Using Weather Information to Identify Pearl Millet Downy Mildew Risk Environments in India

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Introduction

Downy mildew, caused by *Scleropsora graminicola*, is widely prevalent and the most destructive disease of pearl millet (*Pennisetum glaucum*) hybrids in India. Incidence of downy mildew has been quite variable depending on cultivar, season and location (Thakur et al. 2002). Downy mildew, like several other plant diseases, is heavily influenced by weather variables. *Sclerospora graminicola*, an oomycete fungus, is an obligate biotroph and reproduces both by sexual and asexual means. The process of spore germination, infection and disease development is directly influenced by relative humidity (RH) and temperature, and indirectly by rainfall, radiation and wind speed. The asexual zoospores are motile and require a thin film of water on the leaf surface to swim and encyst before they cause infection.

Among the weather factors, RH and temperature during the early vegetative growth of the crop are critical for infection and disease development. The purpose of this study was to understand the relationship between weather parameters such as RH and temperature, and downy mildew incidence for identifying disease risk environments with an ultimate objective of developing decision-making tools for disease management. The most vulnerable crop stage for downy mildew infection is up to 30 days after emergence. The relationship between prevalent weather (temperature and RH) and disease incidence (DI), recorded at 30 days after emergence, formed the basis for identifying the disease risk environment.

Materials and Methods

Downy mildew incidence data and weather data collected from a collaborative Pearl Millet Downy Mildew Virulence Nursery (PMDMVN) at several locations in India were used for the study. The nursery consisted of a set of pearl millet genotypes, resistant and susceptible to downy mildew. Each genotype was grown in 2 rows of 4 m and replicated 2–3 times in a randomized block design. Downy mildew disease pressure was created using an infector-row system at each location (Singh et al. 1997). Data were recorded on downy mildew incidence at 30 and 60 days after seedling emergence. Data for temperature and RH were collected from the meteorological observatory of the research station where the nursery was conducted.

The DI data and weather data were used for a period of 3 to 5 years from five locations, Durgapura (Rajasthan), Jamnagar (Gujarat), Mysore (Karnataka), Patancheru (Andhra Pradesh) and Jalna (Maharashtra). These locations are situated between 12 and 21° N, and 70 and 78° E, with mean annual rainfall ranging from 762 to 1000 mm representing major pearl millet hybrid growing environments. Of the 12 pearl millet genotypes in the PMDMVN, DI data were used for the four susceptible genotypes, BJ 104 (hybrid), NHB 3 (hybrid), 5141B (inbred) and J 104S (inbred).

Simple correlation analyses were performed to find relationships between RH, temperature and DI at each location. There were 16 environments for BJ 104 and 18 environments for each of the other three genotypes. This

Table 1. Weather data and downy mildew disease incidence (DI) in four susceptible pearl millet genotypes at five locations in India during 1994–97[1].

	Relative humidity (%)				Mean temperature (°C)					
	Minimum		Maximum		Minimum		Maximum		DI[2] (%)	
Location	Mean	Range	Mean	Range	Mean	Range	Mean	Range	Mean	Range
Patancheru	66 ± 2.4	61–71	91 ± 1.1	88–93	22 ± 0.4	21–23	30 ± 0.4	29–31	67 ± 5.2	19–100
Mysore	62 ± 0.0	62–62	84 ± 0.5	83–84	22 ± 2.0	20–24	28 ± 0.5	27–28	74 ± 3.4	35–97
Durgapura	62 ± 1.5	60–63	87 ± 2.0	84–93	24 ± 0.0	24	33 ± 0.3	32–33	40 ± 4.1	0–78
Jamnagar	69 ± 4.4	61–76	90 ± 1.8	87–93	24 ± 1.0	22–25	32 ± 0.6	31–33	80 ± 4.0	28–99
Jalna	54 ± 2.4	51–59	92 ± 2.3	90–97	22 ± 0.6	21–23	31 ± 0.3	30–31	82 ± 3.4	43–100

1. Data are means of four years.
2. Data for four genotypes: BJ 104, NHB 3, 5141B and J104S.

discrepancy resulted because of non-inclusion of any of these genotypes in certain years in the nursery.

Results and Discussion

There was considerable variation in RH across locations and years. The mean minimum RH (RHmin) ranged from 54% (Jalna) to 69% (Jamnagar), and the mean maximum RH (RHmax) ranged from 84% (Mysore) to 92% (Jalna) across four crop seasons (Table 1). However, the range of RHmin was 51–76% and that of RHmax was 83–97%. Relative to RH, there was less variation in temperatures across locations and years. The mean minimum temperature (Tmin) ranged from 22 to 24°C and the mean maximum temperature (Tmax) ranged from 28 to 33°C. The range of Tmin was 20–25°C and that of Tmax was 27–33°C (Table 1).

The mean DI on four pearl millet genotypes varied from 40 to 82% across locations and years (Table 1). Considerable year-to-year variations at and across locations were found on these genotypes. Based on the distribution of downy mildew incidence on four genotypes across years and locations, we designated a 70% DI to classify the environments as high disease risk or low disease risk.

BJ 104 showed high mean DI (>70%) in 7 of the 16 environments, NHB 3 in 14 of the 18 environments, 5141B in 10 of the 18 environments and J 104S in 11 of the 18 environments (Table 2). Depending on the DI on individual genotypes during different years at a location, the year × location combinations were classified as high disease risk or low disease risk environment. However, this was not consistent in all the four genotypes even for a single year at a particular location because of variable DI in the genotypes. It would be desirable to consider two equally susceptible genotypes across locations for future study.

Positive relationships were found between RHmax and DI at 30 days after seedling emergence for some locations; eg, for BJ 104 at Mysore and Durgapura in some years. However, the relationship was not consistent across genotypes over environments and years. This could be due to variable rainfall pattern during the experimental years at these locations. The relationships between temperature (both maximum and minimum) and DI were not significantly correlated for any location and year.

While the year-to-year and location-to-location variations in DI were noticed, the causes for such variations were not well understood. We believe the main reason for such insignificant correlations between weather variables and DI could be the lack of weather data from the experimental plots. Because all weather data reported here were collected from the meteorological observatory of the research stations, these may not be representative of the field microclimate data. We suggest that for all such future studies, microclimate data on RH, temperature, leaf wetness and radiation be collected from the experimental plots at the crop canopy level. For wider application of weather data-based disease forecasting, it would be necessary to obtain the data both from the meteorological observatory and microclimate conditions in the field, and determine correlations of these with the DI data. It is often not easy to obtain microclimate data, so it would be necessary to understand the correlation between meteorological observatory data and microclimate data and then with DI data.

Table 2. Frequency of high downy mildew disease incidence on four pearl millet genotypes across environments at five locations in India during 1994–97.

Genotype	Total environments	High disease risk environments (>70% incidence)	Percentage of high disease risk
BJ 104	16	7	44
NHB 3	18	14	77
5141B	18	10	55
J 104S	18	11	61

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