Plant Archives Vol. 24, Special Issue (GABELS), 2024 pp.551-556 e-ISSN:2581-6063 (online), ISSN:0972-5210

Plant Archives

Journal homepage: http://www.plantarchives.org
DOI Url : https://doi.org/10.51470/PLANTARCHIVES.2024.v24.SP-GABELS.082

EFFICACY OF ORGANIC AMENDMENT AND BIOAGENTS ON THE MANAGEMENT DOWNY MILDEW DISEASE OF SORGHUM CAUSED BY *PERONOSCLEROSPORA SORGHI.*

Shahnashi Hashmi*, Anshul Natani and Mehjabi Hashmi
Department of Plant Pathology, Institute of Agricultural Sciences, Bundelkhand University, Jhansi, Uttar Pradesh, India
*Corresponding Author mail: shahnashi@gmail.com

ABSTRACT

Present investigation was carried out in field condition. To test the effectiveness of different organic amendments and bio-agents against downy mildew disease of sorghum. In this experiment total six organic amendments *viz.,* FYM, vermicompost, Coco Peat, neem cake, Mustard cake, Jeevamrit and two bio-agents *viz. Trichoderma spp* and *Pseudomonas spp* were evaluated. The results revealed that, minimum 18.80 and 21.25 per cent disease incidence was recorded in T6 (Soil application of *Trichoderma* spp @ 10g/m^2) followed by 19.70 and 4.80 per cent disease incidence in T_7 (Soil application of *Pseudomonas* @ 10 g/m^2) respectively. Whereas maximum 26.80 and 29.88 per cent disease incidence were recorded in T3 (Soil application of Coco Peat 100g/m$^{2)}$ followed by 25.10 and 28.33 per cent disease incidence in T5 (Soil application of Mustard cake @ 10 g/m^2) after 30 and 60 days after sowing. In case of control (T9) 30.75 and 36.33 per cent disease incidence was recorded. On the basis of present investigation, it can be concluded that the used of *Trichoderma* spp @ 10g/m^2 as a soil application, may be recommended for the management *Peronosclerospora sorghi.*

***Keywords*:** sorghum, *Peronosclerospora sorghi.* disease incidence, bio-agents and organic amendment

Introduction

Sorghum (*Sorghum bicolor* L. Moench), is one of the most important cereal and forage crops in Egypt and all over the world. It is the fourth most important cereal crops after wheat, rice and maize. Globally, sorghum production was estimated at 60.06 million tonnes in 2021-22. The Nigeria stands first in total production with 7 million tonnes (12%), followed by United States of America. India ranks fifth in total sorghum production with 4.23 million tonnes grown in an area of 3.90 million hectares in 2021-22, whereas in kharif 2022-23, sorghum production was 1.69 million tonnes in an area of 2.94 million hectares. Andhra Pradesh produced 2.43 lakh tonnes of sorghum (contributing 5.74 % to total country production) cultivated in 0.77 lakh hectares with a productivity of 3156 kg/hectare in 2021-22. According to 1st advance estimates during 2022-23, sorghum was grown in 0.06 lakh hectares with a production of 0.06 lakh tonnes and productivity was 1038 kg/ha (des.ap.gov.in).

The fungal pathogens causing downy mildew diseases of plants belong to the family Peronoporaceae in the class Oomycetes. Several species are highly destructive to major crops, including pearl millet, sorghum, maize, sunflower, brassica, soybean, cucurbits, opium poppy, onion, grapes, and flowers, such as roses. The major genera causing downy mildews include *Peronospora, Plasmopara, Bremia, Pseudoperonospora, Sclerospora,* and *Sclerophthora.* Among all the downy mildew genera *Peronosclerospora sorghi* (Weston & Uppal) is a disease of worldwide importance on sorghum [*Sorghum bicolor* (L.) Moench]. The fungus produces both local and systemic infection of the crops (Bonde *et al.,* 1985) under favourable environmental conditions. The first systemic infection symptom can appear at any development stage from the young seedling (generally not earlier than first true leaf stage) (Safeeulla, 1976), up to flowering. Typical symptoms of systemic downy mildew infection on sorghum or maize begin with chlorosis at the base of a leaf called as the 'half-leaf' or 'partial leaf' symptom (Williams, 1984), which gradually covers a increasing proportion of successive leaves formed at later stages until the entire leaf is chlorotic.

Local lesions develop after approximately 7 days of conidial infection on the leaves at any growth stage (Cohen and Sherman, 1977). These lesions are elongated, 1-4 mm × 5-15 mm, yellowish in colour. Asexual sporulation occurs on the abaxial side of the lesions but oospore production has never been observed in local lesions. Local infection generally causes insignificant effect on yield (Safeeulla, 1976; Williams, 1984). Soil -borne oospores or aerially disseminated conidia cause systemic infection, whereas local infection is caused by conidia. The local infection acts as a source of inoculum for subsequent systemic infection on young plants.

Sorghum downy mildew incidence has direct impact on the sorghum grain yield since systemic infection results in barren inflorescence in most varieties. Infection of young seedlings causes early death or stunting, depending on stage of infection, resulting in loss of fodder (William, 1984). *P. sorghi* can cause significant yield losses under favourable environmental conditions and yields can be reduced up to 100% in susceptible cultivars depending on environmental conditions (Lukman *et al*., 2013). In India, incidence of 30-70% in Karnataka and Tamilnadu states and annual yield loss of 1×10^5 metric tonnes have been estimated.

Effective disease control through well informed disease management strategies can help contribute to sustainable food production in endemic areas, particularly those that support a burgeoning population. This research covers many aspects of the biology, epidemiology, and control of sorghum downy mildew-but does not claim to be comprehensive. Organic amendments, by using naturally occurring non-pathogenic, antagonistic has been considered as an environmentally safe and sustainable alternative for the management of diseases. The applied organic amendment and bio agents can compete with the pathogen for nutrients inhibit multiplication of pathogens by secreting antibiotics or lytic enzymes or reduce pathogen population through hyperparasitism. Sadoma *et al*. (2011) reported that bio agents (*Trichoderma* and *Pseudomonas*) and organic amendment inhibited germination of oospores and conidia of *P. sorghi*. Further, the authors reported that soil application and foliar application of botanicals and organic amendment or effectively reduced the incidence of downy mildew in maize under field conditions. In this study, the efficacy of various bio control agents and organic amendment selected based on previously determined antagonistic activity against other soil borne fungal pathogens. The aim of the present study was to find out the efficacy of biocontrol agents *Trichoderma* and *Pseudomonas fluorescens* and organic amendment for the management of downy mildew of Sorghum and for promoting plant growth was evaluated.

Materials and Method

In vivo experiment was conducted to evaluate different bioagents and organic amendments against *P. sorghi*. The experiment was conducted during Kharif season at organic Research Farm of Bundelkhand University, Jhansi, Uttar Pradesh. In present investigation six organic amendment viz., FYM @100 g/m^2, vermicompost 100g/m^2, Coco Peat 100g/m^2, neem cake @10 g/m^2 , Mustard cake @ 10 g/m^2 Jeevarit @ 10 % and two bio-agents *viz,. Trichoderma spp*@ 10 % and *Pseudomonas spp* @ 10% were taken. All the organic amendments *viz.,* FYM, vermicompost, Coco Peat, neem cake, Mustard cake were applied as a soil application and bioagents were applied as foliar spray. In control plot only water spray was given. Seven days after spraying, Plant Disease incidence was recorded in all the treatments and calculated the disease reduction in each treatment, per cent disease control.

Preparation of mass culture of bioagents:

Wheat grains were used for mass culture of fungal bio agents (*Trichoderma* spp.). Wheat grains were soaked overnight in water for 12 hours and then spreaded on towel paper to remove the extra water. Dextrose was added in wheat seeds @ 2% of seed and then 250 g of wheat grain were taken in each 500 ml conical flasks. Flasks with wheat grains were plugged with nonabsorbent cotton and wrapped with aluminum foil and sterilized in autoclave at 121^{0}C temperature at 15 lbs pressure/inch^2 for 15 minutes. Flask were taken out from autoclave allow to cool and kept on the bench of laminar flow. The conical flask containing wheat seed were inoculated with 5 mm diameter PDA discs punched from the periphery of actively growing 7 days old culture of *Trichoderma.* All inoculated conical flasks were incubated in a BOD incubator at 25±2 °C temperature. Bioagents were allowed to grow with periodic shaking of the flasks, after 15 days of *Trichoderma* colonized the surface of all wheat seeds.

Whole grains were taken out from flask, and spreaded in neat and clean plastic trays, clumps of grains were broken, then after fungal growth covered grain were shade air dried, after proper drying grains were converted in fine powder with the help of mixer grinder. This fine powder was used for conducting research trials.

Preparation of Jeevamrit

Water (200 lit) + Fresh cow dung (10 kg) + Cow urine (5-10 lit) + Jaggery (gur) (2 kg) + Pulse flour (Besan) (2 kg) + Soil from same farm (100-150g). Add all the material in a plastic drum (220 lit. capacity) and mix thoroughly. Keeps the drum in shade covering with gunny bag. Stir the mixture for 5-10 minutes for twice a day (morning and evening) with wooden stick. Jeevamrit ready for application at 9th day and it can be applied up to 12th day. The details of treatments are as given below.

Treatment Details

1. Soil application of FYM @100 g/m^2
2. Soil application of vermicompost $100g/m^2$,
3. Soil application of Coco Peat $100g/m^2$,
4. Soil application of neem cake @10 g/m^2
5. Soil application of Mustard cake @ 10 g/m^2
6. Soil application of *Trichoderma* spp @ 10 g/m^2
7. Soil application of *Pseudomonas* @ 10 g/m^2
8. Soil application of Jeevamrit @ 10 g/m^2
9. Control

Plant Disease incidence was recorded using following formula

$$PDI = \frac{\text{Number of diseased leaves/ treatment}}{\text{Total number of leaves/ treatment}} \times 100$$

Results and Discussion

Effect of different organic amendment and bioagents on the management of *Peronosclerospora sorghi* after 30 and 60 Day after sowing.

Results (Table 1) revealed that all the treatments were effective in reduced the disease incidence over the check. At 30 days after sowing minimum 18.80 per cent disease incidence was recorded in T_6 (Soil application of *Trichoderma* spp @ 10 g/m^2) followed by 19.70 in T_7 (Soil application of *Pseudomonas* @ 10 g/m^2). While in case of T_8 (Soil application of Jeevamrit @ 10 ml/m^2) 19.80 per cent disease incidence was recorded. Whereas treatment T_3 (Soil application of Coco Peat $100g/m^{2)}$ was recorded the highest 26.80 per cent disease incidence followed by 25.10 in T_5 (Soil application of Mustard cake @ 10 g/m^2), 24.80 in T_2 (Soil application of vermicompost 100 g/m^2) and 22.70 in T_1 (Soil application of FYM@100 g/m^2) after 30 days of sowing. In case if control (T_9) 30.75 per cent disease incidence was recorded after 30 DAS.

At 60 Day after sowing that, minimum 21.25 per cent disease incidence was recorded in T_6 (Soil application of *Trichoderma* spp @ 10 g/m^2) followed by 24.80 in T_7 (Soil application of *Pseudomonas* @ 10 g/m^2). While in case of T_8 (Soil application of Jeevamrit @ 10 ml/m^2) 26.33 per cent disease incidence was recorded. Whereas maximum 29.88 per cent disease incidence was recorded in T_3 (Soil application of Coco Peat $100g/m^{2)}$ followed by 28.33 per cent disease incidence in T_5 (Soil application of Mustard cake @ 10 g/m^2) and T_2 (Soil application of vermicompost 100 g/m^2), in both the treatment respectively. In case of control (T_9) 36.33 per cent disease incidence was recorded after 60 DAS. Similarly Kumar (2007) reported that the significant control of pearl millet downy mildew by foliar application with *Pseudomonas* in combination with organic amendment , and dressing alone (6 g/kg seed). The full dose of Apron alone was more effective than its half dose in combination with *Pseudomonas* spp. 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. Sireesha and Velazhahan (2016) reported that the efficacy of biocontrol agents *viz., Bacillus subtilis* G1, *Bacillus amyloliquefaciens* B2, *Brevibacillus brevis* 57 and *Pseudomonas fluorescens* Pf1 for the management of downy mildew of maize and for promoting plant growth was evaluated. Among them, *B. subtilis* G1 was the most effective to reduce the downy mildew incidence up to 54% under greenhouse conditions. **Latake and Kolase (2007)** evaluated the efficacy of *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.

Table 1 : Effect of different treatments on *Peronosclerospora sorghi* after 30 and 60 DAS

Treatments	Treatments details	PDI after 30DAS	% Control	After 60 DAS	% Control
T1	Soil application of FYM@100 g/m^2	22.70	26.17	27.33	24.77
T2	Soil application of vermicompost 100 g/m^2	24.80	19.34	28.33	22.02
T3	Soil application of Coco Peat 100g/m^2,	26.80	12.84	29.88	17.77
T4	Soil application of neem cake @10 g/m^2	22.90	25.52	27.25	24.99
T5	Soil application of Mustard cake @ 10 g/m^2	25.10	18.37	28.33	22.02
T6	Soil application of *Trichoderma* spp @ 10 g/m^2	18.80	38.86	21.25	41.50
T7	Soil application of *Pseudomonas* @ 10 g/m^2	19.70	35.93	24.80	31.73
T8	Soil application of Jeevamrit @ 10 ml /m^2	19.80	35.60	26.33	27.52
T9	Control	30.75	-	36.33	-
CD@ 5% level		**2.42**	-	**2.88**	-
SEm		**1.337**	-	**1.375**	-

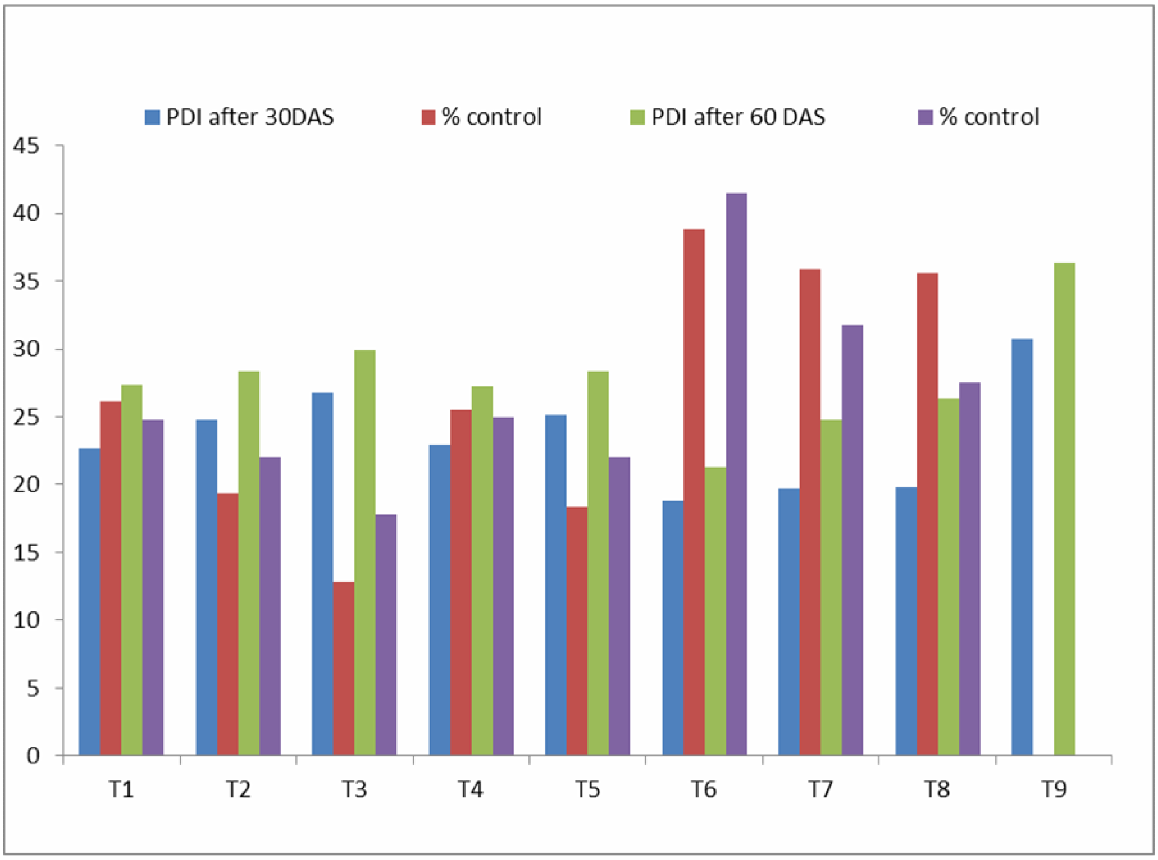

Fig. 1: Effect of different treatments on *Peronosclerospora sorghi* after 30 and 60 DAS

Effect of different treatments on yield :

All the tested bioagents and organic amendment significantly increase the crop yield as compare the control. Data given in Table no. 2 and fig. no. 2 that, maximum 16.75 q/ha Yield was recorded in T_6 (Soil application of *Trichoderma* spp @ 10 g/m^2) followed by 14.55 in T_7 (Soil application of *Pseudomonas* @ 10 g/m^2), 13.80 in T_1 (Soil application of FYM@100 g/m^2) and 13.78 in T_2 (Soil application of vermicompost 100 g/m^2). Whereas minimum 10.33 q/ha yield in T_3 (Soil application of Coco Peat 100g/m^2). In case of control 9.78 q/ha yield was recorded.

Table 2: Effect of different treatments on yield

Treatments	Treatments details	Yield in q/ha.	% yield increased
T1	Soil application of FYM@100 g/m^2	13.80	41.10
T2	Soil application of vermicompost 100 g/m^2	13.78	40.89
T3	Soil application of Coco Peat 100g/m^2,	10.33	5.62
T4	Soil application of neem cake @10 g/m^2	11.88	
T5	Soil application of Mustard cake @ 10 g/m^2	12.44	27.19
T6	Soil application of *Trichoderma* spp @ 10 g/m^2	16.75	71.26
T7	Soil application of *Pseudomonas* @ 10 g/m^2	14.55	48.77
T8	Soil application of Jeevamrit @ 10 ml/m^2	13.75	40.59
T9	Control	9.78	-
CD@ 5% level		**1.26**	-
SEm		**1.212**	-

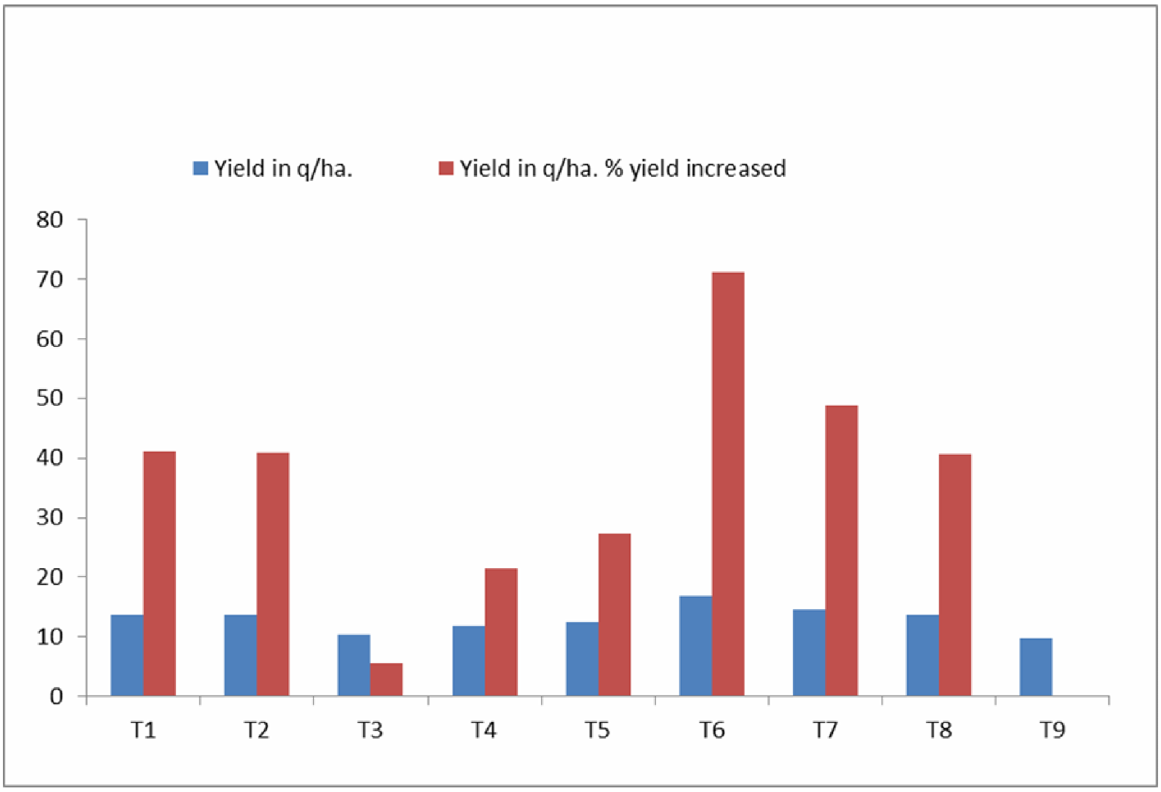

Fig. 2: Effect of different treatments on yield

Conclusion

In the absence of downy mildew resistant cultivars, biological control by means of using antagonistic microorganisms will definitely reduce the environmental pollution and the cost of plant protection measures. The results of this study suggest that *Trichoderma* @ 10 g/m^2 could be considered as a promising alternative to management of sorghum downy mildew and could be successfully exploited as a biocontrol agent within the framework of integrated disease management system.

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