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Ecofriendly alternative for sustainable management of banded leaf and sheath blight of maize (*Zea mays*)

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ABSTRACT

Banded leaf and sheath blight (BLSB) of maize (*Zea mays* L.) caused by *Rhizoctonia solani* f. sp. *sasakii* is one of the most important yield-limiting factors faced by growers in India. Therefore, attempts were made to identify promising suitable bioagents for the management of BLSB of maize. Present study was carried out to check the efficacy of two bioformulations, viz. Pusa Th3 (*Trichoderma harzianum*) and Pusa Cg2 (*Chaetomium globosum*) against BLSB in the Vivek QPM-9 cultivar under field conditions during *kharif* 2018 and 2019 using seven different treatments. All the treatments significantly reduced the disease incidence and contributed higher yield of maize as compared to positive control. The lowest per cent disease index (37.87 and 53.17%) was recorded in case of both seed treatment and foliar spray with *T. harzianum.* It gave 40.39% disease control and also increased the yield up to 28.47% over unprotected plot. It was concluded that BLSB disease can be managed by seed treatment with *T. harzianum* @2 g/kg seed, followed by one spray of *T. harzianum* @0.1% at 30 days after sowing. Sustainable ecofriendly disease management options identified in the study can help maize growers not only in safeguarding the crop but also increase cost: benefit ratio. In addition, the results indicated that bio formulation of Pusa Th3 can be used to substitute chemical fungicides especially in controlling BLSB.

Keywords: Banded leaf, Bioformulations, Maize, *Rhizoctonia solani*, Sheath blight

Maize (*Zea mays* L.) is the third most important cereal crop in India after rice and wheat. It is predominantly a *kharif* crop with 85% of the area under cultivation in the season. It accounts for 9% of total food grain production in the country (Chaudhary *et al.* 2016). Among Indian states Madhya Pradesh and Karnataka has highest area under maize (15% each) followed by Maharashtra (10%), Rajasthan (9%), Uttar Pradesh (8%) and others (ICAR-IIMR 2021). Sustainable maize cultivation is continuously challenged by diseases that cause quantitative and qualitative losses in yield. Many fungal, viral and bacterial pathogens have been reported on maize apart from abiotic stresses (Saxena 2002, Rani *et al.* 2013). Among different fungal diseases affecting maize production, banded leaf and sheath blight (BLSB) induced by *Rhizoctonia solani* f. sp. *sasakii* is a very destructive disease of maize and considered to be one of the major constraint for limited production (Madhavi *et al.* 2011, Hooda *et al.* 2017). The disease causes a considerable reduction of high yielding maize varieties, resulting in premature death, stalk breakage and ear rot. In India yield loss due to BLSB was estimated from 13.6–20.6% (Tang *et al.* 2004, Huang *et al.* 2007, Gogoi *et al.* 2020).

BLSB can be managed through integration of effective cultural practices, botanical pesticides, bio-control agents and fungi toxicants (Singh *et al.* 2019). Some of the cultural practices like clipping of lower 2–3 leaves along with their sheath, field drain prior to planting, use of raised bed for sowing considerably lower disease incidence (Gogoi *et al.* 2018, Kaur *et al.* 2020). Due to non-availability of resistant cultivars, the management of BLSB primarily relies on chemical control but it has adverse ecological implication (Singh and Shahi 2012). To overcome these ecological implications, several fungal micro-organisms like *Trichoderma, Gliocladium* and *Laetisaria*, bacteria (*Pseudomonas*) and nematodes (*Aphelenchus avenae)* are used to effectively manage the diseases (Singh and Sahi 2012, Devi and Thakur 2018). In the present investigation attempts were made to find out the suitable bio rational green approach for effective management of BLSB diseases.

MATERIALS AND METHODS

The experiment was conducted during *kharif* 2018 and 2019 at ICAR-Indian Agricultural Research Institute, New Delhi to evaluate the efficacy of biological control of BLSB disease of maize. Maize hybrid Vivek QPM-9, susceptible cultivar was brought from Vivekanada Parvatiya Krishi Anusandhan Sansthan (VPKAS), Almora (Uttarakhand) and sown in 2.6 m × 2 m plots with 50 m × 20 cm spacing.

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The crop was managed well throughout the period of experimentation by following recommended package of practices. The bio formulations *Trichoderma harzianum* (Th3, ITCC CAT No. 5593) and *Chaetomium globosum* (Cg2) obtained from the Division of Plant Pathology, ICAR-IARI, New Delhi were tested in three ways (Table 1). Disease incidence, PDI and yield were compared with Validamycin, already recommended fungal bioagent and control (inoculated). The bioagents were applied as seed treatment (ST), foliar spray (FS) and both ST + FS, and the result of pooled data of two years (2018 and 2019) were drawn out.

Isolation and culture of pathogen: *Rhizoctonia solani* f. sp. *sasakii* was isolated under aseptic conditions on Potato Dextrose Agar (PDA) from maize plants showing BLSB disease symptoms. The pure culture of the pathogen was identified based on the morpho-cultural characters and maintained on PDA for further studies.

Mass culture of inoculum: The barley grains were soaked for 12 h, drained out excess water and dispense 40 g in 250 ml Erlenmeyer flask. The grain filled flasks were autoclaved twice at 15 lb pressure for 30 min consecutively for two days. Put little quantity of 8-10 days old well grown fungal culture (grown on PDA slants) in the sterilized barley grains. The flasks were incubated at 27± 1°C for 10–15 days and shaken the grains at 3–4 days interval for uniform growth of the fungus on the grains (Ahuja and Payak 1978).

Inoculation of maize plants under field conditions: To prove pathogenicity, 40–day old maize plants of var. BVM 5 were inoculated by inserting 2 to 3 grains covered with mycelial growth of each isolate, separately, between the rind and the leaf sheath of test plants in triplicate and un-inoculated plants served as control. High humidity was maintained during disease development by frequent watering. The inoculated plants were regularly observed for development of symptoms. Re-isolations were made from infected plant parts and compared with previous cultures for resemblance (Ahuja and Payak 1978).

Seed treatment and foliar spray with biological agents: Seven treatments, viz. Seed treatment (ST) with Th3 @2 g/kg; Foliar spray (FS) with Th3 @2 g/l; Both ST and FS with Th3*;* ST with Cg2 @2 g/kg; FS with Cg2 @2 g/l; Both ST and FS with Cg2 and FS with validamycin @2.7 ml/l were made and un-inoculated plants were served as control.

Disease data recording: The observations on disease severity were recorded using at silk drying stage using 1-5 scale (Ahuja and Payak 1982, Shekhar and Kumar 2012). The per cent disease index (PDI) and per cent efficacy of disease control (PEDC) over the un-inoculated control were calculated as formula given by Wheeler (1969).

The BLSB disease rating has been given below:

Resistant

1.0 - Disease on one leaf sheath only; few small, non-coalescent lesions present.

1.5 - Disease on two sheaths: lesions large and coalescent.

Table 1 Biological control of banded leaf and sheath blight (BLSB) of maize

Treatment	Disease incidence* (1-5 scale)				PDI*				Yield (Q/ha)*#			
	2018	2019	Pooled	% DI Reduction	2018	2019	Pooled	% PDI Reduction	2018	2019	Pooled	% Increase
Seed treat. with *Trichoderma harzianum* @2 g/kg	2.25	3.07	2.66	30.36	45.00	61.49	53.25	30.26	31.39	28.60	29.99	19.30
Foliar spray with *T. harzianum* @2 g/l at 3DAI**	1.92	2.93	2.43	37.17	38.33	58.78	48.56	36.40	25.30	37.40	31.35	22.81
Both ST and foliar spray with *T. harzianum*	1.89	2.65	2.27	40.57	37.87	53.17	45.52	40.39	35.75	31.90	33.83	28.47
Seed treat. with *Chaetomium globosum* @2 g/kg	2.33	2.93	2.63	31.15	46.61	58.68	52.66	31.03	24.20	30.25	27.22	11.09
Foliar spray with *C. globosum* @2 g/l at 3DAI**	1.96	2.80	2.38	37.69	39.13	56.15	47.64	37.61	27.50	31.35	29.42	17.74
Both ST and foliar spray with *C. globosum*	2.06	2.69	2.37	37.96	41.13	54.01	47.57	37.70	28.05	33.55	30.80	21.42
Foliar spray of Validamycin @2.7 ml/l	1.74	2.83	2.29	40.05	34.80	56.62	45.71	40.14	36.85	29.15	33.00	26.67
Control (inoculated)	3.28	4.35	3.82	-	65.60	87.12	76.36	-	26.40	22.00	24.20	-
CD (0.05)	0.29	0.33	0.32		5.91	6.75	6.44		N/A	N/A	N/A	

*Mean of three replications, #Yield based on per plant was statistically analyzed, DAI** – Days after inoculation.

2.0 - Disease up to four sheaths; lesions many and always coalescent.

Intermediate

2.5 - As in disease rating symptoms of 2.0 + rind discoloured with small lesions.

3.0 - Disease on all sheaths except two internodes below the ear.

3.5 - Disease up to one inter node below ear shoot; rind discoloration on many internodes with large depressed lesions.

4.0 - Disease up to the inter node bearing the ear shoot but stalk not affected.

Susceptible

4.5 - Disease on the ear; husk leaves show bleaching, bands and caking among themselves as also silk fibres; abundant fungal growth between and on kernels; kernel formation normal except being lusterless; ear size less than normal; some plants prematurely dead.

5.0 - In addition to disease rating symptoms of 4.5, shrinkage of stalk; reduced ear dimensions, wet rot and disorganization of ear, kernel formation absent or rudimentary; prematurely dead plants common; abundant sclerotial production on husk leaves, kernels, ear tips and stalk fibres.

Analysis of the data: The experimental data were subjected to appropriate statistical analysis using CPCS-1 software. The significance of treatments was taken at 5% level of significance. The B:C ratio was calculated using the average minimum support price for maize set by the Union Government of India ₹1850/q. The prevailing market rates were used to calculate the costs of the chemical fungicides, bio control agents and other materials. A simple cost-benefit ratio was used to analyze the relative economic implications of various treatments because farmers are ultimately concerned with their net returns.

RESULTS AND DISCUSSION

A perusal of results indicates that all seven treatments were found significantly effective in reducing the per cent disease incidence and contributed higher yield of maize as compared to positive control in both the testing years. The combination of seed treatment and foliar spray of both bioformulations were highly effective in suppressing BLSB disease. However, Pusa Th3 was superior to Pusa Cg2 with respect to grain yield and PDI.

All the treatments reduced the PDI significantly as compared with control plot and the lowest percent disease index (37.87 and 53.17%) was recorded in case of both ST and FS with *T. harzianum.* It gave 40.39% disease control and increased the yield up to 28.47% over unprotected plot. The yield (33.83 kg/ha) recorded for both ST and FS with *T. harzianum* was significantly higher than all the treatments in both the seasons; however FS of validamycin @2.7 ml/l during *kharif* 2018 and 2019 gave 33.00 kg/ha yield which was statistically at par to ST and FS with *T. harzianum* treatment (Table 1). Lower yield was recorded in the plots sprayed with seed treatment and foliar spray of Pusa Th3 and Pusa Cg2 alone. A combination of ST and FS with Pusa Cg2 also gave good control over disease during both the years.

All the bioagents tested were found significantly effective in controlling the BLSB. Lowest PDI i.e. 30.36 and 31.15 for *kharif* 2018 and 2019, respectively, was recorded when crop seed was treated with *T. harzianum* @2 g/kg and *C. globosum* @2 g/l at 3 DAI during both the seasons of testing. These results are in corroboration with Akhtar *et al.* (2011) who reported that seed treatment as well as soil application of *T. harzianum* resulted in highest reduction in disease severity. Further, *T. harzianum* alone as well as in combination with carbendazim when used as foliar spray, showed best result. Rakesh *et al.* (2011) also found carbendazim (bavistin) as a highly effective seed dressing fungicide with 48.7% control of BLSB disease and highest maize grain yield of 64.7 q/ha over control. Realizing the significance of disease management through biological agents and botanical extracts several workers had reported antagonistic activities of *Trichoderma* spp. and different plant extracts (Muis and Quimio 2006). In earlier studies also *Trichoderma* sp. found to be an effective biocontrol agent which provided as high as 68% inhibition of the mycelia of *R. solani* under *in vitro* condition compared to the control of BLSB (Sharma *et al.* 2002). Like fungal biocontrol agents, Madhavi *et al.* (2011) used beneficial bacterium *Pseudomonas fluorescence* against *R. solani* under *in vitro* condition. Combined seed and foliage treatment with fluorescent *Pseudomonads* of maize rhizoplane origin was most effective in giving 30% reduction in disease incidence of BLSB. Similarly, among several species of *Trichoderma, T. harzianum* had shown good results both *in vitro* and *in vivo* conditions (Meena *et al.* 2003).

In general, the biological control treatments with *T. harzianum* and *C. globosum* fared better than chemical fungicides for economic returns (Table 2). The cost benefit ratio was maximum in treatment with both ST and foliar spray with *T. harzianum* (1:3.38) with minimum disease intensity in comparison to fungicide (1:3.23) treatment and control treatment (1:2.46), which was also earlier evaluated by Verma *et al.* (2008) where *Trichoderma viride* was found effective in reducing the disease severity and increasing cost benefit ratio under field conditions.

In conclusion, it can be observed from above data that seed treatment and foliar spray with *T. harzianum* @2 g/l was most beneficial in terms of decrement in disease severity (40.39) and maximized outputs in cost benefit ratio (1:3.38). Application of these promising, eco-friendly bioagents as seed treatment and successive foliar spray seems quite feasible, economic and efficient and can be recommended for management of maize diseases as package of practice through extension programmes or other communication methods to enable farmers to grow healthy maize crops by overcoming pathogen created biotic stresses.

Table 2 Economic analysis of different treatments of biological control of banded leaf and sheath blight in maize

Treatment	Yield (Q/ha)*	Addition cost of Inputs	Cost of cultivation (₹)	Total returns (₹)	Net returns (₹)	Cost Benefit ratio
Seed treat. with *Trichoderma harzianum* @2 g/kg	29.99	342	18492	55481	36989	1:3.00
Foliar spray with *T. harzianum* @2 g/l at 3DAI	31.35	342	18492	57997	39505	1:3.13
Both ST and foliar spray with *T. harzianum*	33.83	342	18492	62585	44093	1:3.38
Seed treat. with *Chaetomium globosum* @2 g/kg	27.22	400	18550	50357	31807	1:2.71
Foliar spray with *C. globosum* @2 g/l at 3DAI	29.42	400	18550	54427	35877	1:2.93
Both ST and foliar spray with *C. globosum*	30.80	400	18550	56980	38430	1:3.07
Foliar spray of Validamycin @2.7 ml/l	33.00	750	18900	61050	42151	1:3.23
Control (inoculated)	24.20	00	18150	44770	26620	1:2.46

*Average Price of validamycine/ha is ₹750, *Trichoderma* is ₹342, *Chaetomium globosum* is ₹400 (MSP of maize ₹1850/q)

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