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Management of Rust in Pearl millet caused by *Puccinia substriata* var. *penicillariae* using Plant Product, Bioagent and Fungicides

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Abstract—*Rust caused by Puccinia substriata var. penicillariae is one of the major disease affecting both forage and grain production in pearl millet. An attempt was made to manage pearl millet rust using plant product, bioagent and fungicides under screen house and field conditions. The experiment was conducted on susceptible hybrid HHB 197 both under screen house and field condition with eight treatments. Observation on rust severity recorded at grain filling stage. The experiment results indicated that all the treatments were effective in managing the disease but amongst them minimum disease severity (11.7%) and (21.7%) was contracted under screen house and field conditions respectively in treatment of Propiconazole 25% EC (0.1%) followed by Hexaconazole 5% EC (0.1%) and Copper oxychloride 50% WP (0.2%), Carbendazim 50% WP (0.2%), Mancozeb 75% WP (0.2%), Azadirachtin 0.15% (1500 ppm), Trichoderma viride (3%) treated pots and plot. Maximum grain yield (514.7 kg/acre), test weight (8.13 g) and Benefit: cost 3.98: 1 was observed in Propiconazole 25% EC (0.1%) sprayed plot followed by Hexaconazole 5% EC (0.1%) under field conditions.*

Keywords—Plant product, Bioagent, Fungicides, Pearl millet, Puccinia substriata var. penicillariae.

I. INTRODUCTION

Pearl millet [*Pennisetum glaucum* (L.) R.Br. Syn. *Pennisetum americanum* (L.) Leeke] is an important staple cereal in the arid and semi-arid region of the world, particularly in Asia and Africa. India is considered to be the secondary centre of pearl millet diversity (Rao and Wet, 1999). Being most tolerant to drought and salinity, the crop is by and large grown in different countries of the world. Due to its adaptability under very wide range of agro-climatic conditions this crop is mostly grown in the states of Andhra Pradesh, Gujarat, Haryana, Karnataka, Madhya Pradesh, Rajasthan, Tamil Nadu, parts of Delhi, Punjab and Uttar Pradesh. In India the total production of crop was 9.25 m ton with area of 7.89 m ha during 2013-2014 (Anonymous 2013-14). The yield of pearl millet has increased considerably with the introduction of hybrids, but these have become susceptible to fungal diseases. Among various diseases, rust is one of major concern in pearl millet growing areas of the world. *Puccinia substriata* var. *indica* Ramchar and Cumm (syn: *Puccinia substriata* Ell. and Barth. var. *penicillariae* Carvalho *et al.* 2006; *Puccinia penniseti Zimm*), causes rust disease in pearl millet. In present study attempts were made to find out cost effective spray schedule involving plant product, bioagent and fungicides.

II. MATERIALS AND METHODS

The studies were carried out at the experimental area of Plant Pathology, CCS HAU, Hisar during *Kharif* 2015. Plant product Azadirachtin 0.15 EC @1500 ppm, formulation of biocontrol agent *Trichoderma viride @ 3%* and five chemical compounds *viz.,* Carbendazim 50% WP @ 0.2%, Mancozeb 75% WP @ 0.2%, Copper oxychloride 50% WP @ 0.2%, Propiconazole 25% EC @ 0.1% and Hexaconazole 5% EC @ 0.1% were used as foliar sprays for management of pearl millet rust under screen house and field conditions.

III. SCREEN HOUSE EXPERIMENT

This experiment was conducted with eight treatments in completely randomized design (CRD) with five pots per treatment and each treatment had three replications. Five seeds of Hybrid HHB 197 were sown in each pot filled with sterilized soil-sand-FYM (farmyard manure) mix and placed in screen house. Inoculation was done by rubbing rust infected leaves to healthy leaves and infected leaves were taken from field after first appearance of rust. Rust severity (%) was recorded 15 days after inoculation. Different agents were sprayed one week after date of first appearance of disease. The fungicidal solutions of required

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concentrations were prepared by mixing them in the measured quantity of water and sprayed on the plants till run- off, with the help of Knapsack sprayer one week after appearance of rust. Observations on germination percentage (%), No. of tillers, date of first appearance of rust and per cent rust severity at maturity were recorded.

IV. FIELD EXPERIMENT

The experiment was conducted in randomized block design (RBD) with three replications of similar set with all the eight treatments in plot size of 5×3 m by maintaining row to row distance of 50 cm and plant to plant distance of 10 cm. Six lines were maintained in each treatment (Plot) and fifty seeds were sown in each row. Recommended agronomic practices were followed. Different agents were sprayed one week after first appearance of rust. The solutions of all treatment were prepared by mixing them in the measured quantity of water and sprayed on the plants till run- off, with the help of Knapsack sprayer. Spray operations were carried out in the evening to avoid wind drift when the wind was calm. The benefit: cost ratio was calculated based on total grain yield per acre. The increase in grain yield as compared to the control (unsprayed) was calculated by subtracting the yield of control (unsprayed) from the treated plot. For calculation of benefit cost ratio the grain yield was taken *vis-à-vis* expenditure incurred on disease management as per the formula given below.

$$\text{B: C} = \frac{\text{Additional income obtained by treatment}}{\text{Amount spent for disease treatment}}$$

Observations on germination percentage, total number of plants, date of first appearance of rust, rust severity at maturity, grain yield at maturity and test weight were recorded and then Benefit: cost ratio was calculated.

V. RESULTS AND DISCUSSION

Screen house and field experiment

The fungicides, plant product and bioagent used in this study were effective in managing the disease as compared to control under screen house (Table 1) and field conditions (Table 2). Among tested treatments minimum disease severity (11.7%) and (21.7%) was contracted under screen house and field conditions respectively in Propiconazole 25% EC (0.1%) followed by Hexaconazole 5% EC (0.1%) and Copper oxychloride 50% WP (0.2%), Carbendazim 50% WP (0.2%), Mancozeb 75% WP (0.2%), Azadirachtin 0.15 % EC (1500 ppm) treated plot. Baiswar *et al.* (2011) reported that Propiconazole 25 EC (0.1%) and Tebuconazole 250 EC (0.2%) were best in managing soybean rust followed by Triadimefon 25 WP (0.1%), Sulphur 80 WP (0.3%), Carbendazim 50 WP (0.2%), Copper oxychloride 50 WP (50%), Chlorothalonil 75 WP (0.2%), *Trichothecium roseum*, Mancozeb 75 WP (0.25%), Azadirachtin (0.03%), Cymbopogon leaf extract (3 ml/l), Hexaconazole 5 EC (0.1%), Tricyclazole75 WP (0.05%), *Trichoderma* sp. Highest Percent Disease Index was in case of control (65.4) and the yield was also lowest in this case (483.3 kg/ha). Cost benefit analysis also proved that Propiconazole (1.7) and Sulphur (1.6) are the best options for managing soyabean rust.

Among, five fungicides evaluated against pearl millet rust under field conditions, Propiconazole 25% EC @ 0.1% recorded the least rust severity (21.7%), highest seed yield (514.7 kg/acre) and 1000 seed weight (8.13 g) with highest benefit: cost ratio of 3.98 (Table 2). Nagarajan and Patil (2014) evaluated three fungicides *viz.*, Hexaconazole, Propiconazole and Triadimefon against pearl millet rust under field condition and reported that Hexaconazole @ 0.1% recorded the least rust severity (15.30%), highest seed yield (30.50 q/ha) and 1000 seed weight (10.51g) with highest benefit: cost ratio of 2.40.in present investigation grain yield in all the treatments of fungicides was significantly superior in comparison to control under field condition, maximum grain yield (514.7 kg/acre) and test weight (8.13 g) was observed in Propiconazole 25% EC (0.1%) sprayed plot followed by Hexaconazole 5% EC (0.1%) treated plot (480.0 kg/acre and 7.77 g) as compared to control (360.0 kg/acre and 6.37g). The Maximum B: C ratio of 3.98: 1 was observed in Propiconazole 25% EC (0.1%) followed by Hexaconazole 5% EC (0.1%) (3.38: 1), Copper oxychloride 50% WP @ 0.2% (2.59: 1), Carbendazim 50% WP @ 0.2% (2.43: 1), Mancozeb 75% WP @ 0.2% (2.27: 1) and Azadirchtin 0.15% EC (2.16: 1) (Table 2).

Biocontrol agents offer great potential in managing the disease. *Trichoderma* sp. are considered as one of the most important biocontrol fungi for improving plant growth and protecting crops from several fungal plant pathogens (Harman 2000). Rust of pearl millet managed to the extent 30% under screen house condition and 43.3% under field condition with *Trichoderma viride* (3%) spray and it was found significantly superior in comparison to control having rust severity of 56.7% under screen house condition and 91.7% under field condition. Bhushan *et al.* (2014) reported that *Trichoderma harzianum* an antagonistic isolate was able to cause significant reduction in seed-borne mycoflora

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in comparison with *Trichoderma viride* and *Trichoderma hamatum* in *Pennisetum americanum*.

The anti- fungal activity of Azadirachtin 0.15 % EC (1500 ppm) was studied against *Puccinia substriata* var. *penicillariae*. It was observed that in Azadirachtin 0.15 % EC (1500 ppm) treated plot disease was reduced 28.3% (under screen house conditions) and 41.7% (under field conditions) and yield increased significantly 440.0 kg/acre under field condition in comparison to control (360 kg/acre). Under field condition in Azadirachtin 0.15 % EC (1500 ppm) treated plot per cent increase in yield over control and Benefit: cost ratio was 22.22 and 2.16:1 respectively. Rao (2009) revealed that plant received the foliar spray with azadirachtin (0.03%) @ 3 mL/L on 30 and 45 DAS recorded lesser incidence of *Alternaria* leaf blight and powdery mildew. Zade *et al.* (2005) tested *in vitro*, the leaf extracts of neem (*Azadirachta indica*), mehandi (*Lawsonia inermis*), sadaphuli (*Catharanthus roseus*), bael (*Aegle marmelos*), custard apple (*Annona squamosa*) and marigold (*Tagetes patula*) at 50 and 100 per cent concentrations against *Puccinia arachidis*. Among the leaf extracts, the neem leaf extract at both concentrations was the best, followed by mehandi leaf extract at 100 per cent concentration. Kishore and Pande (2005) noted that aqueous leaf extracts of Datura metel and *L. inermis*, known for their high antifungal activity against *Phaeoisariopsis personata* completely inhibited the germination of uredospores of *Puccinia arachidis in vitro*.

Gopal *et al.* (2003) conducted an experiment to determine the efficacy of Difenoconazole (0.1 and 0.5%), Propiconazole (0.1 and 0.05%) and Chlorothalonil (0.25%), as well as different combinations of Tridemorph (0.1%), Carbendazim (0.05%) and Mancozeb (0.2%) in controlling late leaf spot and rust of groundnut. They 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). The incidence of late leaf spot and rust were lowest with the application of Carbendazim 0.05% and Tridemorph 0.1%, respectively. Rojasara *et al.* (2010) evaluated nine fungicides against rust (*Puccinia arachidis*) *in vivo* on groundnut variety GG - 2. Among them Difenoconazole (0.0125%) was the most effective fungicides in controlling the disease (62.43%) followed by Hexaconazole (59.22 %), Tridemorph (54.38%) and Propiconazole (50.03%). The highest pod (1307 kg/ha) and fodder (5173 kg/ha) yield was also recorded in the treatment Difenoconazole. Sunkad *et al.* (2005) tested the bioefficacy of six fungicides for the control of leaf spots and rust disease of groundnut in Karnataka. They recorded maximum disease control with higher dry pod and fodder yield in Hexaconazole, Difenoconozole and Propiconazole treatments. The Mancozeb gave better control of rust. Tirmali and Pawar (2000) examined the efficacy of different fungicides *viz.*, Mancozeb 0.2%, Carbendazim 0.2%, Neem (Neemata) at 5% and Cu chemicals (Copper & Boron at 1000 ppm, K at 30 and 60 kg/ha) against the rust disease of groundnut. All the fungicide and chemical treatments significantly reduced the disease incidence over the control. The Mancozeb was the most effective as it resulted in the highest per cent disease control (47.77%) and the lowest disease intensity (39.99%). This treatment also gave the highest values for pod yield (24.09 q/ha) and per cent increased in yield over control (70.61%).

These results indicate that Propiconazole is the best cost effective options for managing pearl millet rust. Since Propiconazole being a selective fungicide has more chances of development of resistance, so it should be used in conjunction with a non-selective fungicide which will minimize the chances of development of resistance.

Table.1: /Effect of plant product, bioagent and fungicides against pearl millet rust under screen house conditions

S. No.	Treatment	Germination (%)	Mean no. of tillers	Per cent rust severity at maturity
1.	Azadirachtin 0.15 % EC @ 1500 ppm	69.3 **(56.47)***	17.3	28.3 **(32.07)***
2.	Carbendazim 50% WP @ 0.2%	60.0 **(50.87)**	15.0	20.0 **(26.13)**
3.	Mancozeb 75% WP @ 0.2%	61.3 **(51.54)**	15.3	26.7 **(31.05)**
4.	Copper oxychloride 50% WP @ 0.2%	65.3 **(53.99)**	16.3	18.3 **(24.99)**
5.	Propiconazole 25% EC @ 0.1%	70.7 **(57.34)**	17.7	11.7 **(19.29)**

6.	Hexaconazole 5% EC @ 0.1%	62.7 **(52.40)**	15.7	15.0 **(22.28)**
7.	*Trichoderma viride* @ 3%	64.0 **(53.18)**	16.0	30.0 **(33.14)**
8.	Control (unsprayed)	64.0 **(53.12)**	16.0	56.7 **(48.87)**
	CD at 5%	NS	NS	10.75

* Figures in the parenthesis are angular transformed values, Date of first appearance of Rust **14/10/2015,** Date of observation **03/11/2015**

Table.2: Effect of plant product, bioagent and fungicides against pearl millet rust under field conditions

S. No.	**Treatment**	**Germination (%)**	**Mean no. of plants in each plot**	**Per cent rust severity at maturity**	**Grain yield at maturity (kg /acre)**	**Per cent increase in yield over control**	**B:C ratio**	**Test weight (g)**
1.	*Azadirachtin* 0.15 % EC @ 1500 ppm	69.4 **(56.42) ***	208.3	41.7 **(40.15)***	440.0	22.22	2.16:1	6.99
2.	Carbendazim 50% WP @ 0.2%	69.4 **(56.43)**	208.3	36.7 **(37.10)**	457.8	27.16	2.43:1	7.60
3.	Mancozeb 75% WP @ 0.2%	78.1 **(62.58)**	234.3	38.3 **(38.22)**	444.4	23.44	2.27;1	7.50
4.	Copper oxychloride 50% WP @ 0.2%	75.8 **(60.89)**	227.3	28.3 **(32.00)**	471.1	30.86	2.59:1	7.73
5.	Propiconazole 25% EC @ 0.1%	76.2 **(61.06)**	228.7	21.7 **(27.69)**	514.7	42.97	3.98:1	8.13
6.	Hexaconazole 5% EC @ 0.1%	78.8 **(62.62)**	236.3	26.7 **(30.98)**	480.0	33.33	3.38:1	7.77
7.	*Trichoderma viride* @ 3%	77.7 **(61.79)**	233.0	43.3 **(41.10)**	426.7	18.52	0.79:1	6.57
8.	Control (unsprayed)	74.9 **(59.95)**	224.7	91.7 **(76.24)**	360.0	_	_	6.37
	CD at 5%	NS	NS	10.78	29.93			0.389

* Figures in the parenthesis are angular transformed values, Date of first appearance of Rust **10/10/2015,** Date of observation **05/11/2015**

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