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Holistic approach to managing white mold in beans: combating sclerotinia sclerotiorum

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ABSTRACT

White mold caused by Sclerotinia sclerotiorum (Lib.) is one of the important diseases of beans (Phaseolus vulgaris L.). The present study on "Holistic Approach to Managing white Mold in Beans: Combating Sclerotinia sclerotiorum" was conducted during kharif 2017. The pathogenicity of the isolated fungus was established by proving Koch's postulates. Studies were conducted in a field experiment on integrated disease management of white mold of beans using Trichoderma harzianum both as seed treatment and foliar spray, fungicides captan + hexaconazole, mancozeb + carbendazim, and potassium fertilizer (MOP) @ 50, 60 and 70 kg K ha^{-1}. The studies revealed that seed treatment with Trichoderma harzianum @ 10 ml kg^{-1} of seed + 1^{st} foliar spray with (captan 70% + hexaconazole 5%) @ 0.05% + 2^{nd} foliar spray with (mancozeb 63% + carbendazim 12%) @ 0.25% proved most effective treatment exhibiting a disease incidence, intensity and pod yield of 18.27%, 11.72% and 107.8 q ha^{-1}, respectively. Compared to this, highest disease incidence and intensity of 37.65% and 27.34%, respectively and lowest pod yield of 63.24 q ha^{-1} were recorded in case of control. Among the different potassium levels tested, potassium @ 70 kg ha^{-1} proved most effective with lowest white mold incidence (18.93%), intensity (12.25%) and highest pod yield of 98.64 q ha^{-1}. A holistic approach provides sustainable management of white mold in beans but faces challenges in pathogen biology, environmental influence, limited host resistance, variability in biocontrol success, and adoption barriers. Addressing these challenges needs advanced research, multi-location trials, and farmer-friendly integrated strategies.

Keywords: *Beans, Diseases, white mould, Trichoderma, potassium.*

1. INTRODUCTION

Common bean (*Phaseolus vulgaris* L.), which belongs to family leguminosae is native to South Mexico and Central America. It is the most important food legume of the world and is grown for its green leaves, green pods, and immature and/or dry seeds. Depending upon the type, colour and region, common bean is known by many names such as, french bean, black bean, dry bean, kidney bean, navy bean, pinto bean, snap bean, field bean, rajmash etc. [1] They are famous throughout the developing world because of their good nutritional properties, long storage life and ease of storage and preparation [2] .Global production in 2014 was about 23 million tonnes of dry beans, with India as the largest producer (4.11 million tonnes) followed by Brazil (3.29 million tonnes), and 17.1 million tonnes of green beans, with India ranking second after China [3].

In India, common bean is grown mainly in the states of Madhya Pradesh, Maharashtra, Jammu and Kashmir, Himachal Pradesh, Uttar Pradesh, Tamil Nadu (Nilgiri Hills, Palani Hills), Kerala (Parts of Western Ghats), Karnataka (Chickmagalur Hills) and West Bengal (Darjeeling Hills); In Jammu and Kashmir State, beans are grown either as a sole crop or inter-cropped with maize [4]. As vegetable crop, French bean is grown in Kashmir over an area of 2000 hectares with an annual production of 400 metric tonnes [5].

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2. MATERIALS AND METHODS

The present investigations on the Integrated Disease Management of White Mold of Beans (*Phaseolus vulgaris* L.) caused by *Sclerotinia sclerotiorum* (Lib..) de Bary were undertaken in the experimental field of Division of Plant Pathology, Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir, Faculty of Agriculture, Wadura Sopore located at 34̊-20' North latitude and 74̊-24' East longitude at an elevation of 1610 meters above mean sea level (amsl) during 2017. However, three districts located from north to south of the Kashmir valley at 1580 meters to 2000 meters (amsl) were surveyed to assess the disease incidence and intensity. The details of materials and methodologies followed during the course of investigation are described here under:

2.1.1 Isolation and identification of pathogen

Naturally infected French bean (*Phaseolus vulgaris* L.) plants bearing water-soaked lesions, cottony mycelial growth and/ or sclerotia on various plant parts were collected from the fields during *kharif*, 2017 and brought immediately to the laboratory for investigation.

Infected stems and pods showing typical white mold symptoms were selected for the isolation of causal organism. The infected stems and pods were washed with tap water to remove the adhering dust particles and then cut into bits of 2-3 cm length. The bits were surface sterilized with 0.1% mercuric chloride ($HgCl_2$) solution for one minute and rinsed three times in sterile distilled water. The bits were then blotted dry, transferred aseptically to potato dextrose agar medium (Appendix-II) and incubated at 23 $\pm$ 2 ^{0}C. After 14 days of incubation, the mycelial growth/sclerotia formed were again transferred to Petri dishes containing PDA medium and incubated at 23 $\pm$ 2 ^{0}C for 14 days. The pure culture obtained by hyphal tip method was subcultured on PDA medium after every month and stored at 4 $\pm$ 1 ^{0}C in a refrigerator for further studies.

2.1.2 Identification of the pathogen

Various cultural and morphological characteristics viz. size, shape and colour of fungal colony, mycelial growth and sclerotia formed naturally in/on host (French bean plant) and on culture were recorded for the identification of pathogen.

2.1.3 Pathogenicity test

The apparently healthy seeds of French bean were collected from disease-free fields/plants. Five seeds were sown in each earthen pot of 25 cm diameter (containing non-sick soil having no history of white mold fungus). After 15 days thinning was done to maintain single seedling per pot. The pathogenicity test was performed 10 days later by using mycelia and sclerotia of the pathogens. The fungal mass (including PDA) was added to pots having healthy French bean plants @ 20g/kg soil. The plants were frequently watered and covered with polythene sheets for 24 hours to maintain humidity necessary for the development of disease symptoms.

The observations on the development and symptomatology of white mold disease and pathogenicity of the fungus were recorded. The pathogen was then reisolated, cultured and its morphological and cultural characters were compared to those of the pathogen used for inoculation for the establishment of Koch's postulates.

2.1.4 Integrated disease management of white mold of beans

Integrated disease management of white mold disease of beans (*P. vulgaris*) caused by *S. sclerotiorum* was attempted by using fungicides and *Trichoderma harzianum* (bio-agent) as foliar spray and seed treatment, respectively, together with three levels of potassium (Murate of Potash) in a factorial RCBD experiment under field conditions at experimental farm of Division of Plant Pathology, FoA, Wadura, Sopore. After obtaining the potassium nutrient status of the soil sample taken from the experimental plot, different levels of potassium fertilizer as a basal dose were applied to the soil as per the research protocol. Before sowing, seeds of French bean were dipped for 30 minutes in the solutions of biocontrol agent separately, to allow proper adhesion of biocontrol agent with the seed. The seeds were then shade-dried for two hours. A spore suspension of 3 x 10^9 cfu @ 10 ml per litre of water was used. In check treatment, distilled water was used for seed dip. The French bean seeds were sown in the month of May 2017 in a plot size of 1.85 x 2.00 m. A plant spacing of 30 x 15 cm was maintained. The experiment was laid out in randomized block design and each treatment replicated three times. The first spray was given at the first appearance of disease symptoms and second 15 days later. The disease incidence and intensity were recorded 15 days after the last spray.

	Details of treatment combination	
	Seed treatment/ foliar spray	**Potassium levels**
TT_1	Seed treatment with *Trichoderma harzianum* @ 10 ml/litre of water	
TT_2	Seed treatment with *Trichoderma harzianum* @ 10 ml/litre of water + foliar spray of *Trichoderma harzianum* @ 10 ml/litre of water	
TT_3	Seed treatment with *Trichoderma harzianum* @ 10 ml/litre of water + 1st foliar spray with (captan + hexaconazole) @ 0.05% + 2nd foliar spray with (mancozeb + carbendazim) @ 0.25%	
TT_4	Seed treatment with *Trichoderma harzianum* @ 10 ml/litre of water + foliar spray with (captan + hexaconazole) @ @ 0.05%	
TT_5	Seed treatment with *Trichoderma harzianum* @ 10 ml/litre of water + foliar spray with (mancozeb + carbendazim) @ 0.25%	level-I
TT_6	No seed treatment+ water spray	@ 50 kg/ha
TT_7	Seed treatment with *Trichoderma harzianum* @ 10 ml/litre of water	
TT_8	Seed treatment with *Trichoderma harzianum* @ 10 ml/litre of water + foliar spray of *Trichoderma harzianum* @ 10 ml/litre of water	
TT_9	Seed treatment with *Trichoderma harzianum* @ 10 ml/litre of water + 1st foliar spray with (haptan + Hexaconazole) @ @ 0.05% + 2nd foliar spray with (mancozeb + carbendazim) @ 0.25%	
TT_{10}	Seed treatment with *Trichoderma harzianum* @ 10 ml/litre of water + foliar spray with (captan + hexaconazole) @ @ 0.05%	level-II
TT_{11}	Seed treatment with *Trichoderma harzianum* @ 10 ml/litre of water + foliar spray with (mancozeb + carbendazim) @ 0.25%	@ 60 kg/ha
TT_{12}	No seed treatment+ water spray	
TT_{13}	Seed treatment with *Trichoderma harzianum* @ 10 ml/litre of water	
TT_{14}	Seed treatment with *Trichoderma harzianum* @ 10 ml/litre of water + foliar spray of *Trichoderma harzianum* @ 10 ml/litre of water	
TT_{15}	Seed treatment with *Trichoderma harzianum* @ 10 ml/litre of water + 1st foliar spray with (captan + hexaconazole) @ @ 0.05% + 2nd foliar spray with (mancozeb + carbendazim) @ 0.25%	
TT_{16}	Seed treatment with *Trichoderma harzianum* @ 10 ml/litre of water + foliar spray with (captan + hexaconazole) @ @ 0.05%	level-III
TT_{17}	Seed treatment with *Trichoderma harzianum* @ 10 ml/litre of water + foliar spray with (mancozeb + carbendazim) @ 0.25%	@70 kg/ha
TT_{18}	No seed treatment + water spray	

Parameters recorded:

- Disease incidence (%)
- Disease intensity (%)
- Pod yield (q ha^{-1})

3.0 EXPERIMENTAL FINDINGS

3.1. Integrated disease management of white mold of beans

The data on the use of the bio-agent and fungicides along with different levels of potassium fertilization *in vivo* to find out the combined effect against white mold disease of beans are presented in Table 4-6.

3.1.2 Disease incidence

Data pertaining to disease incidence (Table-1) reveals that all the treatments had a significant effect on per cent disease incidence of white mold of beans as compared to check, which recorded highest average disease incidence of 37.65 per cent. Seed treatment with *T. harzianum* + 1st foliar spray with (captan + hexaconazole) + 2nd foliar spray with (hancozeb + carbendazim) proved significantly superior over all other treatments and exhibited the lowest average white mold incidence of 18.27 per cent.

This was followed by seed treatment with *T. harzianum* + foliar spray with (mancozeb + carbendazim) and seed treatment with *T. harzianum* + foliar spray with (captan + hexaconazole), which recorded an average white mold incidence of 22.80 and 26.93 per cent, respectively.

Among the potassium levels used, potassium @ 70 kg ha^{-1} proved to be most effective exhibiting an average white mold incidence of 18.93 per cent followed by potassium @ 60 kg ha^{-1} and potassium @ 50 kg ha^{-1} which exhibited average white mold incidence of 22.52 and 42.90 per cent, respectively.

Among the treatment combinations of seed treatment and foliar sprays along with three levels of potassium fertilizer, the seed treatment with *T. harzianum* + 1st foliar spray with (captan + hexaconazole) + 2nd foliar spray with (mancozeb + carbendazim) and potassium @ 70 kg ha^{-1} proved most effective exhibiting the lowest average disease incidence of 10.43 per cent and was statistically superior over all other treatment combinations. This was followed by seed treatment with *T. harzianum* + 1st foliar spray with (captan + hexaconazole) + 2nd foliar spray with (mancozeb + carbendazim) along with potassium @ 60 kg ha^{-1} and seed treatment with *Trichoderma harzianum* + foliar spray with (captan + hexaconazole) with potassium @ 70 kg ha^{-1}, which recorded an average disease incidence of 15.21 and 17.54 per cent, respectively. The highest average disease incidence of 61.44 per cent was recorded in the treatment combination of control plot (No seed treatment + water spray) with potassium @ 50 kg ha^{-1}.

3.1.3 Disease intensity

Perusal of the data (Table-2) revealed that all the treatments had a significant effect on per cent disease intensity of white mold of beans over check which recorded highest average disease intensity of 27.34 per cent. Seed treatment with *Trichoderma harzianum* + 1st foliar spray with (captan + hexaconazole) + 2nd foliar spray with (mancozeb + carbendazim) proved significantly superior over all other treatments and exhibited the lowest average white mold intensity of 11.72 per cent. This was followed by seed treatment with *T. harzianum* + foliar spray with (captan + hexaconazole) and seed treatment with *T. harzianum* + foliar spray with (mancozeb + carbendazim) which recorded an average white mold intensity of 12.60 and 15.84 per cent, respectively.

Among the potassium levels used, potassium @ 70 kg ha^{-1} proved most effective exhibiting an average white mold intensity of 12.25 per cent followed by potassium @ 60 kg ha^{-1} and potassium @ 50 kg ha^{-1} which exhibited average white mold intensity of 14.04 and 29.20 per cent, respectively.

Among the treatment combinations of seed treatment and foliar sprays along with three levels of potassium fertilizer, the seed treatment with *T. harzianum* + 1st foliar spray with (captan + hexaconazole) + 2nd foliar spray with (mancozeb + carbendazim) along with potassium @ 70 kg ha^{-1} proved most effective exhibiting the lowest average disease intensity of 2.59 per cent and was statistically superior over all other treatment combinations. This was followed by seed treatment with *Trichoderma harzianum* + foliar spray with (mancozeb + carbendazim with potassium @ 70 kg ha^{-1} and seed treatment with *Trichoderma harzianum* + foliar spray with (captan + hexaconazole) with potassium @ 70 kg ha^{-1}, which recorded an average disease intensity of 5.03 and 5.37 per cent, respectively. The highest average disease intensity of 42.48 per cent was recorded in case of control plot (No seed treatment + water spray) with potassium level of 50 kg ha^{-1}.

3.1.4 Pod yield

Perusal of the data (Table-3) revealed that all the treatments had significant effect on pod yield of beans over check which recorded lowest average pod yield of 63.24 q ha^{-1}. Seed treatment with *Trichoderma harzianum* + 1st foliar spray with (captan + hexaconazole) + 2nd foliar spray with (mancozeb + carbendazim) proved significantly superior over all other treatments and recorded the highest average pod yield of 107.8 q ha^{-1}. This was followed by seed treatment with *T. harzianum* + foliar spray with (captan + hexaconazole) and seed treatment with *T. harzianum* + foliar spray with (mancozeb + carbendazim) which recorded an average pod yield of 103.24 and 95.40 q ha^{-1}respectively.

Among the potassium levels used, potassium @ 70 kg ha^{-1} proved most effective recording an average yield of 98.64 q ha^{-1}, followed by potassium @ 60 kg ha^{-1} and potassium @ 50 kg ha^{-1} which recorded pod yield of 86.21 and 79.72 q ha^{-1}, respectively.

Among the treatment combinations of seed treatment and foliar sprays along with three levels of potassium fertilizer, the seed treatment with *T. harzianum* + 1st foliar spray with (captan + hexaconazole) + 2nd foliar spray with (mancozeb + carbendazim) along with potassium @ 70 kg ha^{-1} proved most effective exhibiting the highest pod yield of 124.50 q ha^{-1} and was statistically superior over all other treatment combinations. This was followed by seed treatment with *Trichoderma harzianum* + foliar spray with (mancozeb + carbendazim with potassium @ 70 kg ha^{-1} and seed treatment with *Trichoderma harzianum* + foliar spray with (captan + hexaconazole) with potassium @ 70 kg ha^{-1}, which recorded an average pod yield of 114.59 and 106.76 q ha^{-1}, respectively. The lowest average pod yield of 54.86 q ha^{-1} was recorded in the treatment combination of control (No seed treatment + water spray) with potassium @ 50 kg ha^{-1}.

4. DISCUSSION

Bean (*Phaseolus vulgaris*) has gained importance as a potential pulse/vegetable crop and is grown in almost every state of India. This crop suffers from vagaries of fungal, bacterial and viral diseases. Among the fungal diseases, sclerotinia rot caused by *Sclerotinia sclerotiorum* (Lib.) de Bary earlier considered to be a minor disease, is now becoming increasingly destructive and widely damaging in recent years, particularly in areas of heavy soils receiving four or more irrigations [6].

Application of chemical fungicides alone are often cost-prohibitive, impractical and hazardous to environment and human health. Keeping this in view, the need was felt for an alternative method to manage this disease in integrated manner by using microbial bioagent/s, fungicides and potassium fertilizer. Biological control is of much significance in view of hazards caused by toxic chemicals or in a situation where pathogens develop resistance to fungitoxicants. Seed treatment with *Trichoderma harzianum* + 1st foliar spray with (captan + hexaconazole) + 2nd foliar spray with (mancozeb + carbendazim) proved most effective as it reduced white mold incidence to 11.72 per cent compared to check exhibiting white mold incidence of 27.34 per cent, followed by seed treatment with *Trichoderma harzianum* + foliar spray with (captan + hexaconazole), seed treatment with *Trichoderma harzianum* + foliar spray with (mancozeb + carbendazim) exhibiting white mold incidence of 12.60 and 15.84 per cent respectively. Among the potassium levels used as fertilizer, potassium @ 70 kg ha^{-1} proved most effective exhibiting white mold incidence of 12.25 per cent followed by potassium @ 60 kg ha^{-1} which exhibited white mold incidence of 14.04 per cent. The data about the disease intensity revealed that seed treatment with *Trichoderma harzianum* + 1st foliar spray with (captan + hexaconazole) + 2nd foliar spray with (mancozeb + carbendazim) proved most effective as it reduced white mold intensity to 18.27 per cent compared to check exhibiting white mold intensity of 37.65 per cent, followed by seed treatment with *Trichoderma harzianum* + foliar spray with (mancozeb + carbendazim), seed treatment with *Trichoderma harzianum* + foliar spray with (captan + hexaconazole) exhibiting white mold intensity of 22.80 and 26.93 per cent respectively. Among the potassium levels used as fertilizer, potassium @ 70 kg ha^{-1} proved to be most effective exhibiting white mold intensity of 18.93 per cent followed by potassium @ 60 kg ha^{-1} which exhibited white mold intensity of 22.52 per cent. Further results regarding pod yield revealed that the highest pod yield of 107.8 q ha^{-1} was obtained in case of seed treatment with *Trichoderma harzianum* + 1st foliar spray with (captan + hexaconazole) + 2nd foliar spray with (mancozeb + carbendazim), followed by seed treatment with *Trichoderma harzianum* + foliar spray with (captan + hexaconazole) and seed treatment with *Trichoderma harzianum* + foliar spray with (mancozeb + carbendazim), with average pod yield of 103.24 and 95.40 q ha^{-1} respectively. Among the potassium levels used as fertilizer, potassium @ 70 kg ha^{-1} proved to be most effective with average pod yield of 98.64 q ha^{-1} followed by potassium @ 60 kg ha^{-1} with an average pod yield of 86.21q ha^{-1}.

Ghasolia and Shivpuri (2008) while using fungicides *viz.*, carbedazim (Bavistin @ 0.1 %), mancozeb (Indofil M- 45 @ 0.25 %), captan (Captaf @ 0.25 %) and tebuconazole (Raxil @ 0.1 %) as seed treatment, foliar spray and seed treatment plus foliar spray for management of sclerotinia rot of beans (*S. sclerotiorum*), also confirmed that these chemical treatments were significantly superior over the check/control in controlling the severity of the disease. The present findings regarding the considerable reduction in the severity of white mold of beans by using *T. harzianum* are in agreement with the finding of Singh and Handique [7] who reported destruction of Sclerotia of *S. sclerotiorum* by *T. harzianum*. [8] also found that *Trichoderma* spp. Inhibited the mycelial growth of *S. sclerotiorum* and reported that, *T. harzianum* inhibited sclerotial germination in pot culture experiments, reducing seedling mortality of chick pea stem rot caused by *S. sclerotiorum.* Rollen *et al.* [9] reported that *Trichoderma* spp. could parasitize the sclerotia of *S. sclerotiorum* and *S. minor* at a temperature of 25 °C and 30 °C. [10]also reported the ability of *T. harzianum* to attack the soil-borne plant pathogen. Baker and Cook (1974) reported that integrating biological and chemical control seems very promising way of controlling soil-borne pathogens. [11] also reported that a synergistic effect developed from the interaction between *T. harzianum* and sublethal doses of pentachloronitrobenzene (PCNB) when applied against *S. rolfsii* in peanuts and this synergism is apparently due to partial suppression of soil microflora, enabling a more effective activity of the bio-control agent. Jeyraj and Rambadran (1996) observed that *T. harzianum* and low doses of Carbendazim reduced dry root rot in mung bean. [12] reported that biocides (*T. viride*, *T. harzianum* and *G. roseum*) and captan, carbendazim, Mancozeb were highly effective in reducing the sclerotial viability of *S. sclerotiorum* in cauliflower individually and in combination. [13] reported that lethal dose of carbendazim was compatibible with *T. harzianum* in management of stem rot of soybean. [14]evaluated that combine treatment of fungicides and application of *T. harzianum* through seeds caused an almost total mortality of sclerotia under field condition. Integration of captan at 0.2 per cent with the bio-agents- *T. harzianum* and *G. virens* showed significant reduction in per cent disease incidence and increased plant growth parameters and crop yield of French bean [15]. The data also reveals that increase in the dose of potassium fertilizer reduces the severity of white mold of beans. [16] also confirms the application of potassium reduces the severity of angular leaf spot of beans by about 42 per cent. Our results are also supported by [17] wherein he reports that higher doses of potassium fertilizer reduces leaf spot of groundnut caused by *Cercospora arachidicola* and increase the yield to a great extent. These findings more or less substantiate the results obtained during the present study.

5.0 CONCLUSION

The conclusion drawn from the present investigations is presented as follows:

- The bio-control agent *Trichoderma harzianum* proved effective against the test pathogen.
- The fungicide combinations captan + hexaconazole and mancozeb + carbendazim were effective against test pathogen individually as well as in combination with the bio-control agent *Trichoderma harzianum* and potassium fertilizer.

In light of this, the following integrated disease management capsule is suggested for the management of white mold of beans:

- Seed treatment with *Trichoderma harzianum* @ 10 ml/litre of water.
- 1st foliar spray with captan (70%) + hexaconazole (5%) @ 0.05%.
- 2nd foliar spray with mancozeb (63%) + carbendazim (12%) @ 0.25% after a gap of 15 days.
- Use of potassium @ 70 kg ha^{-1}.

Disease incidence %				
Bio-agent and Fungicide sprays	**Potassium levels @ Kg ha^{-1}**			**Mean**
	50	**60**	**70**	
Seed treatment with *Trichoderma harzianum* @ 10 ml/litre of water	38.11	35.83	18.15	**30.70**
	(6.23)	(6.05)	(4.36)	**(5.55)***
Seed treatment with *Trichoderma harzianum* @ 10 ml/litre of water + foliar spray of *Trichoderma harzianum* @ 10 ml/litre of water	58.28	19.38	19.41	**32.36**
	(7.67)	(4.50)	(4.50)	**(5.56)**
Seed treatment with *Trichoderma harzianum* @ 10 ml/litre of water + 1st foliar spray with (captan + hexaconazole) @ 0.05% + 2nd foliar spray with (mancozeb + carbendazim) @ 0.25%	29.17	15.21	10.43	**18.27**
	(5.48)	(4.01)	(3.37)	**(4.29)**
Seed treatment with *Trichoderma harzianum* @ 10 ml/litre of water + foliar spray with (captan + hexaconazole) @ 0.05%	43.03	20.23	17.54	**26.93**
	(6.61)	(4.59)	(4.29)	**(5.17)**
Seed treatment with *Trichoderma harzianum* @ 10 ml/litre of water + foliar spray with (mancozeb + carbendazim) @ 0.25%	27.39	23.17	17.83	**22.80**
	(5.31)	(4.90)	(4.33)	**(4.85)**
No seed treatment + water spray	61.44	21.29	30.23	**37.65**
	(7.88)	(4.71)	(5.57)	**(6.05)**
Mean	**42.90**	**22.52**	**18.93**	
	(6.53)	**(4.79)**	**(4.40)**	

C. D. (p≤0.05)

Bio-agent and fungicide sprays (M) ;	0.124
Potassium treatments (K) ;	0.88
(M X K) ;	0.215

**Figures in parenthesis are square root transformed values*

Table 2: Intensity of white mold of beans in the experimental field

Disease intensity %				
Bio-agent and Fungicide sprays	Potassium levels @ Kg ha^{-1}			Mean
	50	60	70	
Seed treatment with *Trichoderma harzianum* @ 10 ml/litre of water	32.75 (4.89)	25.77 (4.41)	12.05 (4.36)	**23.52 (4.55)***
Seed treatment with *Trichoderma harzianum* @ 10 ml/litre of water + foliar spray of *Trichoderma harzianum* @ 10 ml/litre of water	34.45 (5.61)	12.97 (3.44)	15.29 (3.72)	**20.90 (4.25)**
Seed treatment with *Trichoderma harzianum* @ 10 ml/litre of water + 1st foliar spray with (captan + hexaconazole) @ 0.05% + 2nd foliar spray with (mancozeb + carbendazim) @ 0.25%	17.22 (3.77)	15.34 (4.12)	2.59 (2.09)	**11.72 (3.33)**
Seed treatment with *Trichoderma harzianum* @ 10 ml/litre of water + foliar spray with (captan + hexaconazole) @ 0.05%	25.21 (4.92)	7.22 (3.22)	5.37 (2.85)	**12.60 (3.65)**
Seed treatment with *Trichoderma harzianum* @ 10 ml/litre of water + foliar spray with (mancozeb + carbendazim) @ 0.25%	23.11 (5.2)	19.39 (4.82)	5.03 (3.09)	**15.84 (4.40)**
No seed treatment + water spray	42.48 (6.59)	17.11 (4.12)	22.43 (4.84)	**27.34 (5.18)**
Mean	**29.20 (5.16)**	**14.04 (4.12)**	**12.25 (3.49)**	

C. D. (p≤0.05)

Bio-agent and fungicide sprays (M) ;	0.28
Potassium treatments (K) ;	0.20
(M X K) ;	0.48

**Figures in parenthesis are square root transformed values*

Table 3: Effect of integrated disease management on pod yield of beans in the experimental field

Pod yield (q ha^{-1})				
Bio-agent and Fungicide sprays	Potassium levels @ kg ha^{-1}			Mean
	50	60	70	
Seed treatment with *Trichoderma harzianum* @ 10 ml/litre of water	69.45	74.59	75.94	**73.32**
Seed treatment with *Trichoderma harzianum* @ 10 ml/litre of water + foliar spray of *Trichoderma harzianum* @ 10 ml/litre of water	71.62	92.43	94.05	**85.94**
Seed treatment with *Trichoderma harzianum* @ 10 ml/litre of water + 1st foliar spray with (captan + hexaconazole) @ 0.05% + 2nd foliar spray with (mancozeb + carbendazim) @ 0.25%	104.32	94.32	124.5	**107.8**
Seed treatment with *Trichoderma harzianum* @ 10 ml/litre of water + foliar spray with (aptan + hexaconazole) @ 0.05%	102.97	99.72	106.76	**103.24**
Seed treatment with *Trichoderma harzianum* @ 10 ml/litre of water + foliar spray with (mancozeb + carbendazim) @ 0.25%	75.4	96.48	114.59	**95.4**
No seed treatment + water spray	54.86	59.72	75.4	**63.24**
Mean	**79.72**	**86.21**	**98.64**	

C. D. (p≤0.05)

Bio-agent and fungicide sprays (M) ;	2.24
Potassium treatments (K) ;	1.48
(M X K) ;	1.96

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