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Biopriming and Integrated Management of Major Diseases of Sesame (*Sesamum indicum* L.) in the Coastal Saline Zone of West Bengal, India

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Biopriming and integrated disease management have the potential to reduce the hazards associated with the increasing use of agrochemicals in agriculture. Field trials were therefore conducted during the two consecutive summer seasons of 2020 and 2021 at Agricultural Experimental Farm, Institute of Agricultural Science, University of Calcutta, West Bengal to evaluate the impact of biopriming and integrated disease management (IDM) practices on disease incidence in sesame as well as its productivity. The treatments consisted of three modules, *viz.*, Bio-intensive (M_1): Seed treatment with *Trichoderma asperellum* @ 10 g kg^{-1} + furrow application of enriched *Trichoderma* (2.5 kg *Trichoderma asperellum* + 100 kg vermicompost) @ 250 kg ha^{-1} + spray of *Pseudomonas fluorescens* @ 10 g L^{-1} at 30-35 DAS and wettable sulphur @ 2 g L^{-1} at 50-60 DAS; Chemical (M_2): Seed treatment with carbendazim @ 2 g L^{-1} + spray of combi-product (Tebuconazole 50% + Trifloxystrobin 25%) @ 0.5 g L^{-1} at 30-35 DAS and second spray @ 2 g L^{-1} at 50-60 DAS; Adaptive (M_3): Seed treatment with *Trichoderma asperellum* @ 10 g kg^{-1} + furrow application of enriched *Trichoderma* (2.5 kg *Trichoderma asperellum* + 100 kg vermicompost) @ 250 kg ha^{-1}+ spray of combi-product (Tebuconazole 50% + Trifloxysrobin 25%) @ 0.5 g L^{-1} at 30-35 DAS and second spray at 50-60 DAS, and Control (M_4): Untreated check. The results revealed that the adaptive module, M_3, was highly effective and recorded significantly the lowest disease incidence of root rot (18.9%), severity of *Alternaria* (11.0%) and *Cercospora* leaf spots (7.0%) with highest seed yield of 0.59 t ha^{-1} and highest benefit:cost ratio of 2.13:1. This module can be used for the effective management of root rot and leaf spot diseases of sesame and ensuring sustained yields, particularly in the coastal agro-climatic condition of West Bengal.

(***Key words:*** *Biopriming, Integrated management,Leaf spot, Root rot, Sesame*)

Sesamum (*Sesamum indicum* L.) is an important oilseed crop that belongs to the family Pedaliaceae. Due to richness in oil content (about 50%), protein (about 23%) and carbohydrate (15%), cultivation of sesame is preferred in India (Ranganatha *et al.*,2012). Besides, it also possesses differentanti-bacterial, anti-viral, anti-fungal properties. For these reasons, sesame is often called the "Queen of oilseeds". India is the largest producer of sesame in the world with a production of 0.82 M t from an area of 1.81 M ha (FAOSTAT, 2021). However, the productivity in India is only 451.5 kg ha^{-1} as against the average world productivity of 508.1 kg ha^{-1}. In West Bengal, where it is locally known as, 'til', sesame is the second most important edible oilseed crop (Mondal *et al.*, 1997) an dis mostly grown in fringe land with minimum care. Sesame is mainly grown during summer, *kharif* and post-*kharif* seasons in West Bengal in an area of about 0.182 M ha (GoWB, 2012). The area, production and productivity of sesame in summer are higher than in *kharif* and post-*kharif* seasons (Duary and Hazra, 2013). But in general, the productivity of sesame is much lower than its potential yield. The low productivity of the crop can be attributed to biotic stresses, poor management practices and cultivation of sesame in marginal and sub-marginal lands (Madhuri and Karuna Sagar, 2018).

Sesame is cultivated during the summer season in the coastal ecosystem of West Bengal and is affected

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by root rot and foliar fungal diseases like *Alternaria* and *Cercospora* leaf spot diseases resulting in low productivity. Root rot of sesame is caused by the pathogen *Macrophomina phaseolina* and it is a very serious and damaging pathogen in all sesame growing areas and causes considerable yield losses (Kaur *et al.*, 2012; Meena *et al.*, 2018). Besides foliar diseases, such as the *Alternaria* and *Cercospora* leaf spots can also cause substantial losses (Palakshappa *et al.*, 2020) impacting the profit of the farmers. Chemical fungicides are the first option for farmers to combat the diseases because of their easy adaptability and immediate action. However, due to the health and environmental hazards resulting from the use of chemical fungicides in plant disease control, it is considered appropriate to limit their use. Since sesame seeds and oil are in high demand for export due to their high unsaturated fatty acid and methionine contents, in recent years focus has been shifted to the use of safer alternatives to chemical fungicides (Adhikary and Roy, 2019; Adhikary *et al.*, 2019).

Seed priming is a pre-sowing seed enhancement technique that boosts the speed, vigour and uniformity of seedling formation (Demir and van de Venter, 1999). Seed priming with bio-agents not only increases germination but also improves stress tolerance during early seedling growth (Krishna *et al.*, 2008; Fallahi *et al.*, 2011). Biopriming is also a sustainable tool to improve the stress tolerance ability of seeds during early seedling growth (Fallahi *et al.*, 2011). Biopriming and integrated management have therefore attained importance in modern agriculture to mitigate the hazards associated with the intensive use of chemicals for disease management. The study was therefore undertaken to assess the impact of biopriming and integrated disease management on reducing disease incidence and enhancing sesame crop yields in the coastal region of West Bengal.

MATERIALS AND METHODS

A field trial was conducted at Agricultural Experimental Farm, Institute of Agricultural Science, University of Calcutta, West Bengal during two consecutive summer seasons of 2020 and 2021. The Agricultural experimental farm is located in a hot and humid zone at 20° 30′ N latitude and 88° 25′ E longitude and elevation of 10 m above mean sea level. The soil of the location was sandy clay in texture, neutral in reaction (pH 6.5-7.8) and non-saline with $EC_{1:2}$ of 0.151 dS m^{-1}. Nitrogen (N), phosphorus (P), potassium (K) and sulphur (S) fertilizers were applied to the experimental field in the form of urea, single super phosphate, muriate of potash and elemental sulphur @ N:P:K:S::50:25:15:15 kg ha^{-1}, respectively. All of the phosphorus, potassium, sulphur and half nitrogen fertilizers were applied as basal at the time of final land preparation before the first irrigation at 7 days after sowing (DAS). The rest of the nitrogen was applied as a foliar spray at 21 DAS. The experiment was laid out in randomized block design with four modules *viz.*, Bio-intensive (M_1): Seed treatment with *Trichoderma asperellum* @ 10 g kg^{-1} + furrow application of enriched *Trichoderma* (2.5 kg *Trichoderma asperellum* + 100 kg vermicompost) @ 250 kg ha^{-1} + spray of *Pseudomonas fluorescens* @ 10 g L^{-1} at 30-35 DAS and wettable sulphur @ 2 g L^{-1} at 50-60 DAS; Chemical (M_2): Seed treatment with carbendazim @ 2 g L^{-1} + spray of combi-product (Tebuconazole 50% + Trifloxystrobin 25%) @ 0.5 g L^{-1} at 30-35 DAS and second spray @ 2 g L^{-1} at 50-60 DAS; Adaptive (M_3): Seed treatment with *Trichoderma asperellum* @ 10 g kg^{-1} + furrow application of enriched *Trichoderma* (2.5 kg *Trichoderma asperellum* + 100 kg vermicompost) @ 250 kg ha^{-1} + spray of combi-product (Tebuconazole 50% + Trifloxysrobin 25%) @ 0.5 g L^{-1} at 30-35 DAS and second spray at 50-60 DAS, and Control (M_4): Untreated check. Each treatment was replicated five times. The sesame variety used for conducting the trial was Savitri. The incidence of *Macrophomina* root rot was recorded individually by counting the number of affected and healthy plants at random quadrat selected in each plot and the percent incidence was calculated. The foliar diseases such as *Alternaria* and *Cercospora* leaf spots were recorded using the scoring scale. In each plot, 10 random plants were selected and all the leaves were scored for the severity of *Alternaria* leaf spot and *Cercospora* leaf spot by using 0-5 scale (0 - No infection, 1-1 to 10% leaf area infected, 2 -11 to 25% leaf area infected, 3 - 26 to 50% leaf area infected, 4 - 51 to 75% leaf area infected and 5 - 76 to100% leaf area infected; AICRP on Sesame and Niger, 1998). The disease incidence and disease index were worked out using the formulae as given below.

$$Disease\ incidence\ (\%) = \frac{Number\ of\ plants\ infected}{Total\ number\ of\ plants\ evaluated} X\ 100$$

$$Per\ cent\ disease\ index\ (PDI) = \frac{Sum\ of\ numerical\ ratings}{Total\ number\ of\ leaves\ scored} X\ \frac{100}{Maximum\ grade}$$

At maturity, the plants were harvested and the grain yield was calculated by dividing the seed weight by the harvested area and converted to per hectare basis. The benefit:cost (B:C) ratio was worked out from the cost of cultivation and the gross returns calculated using the prevailing local market prices. The data were analysed following standard statistical procedures using one-way ANOVA at p =0.05 (Panse and Sukhatme, 1985).

RESULTS AND DISCUSSION

Macrophomina phaseolina (Tassi) Goidis the responsible pathogen for stem and root rot and the typical symptoms of wilting of plants, loss of vigor, blackening of stem at the collar region, drying and death of older leaves and appearance of black dots on the infected stem of sesame plants were observed (Fig.1).

The results revealed that all the modules were superior over the control (Untreated check) insuppressing the disease incidence in sesame during both the summer seasons of 2020 and 2021 (Table 1). Among the modules, the adaptive (M_3) involving seed treatment with *Trichoderma asperellum* @ 10 g kg^{-1} + furrow application of enriched *Trichoderma* (2.5 kg *Trichoderma asperellum* + 100 kg Vermicompost) @ 250 kg ha^{-1} + spray of combi-product (Tebuconazole 50% + Trifloxysrobin 25%) @ 0.5 g L^{-1} at 30-35 DAS and second spray at 50-60 DAS was found to be the most effective integrated management practice. The significantly lowest disease incidence of root rot (17.9 and 19.9%), severity of *Alternaria* leaf spot (10.6 and 11.3%) and *Cercospora* leaf spot (7.5 and 6.4%) was recorded in this treatment during both the years of study (Table 1). The mean incidence of root rot and PDI of *Alternaria* leaf spot and *Cercospora* leaf spot under this module in sesame were found to be 18.9, 11.0 and 7.0%, respectively. Among the other modules, chemical disease management (M_2) involving seed treatment with Carbendazim @ 2 g kg^{-1}, spray of combi-product (Tebuconazole 50% + Trifloxystrobin 25%) @ 0.5 g L^{-1} at 30-35 DAS and second spray 2 g L^{-1} at 50-60 DAS, was found to be the next best practice with lower incidence of root rot (23.5%), severity of *Alternaria* leaf spot (13.4%) and *Cercospora* leaf spot (11.3%) in summer, 2020. Similar trends in the disease incidences were recorded during the summer season of 2021. With

Fig. 1. *Stem and root rot infection of sesame at different stages (a - Seedling, b - Vegetative, c - Maturity, and d - Harvesting)*

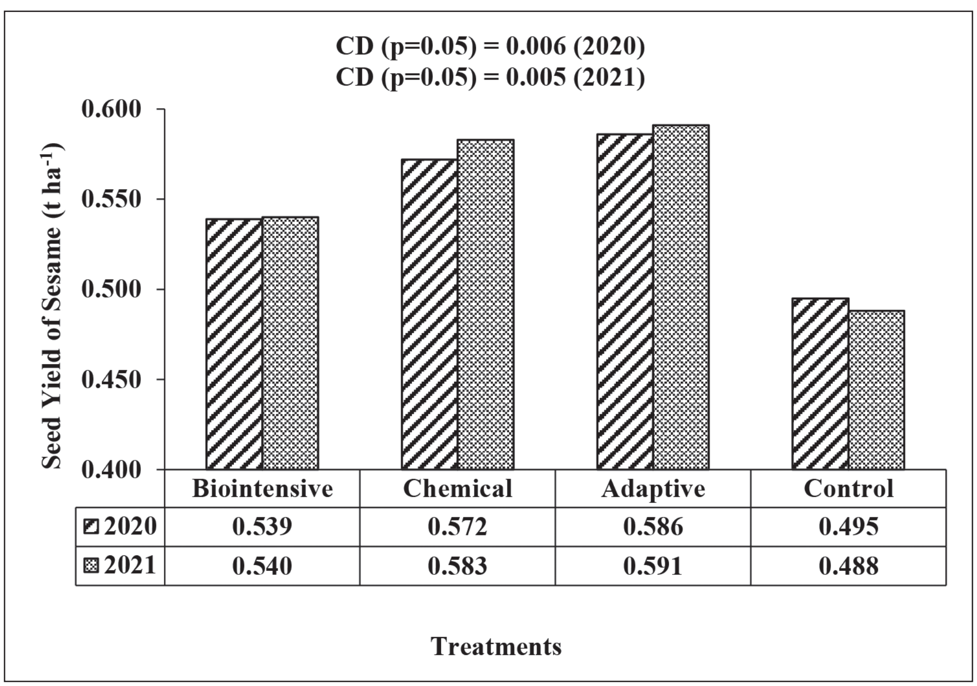
Table 1. *Evaluation of IDM Modules for the management of major diseases of sesame*

Module details	Root rot incidence (%)			*Alternaria* leaf spot (PDI %)			*Cercospora* leaf spot (PDI %)			B:C ratio		
	2020	2021	Mean	2020	2021	Mean	2020	2021	Mean	2020	2021	Mean
M_1: Bio-intensive	31.3 (34.31)	34.3 (36.09)	32.8	18.6 (25.77)	17.9 (25.31)	18.3	15.5 (23.48)	16.2 (24.10)	15.9	1.97	1.99	1.98
M_2: Chemical	23.5 (29.30)	26.8 (31.46)	25.2	13.4 (21.73)	14.1 (22.40)	13.8	11.3 (20.00)	10.8 (19.49)	11.1	2.07	2.09	2.08
M_3: Adaptive	17.9 (25.29)	19.9 (26.03)	18.9	10.6 (19.33)	11.3 (20.05)	11.0	7.5 (16.42)	6.4 (15.06)	7.0	2.12	2.14	2.13
M_4: Untreated check	36.4 (37.39)	40.1 (39.59)	38.3	27.5 (31.90)	26.8 (31.48)	27.2	21.9 (28.23)	19.5 (26.55)	20.7	1.79	1.84	1.82
$S.E_m \pm$	1.43	0.92		1.78	0.84		0.86	0.72				
C.D. (p=0.05)	4.41	2.84		5.48	2.58		2.63	2.21				

Figures in parenthesis are angular transformed values the chemical module, the mean incidence of root rot, and severity of *Alternaria* and *Cercospora* leaf spot diseases were 25.2, 13.8 and 11.1%, respectively. The least reduction in the disease incidence over the control was recorded in the bio-intensive module (M_1) which consisted of seed treatment with *Trichoderma asperellum* @ 10 g kg^{-1} + furrow application of enriched *Trichoderma* (2.5 kg *Trichoderma asperellum* + 100 kg vermicompost) @ 250 kg ha^{-1} + spray of *Pseudomonas fluorescens* @ 10 g L^{-1} at 30-35 DAS and wettable sulphur @ 2 g L^{-1} at 50-60 DAS (Table 1).

The present investigation is in line with the findings of Meena (2021) who also reported significant reductions in root rot, phyllody, *Alternaria* leaf spot and powdery mildew diseases of sesame in Tamil Nadu by following the adaptive module consisting of biocontrol agent and combination of chemical fungicides. In the present experiment, seed treatment (biopriming) with *Trichoderma asperellum* recorded significantly lesser disease incidence. It is inferred that seed treatment with biocontrol agents provides longer protection than the chemicals agents which suppress the soil and seed-borne pathogens only during the early crop growth stage. The lower disease incidence in the plants bio-primed with biocontrol agents could be attributed to the decrease in the level of stress markers and the increase in the levels of defence enzymes such as peroxidase, lipoxygenase, total phenolics, etc. which was not visible in the infected control (Das *et al.*, 2023). The use of biocontrol agents in integrated disease management modules has the potential as an economical and eco-friendly method for controlling diseases and reducing crop losses (Rao *et al.*, 2009; Das *et al.* 2023).

As far as the yield and economics are concerned, the data (Table 1 and Fig. 2) revealed that the highest seed yield of sesame (mean yield of 0.59 t ha^{-1}) and B:C ratio (mean 2.13) was obtained under the adaptive module (M_3) consisting of seed biopriming and integrated disease management options. This treatment was followed by the chemical module (M_2) with a mean yield of 0.58 t ha^{-1} and B:C ratio of 2.08 and was better over the bio-intensive module (M_1) which recorded 0.54 t ha^{-1} mean seed yield and B:C ratio of 1.98. All the modules were found to out perform the untreated control (M_4) in terms of yield and B:C ratio. Das *et al.* (2023), observed a positive effect of biopriming on the yield and biomass of rice due to improved photosynthesis and nitrate reductase activity. The beneficial effects of integrated disease management along with the use of bioagents for biopriming have also been highlighted



	Biointensive	Chemical	Adaptive	Control
2020	0.539	0.572	0.586	0.495
2021	0.540	0.583	0.591	0.488

Fig. 2. *Seed yield of sesame as affected by different disease management modules*

by Rao *et al.* (2009), Adhikary *et al.* (2019) and Meena (2021).

Based on the findings of our study, the adaptive module incorporating seed treatment with *Trichoderma asperellum*, soil application of enriched *Trichoderma* with vermicompost and spraying of combi-product chemical fungicide effectively managed the major diseases of sesame, namely, root rot, *Alternaria* and *Cercospora* leaf spot. The intervention resulted in a significant reduction in disease incidence, substantial yield enhancement and improved cost economics. The findings are valuable for implementing eco-friendly sesame disease management strategies and ensuring sustained yields, particularly in the coastal agro-climatic conditions of West Bengal.

CONFLICTS OF INTEREST

There are no conflicts of interest among the authors.

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