Hordeum jubatum as a Source of Inoculum of Septoria avenae f. sp. triticea and S. passerinii

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ABSTRACT

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Of 125 samples of *Hordeum jubatum* collected throughout the cereal-growing region of Minnesota during a 3-yr period, 46% were infected with *Septoria avenae* f. sp. *triticea* and 19% with *S. passerinii*. The host range of isolates of *S. passerinii* was highly specialized; an isolate from *H. vulgare* infected cultivated *Hordeum*, and one wild *Hordeum* sp., whereas an isolate from *H. jubatum* infected *H. jubatum* and two other wild *Hordeum* spp. but not cultivated *Hordeum*. The host range of *S. avenae triticea* was less specialized; an isolate of *S. avenae triticea* from *H. jubatum* infected 21 accessions of cultivated *Hordeum* and 12 accessions of wild *Hordeum*. Isolates of *S. avenae triticea* from *H. jubatum*, *H. vulgare*, and *Triticum aestivum* completed their life cycles on all three hosts. Some of the isolates of *S. avenae triticea* from *H. jubatum* were more virulent than those from *H. vulgare* or *T. aestivum*. The results suggest that a wide range of *Hordeum* spp. could act as hosts to *S. avenae triticea*.

In Minnesota, *Septoria avenae* Frank f. sp. *triticea* T. Johnson (*Leptosphaeria avenaria* Weber f. sp. *triticea* T. Johnson) and *S. passerinii* Sacc. parasitize *Hordeum jubatum* L. as well as cultivated barley, *H. vulgare* L. *Hordeum jubatum* is widely distributed in the United States (1) and may be found growing alongside and in barley and wheat fields in Minnesota. Because *H. jubatum* is so widely distributed and is parasitized by the two *Septoria* spp., it may be an important source of inoculum of the *Septoria* species that parasitize barley.

MATERIALS AND METHODS

During July and August of 1970, 1972, and 1973, leaves of *H. jubatum* were collected from plants that were growing in fields or on roadsides throughout the cereal-growing area of Minnesota, and taken to the laboratory where the presence of *S. avenae triticea* and *S. passerinii* was determined. The leaves were soaked in 0.5% Tween-20 solution for 1 hr and then a few drops of cotton blue in lactophenol were added to stain the pycnidiospores. After another hour the *Septoria* spp. present were identified (6). When identification was in doubt, single spores were transferred to potato-dextrose agar and the identification was made from colony characteristics. Colonies of *S. avenae triticea* on PDA are mycelial and those of *S. passerinii* are yeastlike (5).

The wheat, barley, and wild *Hordeum* spp. were inoculated and held on glasshouse benches as disease developed, in a glasshouse at 18 C with light intensities at plant height of 1,500 to 24,000 lx, from sunlight and 300-watt incandescent lamps from 0500 to 2300 hours daily. The plants were grown in sandy-loam soil in 18-cm diam pots (five plants/pot). When the wheat and barley were at the three to four-leaf growth stage, and when wild *Hordeum* spp. were at the growth stage when pseudostems were beginning to become erect and leaf sheaths were beginning to lengthen, they were uniformly sprayed until run-off with 0.5% gelatin solution containing 5×10^5 spores of *S. passerinii*, or 5×10^5 spores and mycelial fragments of *S. avenae triticea*, per ml of solution. Methods for isolation, for storage of the isolates, and for increasing inoculum were as described by Shearer et al. (5). After inoculation, the plants were kept moist in plastic bags for 96 hr and then the bags were removed. Fourteen days after inoculation with the isolates of *S. avenae triticea*, conditions conducive for pycnidium formation were provided by incubating the infected plants for 96 hr at 20 C and 12 hr per day of illumination from fluorescent lamps in a water-saturated atmosphere. The percentage of leaf area covered by symptoms of infection (discoloration and necrosis) was estimated (3) on two infected leaves per plant.

RESULTS

The sites where *H. jubatum* was collected during the 3 yr of the study and those sites where plants were infected with the *Septoria* spp. are shown in Fig. 1. *Septoria passerinii* was less common than *S. avenae* f. sp. *triticea* but both pathogens were widely distributed in Minnesota.

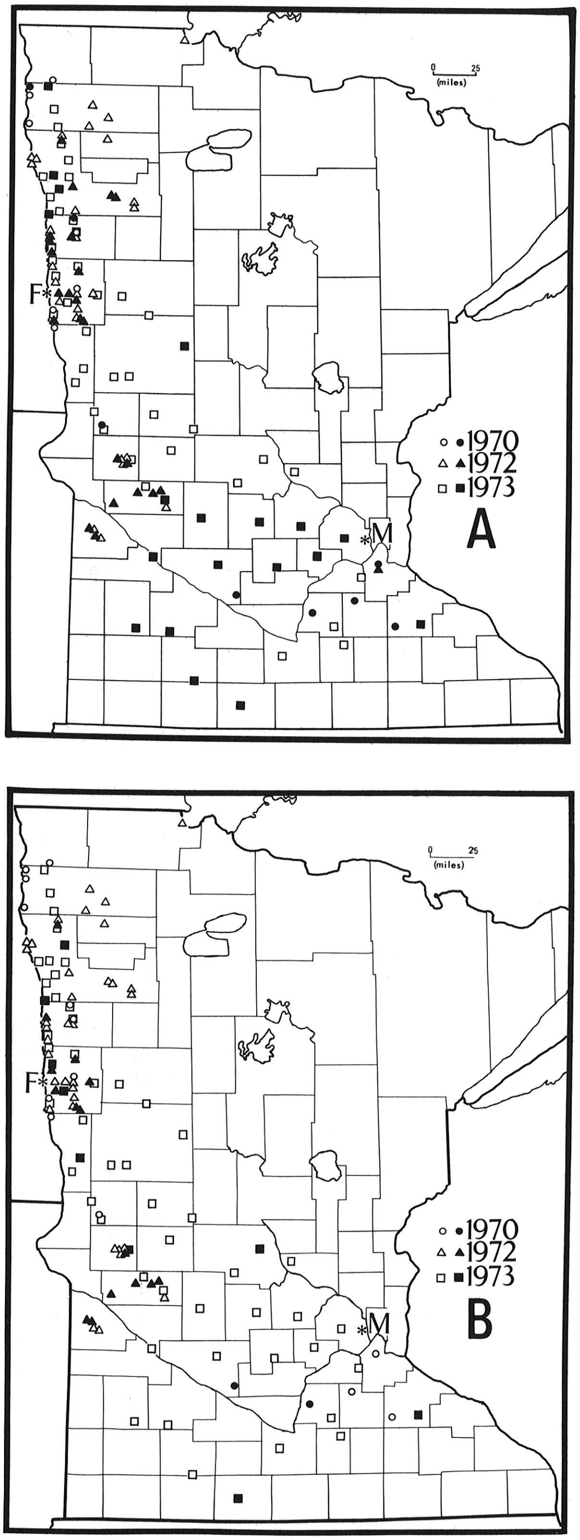

Fig. 1-(A, B). Distribution of *Hordeum jubatum* samples collected in Minnesota in 3 yr. **A**) Samples infected with *Septoria avenae* f. sp. *triticea* (closed symbols). **B**) Samples infected with *Septoria passerinii* (closed symbols). F = Fargo, M = Minneapolis.

Both pathogens were found on infected *H. jubatum* alongside barley or wheat fields and in areas where these crops were not grown.

Of 125 samples of *H. jubatum* obtained (15 in 1970, 52 in 1972, and 58 in 1973), 46% were infected with *S. avenae triticea* and 19% with *S. passerinii*. Only 8% of the samples were infected with both pathogens. The percentage of samples infected with *S. avenae triticea* was 53% in 1970, 48% in 1972, and 37% in 1973. For *S. passerinii*, 13% of the samples collected in 1970 were infected, 28% in 1972, and 16% in 1973.

The pathogenicity of an isolate of *S. avenae triticea* from *H. jubatum* and of isolates of *S. passerinii* from *H. vulgare* and *H. jubatum* were compared (Table 1). The *S. passerinii* isolates were highly specialized on cultivated and wild *Hordeum*. The isolate from *H. vulgare* infected all of the cultivated *Hordeum* spp., with a low level of infection on *H. brachyantherum*, and it did not infect the other wild species. Symptoms on the cultivated *Hordeum* spp. by this isolate began as greenish water-soaked lesions in which a few pycnidia formed. Gradually the lesions coalesced, killing most of the leaves in the susceptible hosts. Of the cultivated species, *H. distichon* and *H. vulgare* were the most susceptible and *H. vulgare pallidum* was the most resistant to *S. passerinii*.

The isolate of *S. passerinii* from *H. jubatum* infected only *H. brachyantherum*, *H. depressum*, and *H. jubatum* but did not infect any of the cultivated barleys. Infection of the *Hordeum* spp. by this isolate of *S. passerinii* resulted in light orange-brown lesions containing pycnidia; pycnidia were more numerous in lesions on *H. jubatum* than on the other species.

The isolate of *S. avenae triticea* from *H. jubatum* was less specialized in its host range than was *S. passerinii*. It infected all of the cultivated and wild *Hordeum* spp. that were inoculated (Table 1). Infection by *S. avenae triticea* began as small brown spots which enlarged to lesions 1 mm in diameter with off-white centers. Gradually the lesions enlarged and coalesced to form a general leaf necrosis with a brown edge. *Hordeum depressum* was most susceptible to *S. avenae triticea* and *H. spontaneum* the least susceptible.

The susceptibility of the wild *Hordeum* spp. to infection by *S. avenae triticea* also was determined in the field. In late July, 1972, healthy plants of the 12 accessions of wild *Hordeum* were transplanted between rows of Era spring wheat naturally infected with *S. avenae triticea*. At the time of transplanting, the plants of the wild species were at the stage when pseudo-stems formed by leaves and sheaths were strongly erect. Small brown spots similar to those caused by infection with *S. avenae triticea* in the glasshouse, were observed on all of the plants 5 days after transplanting. Plants transplanted in an area free of *S. avenae triticea* remained healthy.

The pathogenicity of isolates of *S. avenae triticea* from *H. jubatum*, *H. vulgare*, and *Triticum aestivum* was compared on these three hosts with inoculum of two densities (5×10^4 and 5×10^5 spores/ml). Infection at the high inoculum density was greater than that at the low inoculum density (Table 2). The isolates from *H. jubatum* infected *H. vulgare* and *T. aestivum*. Generally *H. vulgare* appeared to be more susceptible than *H. jubatum* or *T. aestivum*. *Hordeum jubatum* was less susceptible to the isolates from *H. vulgare* and *T. aestivum* than was *T. aestivum*. On each of the hosts isolate 26370 from *H. jubatum* was the most virulent especially at the high inoculum density.

On each of the three hosts, *H. jubatum*, *H. vulgare*, and *T. aestivum*, the number of leaves with pycnidia of *S. avenae triticea* was greater at the high inoculum density than at the low inoculum density. Isolate 26370 from *H. jubatum* more readily formed pycnidia in leaves of the three hosts than did the other isolates. At the high inoculum density, the number of leaves with pycnidia was significantly (P = 0.01) correlated positively with the percentage of leaf area covered by symptoms of infection (r = 0.91, 0.80, and 0.88 for *H. jubatum*, *H. vulgare*, and *T. aestivum*, respectively). At the low inoculum density, there was a significant correlation between pycnidium

TABLE 1. Percentage leaf area of cultivated and wild *Hordeum* spp. covered by symptoms 20 days after inoculation with *Septoria avenae* f. sp. *triticea* or *S. passerinii* from *H. vulgare* or *H. jubatum*

Hordeum spp. inoculated	Accessions tested (no.)	Leaf area showing symptoms following inoculation with: *S. passerinii* from *Hordeum vulgare* 26516[a] (%)	*S. passerinii* from *Hordeum jubatum* 26515 (%)	*S. avenae triticea* from *Hordeum jubatum* 26370 (%)
Cultivated *Hordeum* spp.:				
H. deficiens Steud.	3	56 ± 6[b]	0	51 ± 6
H. distichon L.	3	84 ± 5	0	51 ± 5
H. distichon 'Erectum'	3	81 ± 4	0	59 ± 6
H. distichon 'Nutans'	3	72 ± 7	0	34 ± 4
H. vulgare L.	2	89 ± 4	0	49 ± 8
H. vulgare 'Hexastichum'	1	26 ± 4	0	36 ± 10
H. vulgare 'Nigrum'	2	48 ± 11	0	30 ± 5
H. vulgare 'Pallidum'	3	4 ± 8	0	36 ± 5
H. vulgare 'Trifurcatum'	1	47 ± 4	0	65 ± 8
Wild *Hordeum* spp.:				
H. brachyantherum Nevski	1	8 ± 3	32 ± 9	63 ± 8
H. bulbosum L.	1	0	0	23 ± 7
H. depressum (Scribn. & Smith) Rydb.	1	0	37 ± 10	76 ± 7
H. hystrix Roth	2	0	0	29 ± 8
H. jubatum L.	1	0	55 ± 7	62 ± 8
H. leporinum Link	1	0	0	50 ± 6
H. marinum Huds.	2	0	0	22 ± 5
H. spontaneum C. Koch	1	0	0	8 ± 2
H. stebbinsii Covas	2	0	0	53 ± 5

[a]Isolates stored under this number in the American Type Culture Collection.
[b]Mean ± standard error of the mean of 10 leaves per accession.

TABLE 2. Percentage of *Hordeum* spp. leaf area covered with symptoms 14 days after inoculation of three hosts with eight isolates of *Septoria avenae* f. sp. *triticea* with two levels of inoculum

Inoculum concentration (spores/ml)	Host inoculated[a]	Isolates from: *Hordeum jubatum* 26370[b] (%)	26374 (%)	26375 (%)	26377 (%)	*H. vulgare* 26373 (%)	26376 (%)	*Triticum aestivum* 26371 (%)	26372 (%)
5×10^5	*H. jubatum*	42 ± 10[c]	7 ± 4	t[d]	27 ± 9	t	0	t	t
	H. vulgare[e]	76 ± 8	35 ± 11	24 ± 6	14 ± 4	22 ± 6	4 ± 1	31 ± 7	26 ± 8
	T. aestivum[f]	38 ± 5	9 ± 2	11 ± 2	10 ± 2	4 ± 1	4 ± 1	12 ± 4	3 ± 1
5×10^4	*H. jubatum*	3 ± 1	t	3 ± 1	0	2 ± 1	4 ± 2	t	t
	H. vulgare	48 ± 10	2 ± 0.5	4 ± 1	4 ± 1	t	3 ± 1	4 ± 1	2 ± 1
	T. aestivum	3 ± 0.5	t	2 ± 0.1	3 ± 0.5	2 ± 1	5 ± 1	2 ± 1	2 ± 1

[a]Plants sprayed with inoculum suspension until run-off.
[b]American Type Culture Collection accession number.
[c]Mean + standard error of the mean of 10 leaves.
[d]The letter t = % >0, but ≤1.
[e]Cultivar Larker.
[f]Cultivar Era.

TABLE 3. Number of leaves with pycnidia of *Septoria avenae* f. sp. *triticea*, out of a total of 10 examined, following inoculation of three hosts with eight isolates at two inoculum densities

		Isolates from:								
		Hordeum jubatum				*Hordeum vulgare*		*Triticum aestivum*		
Inoculum concentration (spores/ml)	Host inoculated[a]	26370[b] (no.)	26374 (no.)	26375 (no.)	26377 (no.)	26373 (no.)	26376 (no.)	26371 (no.)	26372 (no.)	Total (no.)
5×10^5	*H. jubatum*	8	3	0	3	0	0	2	0	16
	H. vulgare[c]	9	0	0	3	0	0	0	0	12
	T. aestivum[d]	7	3	0	2	0	2	2	0	16
5×10^4	*H. jubatum*	4	0	0	0	0	1	0	0	5
	H. vulgare[c]	5	1	0	1	0	0	0	0	7
	T. aestivum[d]	3	0	0	0	0	1	0	1	5
Total		36	7	0	9	0	4	4	1	61

[a]*Hordeum* and *Triticum* spp. plants sprayed until run-off, kept moist in plastic bags for 96 hr, placed on a greenhouse bench for 14 days, and then production of pycnidia was induced by 96 hr of incubation at 20 C under 12 hr per day of fluorescent lamp illumination in a saturated atmosphere.
[b]American Type Culture Collection accession number.
[c]Cultivar Larker.
[d]Cultivar Era.

formation and symptoms for *H. vulgare* (r = 0.96), but not for *H. jubatum* or *T. aestivum*.

DISCUSSION

For a wild grass to be an important source of primary inoculum of a crop pathogen it must be widely distributed throughout the region where the crop is grown, it should be infected during periods when the crop host is not grown, and the crop host should be susceptible to infection by inoculum from the wild grass.

Infected *H. jubatum* probably is not a source of primary inoculum of *S. passerinii* for the infection of cultivated barley. Green and Dickson (2) found that several isolates of *S. passerinii* from *H. jubatum* did not infect cultivated barley, and concluded that *H. jubatum* was unimportant in the epidemiology of *S. passerinii* on barley. In our study, only 20% of the samples of *H. jubatum* were infected with *S. passerinii*, and an isolate of this fungus infected *H. jubatum* and two other wild *Hordeum* spp., but not cultivated *Hordeum*.

Hordeum jubatum probably is a source of primary inoculum of *S. avenae triticea* for infection of barley and wheat. In the glasshouse, barley and wheat were infected with inoculum from the infected grass. About half of the samples of *H. jubatum* were infected with *S. avenae triticea*, and the infected samples were distributed throughout the cereal-growing region of Minnesota. That infected *Hordeum jubatum* was found in areas at great distances from barley or wheat crops suggests that the prevalence of *S. avenae triticea* on *H. jubatum* was not simply owing to the presence of infected crop hosts. Since *H. jubatum* is a perennial or winter annual, young shoots could be infected in spring as they grow through the infected debris left from the previous growing season. Therefore, *H. jubatum* could be infected before barley and wheat are planted in late spring.

Johnson (4) concluded that wild grass hosts are highly resistant to *S. avenae triticea* except when the grasses are nearly mature or senescent. The results from this study suggest that *H. jubatum* in the vegetative stage of development can be infected by *S. avenae triticea* and that the degree of infection depends on the isolate and the density of inoculum. The results of glasshouse and field experiments suggest that a wide range of wild *Hordeum* spp. may act as alternative hosts to *S. avenae triticea*.

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