

Management of pearl millet downy mildew by the application of bio-agents and fungicides

Comment [c1]: Please check if the word "bioagent" includes a dash, since other similar terms do not.

Abstract

Pearl millet (*Pennisetum glaucum* (L.) R.Br.) Popularly known as bajra, it 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 progressed from base to top. The majority of infected plants failed to form normal, healthy earheads. The bioagents, viz., seed treatment with *Trichoderma harzianum* (6 g/kg seed), treatment with *Pseudomonas fluorescens* (8 g/kg seed), treatment with *Trichoderma viride* (6 g/kg seed) and Neem oil and water, were also evaluated as seed dressers. The fungicides, viz., Mancozeb at 0.2%, Neem oil, Metalaxyl at 0.25%, and Carbendazim at 0.25%, were effective in terms of a significant reduction of downy mildew (2.83%) as compared to the control, in which 40.33% disease incidence was recorded, respectively. For the control of downy mildew, neem oil was significantly superior over all the tested bioagent seed dressings, as well as the seed dressing with Seed treatment with *Pseudomonas fluorescens* at 8 g/kg seed was statistically at par with seed treatment with *Trichoderma harzianum* at 6 g/kg seed and application of Metalaxyl at 0.25%. Foliar application of Mancozeb at 0.2 % and seed treatment with Metalaxyl (6 g/kg seed) + spray of Propiconazole at 25% EC at 0.25% also significantly checked the downy mildew, and these two were significantly superior over the seed dressing with all the tested bioagents. The encouraging result of neem oil as foliar application gives a sign that it may act as an alternative to fungicides in the light of eco-friendly management of pearl millet downy mildew.

Comment [c2]: Check the punctuation and spacing, as they are inconsistent with the rest.

Comment [c3]: Ensure proper use of capitalization. Change the 'P' to a lowercase 'p'.

Comment [c4]: Verify the correct term, is it "seed dresser" or "seed dressing"?

Comment [c5]: This phrase is unclear. Did you mean that the bioagents were applied as seed treatments, while neem oil and water were used as seed dressings?

Comment [c6]: Ensure proper use of capitalization. Change the 'S' to a lowercase 's'.

Comment [c7]: "Checked" is not the appropriate term. You may use

Comment [c8]: Did you apply it as a foliar treatment or as a seed treatment?

Keywords: pearl millet, bio-agents, fungicides.

Comment [c9]: According to the journal guidelines, provide at least 4-8 keywords. Also, organize the keywords alphabetically and remove the period after the final keyword. Additionally, exclude any words from the title when listing the keywords. You may include keywords such as seed treatment, seed dressing

Comment [c10]: Delete the full stop

Comment [c11]: Review the comment above for punctuation and spacing, as they may not be consistent with the rest.

Comment [c12]: Use parenthesis instead of square brackets

Comment [c13]: Adhere to the standard format for writing in-text citation. The full stop should be placed only after the in-text citation.

Introduction

The world's poorest and most food-insecure societies are found in Asia and Africa's dry, semi-arid, tropical, and subtropical regions, where pearl millet [*Pennisetum glaucum* (L.) R. Br.] is a special crop that serves as a staple food, suitable for cattle, and an important grain. Other names for it include Bajra, Bulrush, and Spiked Millet. It is a C₄ cereal plant that is diploid, with chromosomal number 2n = 14, and is native to central Africa (Wilson et al., 1989). In Africa and India, 90% of the world's pearl millet is produced. Approximately 10% of all food grain production is contributed by pearl millet. With an annual area of 684.1 thousand hectares, India has a production of 978.1 thousand tons and a productivity of 14.30 mt/ha. (Anonymous, 2022). Pesticides are necessary at present but are not a long-term solution for crop health. Besides their non-target effects, being hazardous to nature, and being expensive, some of them are losing their effectiveness because of the development of resistant strains. For quick screening against downy mildew, assaying resistance in terms of biogenetic parameters that are less influenced by the environment would be more reliable. Murthy (1983). The use of biocontrol agents in integrated management of pearl millet downy mildew is the requirement of the 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

Comment [c14]: Refer to the comment above: "Adhere to the standard format for writing in-text citations." The full stop should be placed only after the in-text citation. Additionally, the citation should be written as (Murthy, 1983) instead of Murthy (1983).

this use of botanicals and bio-agents, management approaches may also serve as an alternate line for the eco-friendly management of the disease under field conditions.

Material and Methods

The present study was conducted at Research Farm Rainfed Organic Agriculture Research Farm Narayan Bagh, Institute of Agricultural Sciences, Department of Plant Pathology, Bundelkhand University, Jhansi (Uttar Pradesh) during the *Kharif* season of 2023. It is situated at 78°36 E Longitude and 25°27 N Latitude and is about 178.37 m above mean sea level. The climate is subtropical and semi-arid. The details of the experiment are as follows: Design: RBD, Variety: Leo-7601, Replications: 3, Treatments: 9, Spacing: row: 40cm x plant: 10cm, Plot size: 2 m x 2 m.

T₁: Metalaxyl @ 0.25%

T₂: Carbendazim @ 0.25%

T₃: Seed treatment with Metalaxyl @ 6g/kg seed + Spray of Propiconazole 25% EC @ 0.25%

T₄: Mancozeb @ 0.2 %

T₅: Seed treatment with *Trichoderma harzianum* @ 6g/kg seed

T₆: Seed treatment with *Pseudomonas fluorescens* @ 8g/kg seed

T₇: Seed treatment with *Trichoderma viride* @ 6g/kg seed

T₈: Neem oil

T₉: Control

Comment [c15]: Check the spelling; it should be "spacing"

Comment [c16]: Insert spacing

Comment [c17]: Insert spacing

Comment [c18]: It would be much better if the author considered adding a subtitle for the paragraph.

Comment [c19]: Use "at" instead of the symbol "@" and apply this change to all instances for consistency.

Comment [c20]: Check the spacing

Downy mildew incidence (%):

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

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

Comment [c21]: Replace the phrase with "using" instead.

Seedling emergence

$$\text{Percent seedling emergence} = \frac{\text{Number of seeds germinates}}{\text{Total number of seeds sown}} \times 100$$

Result and Discussion

The bioagents and fungicides when evaluated against downy mildew and were compared with the recommended chemicals and controls. The average number of plants were maximum with seed treatments of Metalaxyl at 0.25% (160.14) and Carbendazim at 0.25% (155.3), followed by seed treatment with Metalaxyl at 6 g/kg seed + Spray of Propiconazole 25% EC at 0.25% (149.77), Mancozeb at 0.2% (145.88), Neem oil (138.8), seed treatment with *Trichoderma harzianum* at 6 g/kg seed (129.83), seed treatment with *Trichoderma viride* at 6 g/kg seed (125.27) and seed treatment with *Pseudomonas fluorescens* @ 8 g/kg seed (121.43) in comparison to control where minimum number of plants (111.8).

Comment [c22]: Replace "when" with "were"

Comment [c23]: Do not italicize

Accordingly, seed treatment with Metalaxyl at 0.25% (55.38) and Carbendazim at 0.25% (52.95) was followed by seed treatment with Metalaxyl at 6 g/kg seed + Spray of Propiconazole at 25% EC at 0.25% (51.53), Mancozeb at 0.2% (48.58), seed treatment with *Trichoderma harzianum* at 6 g/kg seed (45.62), seed treatment with *Pseudomonas fluorescens* at 8 g/kg (43.52), neem oil (41.57), and seed treatment with *Trichoderma viride* at 6 g/kg (40.9), in comparison to the control where the minimum number of plants (38.47).

Comment [c24]: The paragraph is unclear. Revise and check for grammatical accuracy.

Amongst different treatments, neem oil was significantly effective in reducing the incidence of pearl millet downy mildew to a minimum of 1.52% in comparison to 33.97 per cent in control at 30 days after sowing. Seed treatment with *Pseudomonas fluorescens* at 8 g/kg seed ranked next (2.25%), followed by seed treatment with *Trichoderma harzianum* at 6 g/kg seed (3.37%), seed treatment with *Trichoderma viride* at 6 g/kg seed (4.11%), Metalaxyl at 0.25% (4.63%), mancozeb at 0.2% (6.1%), carbendazim at 0.25% (7.53%), seed treatment with Metalaxyl (@ 6 g/kg seed + Spray of Propiconazole 25% EC @ 0.25% (8.42%) Pandya et al. (2000) reported that the seed treatment with Metalaxyl 2 g/kg seed controlled downy mildew up to 20–22 days after sowing (DAS). Similar findings are also given by Gupta et al. (2014). Similar findings are also given by Sasode et al. (2017).

Comment [c25]: Rephrase the sentence. Additionally, cite the reference in the bibliography.

At 60 days after sowing, neem oil was significantly superior in reducing the incidence of pearl millet downy mildew to a minimum of 2.83% in comparison to 40.33 per cent in the control. Seed treatment with *Pseudomonas fluorescens* at 8 g/kg seed ranked next (4.43%), followed by seed treatment with *Trichoderma harzianum* at 6 g/kg seed (6.5%), seed treatment with *Trichoderma viride* at 6 g/kg seed (7.72%), metalaxyl at 0.25% (8.09%), mancozeb at 0.25% (12.13%), carbendazim at 0.25% (14.23%), and seed treatment with metalaxyl at 6 g/kg seed + spray of Propiconazole at 25% EC at 0.25% (16.1%). Pearl millet seed dressing with Apron 35 SD at 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). Similarly, Pooja and Kushal (2016) conducted field trials to manage downy mildew. A minimum disease incidence of 9.3% was observed in the treatment of Chitosan and *Bacillus pumulis*, with a maximum germination percentage of 53.5%.

Comment [c26]: The scientific name should be italicized. Additionally, check the species to determine whether it is "pumulus" or "pumilis."

Comment [c27]: Same as the comment above, the scientific name should be italicized. Additionally, check the species to determine whether it is "pumulus" or "pumilis."

References

1. Anonymous, (2022). <https://www.indiastatagri.com/table/agriculture/area-production-productivity-bajra-india-1949-1950/7267>.
2. Murthy SE, Nagarajan C, Parasade MN, Ravvendran TS, Shanmugam N. Identification of the sources of resistance to pearl millet downy mildew. On Breeding Crop Plants for Resistance to Pests and Diseases, Tamil Nadu Agric. Univ. Coimbatore, Tamil Nadu, India, 1983.
3. Pandya RK, Singh Reeti, Tripathi ML. Efficacy of metalaxyl and Aliete on downy mildew of pearl millet. Crop Res. Hisar. 2000; 20(1):134-136.
4. Pooja S, Kushal R. Evaluation of bioagents for management of downy mildew of pearl millet caused by *Sclerospora graminicola* (Sacc.) Schroet. Forage Res. 2016; 42(1):44-47.
5. Rajni Singh Sasode, RK Pandya and Pramod Kumar Fatehpuria (2017). Management of pearl millet downy mildew by the application of bio-agents, chemicals and botanical, *International Journal of Chemical Studies* 2018; 6(1): 606-608.
6. Rajput SS. Pearl millet downy mildew status in Northern Madhya Pradesh and its integrated management. M. Sc. (Ag) Thesis Plant Pathology, JNKVV, Jabalpur, 2009.

Comment [c28]: Adhere to the standard referencing style or format specified by the journal.

Comment [c29]: Omit the use of blue-colored text in the references and do not underline any text.

7. Wilson, J. P., and R. N. Gates, (1993). Forage yield losses in hybrid.

Table: - 1. Evaluation of various biocontrol agents against downy mildew of pearl millet during kharif2023 under field conditions.

Treatments	Average no. of plants	Per cent Seedling emergence	Downy mildew incidence Per cent at 30 DAS	Downy mildew incidence Per cent at 60 DAS
Metalaxyl @ 0.25%	160.14	55.38 (7.48)	4.63 (2.26)	8.09 (2.93)
Carbendazim @ 0.25%	155.3	52.90 (7.31)	7.53 (2.83)	14.23 (3.84)
Seed treatment with Metalaxyl (@ 6g/kg seed + Spray of Propiconazole 25% EC @ 0.25%	149.77	51.53 (7.21)	8.42 (2.99)	16.1 (4.07)
Mancozeb @ 0.2 %	145.88	48.58 (7.01)	6.1 (2.57)	12.13 (3.55)
Seed treatment with <i>Trichoderma harzianum</i> (@ 6g/kg seed	129.83	45.62 (6.79)	3.37 (1.97)	6.5 (2.65)
Seed treatment with <i>Pseudomonas fluorescens</i> @ 8g/kg seed	121.43	43.52 (6.63)	2.25 (1.66)	4.43 (2.22)
Seed treatment with <i>Trichoderma viride</i> (@ 6g/kg seed	125.27	40.9 (6.43)	4.11 (2.15)	7.72 (2.87)
N neem oil	138.8	41.57 (6.49)	1.52 (1.41)	2.83 (1.82)
Control	111.8	38.47 (6.24)	33.97 (5.87)	40.33 (6.39)
S. Em±	0.849	0.018	0.053	0.033
C.D. @ 5%	2.545	0.053	0.160	0.098

All data are means of three replications.

*Figures in parentheses are angular transformed value.

Comment [c30]: Delete the colon and dash symbols.

Comment [c31]: Combine it into one word

Comment [c32]: Ensure proper use of capitalization. Change the 'S' to a lowercase 's'.

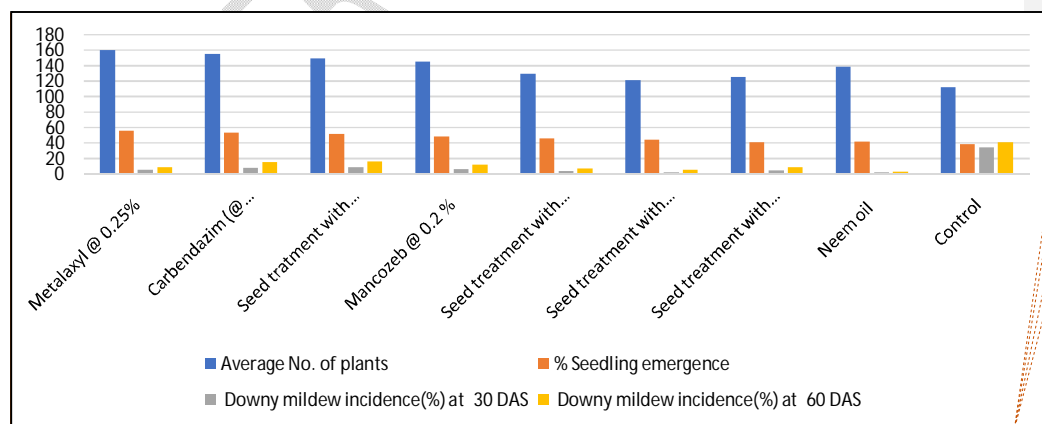
Comment [c33]: Ensure proper use of capitalization. Change the 'P' to a lowercase 'p'.

Comment [c36]: Ensure proper use of capitalization. Change the 'P' to a lowercase 'p'.

Comment [c34]: Combine it into one word

Comment [c35]: Specify the meaning of the acronym in the legend below the table.

Comment [c37]: Combine it into one word



Comment [c38]: It would be better to omit the line background inside the graph

Comment [c39]: Ensure proper use of capitalization. Change the 'N' to a lowercase 'n'.

Comment [c40]: Insert spacing in between "incidence" and "%"

Comment [c41]: Double-check the font size and font style and make any necessary revisions. Additionally, some words are missing in the treatment label, so it would be best to complete it. Also, verify the spelling of the word "treatment" in the bar graph column.

Fig: - 1 Evaluation of various biocontrol agents against downy mildew of pearl millet during kharif 2023 under field conditions.

Comment [c42]: Delete the colon and dash symbols.