
Ikone	21.0	2.5	8.0	39.0	17.6	0.81	0.19	0.82	0.18
Leikva	29	1.5	0.5	38.0	17.3	0.38	0.62	0.44	0.56
Haga	14.1	0.5	3.0	51.0	17.2	0.87	0.13	0.71	0.29
H87-429	12.4	0	3.1	53.0	17.1	0.95	0.05	0.88	0.12
Challenger	12.3	0.5	3.5	52.0	17.1	0.85	0.15	0.76	0.24
Suffolk	15.5	2.1	3.0	47.5	17.0	0.86	0.14	0.77	0.23
Barblue	10.5	0	5.5	52.0	17.0	0.70	0.29	0.60	0.39
Ampella	19.0	0	8.5	39.5	16.7	0.70	0.30	0.71	0.29
Georgetown	10.0	0	4.0	51.5	16.4	0.98	0.0	0.85	0.15
R-729	22.1	1.5	5.9	35.5	16.3	0.96	0.04	0.70	0.30
Platini	26.4	0	3.5	35.0	16.2	0.81	0.19	0.93	0.07
Enmundi	24.8	0.5	9.1	29.0	15.9	0.79	0.21	0.97	0.03
Banff	13.2	1.5	2.0	46.5	15.8	0.96	0.04	0.76	0.24
Summit	26.0	1.9	1.9	31.3	15.3	0.72	0.28	0.67	0.33
Dawn	9.5	0.5	4.0	46.5	15.1	0.88	0.12	0.67	0.32
Freedom	15.7	2.0	2.0	40.0	14.9	0.91	0.09	0.94	0.06
Sophia	33.2	0.63	3.1	22.5	14.9	0.63	0.37	0.91	0.09
Nassau	10.5	8.4	1.0	39.0	14.7	0.82	0.18	0.88	0.12
A7-341	17.5	2.0	4.5	32.5	14.1	0.94	0.06	0.96	0.04
Flying	18.0	2.5	4.0	32.0	14.1	0.89	0.11	0.99	0.01
Victa	19.3	1.0	10.5	24.5	13.8	0.79	0.21	0.85	0.15
Merit	17.0	2.5	10.0	24.5	13.5	0.95	0.05	0.92	0.08
Merion	10.8	0.5	6.5	36.0	13.5	0.79	0.21	0.74	0.26
Gnome	16.1	2.5	6.5	28.5	13.4	0.76	0.24	0.66	0.34
A83-285	20.0	0	0.5	33	13.4	0.85	0.14	0.93	0.06
Harmony	34.5	1.3	0	17.5	13.3	0.28	0.79	0.54	0.46
Compact	14.5	0.5	0.5	35.5	12.8	0.57	0.43	0.21	0.79
Yo 88	7.5	1.5	1.0	40.5	12.6	0.97	0.03	0.92	0.08
Trenton	15.0	2.0	5.0	28.0	12.5	0.97	0.03	0.62	0.38
Aguila	12.5	1.5	0.5	31.0	11.4	0.89	0.10	0.90	0.09
Geronimo	12.5	1.0	0	31.5	11.3	0.77	0.23	0.89	0.11
Blacksburg	16.0	0.5	0.5	27.0	11.0	0.80	0.20	0.96	0.04
Conni	14.1	0.5	7.0	22.0	10.9	0.64	0.35	0.63	0.37
Engrapp 03-6-48-3	21.1	2.0	5.0	15.0	10.8	-0.27	0.73	-0.51	0.49
R-740	8.5	1.0	2.5	31.0	10.8	0.85	0.14	0.91	0.09

(continued on next page)

^a Correlation (*r*) between yearly mean incidence and days with rain between flower initiation and seed maturity (susceptible period) and probability value (*P*) associated with the correlation.

^b Correlation (*r*) and probability (*P*) between incidence and length of susceptible period.

Table 1. (continued from preceding page)

Cultivar	% seeds heads with sclerotia					Days with rain ^a		Susceptible period ^b	
	1994	1996	1997	1998	4-year mean	r	P	r	P
Tendos	9.4	5.0	1.0	26.5	10.5	0.85	0.15	0.74	0.25
Mystic	13.2	1.3	0	26.5	10.2	0.48	0.52	0.76	0.24
Parade	9.0	1.5	5.0	25.0	10.1	0.96	0.04	0.72	0.28
Cynthia	9.1	1.5	0	28.0	9.7	0.94	0.06	0.92	0.08
Joy	15.5	4.5	0	17.5	9.4	0.42	0.58	0.49	0.51
Marguis	15.9	0.5	4.0	16.5	9.2	0.80	0.20	0.92	0.08
Ronde	20.1	0.5	0	15.5	9.0	-0.07	0.93	0.07	0.93
Hatfjelldal	4.4	3.0	0.5	28.0	9.0	0.66	0.34	0.47	0.53
Kenblue	15.5	14.1	0	5.5	8.8	0.15	0.85	0.41	0.59
Nutop	4.5	0.5	0.5	28.5	8.5	0.96	0.04	0.89	0.11
Wabash	10.0	0	2.5	20.0	8.1	0.92	0.08	0.93	0.07
Engrapp Conni	10.3	0.5	6.0	14.5	7.8	0.80	0.20	0.80	0.21
Balin	8.0	2.0	0.5	20.5	7.8	0.56	0.44	0.65	0.35
Nugget	14.6	4.1	1.0	9.5	7.3	0.34	0.67	0.83	0.17
Ryss	9.7	5.0	0	13.5	7.0	0.76	0.24	0.99	0.01
Kver 9009	5.0	0.6	6.0	16.0	6.9	0.97	0.03	0.62	0.38
Vaer 8703	16.0	0.5	1.0	8.0	6.4	-0.78	0.31	-0.62	0.38
Welcome	6.9	1.5	1.5	14.5	6.1	0.85	0.14	0.89	0.11
Engrapp 03-6-54-4	4.5	0	2.5	17.0	6.0	0.97	0.03	0.76	0.24
Holt	0	5.0	0	18.5	5.9	0.75	0.15	0.75	0.25
Engrapp 03-6-53-2	7.6	0	1.0	14.0	5.7	0.29	0.71	0.27	0.73
Kver 9021	2.5	2.0	0	18.0	5.6	0.82	0.18	0.62	0.35
Alene	4.5	7.5	0	10.0	5.5	0.72	0.46	0.94	0.06
Columbia	9.0	1.0	2.0	9.5	5.4	0.80	0.02	0.97	0.03
Ram 1	5.5	0.5	0	12.0	4.5	0.86	0.14	0.93	0.07
Lavang	2.3	1.0	0.5	14.0	4.4	0.72	0.28	0.71	0.29
Limosine	7.5	1.5	1.0	7.5	4.4	0.69	0.44	0.93	0.07
Vaer 8702	1.7	1.5	0	13.5	4.2	0.70	0.30	0.41	0.59
Birka	9.5	0	1.0	5.0	3.9	0.53	0.20	0.96	0.05
Kver 9030	1.5	2.5	0.5	11.0	3.9	0.99	0.002	0.84	0.16
Amazon	3.8	0	0.5	9.5	3.4	0.98	0.22	0.85	0.14
South Dakota	10.5	0.5	0	2.5	3.4	-0.63	0.28	-0.49	0.51
Ginger	0.5	2.0	0	3.0	1.4	0.98	0.37	0.78	0.22
Troy	4.0	0.5	0	1.0	1.4	-0.56	0.02	-0.17	0.83
Huntsville	2.5	0	0	0	0.6	-0.36	0.64	0.05	0.95
LSD (0.05)	15.36	6.74	7.67	21.62	6.94				

[N'-(3,4 dichlorophenyl)-N,N-dimethyl-urea] each fall.

Plant growth and ergot assessments were made during each spring from 1994 through 1998, except for 1995, when a severe stripe rust (caused by *Puccinia striiformis* Westend) outbreak compromised the seed production and interfered with ergot development. In subsequent years, Tilt (1-[[2-(2,4-dichlorophenyl)-4 propyl-1,3-dioxolan-2-yl] methyl]-1H-1,2,4-triazole) (0.3 ml a.i. ha⁻¹) was applied prior to flowering for rust control. Plots were examined two to three times each week during the period from flower initiation to seed maturity, and the date of flower initiation, ending flowering, and seed maturity were noted for each plant.

Assessment of ergot. Four different methods of ergot assessment were based on 20 panicles from each of two plants in a plot (total 40 panicles per plot). Following enumeration of panicles with sclerotia, a rubbing block was used to hand thresh the panicles. Stem pieces and large debris were removed with hand screens. Large sclerotia or those stuck to debris from honeydew were removed and combined with sclerotia from other fractions. Fine debris was removed with an air column set to remove lightweight debris but not seed. The fractions were checked periodically to verify

that no seed or sclerotia were lost. Sclerotia were removed by hand, counted, and weighed. After removal of sclerotia, the seed was weighed and a seed counter (Count-A-Pak model 701A, Martec Research, Inc., Batavia, IL) was used to separate 1,000 seed for determination of 1,000-seed weight. Seed number was obtained by dividing total seed weight by individual seed weight, as determined from the 1,000-seed weight. Disease incidence was expressed as the percentage of panicles with sclerotia. Disease severity was quantified in terms of sclerotia per infected panicle (total number of sclerotia divided by total panicles with sclerotia in each 40-panicle sample), percentage of sclerotia based on seed number ([number of sclerotia divided by {number of seed + sclerotia}] × 100), or percentage of sclerotia based on seed weight (sclerotia weight divided by [sclerotia weight + seed weight] × 100). Rain-fall data were obtained from the Hyslop research farm weather station.

Statistical analysis. A square root transformation was made on all assessment data after checking for normality and heteroscedasticity. Transformed data were analyzed using the general linear models (GLM) procedure (11) to conduct an analysis of variance as repeated measures in a split-plot in time over 4 years (14).

Mean separations on antitransformed data were by *t* tests and Fisher's least significant difference using the LSMEANS option of GLM. All effects except replications were considered random in the statistical model. Additional statistical analyses included analysis of covariance using PROC MIXED, and GLM was used for Spearman rank correlation and Pearson product moment correlation. The disease incidence covariate in covariance analysis was days with rain during the period of susceptibility. Spearman rank correlation was used to determine if ranking of cultivars for susceptibility within each year for each of the four assessment methods was significant. Spearman rank correlation was also used to determine if ranking of cultivars for susceptibility was significant across years for each of the assessment methods. Pearson product moment correlation was used to determine if yearly mean values of incidence for each cultivar were correlated with mean duration of the susceptible period for each corresponding cultivar or with the period of rainfall during the period of susceptibility (beginning of flowering to maturity) for each corresponding cultivar.

RESULTS

Yearly mean incidence of ergot among cultivars ranged from 1.0 to 97.5% for the

Table 2. Partial analysis of variance (ANOVA) for square root transformed data for four disease assessment methods^a

Source	df	Mean square			
		% Seed heads with sclerotia ^b	Sclerotia per panicle ^{b,c}	% Sclerotia by number of seed ^d	% Sclerotia by seed weight ^{b,e}
Entry ^f	103	21.76**	1.57**	0.41**	1.33**
Year ^f	3	2146.70**	112.39**	33.62**	134.15**
Entry × Year	309	7.91**	0.73**	0.22**	0.65**
Residual	1236	1.96	0.13	0.05	0.15

^a Disease assessment methods: disease incidence (% seed heads with sclerotia), sclerotia/panicle, % sclerotia by number of seed, and % sclerotia by seed weight in Kentucky bluegrass.

^b Based on 40 panicles from each of five replicate plots. ** indicates significance at $P \leq 0.01$.

^c (Total number of sclerotia divided by panicles with sclerotia) × 100.

^d Sclerotia number divided by (sclerotia number + seed number) × 100.

^e Sclerotia weight divided by (sclerotia weight + seed weight) × 100.

^f Main effects were tested by Entry × Year.

Table 3. Yearly mean disease incidence and severity^a

Year	% Seed heads with sclerotia ^b	Sclerotia/panicle ^{b,c}	% Sclerotia by number of seed ^d	% Sclerotia by seed weight ^{b,e}	Rain days ^f
1994	16.8	0.45	0.05	0.20	12.8
1996	2.2	0.56	0.06	0.17	10.5
1997	5.8	0.37	0.19	0.49	13.3
1998	33.9	2.14	0.60	2.30	19.1
LSD (0.05)	1.4	0.15	0.07	0.15	0.3

^a Mean disease incidence (% seed heads with sclerotia) and severity (sclerotia/panicle), (% sclerotia/sclerotia and seed), and (% sclerotia by seed weight) during 1994, 1996, 1997, and 1998.

^b Based on 40 panicles from each of five replicate plots.

^c (Total number of sclerotia divided by panicles with sclerotia) × 100.

^d Sclerotia number divided by (sclerotia number + seed number) × 100.

^e Sclerotia weight divided by (sclerotia weight + seed weight) × 100.

^f Number of days with rain during the susceptible period.

highly susceptible HV102 to 0.0 to 2.5% for the resistant Huntsville (Table 1), with remaining cultivars distributed between the extremes. Sclerotia per panicle were up to 48 on HV102, equating to about 9% seed replaced by sclerotia or 21% sclerotia based on weight of seed plus sclerotia. Analysis of variance revealed significant differences ($P < 0.0001$) among cultivars and among years for each of the disease assessment methods and days with rain during the flowering period (Table 2). Considerable year to year variation in ergot incidence or severity was noted (Table 3).

The period of susceptibility for most of the cultivars extended from about calendar day 140 to day 170. Fewer days with rain occurred during the susceptible period in 1996, compared with that in 1994, 1997, and 1998 (Fig. 1). Analysis of covariance indicated no significant effect among cultivars for ergot incidence adjusted for rain ($F = 1.10$, $P = 0.25$), but cultivars responded differently to rain as indicated by a significant interaction ($F = 2.47$, $P < 0.0001$), indicating heterogeneity among cultivars for the relationship of incidence with days with rain during the susceptible period. Most of this variability was accounted for by days with rain ($F = 70.86$, $P < 0.0001$). Pearson product moment correlation calculated for each of the 104 cultivars indicated that ergot incidence was correlated ($P \leq 0.05$) with days with rainfall during the susceptible period in 22 of the 104 cultivars (Table 1). Ergot incidence

was correlated ($P \leq 0.05$) with duration of the susceptible period in 11 of the cultivars (Table 1).

Spearman rank correlation analysis indicated that ranking of cultivars within each year among the four ergot assessment methods were significantly correlated ($P < 0.001$) (Table 4). However, in examining year-to-year cultivar ranking for the four disease measurements (Table 5), 1996 was negatively correlated with 1997 and was not correlated with the other years, except for ergot by seed weight in 1994 and 1998.

DISCUSSION

Considerable variability in incidence and severity of ergot in Kentucky bluegrass was observed. In HV 102 for example, ergot incidence in 1996 and 1998 was 1 and 97.5%, respectively. Our results suggest that rainfall (days with rain during the period of flowering) accounted for much of this variability. Rainfall occurred on almost twice as many days during the susceptible period in 1998 than in 1996. Although a significant effect of rainfall on incidence was noted in analysis of covariance, the effect was less dramatic when individual cultivars were examined. Environmental conditions, especially timing of rainfall, may have a confounding effect on comparison of cultivars when they have differences in the timing and duration of flowering and seed maturity. Although rankings did not differ significantly among the four measures of ergot, some shifts in ranking

Fig. 1. Occurrence of rainfall during 1994, 1996, 1997, and 1998 at Hyslop Research Farm, Corvallis, OR.

of individual cultivars could be expected depending on timing and duration of flowering in relation to occurrence of rainfall.

Previous studies demonstrated the effect of rainfall on production and release of ascospores (1,8) that serve as primary inoculum. Within about 7 to 10 days of infection, conidia are produced and ooze from infected flowers in a mixture of conidia and a sugary syrup derived from the plant sap (honeydew). The contribution of conidia to disease development is believed to be facilitated by insects, but quantitative studies are lacking, and it is not clear to what extent insect transmission contributes to disease development.

Ergot incidence and severity assessments in Kentucky bluegrass can be confounded by cultivar variability in both number of panicles produced per plant and number of seed produced per panicle. In addition, sclerotia of *C. purpurea* were not distributed randomly among panicles but tended to cluster in variable numbers on individual panicles. Assessment of ergot based on individual panicles could be subject to variability from unequal distribution of sclerotia. Estimates based on incidence

Table 4. Spearman rank correlations among ergot assessment methods within years of seed production^a

	Sclerotia per panicle ^b	Sclerotia by seed number ^c	Sclerotia by seed weight ^d
1994			
Panicles with sclerotia	0.84**	0.82**	0.79**
Sclerotia per panicle		0.87**	0.81**
Sclerotia by seed number			0.89**
1996			
Panicles with sclerotia	0.73**	0.76**	0.76**
Sclerotia per panicle		0.96**	0.89**
Sclerotia by seed number			0.94**
1997			
Panicles with sclerotia	0.92**	0.91**	0.92**
Sclerotia per panicle		0.99**	0.95**
Sclerotia by seed number			0.96**
1998			
Panicles with sclerotia	0.84**	0.72**	0.84**
Sclerotia per panicle		0.84**	0.79**
Sclerotia by seed number			0.89**

^a ** = Significantly different from 0 at $P < 0.01$.

^b (Total number of sclerotia divided by panicles with sclerotia) $\times$ 100.

^c Sclerotia number divided by (sclerotia number + seed number) $\times$ 100.

^d Sclerotia weight divided by (sclerotia weight + seed weight) $\times$ 100.

Table 5. Spearman rank correlations among years for each of four ergot assessment methods

	1996	1997	1998
Panicles with sclerotia			
1994	0.06 ^{NSa}	0.46**	0.56**
1996		-0.21**	0.05 ^{NS}
1997			0.48**
Sclerotia per panicle ^b			
1994	0.10 ^{NS}	0.37**	0.41**
1996		-0.28**	0.05 ^{NS}
1997			0.30**
Sclerotia by seed number ^c			
1994	0.11 ^{NS}	0.43**	0.39**
1996		-0.20*	0.19 ^{NS}
1997			0.24*
Sclerotia by seed weight ^d			
1994	0.20*	0.34**	0.45**
1996		-0.19 ^{NS}	0.23*
1997			0.32**

^a NS = not significantly different from 0 at $P < 0.05$; * Significantly different from 0 at $P < 0.05$; ** Significantly different from 0 at $P < 0.01$.

^b (Total number of sclerotia divided by panicles with sclerotia) $\times$ 100.

^c Sclerotia number divided by (sclerotia number + seed number) $\times$ 100.

^d Sclerotia weight divided by (sclerotia weight + seed weight) $\times$ 100.

do not account for seed yield. Cultivars with either low or high seed yields may not reflect the number of flowers with sclerotia (disease severity). Although estimates of disease severity may provide more quanti-

tative data than estimates of incidence, results from Spearman rank correlations indicated no significant difference in cultivar rankings among the assessment methods. This suggests no advantage of severity

over incidence data in comparing cultivars. The extent of variability in host and environment likely overwhelm any gain in the precision of severity data. Since collection of incidence data is much faster and easier than determination of severity, incidence data provide a time and efficiency advantage in Kentucky bluegrass trials for ergot resistance. In large trials in particular, incidence (percentage of panicles with ergot) would provide the most timely and efficient means for ergot assessment.

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