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Evaluation of different fungicides and bio-agents against anthracnose of bean

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Abstract
Anthracnose of bean (*Phaseolus vulgaris* L.) caused be *Colletotrichum lindemuthianum*. The major constraints in its low productivity are fungal and viral disease. The pathogen was tested with four fungicides and three bio-agents *In-vitro* and *In-vivo* condition three fungicides and two bio-agents were tested in the year 2021-22 and 2022-23. The tested fungicide and bio-agent namely, Carbendazim, Sulphur, Mancozeb, Chlorothalonil and Bio-agent *T. harzianum*, *T. viride* and *P. fluorescens*. Among the tested fungicide Carbendazim was most effective fungicide which showed (3.13 mm) average fungal growth and 96.80 percent inhibition over control. The bio-agent *P. fluorescens* was least effective which showed (15.63 mm) average fungal growth with 84.05 percent inhibition over control. *In-vivo* condition Chlorothalonil was most effective fungicide which showed the minimum mean diseases incidence (8.09) percent and maximum yield (95.47 q/ha.) respectively. The bio-agent *T. harzianum* was least effective which was showed the maximum mean disease incidence (32.33) percent and minimum mean yield was (58.91 q/ha.).

Keywords: Evaluation, fungicides, bio-agents, anthracnose of beans

Introduction
Common bean (*Phaseolus vulgaris* L.) is the most important food grain legume across the Tropical regions. Its production has been estimated at 28.43 million metric tons, which represents 40.7% of total world food grain-legume production (FAO, 2021) [3]. For many millions of households in the Tropical regions, the crop is a source of food nutrients (Proteins, Minerals, Fiber, and Vitamins) and also a source of cash (Popelka *et al.,* 2004) [10]. The highest production and area under beans in Africa is in the east and central Africa regions, where beans are mainly grown by resource poor farmers (Wortman *et al*., 1998) [13]. Economic significance of bean is quite considerable since it represents one of the major food and cash crops (Habtu, 1994) [4]. In Ethiopia, common bean is mainly grown in eastern, southern, southwestern and the Rift Valley areas of the country (Habtu *et al*., 1996) [5].
Both biotic and abiotic constraints are responsible for reducing the production of common beans. Among them anthracnose caused by *Colletotrichum lindemuthianum* (Sacc. & Magn.) is an important disease of the beans (Muimba-Kankolongo, 2018) [8]. It is the major yield-limiting disease impacting seed quality and marketability. The disease can cause 95– 100% yield loss when the infected seed is used for cultivation and favorable weather conditions occur during the crop cycle (Yesuf and Sangchote, 2007) [14]. The disease is particularly important in relatively cool, wet areas of tropical and temperate regions. In Nepal, it causes a huge loss in the temperate and sub-tropical areas (Manandhar *et al.,* 2016) [7]. The disease symptoms are seen in all the above-ground parts including leaf, stem, pods and seeds (Agrios, 2005) [1]. On leaves, symptoms generally occur on the underside as linear, dark brick-red to black lesions on the leaf veins. As the disease progresses, discoloration appears on the upper leaf surface.

Materials and Methods
Screening of fungicides and Bio-agents *In-Vitro*
Relative efficacy of available four selected fungicides, and three bio-agents namely Carbendazim, Sulphur, Mancozeb and Chlorothalonil. The bio-agents *Trichoderma harzianum*, *Trichoderma viride* and *Pseudomonas fluorescens* was tested at 250 ppm was studies *In-vitro* by judging the extent of their inhibitory effect on the growth of the pathogen on 2 percent Potato dextrose agar. Each treatment was replicated 3 times with CRD design.

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Percent inhibition over control $= \frac{C-T}{T}$ X100

Where,

C= Percent disease incidence of control

T= Percent disease incidence in treated plate

Screening of fungicides and bio-agent *In-Vivo*

To find out suitable fungicides and bio-agents witch was found effective *In-vivo* conditions. The effective fungicide and bio-agents were selected in field trial during *Kharif* season 2021-22 and 2022-23. A highly susceptible verity was grown and infected with Anthracnose of bean was selected. The bean variety ("Anasazi") was sowing in (3x3) meter plot size in randomized block design with four replication. The three fungicide Carbendazim, Sulphur, Mancozeb, @ 0.2% two bio-agents @ 0.5% *Trichoderma viride* and *Trichoderma harzianum* were use as spray for regarding the disease incidence 20 randomly selected plant per plot were examined and the disease incidence in percentage was transformed in to analysis statically. The yield was estimated and plot basic without the border rows in the q/h.

The percentage disease incidence was selected given formula % disease incidence

$$\% \text{ disease incidence} = \frac{\text{Total no. of infected plant}}{\text{Total no. of plant}} \times 100$$

Result and Discussion

Screening of different fungicides and Bio-agents under *In-vitro* condition

The result indicate in Table-1, corresponding histogram- 1 and Fig. 1 that all the fungicides tested were significantly superior over the control and inhibiting the growth of the pathogen. The Carbendazim (3.13 mm) proved to be most effective fungicide as they inhibition the growth of the pathogen 96.80%. The remaining fungicides in order of their decreasing inhibitory effect against the pathogen were Sulphur (5.67 mm) and Mancozeb (7.95 mm) were found to be the next best effective fungicide in inhibiting the growth of pathogen. Both the fungicide was statistically at par which sowing (94.20 and 91.88) per cent inhibition over control respectively. These were statically at par with each others of the tested fungicides. The Chlorothalonil (13.20 mm) was least effective and showed the (86.53%) inhibition over control. The bio-agent *Trichoderma harzianum* was recorded (12.45 mm) radial growth and its inhibition over growth (87.29%) followed by *Trichoderma viride* (12.87 mm) radial growth and 87.27% inhibition over control. Both the treatments are statically at par with each other. The bio-agent *Pseudomonas fluorescens* (15.63 mm) was least effective showed the (84.05%) inhibition control against the pathogen. The observation are similar to the finding of Shovan *et al*., (2008) [11] and Jagtap *et al.,* (2013) [6].

Table 1: Inhibitory effect of different fungicides and Bio-agents on growth of *Colletotrichum lindemuthianum In-Vitro* after 8 days incubation at 25±2 °C.

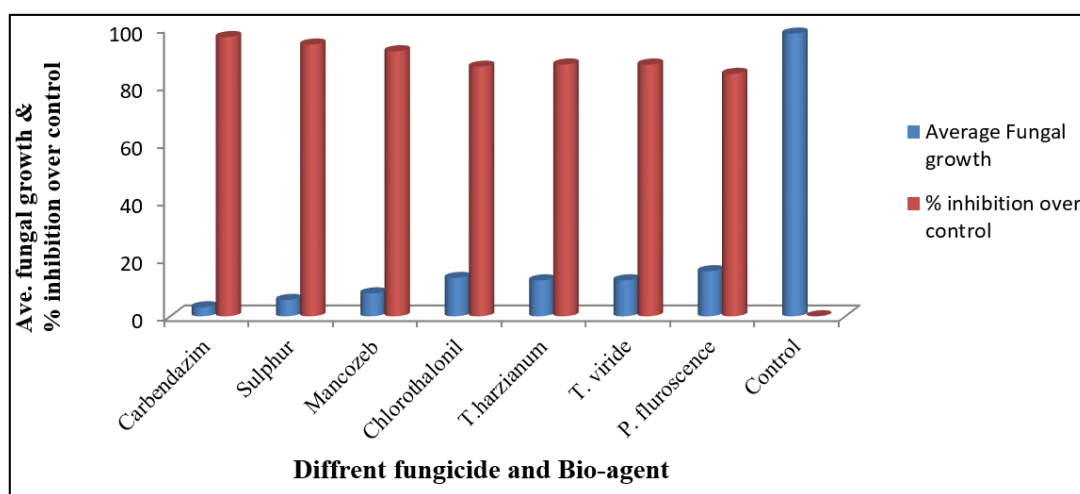| S. No.	Name of Treatments	Dose (ppm)	Average fungal growth (mm)	Percent inhibition over control (%)
1.	Carbendazim	250	3.13	96.80
2.	Sulphar	250	5.67	94.20
3.	Mancozeb	250	7.95	91.88
4.	Chlorothalonil	250	13.20	86.53
5.	*Trichoderma harzianum*	250	12.45	87.29
6.	*Trichoderma viride*	250	12.47	87.27
7.	*Pseudomonas fluorescens*	250	15.63	84.05
8.	Control	…..	98.00	…..
	C.D.		2.13	

Fig 1: Average fungal growth and % inhibition over control of the pathogen under *In-vitro* condition.

Screening of different fungicides and Bio-agents under *In-vivo* condition

The results are presented in Table-2 and its corresponding histogram-2 of trail with three fungicides and two bio-agents indicate their effectiveness in minimizing the disease incidence. In the year 2021-22 spraying of fungicide

Chrolothalonil (7.06%) at the interval of 20 days was most effective minimize the disease the incidence and increasing the maximum yield (96.61q/h). the next effective fungicide was Mancozeb and Sulphur which showed (14.41 and 20.92) % disease incidence and (89.22 and 80.39 q/h) yield and both the fungicide statistically at different with each other. The bio-agents *Trichoderma viride* was showed (27.61%) disease incidence and (73.58 q/h) yield. The *Trichoderma harzianum* proved to be the least effective bio-agents which showed maximum (31.06%) disease incidence and minimum yield (67.02 q/h).

In the year 2022-23 Chlorothalonil was most effective fungicide which showed minimum (9.12) percent disease incidence and maximum (94.39q/h) yield. The next best effective fungicide was Mancozeb and Sulphur which showed

percent disease incidence 16.52 and 22.00 and corresponding yield 87.40 and 79.86 q/ha. Both the treatment statistically different with each other. Next order of superiority bio-agents *Trichoderma viride* (28.42%) disease incidence and (73.58q/h) yield respectively. The *Trichoderma harzianum* was least effective bio-agents which showed maximum (33.61) percent disease incidence and maximum (63.41q/h) yield. The present finding is are closed agreement with the finding of (Tesfaye, 1997) [12] on Haricot bean due to Anthracnose and (Podder *et al*., 2010) [9] suggested that the Anthracnose of common bean could be managed by spraying of bio-agent and bio-pesticide which was radial the percent disease incidence and increasing the yield of common bean. Amin *et al.,* 2014 [2] recover the effect of fungicide and bio-agent against Anthracnose of common bean.

Table 2: Inhibitory effect of different fungicides and Bio-agents on growth of *Colletotrichum lindemuthianum in-vivo* condition.

S. No.	Name of Treatment	Dose (%)	% disease incidence		Mean	Yield (q/ha)		Mean
			2021-22	2022-23		2021-22	2022-23	
1.	Chlorothalonil	0.2	7.06	9.12	8.09	96.61	94.34	95.47
2.	Mancozeb	0.2	14.41	16.51	15.46	89.22	87.40	88.31
3.	Sulphur	0.2	20.92	22.00	21.40	80.39	79.86	80.12
4.	*T. viride*	0.5	27.61	28.42	28.01	74.61	73.58	74.09
5.	*T. harzianum*	0.5	31.06	33.61	32.33	67.02	63.41	62.21
6.	Control	….	38.39	39.49	38.94	60.41	57.42	58.91
	CD		2.71	3.26		2.21	4.13	

Fig 2: Inhibitory effect of different fungicides and Bio-agents on growth of *Colletotrichum lindemuthianum In-Vitro* after 8 days incubation at 25±2 °C.
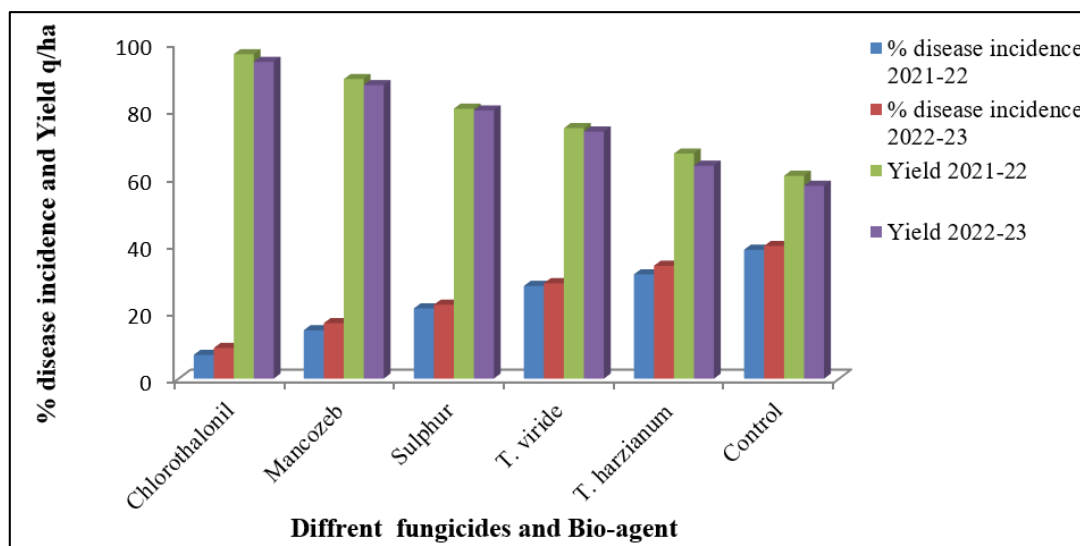
Fig 3: Effect of fungicide and bio-agent against the pathogen *In-vivo* in both the year

Conclusion

The present study suggested that it is the safest chemical and bio-agent be used for the management of the Anthracnose of bean under *In-vitro* and *In-vivo* condition under *In-vitro* condition the Carbendazim was most effective fungicide which showed (3.13 mm) fungal growth and (96.80) percent inhibition over control. *In-vivo* condition highest average yield (95.47 q/ha) with lowest average disease incidence (8.09) percent recorded with application Chlorothalonil it was followed by Mancozeb and Sulphur in which (15.46 and 21.40) average disease incidence were observed corresponding to which the yield was recorded as (88.31 and 80.12 q/ha.) respectively.

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