Influence of Environment on the Spread of Barley Stripe Disease in California

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ABSTRACT

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Barley was grown at five sites in California and exposed to the same sources of inoculum of barley stripe disease at each site to determine the effect of environment of seed production on floral infection. Seed samples were taken from plots of barley planted with seed originating from two seed lots known to be infested with *Drechslera graminea*. Source seed lots from cvs. Prato and Kombyne had 15 and 70% infestation, respectively, and were either treated with fungicides to control barley leaf stripe or left untreated. Percentage of infection in plots from the untreated seed was 50% for untreated Kombyne and ranged from 1 to 10% for untreated Prato. Fungicide treatment reduced disease levels to 1% or less in the remaining plots. Seed samples from the plots grown in 1984 at each site were planted in replicate 2.4-m rows at the University of California at Davis in 1985 to determine the amount of floral infection that had occurred in 1984. Infection percentages varied from 0 to 50%, with significant differences in infection between sites of origin of seed lots. Gradients of infection frequency with distance from heavily infected source plants varied according to site of origin of seed.

Barley leaf stripe is caused by the seedborne pathogen *Drechslera graminea* (Rab.) Shoem. (perfect state *Pyrenophora graminea* Ito & Kuribay.). Estimates of yield reduction range from 0.5 to 1% per 1% incidence of stripe in the field (2,5,6). Seedlings of barley are infected by *D. graminea* before they emerge from the soil by mycelium within the hull and pericarp. Conditions favoring systemic infection of seedlings from seedborne inoculum include relatively low soil temperatures for a period after planting (2,4,5,8,9) and favorable soil moisture status, with intermediate soil moisture conditioning maximum infection (4,9). At heading, conidia produced on leaves under high moisture conditions mature in about 16 hr at 12 C, are windborne, and infect seed during the period from before head emergence to the soft/hard dough stages (2). Teviotdale and Hall (9) found seed was more susceptible to infection in the early stages of maturation than in the later stages and that infection levels decreased from boot stage to milk stage. Infection can occur in a temperature range of 10–33 C, and free water, although beneficial, is not required. Suneson (7) reported high levels of natural infections in California despite infrequent rains from flowering to maturity and attributed infections to high relative humidity in the evening. Metz and Scharen (3) found that irrigation applied near heading enhanced infection and that infection levels were near zero for dry, nonirrigated conditions.

This paper reports differences in the degree of spread of infection of barley stripe disease at five sites in California from the same sources of inoculum (infested seed lots) and demonstrates the importance of environment of seed production on floral infection and distance of disease spread.

MATERIALS AND METHODS

As previously reported (1), five field trials were planted in 1984 using seed lots of cvs. Kombyne and Prato with barley stripe infection levels of 70 and 15%, respectively, to determine the effectiveness of several seed treatment fungicides. Imazalil-treated Kombyne was subsequently free from barley stripe at all sites, whereas untreated Kombyne showed 50% stripe. Various fungicides reduced disease levels to 1% or less in Prato, whereas untreated Prato showed from 1 to 10% stripe. For the present study, seed was collected from all plots at the five sites for grow-out in 1985 to determine the effect of the environment of seed production on disease spread. Three sites were in the Sacramento Valley, in Sutter and Butte counties and at the University of California at Davis (UC Davis) in Yolo County. The other two sites were in the San Joaquin Valley, in Kings County and at the University of California West Side Field Station (WSFS) in Fresno County. Plots were 1.2 × 7.6 m and were replicated four times in randomized complete block designs. The plots consisted of six drill rows spaced at 16.5 cm. The distance separating the outer drill rows of adjacent plots was 30.5 cm, but plants in the outer drill rows of adjacent plots were in contact with each other by heading because of closure of the canopy by tillering. Trial dimensions were 3.7 × 114.3 m at UC Davis and Kings County, 4.9 × 83.8 m at Sutter and Butte counties, and 6.1 × 68.6 m at WSFS.

Planting dates for the 1984 tests were early December 1983 for WSFS and Kings County and late January 1984 for UC Davis and Sutter and Butte counties. Weather conditions and irrigation practices were recorded for a 4-wk period that encompassed heading through medium dough stage, 1–28 April for December plantings and 22 April–19 May for January plantings (Table 1). Daily weather data (minimum and maximum temperatures, precipitation, dew point, and average wind speed) were obtained from weather stations that are part of the California Irrigation Management Systems computerized weather

Table 1. Weather conditions during the 4-wk period[a] from heading through medium dough stage for barley grown at five sites in California in 1984

	Number of days in 4-wk period							Daily wind speed (mph)	
				Maximum temperature (C)					
Site[b]	Rain[c] (mm)	Irrigation[d]	Dew point reached	>30	25–30	20–25	15–20	Average	Range
Kings County	3	1	11	1	7	13	7	6	2–9
Sutter County	1	1	8	9	6	10	3	6	2–13
WSFS	2	2	2	3	5	14	6	8	4–18
Butte County	2	1	8	5	8	12	3	6	2–12
UC Davis	2	2	2	7	7	11	3	7	4–18

[a] Kings County and WSFS, 1–28 April; Butte and Sutter counties and UC Davis, 22 April–19 May.
[b] WSFS = University of California West Side Field Station, Fresno County; UC Davis = University of California at Davis, Yolo County.
[c] Total amounts for Kings County, Sutter County, WSFS, Butte County, and UC Davis were 8, 6, 3, 3, and 3 mm, respectively.
[d] Applied by sprinklers at WSFS (36 and 38 mm) and by border flood or furrow at Kings (114 mm), Sutter (152 mm), and Butte (127 mm) counties and UC Davis (152 and 152 mm).

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network operated by the California Department of Water Resources. Although no weather stations were located on the exact sites of the experiments, the nearest stations in the network to each site gave the best available approximation of prevailing weather conditions for that site. The stations used were in the immediate vicinity of the plots at UC Davis and WSFS and were within 5 miles of the Butte County site and within 10 miles of the Sutter County and Kings County sites.

The percentage of infected plants in each plot was visually estimated before the heading stage of growth. At harvest, seed from each plot was kept separate, cleaned, and then used as source seed for planting in the 1985 test. Records were kept of the exact location of the plot from which a particular seed lot originated relative to other plots at each site.

The 1985 grow-out was planted at the Plant Pathology farm at UC Davis in October 1984. Seed from each plot of the five 1984 sites (44 plots per site) was planted in 2.4 m-rows, 50 seeds per row, in a randomized complete block design with four replications (880 rows in total). Stand counts were made when plants were well established, and infected plants were counted at heading time when symptom expression was optimum. An analysis of variance was performed to determine differences in infection percentages among sites and among seed lots originating from each site. Mean separation was by Fisher's LSD. The percentage of infection of a seed lot expressed in 1985 was compared with the position of the plot from which the seed was produced relative to sources of inoculum (plots derived from untreated seed of Kombyne and Prato) at each site in 1984.

RESULTS

The inoculum for infection of kernels at flowering through medium dough stage was produced primarily on plants from the 40 plots sown with untreated seed of Prato and Kombyne. Seed treatment had reduced the inoculum level to zero in most other plots (Fig. 1).

Average emergence of seed lots (derived from 1984 plots) in 1985 ranged from 76 to 80%. There were no significant differences in emergence among seed lots except for UC Davis, where several seed lots, particularly those originating from plots planted with untreated infested Kombyne seed in 1984, had lower percent emergence (minimum of 53%). Symptom expression on emerged plants was good, permitting easy visual assessment of disease. Average percentage of infection observed in the 220 seed lots (44 from each of the five sites of 1984) ranged from 0 to 50%. There were significant differences in infection percentages both among seed lots at each site and among different sites of seed lot origin. Average infection percentages ranged from a low of 3% for seed lots from UC Davis to a high of 15% for seed lots from Kings County (Table 2).

The 20 seed lots that originated from untreated Kombyne seed in 1984 had the highest infection levels, ranging from 26–38% for seed lots from Kings County to 10–18% for seed lots from UC Davis

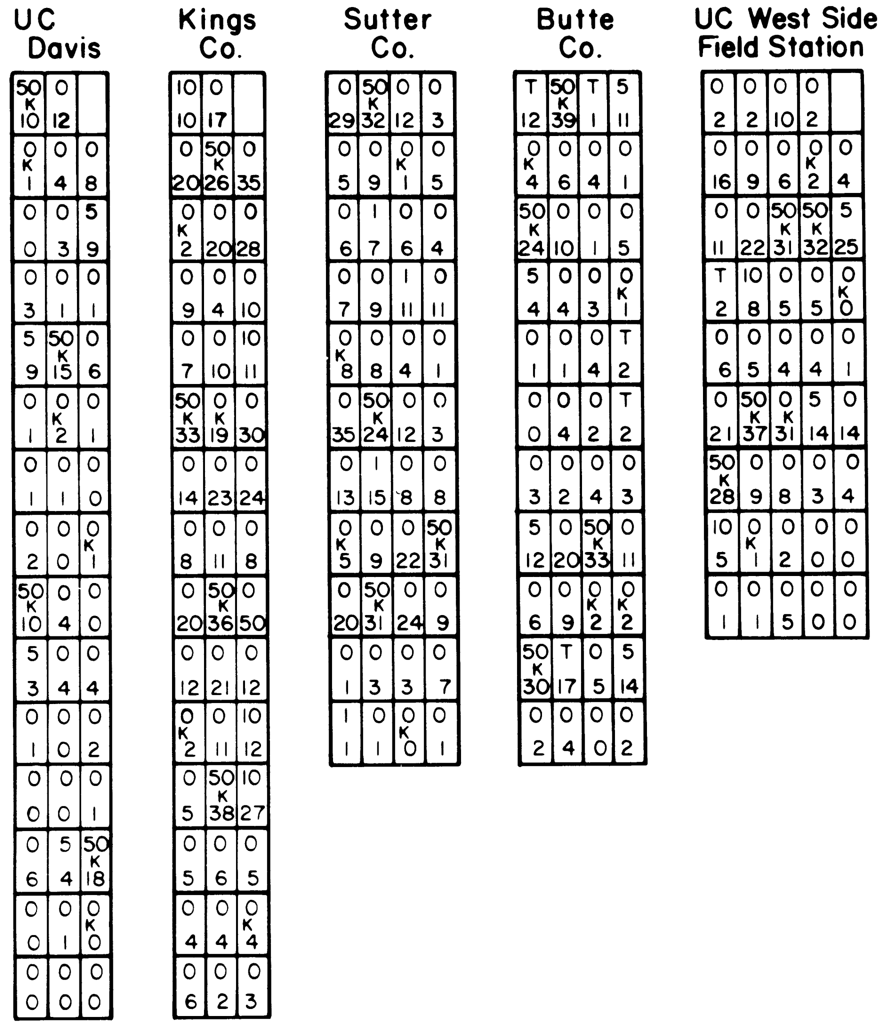

Fig. 1. Spread of barley stripe disease from infested seed lots at five California sites. Upper number in each box (plot) is percentage of infection detected in 1984. Lower number in each box is percentage of infection detected in plots grown in 1985 at the University of California at Davis from seed produced on plants from plots in 1984. T = trace infection. K = cv. Kombyne; all other plots, cv. Prato.

Table 2. Barley stripe infection expressed in 1985 by seed lots of barley cultivars Kombyne and Prato derived from plants exposed to sources of inoculum at five sites in California in 1984

	Percent infection		Number of seed lots[b] for which percent infection was:			
Site[a]	Mean	Range	0	0–10	10–30	>30
Kings County	15	2–50	0	20	13	3
Sutter County	11	0–35	1	26	8	1
WSFS	9	0–37	5	33	6	1
Butte County	7	0–39	2	30	4	0
UC Davis	3	0–18	12	23	1	0
LSD (0.05)	1.2					

[a] WSFS = University of California West Side Field Station, Fresno County; UC Davis = University of California at Davis, Yolo County.

[b] Thirty-six seed lots per site, excluding those derived from 1984 untreated Kombyne and Prato seed. At Kings County, Sutter County, WSFS, Butte County, and UC Davis, percent infection of seed lots derived from untreated Kombyne was 28–38, 24–32, 28–37, 20–39, and 10–18%, respectively, and of seed lots derived from untreated Prato, 10–27, 1–15, 5–25, 4–14, and 3–9%, respectively.

(Fig. 1). The 20 seed lots that originated from untreated Prato seed had infection levels ranging from 10–27% at Kings County to 3–9% at UC Davis. Infection levels in the remaining 180 seed lots varied widely but primarily depended on proximity to plots from untreated infested seed of Kombyne or Prato.

Lateral spread of barley leaf stripe occurred at each location, but infection percentages dropped rapidly with distance from sources of inoculum. Some seed lots had very low infection levels despite their origin from plots bordering strong sources of inoculum (Fig. 1). Although higher infection levels were detected in seed lots from sites where conditions were more favorable for floral infections (Kings and Sutter counties), plots separated from plots with strong sources of inoculum by as little as the width of one intervening plot (1.2 m) produced seed that differed greatly in the amount of infection. Among seed lots showing more than 30% infection, only one of five did not originate from a plot directly adjacent to a plot that had been planted with untreated Kombyne seed. The majority of seed lots had less than 10% infection. No infection was detected in 12 seed lots from UC Davis, compared with one, two, and five seed lots with no infection from Sutter County, Butte County, and WSFS, respectively. Infection was detected in all seed lots from Kings County (Table 2).

Weather conditions for each site are given in Table 1. The Kings County site had the fewest days with maximum temperatures greater than 30 C and the most days with maximum temperatures less than 20 C, although most of the days at each site had maximum temperatures of 20–30 C. Precipitation events and irrigation during the critical period were not very different at the various sites, with one to three rainfall events occurring and one or two irrigations applied. The total amount of precipitation during the period ranged from 3 mm (UC Davis, Butte County, WSFS) to 8 mm (Kings County). Kings County did have the highest infection level and the most rainfall events, but WSFS, which was the only site with sprinkler irrigation, had one of the lower infection levels. The dew point temperature was reached more times at Kings County (11 times) than at the other sites (two times each for UC Davis and WSFS and eight times each for Butte and Sutter counties). Average daily wind speeds over the critical period (6–8 mph) and the ranges of daily wind speeds (2–18 mph) did not differ greatly among sites. We were not able to monitor wind direction, which likely influenced direction of spread.

DISCUSSION

Significantly different infection levels, averaging from 3 to 15% among sites and ranging from 0 to 50%, were detected in 1985 in seed lots that were exposed to barley stripe disease under different environments in California's Central Valley in 1984. Heading time temperatures were relatively high and rainfall was rare during flowering and grain-fill, providing less than optimal conditions for floral infections. No single factor appeared to account for the different infection levels that were detected in seed lots produced at the different sites. Rather, a combination of factors was responsible. Kings County, which produced seed with the highest infection levels, had the most rainfall events, the fewest days with maximum temperatures greater than 30 C, the most days with maximum temperatures less than 20 C, and the most days when the dew point temperature was reached. The lowest infection levels were detected among seed lots produced at UC Davis, where the dew point temperature was reached only twice and maximum temperatures exceeded 30 C a total of 7 days. The dew point temperature was reached only twice at WSFS also, but sprinkler irrigation presumably provided more favorable conditions for infection and 30 C was exceeded on only 3 days. The differences in infection levels among seed lots originating from the other sites are not as easily explained. Seed lots from Sutter County, for example, which had the second highest infection levels, were produced where the most days of unfavorably high maximum temperatures occurred during the critical infection period. This unfavorable factor may have been balanced by the relatively high number of days in which the dew point temperature was reached. Collectively these results indicate that limiting seed production to drier areas could contribute to control of barley stripe disease.

Differences in infection levels among seed lots from a particular site were attributed to the position of origin of the seed lot relative to strong sources of inoculum, not to differences in cultivar susceptibility. Of particular interest was the low degree of spread of disease detected within each site despite the presence of strong sources of inoculum. In the solid planted plots, some seed lots from plots separated by as little as the width of one intervening plot (1.2 m) from plots where up to 50% of the plants were infected had only trace or very low amounts of infection in seed produced. Conditions under which spores were dispersed either did not favor infections or favored only very short distance dispersal of spores.

The limited lateral spread from infected plants to developing seed observed in these experiments suggests that under the relatively dry conditions in California, percentages of barley stripe infected seed would increase gradually in seed lots from year to year. Even so, since 1% infection translates into 0.5–1% loss, we do not interpret these results as justifying only alternate year or more seed treatment for control of the disease.

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