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Management of pearl millet downy mildew by the application of bio-agents, chemicals and botanical

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Abstract
Pearl millet (*Pennisetum glaucum* (L.)R.Br.) Popularly known as bajra is a major warm-season cereal, largely grown under rainfed conditions in India. Downy mildew incited by *Sclerospora graminicola* (Sacc.) Schroet is the most widespread and destructive disease of pearl millet in India. The disease was observed two weeks after sowing as chlorotic strips on the upper surface of the leaves which progresses from base to top majority of infected plants were fail to form normal healthy earheads which ultimately effected the yield. The bio agent viz., *Psuedomonas fluorescence, Bacillus subtilis, Trichoderma viride* and*Trichoderma harzianum* were evaluated as seed dresser. The fungicide viz., Metalaxyl @ 6g/kg and Amectoctradin + Dimethomorph @ 0.4 ml/ 500 ml water were also evaluated as seed dresser while Mancozeb @ 0.2% and Neem leaf extract @10% were applied once as foliar application. Foliar application of Mancozeb @ 0.2% was found most effective in respect of significant reduction of downy mildew (2.28%) and grain yield enhancement2025 kg/ha as compare to control in which 10.19% and 1679 kg/ha disease incidence and yield was recorded respectively. For the control of downy mildew Mancozeb was significantly superior over all the tested bio agent seed dressing and also with the seed dressing with Amectoctradin+ Dimethomorph @0.4 ml/ 500 ml waterwhiles it was statistically at par with metalaxyl seed dressing and application of Neem leaf extract @ 10%. Foliar application of Neem leaf extract @10% and seed dressing with Metalaxyl @ 6g/kg also significantly checked the downy mildew and these two were significantly superior over the seed dressing with all the tested bio agents also. The encouraging result of neem leaf extract as foliar application gives a sign that it may act as an alternative to the fungicides in the light of an eco-friendly management of pearl millet downy mildew.

Keywords: Pearl millet, Mancozeb, Neem, *Trichoderma harzianum*, Seed dressing, bio-agents

Introduction
Pearl millet (*Pennisetum glaucum*) is a staple cereal grown on about 29 million ha in the arid- and semi-arid tropical regions of Africa, Asia and Latin America with India having the largest area of 9.3 million ha (http:// www.icrisat.org/PearlMillet/PearlMillet.htm). The crop is grown as a nutrient-rich food source for humans as well as a forage/fodder crop for livestock. In India, pearl millet is cultivated over an area of 79.52 lakh ha with the production of 87.96 lakh tones and the productivity is 1106 kg/ha. It occupies 1.87 lakh ha with an annual production 3.05 million tonns and productivity of 1698 kg/ha. Rajasthan ranks first with an area of 3.98 mha and annual production 38.7 million tons (Anon., 2014) [1]. Amongst various diseases affecting Pearl millet crop, Downy mildew [*Sclerospora graminicola, (*Sacc). Schroet] is a highly destructive and widespread disease in most pearl millet growing areas of Asia and Africa. Pesticides are necessary at present but are not a long term solution for crop health; besides their non-target effects, hazardous to nature and expensive, some of them are losing their effectiveness, because of development of resistant strains. For quick screening against downy mildew, assaying resistance in terms of biogenetic parameters which are less influenced by the environment would be more reliable (Murthy, 1980). Use of bio control agents in integrated management of pearl millet downy mildew is the requirement of current era to avoid all inherent ill effects *viz*., environmental pollution, residual toxicity, development of resistance by the pathogen, cost ineffectiveness etc. caused by the continuous use of chemicals apart from this use of botanicals, bio-agents, and other non-chemical management approaches may also serve as an alternate line for the eco-friendly management of the disease under field condition.

Material and Methods

The present study was conducted at Research Farm, College of Agriculture, Gwalior during *kharif* season of 2016. Gwalior is situated in Northern part of Madhya Pradesh at an elevation of 211.52 meters from mean sea level and lies between latitude and longitude 26º14' North and 78º15' East, respectively. The detail of the experiment is as follows:-

Design: RBD Variety: PAC-909
Replications: 04 Treatments: 10
Plot size: 4 m X3 m
T1-*Trichoderma viride* (MYS 13@4g/Kg of seed)
T2-*Trichoderma viride* (TNAUTv-1@4g/Kg of seed)
T3-*Bacillus subtilis* (TNAU EPCo16 @8g/Kg of seed)
T4-*Pseudomonasfluorescence* (MYS 14 @8g/Kg of seed)
T5-Metalaxyl (@6g/Kg of seed)
T6-Seed treatment with Metalaxyl (@6g/Kg of seed)+transplanting
T7-Transplanting without seed treatment
T8-Foliar application of Mancozeb @ 0.2%
T9- Foliar application of Neem leaf extract @ 10%
T10-Control

The total numbers of plants were recorded at the time of thinning i.e. fifteen days after sowing, while the numbers of downy mildew infected plants were recorded at 30 and 60 days after sowing. Then the Downy mildew incidence per cent was calculated with the help of following formula:

$$\text{Downy mildew incidence (\%)} = \frac{\text{Downy mildew infected plants}}{\text{Total number of plants}} \times 100$$

Result and Discussion

The bio-agent, botanicals and plant extracts when evaluated against downy mildew and were compared with recommended chemical and control. The data on disease incidence was recorded at 60 days after sowing and the data are summarized in table.1 (Fig 1). At 60 days after sowing none of this treatments remained completely free from downy mildew, but its minimum incidence (2.28%) was recorded in the treatment foliar application of Mancozeb @ 0.2% T8 followed by T7 (Metalaxyl @ 6g/kg) (4.3%) and T9 foliar application of Neem leaf extract @ 10% (4.33%)**,** T6 Amectoctradin+Dimethomorph (0.4ml/500 ml water) (5.8%),,T1 *Pseudomonas fluorescens* (MYS14@8g/Kg) (7.00%),T3 *Trichoderma viride* (MYS 13 @4g/kg) (7.3%), T2 *Bacillus sublitis* (TNAUEPCO 16@8g/Kg) (8.10%), T5 *Trichoderma harzianum* (JAU @8g/kg) (9.3%) and T4 *Trichoderma viride* (TNAU Tv-1 @4g/kg) (10.1%) while the maximum downy mildew incidence 10.19% was recorded in control. The treatment T8 foliar application of Mancozeb @ 0.2**%**was significantly superior over all treatments and untreated control. Pandya *et al.* (2000) [5] reported that the seed treatment with metalaxyl (Apron 35 WS) 2 g ai/kg seed controlled downy mildew up to 20-22 days after sowing (DAS). Seed treatment by Apron 35 WS 2 g ai/kg seed followed by one spray of Ridomil MZ 72 WP (metalaxyl + mancozeb) at 4 g/l at 20 DAS gave the best results, with the disease incidence 4.63 and 41.59% as compared to 39.10 and 69.92% in control at 30 and 60 DAS, respectively. Development of malformed ear heads was also controlled significantly in the Ridomil sprayed plots (13.39%) as compared to control (46.99%) and also gave 15% more grain yield than the control. Seed treatment with Aliete [Aliette] [Aluminum tris-o-ethyl phosphate] alone at 5 g/kg seed was ineffective in controlling downy mildew. Similar findings are also given by Gupta *et al*., (2014) [2]. The Mancozeb @ 0.2%also gave maximum grain (2025 kg/ha.) is followed by T5 *Trichoderma harzianum* (JAU @8g/kg) (1944 kg/ha.), (Metalaxyl @ 6g/kg (1927 kg/ha.)**,** *Trichoderma viride* (TNAU Tv-1 @4g/kg) (1830 kg/ha.),Neem leaf extract @10 (1802 kg/ha.), and Amectoctradin+Dimethomorph (0.4ml/500 ml water) (1769 kg/ha.). Three treatments were found with minimum grain yield viz, *Pseudomonas fluorescens* (MYS14@8g/Kg) (1627 kg/ha.), *Bacillus subtilis* (TNAUEPCO 16@8g/Kg (1621 kg/ha), and *Trichoderma viride* (MYS 13 @4g/kg) (1444kg/ha.) than control yield (1679 kg/ha.) It indicate the overall effect of the treatment on grain yield was found not significantly. Similarly, Latake and Kolase (2007) [3] screened *Trichoderma viride, T. harzianum, T. hamatum* and *Pseudomonas fluorescens* against downy mildew of pearl millet and reported seed treated with *T. viride, T. harzianum, T. hamatum and P. fluorescens* were the most promising in reducing the disease incidence with increase in emergence of crop and grain yield. Patidar (2007) [6] reported significant control of pearl millet downy mildew by seed dressing with *Bacillus pumulis* in combination with Apron (3 g/kg seed), and Apron seed dressing alone (6 g/kg seed). The full dose of Apron alone was more effective than its half dose in combination with *Bacillus pumulis* at tillering stage of the crop, but at dough stage the combined treatments was more effective than the Apron alone in respect of disease and yield both. Pearl millet seed dressing with Apron 35 SD @ 6 g/kg seed, *Bacillus pumulis* (INR 7) and chitosan significantly checked the incidence of downy mildew at 30 and 60 days after sowing (Rajput, 2009) [8]. Similarly, Pooja and Kushal (2016) [7] conducted field trials to manage downy mildew, minimum disease incidence (9.3%) was observed in treatment of Chitosan + Bacillus pumulis with maximum germination percentage of 53.5% and grain yield (1091.7 kg/ha).

Table 1: Evaluation of chemicals, bio-agents and neem leaf extract against downy mildew of pearl millet.

S. No	Treatment	DM incidence (%) at dough stage	Grain yield kg/ha.
1	*Seed treatment with Pseudomonas fluorescens* (MYS14@8g/Kg)	7.00(15.34)	1627
2	*Seed treatment with Bacillus subtilis* (TNAUEPCO 16@8g/Kg)	8.10 (16.43)	1621
3	*Seed treatment with Trichoderma viride* (MYS 13 @4g/kg)	7.3(15.68)	1444
4	*Seed treatment with Trichoderma viride* (TNAU Tv-1 @4g/kg)	10.1(18.53)	1830
5	*Seed treatment with Trichoderma harzianum*(JAU @8g/kg)	9.3(17.76)	1944
6	*Seed treatment with* Amectoctradin + Dimethomorph (0.4ml/500 ml water)	5.8(13.94)	1769
7	*Seed treatment with* Metalaxyl (6g/kg)	4.3(11.97)	1927
8	Foliar application of Mancozeb @ 0.2%	2.28(9.63)	2025
9	Foliar application of Neem leaf extract @10%	4.33(11.97)	1802
10	Control (Untreated)	10.19 (18.53)	1679
	SEm±	**0.988**	**108.70**
	CD at 5%	2.881	317.22

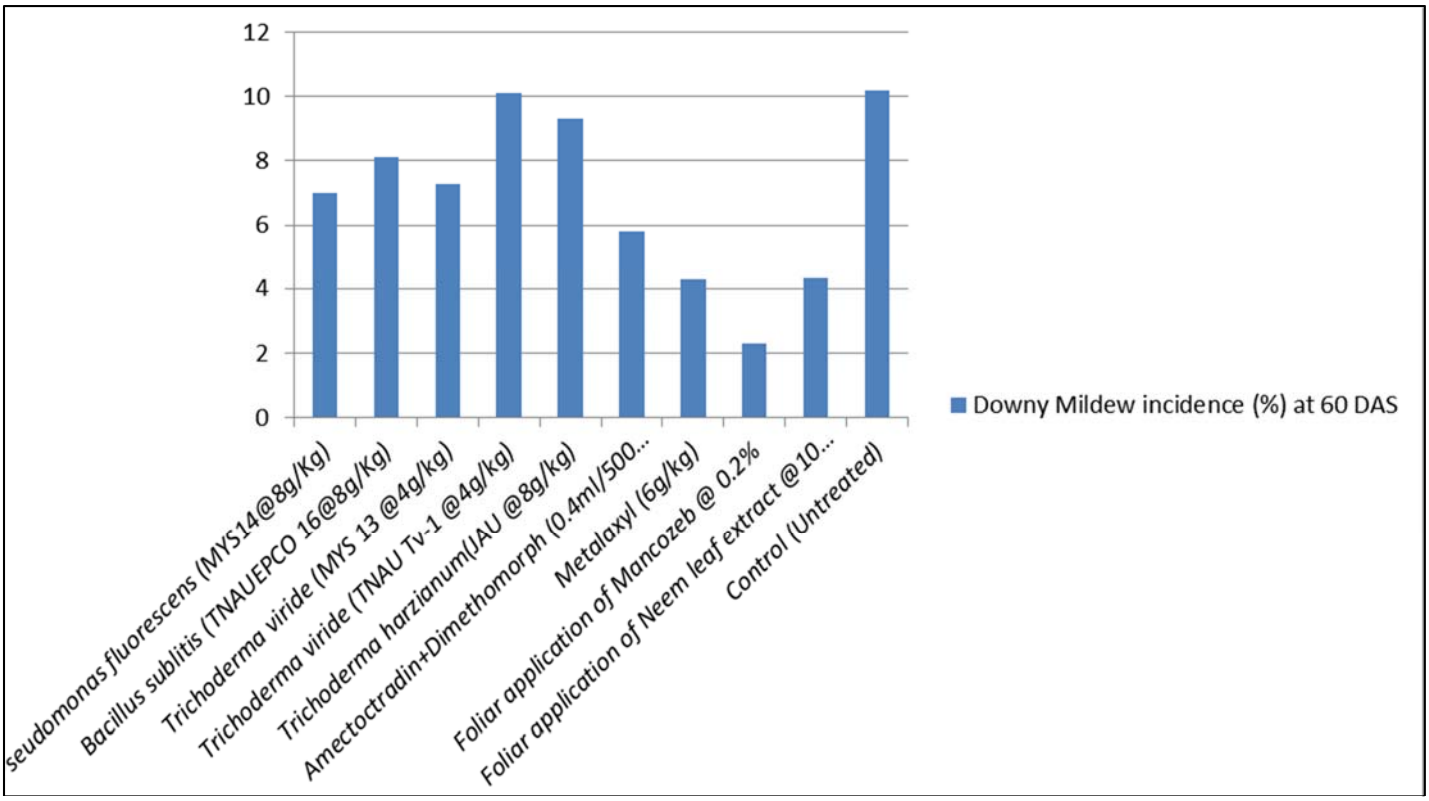

Fig 1: Downy Mildew incidence (%) at 60 DAS

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