Original Research Article

Integrated Management of Foliar Diseases ofMungbean(*Vigna radiata* L.)Under Natural FieldConditions

ABSTRACT

Aims: To determine the efficacy of chemicals/bioagents against foliar diseases of mungbean.

Study Design: Randomized Block Design (Field experiments)

Place and duration of the study: Field experiments were conducted at Agricultural Research Station, Mandor, Jodhpur during the *Kharif* 2022 &*Kharif* 2023

Methodology: Different novel fungicides/bioagents were applied against foliar diseases of mungbean. Ten treatments *viz*; soil application with *Trichoderma harzianum* @ 5kg/ha enriched in 100 kg of FYM., seed treatment with *Trichoderma harzianum* @ 10g/kg seed, foliar spray of *Trichoderma harzianum* @ 2g/l, foliar spray of carbendazim 50% WP @ 0.1%, foliar spray of difenoconazole 25 EC @ 0.1 %, foliar spray of tebuconazole 250 EC @ 0.1%, foliar spray of tebuconazole 50% + trifloxystrobin 25% WG @ 0.1%, foliar spray of pyraclostrobin 133g/l+ epoxiconazole 50 g/l w/w SE @ 0.15%, foliar spray of azoxystrobin 18.2 % + difenoconazole 11.4 % SC @ 0.1%, and control (untreated) were taken in study. The diseases assessment was done after 10 days of spraying and percent disease incidence was calculated.

Results: Foliar spray of tebuconazole 50% + trifloxystrobin 25% WG @ 0.1% was most effective in reducing the anthracnose PDI (19.41%) and cercospora leaf spot (18.26%) followed by foliar spray of azoxystrobin 18.2 % + difenoconazole 11.4 % SC @ 0.1% (24.36 and 21.05 %).

Conclusion: Among all the tested treatments, foliar spray of tebuconazole 50% + trifloxystrobin 25% WG @ 0.1% was most effective followed by foliar spray of azoxystrobin 18.2 % + difenoconazole 11.4 % SC @ 0.1% in managing both the diseases.

Keywords: Mungbean;Colletotrichum sp.;Cercospora sp.; fungicides; bio agents.

1. INTRODUCTION

The mungbean [*Vigna radiata* (L.)Wilczek, Syn.: *Phaseolus aureus*Roxb., *Phaseolusradiatus* L.] is the third most important pulse crop in India, following chickpea and pigeon pea. This short-duration legume, belonging to the family Leguminosae [1,2], is believed to have originated in India [3,4,5] or the Indo-Burmese region [6,7,8].Mungbean is extensively cultivated in southern and eastern Asia and is a crucial dietary source of protein and essential nutrients in South and West Asia, and North and East Africa. With 26% protein, it also contains 51% carbohydrates, 10% moisture, 4% minerals, and 3% vitamins. Mungbean seeds are rich in lysine, an essential amino acid typically deficient in cereal proteins. This crop is a valuable human food, consumed as dry seeds and used as fodder. It is often grown in rotation with cereals to enhance soil fertility through its nitrogen-fixing ability.Mungbeanproduction is mainly (90%) situated in Asia, with India being the largest producer, contributing over 50% of the global production but consuming almost all of its production. China also produces significant amounts of mungbean, accounting for 19% of its legume production. However, mungbean cultivation faces numerous challenges, including diseases caused by fungi, bacteria, viruses, nematodes, and abiotic stresses.

Anthracnose disease ofmungbean, caused by *Colletotrichum lindemuthianum* (Sacc. & Magn.) Bri. & Cav., is one of the most significant diseases affecting this crop.This cosmopolitan, seed-borne disease can lead to complete yield loss under favourable conditions when infecting susceptible cultivars [9,10,11,12].Despite the availability of management practices like seed and foliar treatment with fungicides, crop rotation, use of certified seed and genetic resistance, bean anthracnose persists in many regions. Planting resistant cultivars remains the most effective, least expensive, and easiest strategy for farmers to adopt. However, high pathogenic variability within the pathogen undermines this approach due to the continuous breakdown of resistance in recommended cultivars with good agronomic and marketability traits [10]. Therefore, the current study aims to investigate the use of biocontrol agents in combination with fungicides under field conditions to develop an effective management strategy.

Cercospora leaf spot is an important foliar disease of Mungbean caused by *Cercosporacanescens*. The disease was reported first time in Delhi, India [13] and can be occurred in all parts of the humid tropical areas of Asia and many other countries and is prevalent in all parts of humid tropical areas of India, Bangladesh, Indonesia, Malaysia, Philippines, and Thailand. In Pakistan, grain yield losses of up to 61% have been observed. The disease can cause qualitative and quantitative losses of up to 96% under natural epiphytotic conditions [14].

Thus, the primary objective of this study is to evaluate the efficacy of bioagents, both alone and in combination with fungicides, in various application modes. This approach aims to develop an integrated and effective management strategy to mitigate foliar disease impacts and reduce grain yield losses in mungbean.

2. MATERIALS AND METHODS

2.1 Details of the experiment

The field experiment was conducted at the Agricultural Research Station, Mandor, Agriculture University, Jodhpur during the*Kharif*season 2022 and 2023, using mungbeanvariety GM-4. All the bio agents and fungicides were obtained from Agricultural Research Station, Mandor and complete package and practices were followed during entire crop season. Bioagent treatments were applied at the time of sowing, and fungicidal treatments were administered at the first appearance of the disease. A control plot was maintained for each replication without any fungicidal treatments.Observations on the intensity of anthracnose and cercospora diseases were recorded 15 days after the last spraying. Ten plants were randomly selected and labelled from each plot to assess disease intensity. The disease intensity was recorded by observing three trifoliate leaves from the basal, middle, and upper portions of the plants. These selected plants were graded using a 0-9 disease rating scale for anthracnose (Table 1) and 1-9 disease rating scale for cercospora (Table 2), based on the percentage area of leaves infected by the pathogen [15]. The seed yield (kg/ha) was also recorded.

Table 1:Rating Scale for mungbean anthracnose disease

Scale	Description
0	No symptoms on leaves.
1	Small size lesions covering 1% or less ofleaf area
3	Small size lesions covering 1-10% of leafarea.
5	Lesions size big but not coalescing covering,11-25% of the leaf area.
7	Lesions on leaves covering 26-50% ofleaf area. Cankers on stem and podinfection.
9	Lesions on leaves covering 51% or moreof leaf area. Defoliation of leaves, deepcankers on stem and pods, blighting ofplant occurs.

Table 2:Rating Scale for mungbeancercospora leaf spot disease

Scale	Description
1	Small pinhead size brown lesions on leaf covering less than 1% leaf area
3	Small round, brown lesions on leaf covering 1-10% of leaf area
5	Lesions on leaves bigger, covering 1-25% of leaf area
7	Lesions enlargingand coalescing covering 26-50% of leaf area, shot-holesymptoms produced
9	Lesions coalescing 51%or more of leaf area, shot hole symptoms produced, lesions also on pods

The percent disease intensity (PDI) for both the disease wascalculated by using the formula given by Mayeeand Datar [15].

$$\text{Percent Disease Intensity (PDI)} = \frac{\text{Sum of numerial rating}}{\text{No. of leaves observed x Maximum rating}} \text{x100}$$

3. RESULT AND DISCUSSION

The results of this study demonstrate the significant impact of integrated management of anthracnose (*Colletotrichum lindemuthianum*) and cercospora leaf spot (*Cercosporacanescens*) in mungbean crops. The field experiment's outcomes, as presented in Table 3, clearly indicated that the disease severity was significantly low in all the treated plots compared to the unsprayed control plot.The treatment with tebuconazole 50% + trifloxystrobin 25% WG at 0.1% was the most effective, resulting in the lowest disease intensities for both anthracnose (19.41%) and cercospora leaf spot (18.26%). This efficacy can be attributed to the synergistic action of tebuconazole, a triazole fungicide known for its broad-spectrum activity, and trifloxystrobin, a strobilurin fungicide that inhibits spore germination and mycelial growth.The combination of azoxystrobin 18.2% + difenoconazole 11.4% SC at 0.1% also showed substantial effectiveness, with disease intensities of 24.36% for anthracnose and 21.05% for cercospora leaf spot. azoxystrobin, another strobilurin fungicide, provides broad-spectrum control, while difenoconazole, a triazole, further enhances the treatment's efficacy.The untreated control plots showed the highest disease intensities, with 39.59% for anthracnose and 36.62% for cercospora leaf spot, and the lowest seed yield (1384 kg/ha).

The economic analysis (Table 4) revealed that the foliar spray of tebuconazole 50% + trifloxystrobin 25% WG at 0.1% not only controlled the diseases effectively but also provided the highest benefit-cost (BC) ratio of 3.82. This indicates that the investment in this fungicidal treatment resulted in substantial economic returns due to the improved seed yield and reduced disease losses.The azoxystrobin 18.2% + difenoconazole 11.4% SC at 0.1% treatment also proved to be cost-effective, with a BC ratio of 3.68, demonstrating a favourable balance between the cost of treatment and the economic benefits of higher yields and lower disease intensity. The untreated control had the lowest (2.45) BC ratio.The observed economic benefits further justify the adoption of these fungicidal treatments by farmers, promoting sustainable and profitable mungbean cultivation.

Similarly,[16] reported that Carbendazim completely inhibited the mycelial growth of *C. canescens* at 200 ppm concentration under *in vitro* and bio-agent, *Trichoderma viride*was also found effective against the pathogen [17]also mentioned thatleast percent disease intensity of anthracnose was reported with fungicidal seed treatment with carbendazim + spraying with propiconazole followed by spraying of propiconazole alone. Combine seed treatment of carbendazim + *T. viride*also exhibited encouraging result in reducing disease intensity and higher seed yield and BC ratio.Similar outcomes have been accounted by [18] that among the combi fungicides evaluated, cent per cent inhibition was recorded in tricyclozole 18% + mancozeb 62%WP and carbendazim 12% + mancozeb 63% WP at 0.3 per cent concentration. In case of bioagents screened against *C. truncatum*, the highest mycelial inhibition was found in the *T. viride* strain (Tv- 29) followed by strain Tv– 1 and Tv– 10. While among the bacterial bioagents, *B. subtilis* strain (Bs–21) and *P. fluorescens* strain (Pf–26) showed highest mycelial inhibition.

An observation was made [19] that a combination of seed treatment with thiamethoxam at 4 g kg^{-1}, carboxin at 2 g kg^{-1} and Pusa 5SD (*Trichoderma virens*) at 4 g kg^{-1} followed by simultaneous foliar sprays of thiamethoxam 0.02% and carbendazim 0.05% at 21 and 35 days after sowing resulted in the highest seed germination and grain yield in mungbean with the lowest intensities of cercospora leaf spots and other diseases. Several researchers have been reported effectiveness of chemicals in the past investigations[20,21,22,23,24].

Table3:Integrated Management of Foliar Diseases of Mungbean

	Treatment	Percent Disease Intensity (%)						Yield (Kg/ha)		
		Anthracnose			Cercospora leaf spot					
		2022	2023	Pooled	2022	2023	Pooled	2022	2023	Pooled
T_1	Soil application with *Trichoderma harzianum* @ 5kg/ha enriched in 100 kg of FYM	31.33(34.01) *	36.00 (36.85)	35.43	24.00 (29.24)	28.00 (31.91)	30.57	1023	975	999
T_2	Seed treatment with *Trichoderma harzianum* @ 10g/kg seed	28.67 (32.33)	32.00 (34.42)	33.38	20.67 (26.75)	24.00 (29.28)	28.02	1043	1010	1026
T_3	Foliar Spray of *Trichoderma harzianum* @ 2g/ l	32.67 (34.70)	37.33 (37.66)	36.18	26.00 (30.61)	30.67 (33.62)	32.11	1000	781	890
T_4	Foliar spray of carbendazim 50% WP @ 0.1%	22.00 (27.96)	28.00 (31.91)	29.93	17.33 (24.22)	21.33 (27.49)	25.86	1123	1063	1093
T_5	Foliar spray of difenoconazole 25 EC @ 0.1 %	24.67 (29.58)	30.67 (33.62)	31.60	18.67 (25.34)	22.67 (28.36)	26.85	1095	1038	1067
T_6	Foliar spray of tebuconazole 250 EC @ 0.1%	20.67 (26.93)	25.33 (30.21)	28.57	15.33 (22.94)	17.33 (24.57)	23.75	1153	1148	1151
T_7	Foliar spray of tebuconazole 50% + trifloxystrobin 25% WG @ 0.1%	8.00 (16.35)	14.67 (22.47)	19.41	9.33 (17.53)	10.67 (18.99)	18.26	1413	1355	1384
T_8	Foliar spray of pyraclostrobin 133g/l+ epoxiconazole 50 g/l w/w SE @ 0.15%	16.00 (23.47)	24.00 (29.33)	26.40	10.67 (18.95)	13.33 (21.37)	20.16	1213	1261	1237
T_9	Foliar spray of azoxystrobin 18.2 % + difenoconazole 11.4 % SC @ 0.1%	14.67 (22.22)	20.00 (26.49)	24.36	14.67 (22.45)	11.33 (19.66)	21.05	1293	1289	1291
T_{10}	Untreated control	36.00 (36.87)	45.33 (42.32)	39.59	32.00 (34.41)	39.33 (38.83)	36.62	971	571	771
	SE(m) ±	**2.09**	**1.14**	**2.39**	**2.28**	**1.20**	**2.58**	**55.34**	**61.12**	**58.30**
	CD at 5%	**6.23**	**3.41**	**6.86**	**6.80**	**3.56**	**7.41**	**164.44**	**181.61**	**236.51**
	CV (%)	**12.78**	**6.10**	**9.61**	**15.70**	**7.59**	**12.03**	**8.46**	**10.09**	**9.25**

*****Figures in parenthesis indicate angular transformation values

Table 4:Effect of Integrated Management of Foliar Diseases on economics of Mungbean

	Treatment	Gross Return(₹/ha)			Net Return (₹/ha)			B:C Ratio		
		2022	2023	Mean	2022	2023	Mean	2022	2023	Mean
T_1	Soil application with *Trichoderma harzianum* @ 5kg/ha enriched in 100 kg of FYM	79334	83441	81387	52834	56941	54887	2.99	3.15	3.07
T_2	Seed treatment with *Trichoderma harzianum* @ 10g/kg seed	80885	86436	83660	55435	60986	58210	3.18	3.40	3.29
T_3	Foliar Spray of *Trichoderma harzianum* @ 2g/ l	77550	66838	72194	51800	41088	46444	3.01	2.60	2.80
T_4	Foliar spray of carbendazim 50% WP @ 0.1%	87089	90972	89030	60789	64672	62730	3.31	3.46	3.39
T_5	Foliar spray of difenoconazole 25 EC @ 0.1 %	84917	88832	86875	58717	62632	60675	3.24	3.39	3.32
T_6	Foliar spray of tebuconazole 250 EC @ 0.1%	89415	98246	93830	63215	72046	67630	3.41	3.75	3.58
T_7	Foliar spray of tebuconazole 50% + trifloxystrobin 25% WG @ 0.1%	109578	115961	112770	79978	86561	83270	3.70	3.94	3.82
T_8	Foliar spray of pyraclostrobin 133g/l+ epoxiconazole 50 g/l w/w SE @ 0.15%	94068	107916	100992	66618	80366	73492	3.43	3.92	3.67
T_9	Foliar spray of azoxystrobin 18.2 % + difenoconazole 11.4 % SC @ 0.1%	100272	110313	105292	71672	81713	76692	3.51	3.86	3.68
T_{10}	Untreated control	75301	48866	62084	50001	23566	36784	2.98	1.93	2.45

4. CONCLUSION

In conclusion, the field experiment demonstrated that the management approach using specific fungicide treatments significantly reduced the severity of anthracnose and cercospora leaf spot diseases in mungbean. The most effective and economically beneficial treatment was the foliar spray of tebuconazole 50% + trifloxystrobin 25% WG at 0.1%, followed closely by the azoxystrobin 18.2% + difenoconazole 11.4% SC at 0.1%. These treatments not only minimized disease intensity but also maximized seed yield and economic returns. The study demonstrates that effective fungicidal treatments not only reduce disease severity in mungbean but also enhance economic returns, making them a crucial component of integrated disease management strategies. The results provide a strong basis for recommending these treatments to mungbean farmers for sustainable crop production.

REFERENCES

1. Wilczek R. Vigna. In: Fiore du Congo Beige.1954;6:343-393.
2. Verdcourt B. Studies in the Leguminosae-Papilionoideaefor the Flora of Tropical EastAfrica: IV. Kew Bulletin.1970;24:507-569.
3. De Candolle, A. Origin of Cultivated Plants. Hafner Publ. Co., New York, N.Y. (2nd ed. 1959). 1886.
4. Zhukovsky, P.M. Cultivated plants and their wild relatives (Translation by P. S. Hudson. 1962. Commonwealth Agricultural Bureau, Farnham Royal, England, p. 107). 1950.
5. Bailey, L.H. Manual of Cultivated Plants. (Rev.) MacMillan, New York. 1970;1116 p.
6. Vavilov, N. I. The Origin, Variation, Immunity, and Breeding of Cultivated Plants. (Translation by K.S. Chester). Chron. Bot. 1951;13:364 p.
7. Singh HB, Joshi BS and Thomas TA. The Phaseolus group. In: P. Kachroo and M. Arif (eds.). Pulse Crops of India. Indian Council Agric.Res., New Delhi.1970;pp.136-164.
8. Jain HK, Mehra KL. Evolution, adaptation, rela-tionships and uses of species of Vigna cultivated in India. In:Summerfield R.J. and Bunting A.H. (eds), Advances inLegume Sciences. 1980;pp.459–468
9. Araya CM. La Antracnosis del frijol (*Phaseolus Vulgaris* L.) en Costa Rica. ManejoIntegradodePlagas (*Costa Rica*). 1989;13:83-9.
10. Sharma PN, Sharma OP, Tyagi PD. Status and distribution of bean anthracnose in Himachal Pradesh. Himachal journal of Agricultural Research. 1994;20:91-96.
11. Sharma PN, Sugha SK. Management of bean anthracnose through chemicals. Indian Phytopathology. 1995;48:304-307.
12. Somavilla L, Prestes AM. Identification of *Colletotrichum lindemuthianum* pathotypes occurring in some bean production regions of Rio Grande do Sul. *Fitopatologia Brasileira*. 1999;24:416-421.
13. Munjal RL, Lall G, Chona BL. Some Cercospora species from India-IV. Indian Phytopatholology. 1960;13:144-149.
14. Iqbal SM, Ghafoor A, Bashir M, Malik BA. Estimation of losses in yield components of mugbean due to Cersospora leaf spot. Pakistan J. Phytopathol. 1995;7: 80–83.
15. Mayee CD, Datar VV. Phytopathometry" Technical Bulletin-I, Marathawada Agricultural University, Parbhani, India. 1986; pp. 146.
16. Raghuvanshi RS, Chandra S, Singh A, Singh V, Pandey S, Raghuvanshi VV. Management of Cercospora Leaf Spot in Mungbean by use of Botanicals, Fungicides and Bio-agents. Biological Forum – An International Journal. 2022;14(4):276-287.
17. Misal DM, Khaire PB, Misal MR, Hingole DG. Integrated evaluation of fungicides, botanicals and bioagents against anthracnose of mungbean on natural field condition. International Journal of Chemical Studies. 2019;7(2),1975-1978.
18. Rajashree G, Patil MB, Aswathanaryana DS, Mallikarjun K, Sreenivas AG. *In vitro* evaluation of different fungicides against *Colletotrichum truncatum* causing anthracnose of green gram. International Journal of Chemical Studies. 2019;7(5):3295-3299.

19. Dubey SC, Singh B. Integrated management of major diseases of mungbean by seed treatment and foliar application of insecticide, fungicides and bioagent. Crop Protection. 2013;47,55-60.
20. Patel MK, Ranganathswamy Math. Evaluation of mix fungicides against *Colletotrichum truncatum*causing anthracnose of black gram. The Pharma Innovation Journal. 2023;12(9):2220-2223.
21. Purushotham P, Rakholiya KB, Vanani KD. Effectiveness of fungicides against *Colletotrichum lindemuthianum*causing anthracnose of green gram [*Vigna radiata* (L.) Wilczek]. *Legume Research*. 2023.https://arccjournals.com/journal/legume-research-an-international-journal/LR-5137
22. Prasad D, Gupta K, Singh VP. Management of Cercospora Leaf Spot of Mungbean [*Vigna radiata* (L.) Wilczek] using Fungicides and Host Resistance in Bundelkhand Region of Uttar Pradesh, India. Legume Research: An International Journal. 2024;47(2).
23. Chaudhari KA, Gohel NM. Management of anthracnose disease of mungbean through new fungicidal formulations. J. Pure Appl. Microbiol. 2016;10(1),691-696.
24. Singh S, Prasad D, Singh VP. Evaluation of fungicides and genotypes against anthracnose disease of mungbean caused by *Colletotrichum lindemuthianum.* International Journal of Bio-resource and Stress Management. 2022;13(5),448-453.