Reduction of Downy Mildew of Pearl Millet With Fertilizer Management

S. S. Deshmukh, C. D. Mayee, and B. S. Kulkarni

Marathwada Agricultural University, Parbhani 431 401 Maharashtra, India.
The authors thank V. S. Khuspe, Vice Chancellor, for encouragement. A portion of senior author's M. Sc. (Agriculture) thesis.
Accepted for publication 30 January 1978.

ABSTRACT

DESHMUKH, S. S., C. D. MAYEE, and B. S. KULKARNI. 1978. Reduction of downy mildew of pearl millet with fertilizer management. Phytopathology 68: 1350-1353.

Phosphorus (P) as superphosphate (16% P) decreased the severity of downy mildew on pearl millet in field trials. The decrease in disease was proportional to the amount of P added up to 50 kg/ha. Nitrogen (N) and Potassium (K) up to 100 kg N/ha and 50 kg K/ha, respectively, did not counteract the effect of P. The reduction in disease resulted in increased grain yield. Higher rates of N also reduced downy mildew and enhanced yield. Application of K had no effect on either the disease or yield.

Additional key words: *Sclerospora graminicola*, cultural control.

Downy mildew [which is caused by *Sclerospora graminicola* (Sacc.) Schroet.] is among the most important of all diseases and pests of pearl millet [*Pennisetum typhoides* (Burm.) Stapf and Hubb.]. The disease occurs in most pearl millet-growing countries of the world (3, 9). The capacity for epidemic development of this disease has greatly discouraged the cultivation of high-yielding pearl millet hybrids in India. Heavy losses in yield have been reported frequently since the introduction of hybrids (7, 9).

The pathogen exists between susceptible crops as oospores in plant debris in the soil and on the seed. The oospores are the source of primary inoculum. Whether or not the pathogen survives as mycelium in seed and is transmitted by seed is in controversy (9). Plants become systemically infected where environmental conditions are favorable for the disease. Sporangia are produced in large numbers in the " downy mildew" growth of the pathogen on leaves growing from systemically infected plants. Secondary spread is achieved quickly through sporangia which give rise to zoospores. In later stages, systemically infected plants show various degrees of malformation normally called 'green ear'. Abundant oospores are formed in infected leaf tissues and inflorescences.

Balasubramanian (2) reported that the incidence of downy mildew of sorghum almost doubled when phosphorus (P) was increased from 0 to 30 kg/ha. With further increase in P, there was no change in the incidence and nitrogen (N) had no effect on the incidence of the disease. Singh (10) reported that the incidence of downy mildew of pearl millet increased as N levels were raised from 0 to 40 kg/ha, but that between 40 and 80 kg/ha, there was no significant increase. Phosphorus and potassium (K), up to 40 kg/ha, did not counteract the effect of N. This paper reports on the response of pearl millet downy mildew to N, P, and K fertilizer applications and on the possible use of these fertilizers in control of the disease.

MATERIALS AND METHODS

The effect of N, P, and K on downy mildew was tested at Parbhani (Pbn) and also at Aurangabad (Abd) (about 215 km apart). The residual levels of N, P, and K in the top 15 cm of soil in these fields were: 510 kg N/ha, 24 kg P/ha, 438 kg K/ha for Pbn; and 350 kg N/ha, 15 kg P/ha, 392 kg K/ha for Abd. The pearl millet hybrid HB 3 (highly susceptible to downy mildew) was grown under standard grower's practices except for variations of fertilizers. Urea (46% N), superphosphate (16% P), and muriate of potash (60% K) were broadcast to provide 25, 50, 75, and 100 kg N/ha; 12.5, 25, 37.5, and 50 kg P and K/ha incorporated into soil prior to sowing. The total N dose of each treatment was split; half was applied as preplant and the remainder 30 days later.

Selected combinations of 25 treatments including the ones without N, P, K were arranged in 5^3 fractional replication design (5). Fractional replication is an extension of factorial experiment and is a design in the series of response surface designs in which the fraction of replication is obtained by confounding higher-order interactions of factors. In the present study, it was achieved by confounding the interactions of NP, NK, PK, and NPK, thereby reducing the replication size to one-fifth of a replicate in the 5^3 factorial experiment. Twenty-five treatment combinations of N, P, and K constituting the fractional replication were obtained by treating the dosages of N as "rows", those of P as "columns", and those of K as treatments in a latin square; the K levels were randomized. This was to facilitate inoculations, management, and care of individual plots and also to permit observation of the effect of each nutrient alone on downy mildew. Individual plots were 6.0 m × 8.0 m. The

00032-949X/78/000 244$03.00/0

area selected within each plot for observations was 4.5 m × 6.8 m. Spacing between plots was 1.5 m and that between rows and plants were 45 cm and 15 cm, respectively.

"Spreader" rows of HB 3 pearl millet were planted around the plots 21 days prior to main plot sowing to help create an epiphytotic (Fig. 1). The spreader rows were planted along with dried (finely powdered) infected plant material containing abundant oospores. In addition, oosporic material was incorporated into each plot at 10 g/plot before main plot sowing. "Protector" rows of maize (a local tall cultivar) were planted around and along spreader rows at a distance of 45 cm from the border of each plot (Fig. 1). This was done mainly to obstruct movement of sporangia from plot to plot and also to help raise the humidity within the plots. Use of spreader and protector rows was suggested by R. J. Williams, Pathologist, International Crops Research Institute for the Semi Arid Tropics (ICRISAT), Hyberabad, who obtained high levels of disease by this method.

Two parameters were used to quantify the amount of infection. These were: percentage incidence 30 days after planting (% INF 30) and percentage infection index (INFINDX), calculated from the incidence and severity ratings. Severity rating was done at dough stage of grain maturity according to the standardized method used by All India Co-ordinated Millet Improvement Project (AICMIP) and ICRISAT (Fig. 2). Essentials of the index rating scale are:

1. No visible symptoms;
2. Symptoms on nodal tillers only;
3. Symptoms on main tillers but still three or more productive heads;
4. Symptoms on many main tillers so that there are only one or two productive heads;
5. Symptoms on main stems and tillers so that there are no productive heads (plants may have died at an early stage leaving clumps of straw or gaps).

The INFINDX is calculated from the following formula when Y is the number of plants in each category and N is the total number of plants.

$$\text{INFINDX} = \frac{Y(1-1) + Y(2-1) + Y(3-1) + Y(4-1) + Y(5-1)}{N \times 4} \times 100$$

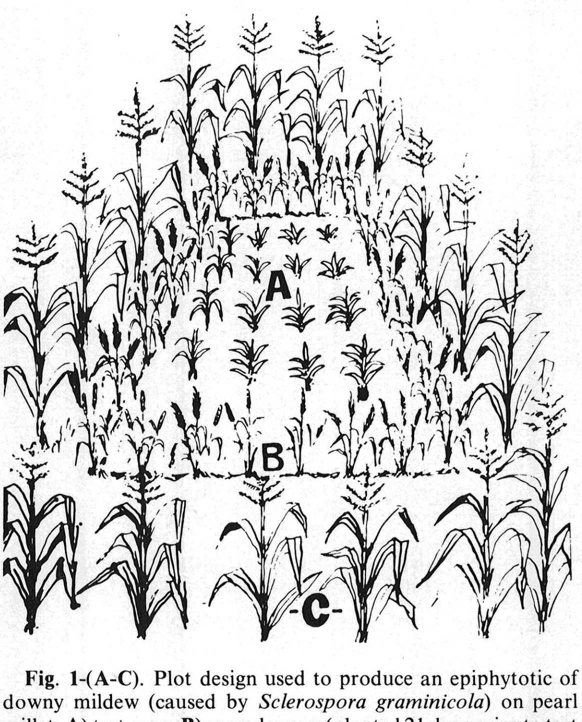

Fig. 1-(A-C). Plot design used to produce an epiphytotic of downy mildew (caused by *Sclerospora graminicola*) on pearl millet; **A**) test rows, **B**) spreader row (planted 21 days prior to test rows), and **C**) protector row (planted along with spreader row).

RESULTS

Influence of phosphorus.—The incidence and intensity of downy mildew on pearl millet both decreased with increasing levels of P at both the locations (Table 1). Phosphorus at 50 kg/ha lowered the incidence and intensity significantly ($P = 0.05$) over all other treatments

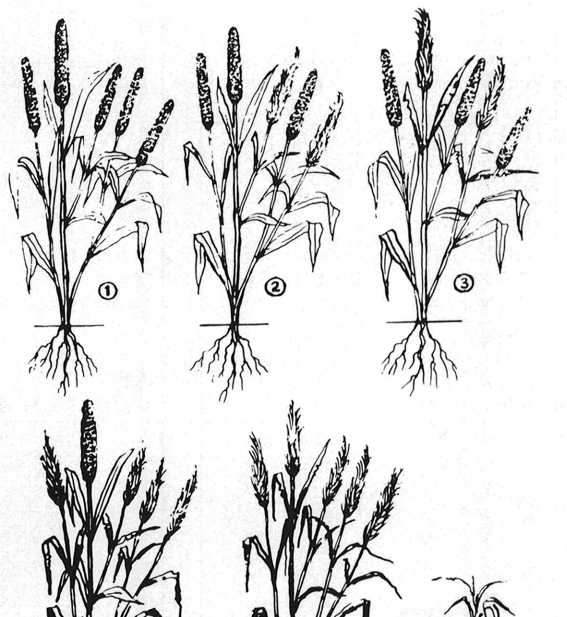

Fig. 2. Disease rating scale used to assess the severity of downy mildew (*Sclerospora graminicola*) on pearl millet: 1 = no visible symptoms; 2 = symptoms on nodal tillers only; 3 = symptoms on main tillers, but still three or more productive heads; 4 = symptoms on many main tillers so that there are only one or two productive heads, and 5 = symptoms on main stems and tillers so that there are no productive heads (plants may have died at any early stage leaving clumps of straw at gaps in the row).

TABLE 1. Effect of different rates of phosphorus (P) fertilization on incidence and intensity of downy mildew caused by *Sclerospora graminicola* and on yield of HB 3 pearl millet hybrid

P (kg/ha)	Incidence (%INF 30)[x] Intensity (INFINDX)[y] Grain yield (kg/ha)					
	Pbn[z] (%)	Abd[z] (%)	Pbn	Abd	Pbn	Abd
0	49.6 (44.8) a	45.4 (42.3) a	38.2 (38.1) a	36.0 (36.6) a	741 a	1,019 a
12.5	35.7 (36.2) b	36.7 (37.0) ab	32.0 (34.1) ab	29.5 (32.6) ab	834 a	1,227 ab
25	30.5 (33.4) b	29.9 (33.0) bc	24.1 (29.3) bc	22.9 (28.5) bc	874 b	1,445 ab
37.5	24.6 (29.4) b	23.3 (28.6) cd	19.8 (26.2) c	18.1 (24.8) cd	882 b	1,186 ab
50	10.2 (18.5) c	18.1 (25.1) d	11.5 (19.8) d	14.7 (22.3) d	998 c	1,471 c

[x]Percentage incidence of disease 30 days after planting.

[y]Percentage intensity of disease (percentage infection index = INFINDX) at the dough stage of grain maturity calculated from the following formula when Y is the number of plants in each category and N is the total number of plants.

$$\text{INFINDX} = \frac{Y(1\text{-}1)+Y(2\text{-}1)+Y(3\text{-}1)+Y(4\text{-}1)+Y(5\text{-}1)}{N \times 4} \times 100$$

Abbreviations: Pbn = Parbhani and ABD = Aurangabad (experiment sites in India). Figures in brackets are transformed values and statistics applies to them. Values in the same column followed by common letters do not differ significantly, $P = 0.05$.

TABLE 2. Effect of different rates of nitrogen (N) fertilization on incidence and intensity of downy mildew caused by *Sclerospora graminicola* and on yield of HB 3 pearl millet hybrid

N (kg/ha)	Incidence (%INF 30)[x] Disease intensity (INFINDX)[y] Grain yield (kg/ha)					
	Pbn[z] (%)	Abd[z] (%)	Pbn (INFINDX)	Abd (INFINDX)	Pbn (kg/ha)	Abd (kg/ha)
0	37.4 (37.3) a	41.5 (39.9) a	28.8 (31.3) a	33.7 (35.2) a	664 a	1,005 a
25	25.2 (29.3) ab	33.1 (35.0) b	27.6 (31.2) a	27.6 (31.4) ab	831 bc	1,081 a
50	30.5 (32.4) ab	30.0 (32.7) b	24.1 (28.6) ab	23.5 (28.5) b	797 b	1,498 b
75	37.2 (36.6) ab	29.8 (32.6) b	29.1 (32.0) a	22.1 (27.6) b	947 c	1,318 b
100	20.4 (26.6) b	19.0 (25.8) c	17.1 (24.3) b	14.4 (22.2) c	1,073 d	1,644 c

[x]Percentage incidence of disease 30 days after planting.

[y]Percentage intensity of disease (percentage infection index = INFINDX) at the dough stage of grain maturity calculated from the following formula when Y is the number of plants in each category and N is the total number of plants.

$$\text{INFINDX} = \frac{Y(1\text{-}1)+Y(2\text{-}1)+Y(3\text{-}1)+Y(4\text{-}1)+Y(5\text{-}1)}{N \times 4} \times 100$$

[z]Abbreviations: Pbn = Parbhani and Abd = Aurangabad. Figures in brackets are transformed values and statistics applies to them. Values in the same column followed by common letter do not differ significantly $P = 0.05$. Pbn = Parbhani, Abd = Aurangabad.

except at Aurangabad where 37.5 kg P/ha was as good as 50 kg P/ha. Grain yield increased in direct relation to the amount of P applied.

Influence of nitrogen.—Application of N at 100 kg/ha reduced downy mildew incidence and intensity at both locations (Table 2). At Parbhani, the response to N at 25 to 75 kg/ha was marginal. The reduction in disease intensity at 100 kg N/ha was significantly greater ($P =$ 0.05) over all other N treatments. Grain yield also increased in response to the higher levels of N.

Influence of potassium.—Potassium fertilization did not influence either the disease or the yeild, nor did the various levels of K alter the effect of P or N on disease.

DISCUSSION

Fertilization of hybrid pearl millet fields with N is essential for maximum production in India (4, 6, 8). The role of P, however, has not been critically evaluated from the standpoint of yield. It has been a practice of the farmers to raise pearl millet with a minimum of monetary inputs, especially fertilizer inputs. The results presented herein indicate that the amount of downy mildew disease can be expected to decrease with increasing dosages of P and possibly also N. The practice may help reduce downy mildew in fields planted annually to pearl millet.

The data presented in Tables 1 and 2 give an indication of the amount of yield increase attributable to reduced disease. Addition of P at 50 kg/ha compared with no P, increased the yields from 741 kg to 998 kg at Parbhani by reducing % INF 30 from 49.6 to 10.2 and INFINDX from 38.2 to 11.5. Similar results were obtained at Aurangabad where percent INF 30 dropped from 45.4 to 18.1 and INFINDX from 36.0 to 14.7 and yields increased from 1,019 kg to 1,471 kg.

Low rates of N did not influence development of the disease. However, the highest level of N (100 kg/ha) significantly reduced the disease at both locations. The grain yield was higher where higher levels of N were used. The amount of disease reduction with respect of N was low compared to reductions obtained with P, but the reverse was true for response based on yield. A recent report of field trials in downy mildew-free plots at Aurangabad states that the yield of pearl millet did not improve by addition of P up to 40 kg/ha, whereas significant increase was observed by addition of N up to 90 kg/ha (1). This indicates that application of P has a direct effect on fungus multiplication and the increased yield obtained in our studies is a direct consequence of reduced disease. In contrast, N improved plant growth and vigor which probably resulted in reduction of systemic fungal movement and thereby less disease.

An identical study was carried out by Singh (10) at Delhi, who reported that the incidence of downy mildew of pearl millet increased as N levels were raised from 0 to 40 kg/ha but between 40 and 80 kg/ha there was no significant increase. Phosphorus and K up to 40 kg/ha did not counteract the effect of N. The soil analysis prior to laying out the trial was not done and hence a strict comparison is not possible. However, it is possible that differences between his findings and ours may be due to different soil conditions existing at Delhi. Also, the results of Balasurbramanian (2), which were obtained with a different downy mildew host-parasite combination, are in conflict with the findings of both Singh and this study. Therefore, the recommendations indicated here cannot necessarily be considered applicable to another downy mildew host-parasite interaction or to the same host-pathogen combination in a different set of environmental conditions.

The results suggest that it may be possible to minimize downy mildew and obtain higher yields through application of P and N at proper levels.

LITERATURE CITED

1. ANONYMOUS. 1977. Agricultural research subcommittee report for 1976-77; Agronomist, All India Coordinated Millet Improvement Project, Aurangabad, Marathwada Agricultural University, Parbhani, India 24, p.
2. BALASUBRAMANIAN, K. A. 1973. Influence of nitrogen and phosphorus fertilizers on the expression of downy mildew of sorghum. Plant Soil 38:477-479.
3. BHAT, S. S. 1973. Investigations on the biology and control of Sclerospora graminicola on bajra. Ph.D. Thesis, Mysore Univ., Mysore, India. 165 p.
4. CHUNDAWAT, G. S., D. C. SHARMA, and G. S. SHEKHAWAT. 1970. Note on the response of hybrid bajra to time of nitrogen application, Indian J. Agron. 15:189.
5. COX, D. R. 1958. Planning of experiments. John Wiley and Sons, Canada. 308 p.
6. FARODA, A. S. 1968. Fertilization of bajra (Pennisetum typhoides). Fert. News 13:25-26.
7. MATHUR, R. L.,and G. G. DALELA. 1971. Estimation of losses from 'green ear' disease (Sclerospora graminicola) of bajra (Pennisetum typhoides) and grain smut (Sphacelotheca sorghi) of jowar (Sorghum vulgare) in Rajsthan. Indian Phytopathol. 24:101-104.
8. MURTHY, B. R. 1967. Response of hybrids of sorghum jowar and bajra to nitrogen. J. Postgraduate School, Indian Agricultural Research Institute, New Delhi, India 5:149-157.
9. NENE, Y. L., and S. D. SINGH. 1976. Downy mildew of pearl millet Pest Artic. News Summ. 22:366-385.
10. SINGH, S. D. 1974. Studies on downy mildew disease, Sclerospora graminicola (Sacc.) Schroet., of bajra, Pennisetum typhoides (Burm. D) Stapf (E. Hubb.) Ph.D. thesis, Indian Agricultural Research Institute, New Delhi, India. 126 p.