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Management of pearl millet rust through fungicides under artificially created epiphytotic conditions

D. L. KADVANI[1] AND I. U. DHRUJ[2]

Pearl millet Research Station
Junagadh Agricultural University, Jamnagar - 361 006 (Gujarat)

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ABSTRACT

Six fungicides were tested in *vivo* against pearl millet rust (*Puccinia substriata* var. *indica*) at Pearl Millet Research Station, J. A. U. Jamnagar during 2007 to 2009 under artificial inoculated condition on pearl millet variety GHB 715. The fungicides mancozeb 0.2 per cent and difenoconazole 0.0125 per cent were proved the most effective with respect to disease control and they offered 62.62 and 61.29 per cent disease control, respectively. The maximum grain yield per cent was increased in the treatment difenoconazole (33.83 %) followed by mancozeb (31.31 %), hexaconazole (16.49 %) and propiconazole (12.09 %) in comparison to check. The maximum per cent fodder yield increase over control was also followed the same trend as difenconazole (39.00 %), mancozeb (35.55 %), hexaconazole (23.49 %) and propiconazole (20.73 %). The highest grain and fodder yield was recorded in the treatment difenoconazole 2069 kg/ha and 3621 kg/ha followed by mancozeb 2030 kg/ha and 3531 kg/ha, respectively. Maximum net return was obtained with two sprays of hexaconazole 0.005 per cent (1:4.37) followed by mancozeb 0.2 per cent (1:4.22) and difenoconazole 0.0125 per cent (1:3.79).

Key words : Pearl millet, rust, artificial inoculation, fungicides.

Pearl millet [*Pennisetum glaucum* (L.) R. Br.] is the world's sixth and India's fourth most important cereal food crop. The pearl millet grain contains 8.42 - 14.49 per cent protein and it has good amount of iron and zinc. Pearl millet is being grown in plane as well as costal areas during kharif, rabi and summer seasons in Gujarat. This crop is affected by many diseases; *viz.*, downy mildew, smut, rust, blast and ergot. Rust has been reported from many countries of Asia, Africa and also from the United States and Brazil (Sing and King, 1991). As the rust disease has been considered as a minor till recently, very limited work has been done on this disease and management. Worldwide, this disease is greater importance on multicut forage hybrids where even low rust severities can result in substantial losses of digestible dry matter yield (Wilson *et al.*, 1991). In India, the disease has become prevalent due to several factors such as wide spread cultivation of high yielding and rust susceptible cultivars, large scale seed production during summer season and overlapping of cultivation in Gujarat and Tamilnadu (Hash *et al.*, 1999). Therefore, there is a need to evolve better disease management technology through chemical management approach.

MATERIALS AND METHODS

The fungicides were evaluated by creating artificial inoculated condition in the field at Pearl Millet Research Station, J. A. U. Jamnagar during semi-*rabi* seasons from 2007 to 2009 on variety GHB 715. To maintain the congenial condition for disease development approximately 5 x 10^5 uredospores per

[1]Assistant Research Scientist, [2]Associate Director of Research, Directorate of Research, Junagadh.

ml of water were sprayed with the help of sprayer in experimental plots. The uredospores inoculum were sprayed twice at five day intervals after 15 days of germination. The uredinia bearing leaves were also spread among each treatment after 30 days of germination. The crop was regularly irrigated to maintain high humid condition.

A total numbers of six fungicides were tested under field conditions. The experiment was conducted in randomized block design. The gross and net plot size was 5.0 x 3.60 m and 4.0 x 2.40 m, respectively. The inter and intra row spacing was maintained at 60 cm x 10 cm. Recommended agronomic practices were followed for all the treatments. The two sprayings of each fungicide was carried out at onset (vegetative and flowering stage *i.e.*, 35 and 50 days) of disease at 15 days intervals as below.

T_1 - Hexaconazole 5%EC0.005 %

T_2 - Difenoconazole 25 % EC 0.0125 %

T_3 - Propiconazole 25 EC0.025%

T_4 - Tridemorph 80%EC 0.04 %

T_5 - Mancozeb 75 % WP 0.2%

T_6 - Iprodione 25 % + Carbedazim 25 % (50 % WP) 0.05%

T_7 - Control (Check)

The intensity of disease was recorded from ten randomly selected plants in each treatment as per modified Cobb scale 0-6 (8) after 15 days of second spray. The grain and fodder yield were also recorded (kg per net plot) and converted to per hectare basis. The statistical analysis was carried out using standard method.

Modified Cobb scale (8).

0 = No disease.

1 = Five per cent leaf area infected.

2 = Ten per cent leaf area infected.

3 = Twenty five per cent leaf area infected.

4 = Forty per cent leaf area infected.

5 = Sixty five per cent leaf area infected.

6 = Hundred per cent leaf area infected.

The per cent disease intensity (PDI) in each treatment was worked out by using the following formula.

$$PDI = \frac{\text{Sum of the total rating}}{\text{Total plants observed}} \times \frac{100}{\text{Maximum disease rating}}$$

The percentage disease control and percentage deviation in yield was calculated with the help of the following formula.

$$\text{Per cent disease control} = \frac{\text{PDI in check - PDI in treatment}}{\text{PDI in check}} \times 100$$

$$\text{Per cent increase in yield} = \frac{\text{Yield in treatment - Yield in check}}{\text{Yield in check}} \times 100$$

RESULTS AND DISCUSSION

Rust intensity

The results for management of rust disease were significant in all the years. The minimum rust intensity was recorded in the treatment of mancozeb 0.2 followed by difenoconazole 0.0125 and hexaconazole 0.005 per cent as compared to the check and remaining treatment during individual season of *rabi* 2007, 2008 and 2009. The pooled analysis of fungicidal control revealed that mean disease intensity was statistically significant (Table1). The pooled data on disease intensity indicated that all the treatment were statistically significant over check. The lowest disease intensity was observed with mancozeb 0.2 per cent (27.36 %) followed by difenoconazole 0.0125 per cent, hexaconazole 0.005, propiconazole 0.025, tridemorph 0.04, per cent and iprodione 25 per cent + carbedazim 25 per cent (50 % WP) 0.05; they reported 28.33, 34.86, 38.89, 46.94 and 48.19 per cent, respectively. The highest disease control (62.62 %) was achieved under the treatment of mancozeb 0.2 per cent followed by difenoconazole 0.0125, hexaconazole 0.005 and propiconazole 0.025 per cent. These treatments gave 61.29, 52.37 and 46.86 per cent disease control, respectively.

Grain and fodder yield

The maximum grain and fodder yield were recorded in the treatment of difenoconazole 0.0125 followed by mancozeb 0.2 and hexaconazole 0.005 per cent as compared to the check during individual season *rabi* 2007, 2008 and 2009. The pooled analysis of fungicidal control revealed that grain yield and fodder yield were statistically significant (Table 2). The pooled results on grain yield indicated that

Table1 Effect of different fungicide sprays on rust disease intensity

Treatment	Mean disease intensity (%)				% disease control
	2007	2008	2009	Pooled	
Hexaconazole 5%EC0.005 %	35.49 (33.75)*	35.24 (33.33)	37.75 (37.50)	36.16 (34.86)	52.37
Difenoconazole 25 % EC 0.0125 %	31.59 (27.50)	34.48 (32.08)	30.24 (25.42)	32.10 (28.33)	61.29
Propiconazole 25 EC0.025%	38.97 (39.58)	37.24 (36.66)	39.46 (40.42)	38.56 (38.89)	46.86
Tridemorph 80%EC 0.04 %	42.35 (45.42)	45.47 (50.83)	41.88 (44.58)	43.23 (46.94)	35.87
Mancozeb 75 % WP 0.2%	30.21 (25.42)	34.23 (31.67)	29.95 (25.00)	31.46 (27.36)	62.62
Iprodione 25 % + Carbedazim 25 % (50 % WP) 0.05%	43.07 (46.67)	43.79 (47.92)	44.99 (50.00)	43. 95 (48.19)	34.16
Control (Check)	59.19 (73.75)	62.85 (79.17)	54.76 (66.67)	58.93 (73.19)	-
S.Em. ± Treatment	1.13	0.82	0.91	1.21	-
S.Em. ± Year x Treat.	-	-	-	0.96	-
C. D. at 5 % Treatment	3.34	2.44	2.70	3.72	-
C. D. at 5 % Year x Treat.	-	-	-	2.73	-
C. V. %	5.61	3.93	4.56	4.73	-

* Data given in parenthesis are retransformed value.

Table 2 Effect of different fungicide sprays on grain yield

Treatment	Grain yield (kg/ha)				Yield increase (%)
	2007	2008	2009	Pooled	
Hexaconazole 5%EC0.005 %	1745	1648	2010	1801	16.49
Difenoconazole 25 % EC 0.0125 %	2083	1844	2279	2069	33.83
Propiconazole 25 EC0.025%	1716	1589	1896	1733	12.09
Tridemorph80%EC 0.04 %	1568	1497	1878	1648	6.60
Mancozeb 75 % WP 0.2%	2018	1815	2255	2030	31.31
Iprodione 25 % +Carbedazim 25 % (50 % WP) 0.05%	1638	1560	1815	1671	8.09
Control (Check)	1505	1404	1729	1546	-
S.Em. ± Treatment	91.941	78.26	114.52	51.29	-
S.Em. ± Year x Treat.	-	-	-	96.07	-
C. D. at 5 % Treatment	273	23 3	340	14 5	-
C. D. at 5 % Year x Treat.	-	-	-	NS	-
C. V. %	10.49	9.65	11.57	10.76	-

maximum grain yield was obtained in the treatment of difenoconazole 0.0125 per cent (2069 kg/ha) followed by mancozeb 0.2 per cent (2030 kg/ha). These treatments were at par with each other and statistically superior over rest of the treatments. The treatments, hexaconazole, propiconazole, iprodione 25 per cent + carbedazim 25 per cent (50 % WP) and tridemorph were remained at par with each other except hexaconazole with tridemorph.

The maximum per cent grain yield increase was found in the treatment difenoconazole 0.0125 per cent (33.83 %) followed by mancozeb 0.2 per cent (31.31 %). The remaining treatments hexaconazole 0.005, propiconazole 0.025, and iprodione 25 per cent + carbedazim 25 per cent (50 % WP) 0.05 and tridemorph 0.04, per cent, gave 16.49, 12.09, 8.09 and 6.60 per cent yield increase, respectively as compared to the check (Table 2).

The pooled data on fodder yield indicated that all the treatments were found significant over check. Maximum fodder yield observed under the treatment difenoconazole 0.0125 per cent followed by mancozeb 0.2, hexaconazole 0.005 and propiconazole 0.025 per cent, they reported 3621, 3531, 3217 and 3145 kg/ha, respectively (Table 3). The maximum fodder yield increase over control with the treatment difenconazole (39.00 %) followed by mancozeb (35.55 %), hexaconazole (23.49 %) and propiconazole (20.73 %).

Overall, it can be concluded that spraying of either difenconazole, mancozeb or hexaconazole reduced the disease intensity and increased the grain and fodder yield of pearl millet. These findings are in agreement with many research workers who have used different chemicals fungicides for rust disease control. Kapooria (1972) reported that Cupramar,

Table 3 Effect of different fungicide sprays on fodder yield

Treatment	Fodder yield (kg/ha)				Yield increase (%)
	2007	2008	2009	Pooled	
Hexaconazole 5%EC0.005 %	3440	2927	3284	3217	23.49
Difenoconazole 25 % EC 0.0125 %	3883	3195	3784	3621	39.00
Propiconazole 25 EC0.025%	3279	2930	3227	3145	20.73
Tridemorph 80%EC 0.04 %	2927	2536	3206	2890	10.94
Mancozeb 75 % WP 0.2%	3693	3169	3732	3531	35.55
Iprodione 25 % + Carbedazim 25 % (50 % WP) 0.05%	2977	2919	3151	3016	15.78
Control (Check)	2708	2312	2794	2605	-
S.Em. ± Treatment	176.404	153.989	170.99	92.409	-
S.Em. ± Year x Treat.	-	-	-	167.40	-
C. D. at 5 % Treatment	524.141	457.542	508.053	261.110	-
C. D. at 5 % Year x Treat.	-	-	-	NS	-
C. V. %	10.78	10.78	10.33	10.64	-

Ceresan, Dithane M-22, Dithane S-31 and o-phenanthroline at 100 ppm, spray before and at the time of inoculation, reduced the pearl millet rust incidence. Sharma and Sharma (1976) and Sokhi *et al*. (1978) they found that fungicide Dithane M-45 reduced the rust intensity thereby increasing grain yield of *bajra*. Muthusamy and Ragupathy (1980) noted that highest yield of pearl millet grain was obtained with two sprays of copper oxychloride followed by one spray of Bayleton and Bayleton dry seed treatment. Lukose *et al*. (1992) reported the maximum grain yield (1600 kg/ha) and fodder yield (3793 kg/ha) with minimum rust intensity (34.05 %) in foliar application of mancozeb followed by zineb in pearl millet. Similarly, Ahmed *et al*. (1993) noted that fungicides propiconazole, butrizol, tridemefon and mancozeb reduced the severity of leaf rust caused by *Puccinia recondita* and increased grain yield/plant and 1000 grain weight.

Jadeja *et al*. (1999) reported that trizole fungicides difenoconazole, propiconazole and hexaconazole reduced both rust and leaf spot disease of groundnut, while carbendazim was effective against leaf spot and mancozeb against rust. Tirmali and Pawar (2000) reported that the Dithane M 45 was the most effective as it resulted in the highest per cent disease control (47.77 %) and the lowest rust disease intensity (39.99 %) in groundnut. This treatment also gave the highest pod yield (24.09 q/ha) and per cent increase in yield over control (70.61 %). Gopal *et al*. (2003) reported that difenoconazole (0.1 %) treatment resulted in the highest mean yield (2150 kg/ha) followed by carbendazim (0.05 %) + tridemorph (0.1 %) treatment (2090 kg/ha) in controlling late leaf spot and rust of groundnut cultivar JL-24. Gururaj Sunkud *et al*. (2005) noted that the maximum disease control with higher dry pod and fodder yield was obtained with hexaconazole, difenoconozole and propiconazole treatments for the control of leaf spots and rust of groundnut. They also noted that mancozeb gave better control of rust.

Economics

The economics of various fungicides (Table 4) for control of pearl millet rust indicated that the highest

Table 4 Economics of various fungicides for controlling rust of pearl millet

Treatment /Concentration	Required quantity of fungicides ml or g/l	Rate (₹) Kg/L	Total cost of fungicides (₹)	Labour Charges/ ha spray)	Total expen-diture	Grain yield kg/ha	Fodder yield kg/ha	Total income	Income increased over control	ICBR
Hexaconazole 5% EC 0.005 %	1.00	450	472.50	250	722.50	1801	3217	21227	3162	1:4.37
Difenoconazole 25 % EC 0.0125 %	0.50	2660	1396.50	250	1646.50	2069	3621	24311	6246	1:3.79
Propiconazole 25 % EC 0.025%	1.00	1250	1312.50	250	1562.50	1733	3145	20475	2410	1:1.54
ridemorph 80 % EC 0.04 %	0.50	1200	630.00	250	880.00	1648	2890	19370	1305	1:1.48
Mancozeb 75 % WP 0.2 %	2.66	400	1117.20	250	1367.20	2030	3531	23831	5766	1:4.22
Iprodione 25 % + Carbedazim 25 % (50 % WP) 0.05%	1.00	1200	1260.00	250	1510.00	1671	3016	19726	1661	1:1.10
Control	-	-	-			1546	2605	18065	-	-

Price of bajra grain ₹ 1000/100 kg, Price of bajra Fodder ₹ 100/100 kg, Labour Charges (₹ 250 /ha)
Water requirement for 1st spray 400 l/ha, Water requirement for 2nd spray 650 l/ha

total income of Rs. 24311/- followed by 23831/- and 21227/-were obtained in the treatments of difenoconozole, mancozeb and hexaconazole, respectively. However, the highest incremental cost benefit ratio (ICBR) was recorded in two sprays of hexaconazole 0.005 per cent (1:4.37) followed by mancozeb 0.2 per cent (1:4.22) and difenoconazole 0.0125 per cent (1:3.79).

CONCLUSION

It was observed that mancozeb and difenoconazole gave better control of rust disease with higher grain and fodder yield. It can be concluded that spraying of either mancozeb or difenoconazole gave better yield of pearl millet than control.

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