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Evaluation of Fungicides and Genotypes Against Anthracnose Disease of Mungbean Caused by *Colletotrichum lindemuthianum*

Shwetank Singh, Durga Prasad and Virendra Pratap Singh

Dept. of Plant Pathology, Banda University of Agriculture and Technology, Banda, Uttar Pradesh (210 001), India

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Corresponding dp.shubh@gmail.com

0000-0002-0678-0859

ABSTRACT

Mungbean [*Vigna radiata* (L.) Wilczek] is an important crop grown extensively in Bundelkhand region of Uttar Pradesh. Despite the multifaceted importance of this crop, its production could not be stabilized in the Uttar Pradesh as well as in the country. There are several biotic and abiotic constraints hampering the production of mungbean crop. Among the diseases, anthracnose disease caused by *Colletotrichum lindemuthianum* is one of the most important fungal diseases of mungbean in India. In recent past, it has become a major threat for mungbean cultivation particularly in Bundelkhand region of Uttar Pradesh during the *Kharif* crop season. Field experiments were conducted during July to September in 2019 and 2020 to find out a suitable management option for anthracnose in mungbean. Nine different fungicides and 190 mungbean germplasm were assessed against anthracnose. Twice sprays of Carbendazim at 1st appearance of symptoms at15 days interval gave the maximum reduction in incidence and severity of anthracnose *i.e.* 51.12% and 64.56%, respectively along with significant enhancement (53.39%) in grain yield during both the crop seasons. The second best effective fungicide for reduction of incidence and severity was combination of Carbendazim + Mancozeb followed by Azoxystrobin and Tebuconazole. Out of 190 mungbean germplasm, evaluated for resistance against anthracnose disease during two crop seasons, four genotypes viz., Pairy Mung, PMG-991, MGG-295 and Kopargaon were found to be moderately resistant against anthracnose disease. None of the germplasm were found to be resistant.

KEYWORDS: Anthracnose disease, *Colletotrichum lindemuthianum*, mungbean, greengram, host resistance

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Data Availability Statement: Legal restrictions are imposed on the public sharing of raw data. However, authors have full right to transfer or share the data in raw form upon request subject to either meeting the conditions of the original consents and the original research study. Further, access of data needs to meet whether the user complies with the ethical and legal obligations as data controllers to allow for secondary use of the data outside of the original study.

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1. INTRODUCTION

Mungbean [*Vigna radiata* (L.) Wilczek] is an important summer food legume crop of short duration and cultivated in the tropical and sub-tropical countries of the world. In India, this crop is cultivated in all three seasons' viz., *Kharif*, *Rabi* and *Zaid*. Its seed are a good source of dietary protein, vitamins and minerals for humans especially for marginal and vegetarian people. It is an ideal crop for smallholding farmers due to its low input requirement, nitrogen fixation capability and short duration. These qualities make it highly suitable for crop rotation (Nair et al., 2019, Udomkun et al., 2019). Worldwide, the total cultivated area and production of mungbean are 7 million ha and 5 million tonnes respectively. The yield potential of this crop ranges from 2.5 to 3.0 t ha^{-1}; however, the global average productivity is 0.5 t ha^{-1}. South Asia contributes 90% of total mungbean production worldwide, and India is the largest producer in South Asia with production of about 1.5 to 2.0 million tonnes from about 3 to 4 million hectare annually, with average productivity of 0.5 t ha^{-1} (Clarry, 2016, Pratap et al., 2020).

In general, the low productivity of pulses including mungbean is due to its cultivation in marginal lands, low rainfall areas, poor management and crop husbandry, high rate of flower and fruit drop, non-uniform maturity, pod shattering and susceptibility to pests and diseases. The production of mungbean is hampered by several biotic and abiotic stresses, including anthracnose, a prevalent fungal disease widely spread in Asian countries (Nair et al., 2019) and Sub-Saharan Africa (Mbeyagala et al., 2017, Noble et al., 2019)). Among biotic stresses, fungal diseases can reduce the yield up to 40–60% in mungbean (Kaur et al., 2011). Mungbean crop is affected by about sixty fungal, three bacterial and five viral diseases (Mukerji and Bhasin, 1986). Anthracnose disease in mungbean is caused by multiple species of the fungus Colletotrichum and severity of disease depends on the weather conditions (Mandal et al., 2015, Sharma et al., 2005, 2011). The pathogen infects many crops, hence management of disease in mungbean is little difficult (Buchwaldt et al., 2013, Rogerio et al., 2019). In India, losses due to anthracnose are estimated to range from 20 to 100% (Sharma et al., 2007, Deeksha and Tripathi, 2002). The yield loss is proportional to the disease severity, and it differs depending on the host genotypes and environmental conditions. The infection of pods directly damages the grain and reduces its viability thus may result in complete yield loss also.

Although scientific recommendations for management of a particular disease are more or less similar in different parts of the world. However, the management strategies in a particular region prove better when devised out of local scientific studies because nature of the host and pathogen on one hand and actual determinant of amount and spread of any disease on other hand. These determinants include ecology and environment and may affect virulence of pathogen and proneness of host as well. Therefore, the biotic stresses experienced by this crop in Southern region of Uttar Pradesh need to be addressed in the light of the knowledge generated in local area. Until now very few varieties of Mungbean have been found resistant to anthracnose, although several improved varieties have been developed through selection, hybridization and mutation. Use of chemicals in disease management is inevitable in most of the host pathogen combinations especially those involving polycyclic pathogens, though other ecofriendly and economical strategies are available. In view of importance of mungbean and associated anthracnose disease as well, the present investigation was therefore conducted to identify suitable resistant host genotypes and fungicidal molecule for management of disease under field conditions.

2. MATERIALS AND METHODS

2.1. Evaluation of fungicides against anthracnose disease

The present investigation on anthracnose of mungbean was conducted in the experimental field of Banda University of Agriculture and Technology, Banda (Uttar Pradesh), India which is located at 25° 4'N latitude, 80° 3'E longitudes and at an altitude of 141 meters above the mean sea level. Experiments were conducted in 2019 and 2020 during July to September to evaluate the efficacy of different fungicides on anthracnose disease of mungbean under natural epiphytotic conditions. The crop was sown in mid-July and harvested in the last week of September in both years. The NPK fertilizers were applied @ 30:50:30 kg ha^{-1}, respectively at the time of last harrowing besides ensuring recommended agronomy package of the crop. The mean of maximum/ minimum temperature, relative humidity and rainfall from July to September, 2019 was 30.58°C, 24.89°C, 79.15% and 99.64 mm, respectively, and it was 35.78°C, 27.07°C, 83.75% and 47.85 mm during the months from July to September in the year 2020. In the field experiment, nine fungicides including Propiconazole 25% EC @ 0.10%, Carbendazim 50% WP @ 0.15%, Copper oxychloride 50% WP @ 0.25%, Captan 70%+Hexaconazole 5% WP @ 0.20%, Hexaconazole 5% EC @ 0.25%, Mancozeb 75% WP @ 0.25%, Tebuconazole 25.9% EC @ 0.10%, Carbendazim 12% WP+Mancozeb 63% WP @ 0.20% and Azoxystrobin 23% SC @ 0.10% were assessed against anthracnose disease using IPM 2–3 as a test variety during both the seasons. All treatments were replicated thrice under randomized block design. The fungicide treatments were applied as foliar sprays during the evening with the help of Knap sack sprayer and a total of two sprays were given at the time of initiation of anthracnose symptoms and second spray at fifteen days after first spray. Only plain water was sprayed in the untreated plot.

Data was collected regarding per cent incidence of anthracnose disease at 60 days of sowing. The anthracnose severity was recorded with the help of randomly selected five plants in a plot having 4×3 m^2 size using 0–9 disease rating scale on the basis of percentage area of leaves infected by the pathogen (Mayee and Datar, 1986). The per cent disease index and per cent disease control was computed on the basis of above observations by the formula given by McKinney (1923) and Lodha (1976), respectively. Observations on yield parameters i.e. number of primary branches $plant^{-1}$ and number of pod $plant^{-1}$ were recorded with the help of randomly selected five plants in a plot. Number of seed/pod was counted on the basis of five randomly selected pods from each plot prior to harvesting of crop. Pod yield $plot^{-1}$ (kg) was recorded prior to threshing of harvested pods. One hundred seed weight (g) and yield (q ha^{-1}) were recorded after threshing and cleaning of seed. The data of each observation recorded in above investigation were statistically analyzed and calculations were made after applying the test of significance for the treatment means. Analysis of data was carried out using angular transformation at 5% level of significance with the help of OPSTAT software. Percent yield increased in treated plots was calculated on the basis of yield obtained in untreated plot in which fungicide was not applied.

2.2. *Reaction of mungbean genotypes against anthracnose disease*

Total 190 mungbean genotypes including germplasm and cultivars were evaluated for their reactions against *C. lindemuthianum*. The experiments were laid out in augmented design with 8 blocks and 5 checks during both seasons i.e. *kharif* 2019 and 2020 to evaluate mungbean germplasm for resistance against anthracnose disease under natural epiphytotic conditions. Each genotype was sown in 3×0.6 m^2 plots (2 rows) with inter-row and inter-plant spacing of 30 cm and 10cm, respectively. One local susceptible cultivar i.e. IPM 2–3 was included in the screening programme which was sown around the experimental blocks to ensure abundant and uniform inoculum pressure in the field. Land preparation, fertilizer application and sowing was done as described in above experiment. Observations for disease severity were recorded at 60 days of sowing using 0–9 scale, for which a random sample of 10 plants were taken in each plot. The cumulative disease severity was computed and based on per cent disease severity, the test entries of mungbean were categorized for different level of resistance/susceptibility on the basis of scale given by Mayee and Datar (1986).

3. RESULTS AND DISCUSSION

3.1. *Effect of fungicides on anthracnose disease and yield parameters*

The results (Table 1) of both crop seasons (*Kharif*, 2019 and 2020) showed that twice sprays of Carbendazim at 1^{st} appearance of anthracnose symptoms and second after 15 days of first spray gave the maximum reduction in the incidence (51.12%) and severity (64.56%) of anthracnose along with the highest increase in seed yield (53.39%) and 100-seed weight (24.91%) followed by twice sprays of combination of Carbendazim+Mancozeb which resulted in 39.76% and 58.16% reduction in incidence and severity respectively with 44.88% enhancement in seed yield and 22.84% enhancement in 100-seed weight. The next effective fungicide was Azoxystrobin which resulted in minimizing the disease incidence and severity by 34.49% and 45.41% respectively and 38.82% enhancement in seed yield. Azoxystrobin was followed by Tebuconazole for minimizing the level of disease and also the enhancement of yield. In the investigation, it was observed that application of fungicides increased the seed yield significantly over the unprotected crop. Among all nine fungicidal sprayed, twice sprays of Captan + Hexaconazole was found to be least effective in reducing disease incidence (8.52%), and severity (6.75%) and increasing the yield (12.99%) and 100-seed weight (0.35%) as well. In the experiment it was noticed that effect of fungicides on number of primary branches per plant or number of seed pod^{-1} was non-significant. However, twice application of fungicides increased the other yield parameters like number of pod $plant^{-1}$, pod yield $plot^{-1}$, hundred seed weight and seed yield ha^{-1}. Maximum enhancement in seed yield was recorded due to application of Carbendazim followed enhancement in seed yield due to Carbendazim+Mancozeb and Azoxystrobin, respectively. There was a noticeable point that the yield components like pod yield per plot (kg 12 m^{-2}) and 100 seed weight (g) obtained in the crop applied with Carbendazim or combination of Carbendazim+Mancozeb were statistically at par with each other but in view of overall seed yield (q ha^{-1}); carbendazim gave the highest yield (10.63 quintal ha^{-1}) because of highest number of pods $plant^{-1}$. It is already reported that Carbendazim and Mancozeb fungicides are effective in management of mungbean anthracnose and also used by the mungbean growers in developing countries to manage the anthracnose disease. (Khan et al., 2005). Jagtap et al. (2013) conducted experiment to control *Colletotrichum truncatum* causing anthracnose/pod blight of soybean with fungicides and found carbendazim @ 0.1% exhibited minimum disease intensity (19.55%) and pod infection (9.63%), with highest seed yield (2605 kg ha^{-1}) followed by mancozeb, 0.1% which exhibited the minimum disease

Table 1: Effect of different fungicides on anthracnose disease and yield parameters of mungbean

Fungicides and their concentrations	Disease incidence		Disease severity		No. of primary branches plant^{-1}	No. of pod plant^{-1}	
	Percent incidence	Percent reduction in incidence	Percent severity	Percent reduction in severity		No. of pod	Percent increase in number of pods
T_1-Propiconazole 25% EC @ 0.10%	70.50 (57.34)*	14.20	35.68 (36.56)	25.28	2.65	14.40	8.43
T_2-Carbendazim 50% WP @ 0.15%	40.17 (39.23)	51.12	16.92 (24.18)	64.56	2.80	21.38	60.99
T_3-Copper Oxychloride 50% WP @ 0.25%	65.00 (53.83)	20.90	34.38 (35.84)	28.00	2.62	15.00	12.95
T_4-Captan 70%+ Hexaconazole 5% WP @ 0.20%	75.17 (60.26)	8.52	44.53 (41.82)	6.75	2.62	13.55	2.03
T_5-Hexaconazole 5% EC @0.25%	61.17 (51.51)	25.56	32.49 (34.69)	31.95	2.53	14.93	12.42
T_6-Mancozeb 75% WP @ 0.25%	72.33 (58.52)	11.97	38.68 (38.43)	19.00	2.60	14.51	9.26
T_7-Tebuconazole 25.9% EC @ 0.10%	57.50 (49.35)	30.02	29.02 (32.47)	39.23	2.65	16.19	21.91
T_8-Carbendazim 12%WP+ Mancozeb 63% WP @ 0.20%	49.5 (44.71)	39.76	19.98 (26.47)	58.16	2.77	19.32	45.48
T_9-Azoxistrobin 23% SC @ 0.10%	53.83 (47.22)	34.49	26.07 (30.51)	45.41	2.75	18.17	36.82
T_{10}-Untreated control	82.67 (65.48)	0.00	47.76 (43.72)	0.00	2.62	13.28	0.00
SEm±	0.91	-	0.82	-	0.05	0.30	-
CD (p=0.05)	2.70	-	2.43	-	N/S	0.88	-

Table 1: Continue...

Fungicides and their concentrations	No. of seed pod^{-1}	Pod yield plot^{-1} (kg/12 m^2)		Seed yield (Q ha^{-1})		100- seed weight (g)	
		Pod yield	Percent increase in pod yield	Seed yield	Percent increase in seed weight	Seed weight	Percent increase in seed weight
T_1-Propiconazole 25% EC @ 0.10%	9.72	1.05	23.41	8.15	17.60	3.05	5.54
T_2-Carbendazim 50% WP @ 0.15%	10.38	1.67	96.47	10.63	53.39	3.61	24.91
T_3-Copper Oxychloride 50% WP @ 0.25%	9.76	1.13	32.94	8.28	19.48	3.14	8.65
T_4-Captan 70%+ Hexaconazole 5% WP @ 0.20%	9.56	0.94	10.59	7.83	12.99	2.90	0.35
T_5-Hexaconazole 5% EC @0.25%	9.87	1.18	38.82	8.42	21.50	3.26	12.80
T_6-Mancozeb 75% WP @ 0.25%	9.60	1.00	17.65	8.01	15.58	3.03	4.84
T_7-Tebuconazole 25.9% EC @ 0.10%	9.99	1.33	56.47	8.64	24.68	3.28	13.49
T_8-Carbendazim 12%WP+Mancozeb 63% WP @ 0.20%	10.28	1.58	85.88	10.04	44.88	3.55	22.84
T_9-Azoxistrobin 23% SC @ 0.10%	10.20	1.46	71.76	9.62	38.82	3.37	16.61
T_{10}-Untreated control	9.60	0.85	0.00	6.93	0.00	2.89	0.00
SEm±	0.14	0.08	-	0.18	-	0.05	-
CD (p=0.05)	N/S	0.24	-	0.54	-	0.14	-

*Figures given in parentheses are angular transformed values; Note: The data related to anthracnose disease and yield parameters as mentioned in above table are pooled data of experiments conducted twice during *kharif,* 2019 and 2020 intensity (21.50%) and pod infection (10.78%). Both these fungicides are frequently used for the management of fungus Colletotrichum causing anthracnose in other crops, such as soybean (Jagtap and Sontakke, 2009), chili (Goswami et al., 2013) and urdbean (Saha and Mohanty, 2017). Ahiladevi and Prakasam (2013) reported that Azoxystrobin 25 SC @ 0.15% is effective in control of chilli anthracnose disease under field conditions. Hence, the findings of present investigation are quite in agreement with the reports of earlier workers.

3.2. Screening of mungbean genotypes for resistance against anthracnose disease

Anthracnose management can be achieved using multiple approaches including use of disease-resistant cultivars (Chankaew et al., 2013). Anthracnose-resistant varieties would be cost-effective, practically feasible, eco- and farmer's friendly and a viable alternative to manage this disease. Efforts to identify resistant sources against anthracnose disease have made by several workers; however, most of the lines identified did not maintain the same level of resistance over time. Therefore, continuous efforts are needed to find out the sources of resistance. So in the present study an attempt was made to screen diverse mungbean genotypes for resistance against the anthracnose disease. In this connection a set of 190 genotypes were evaluated for resistance against anthracnose during *kharif,* 2019 and 2020 crop seasons under natural epiphytotic conditions in the field. Out of 190 mungbean genotypes, four genotypes viz., Pairy Mung, PMG-991, MGG-295 and Kopargaon exhibited moderately resistant reaction to *Colletotrichum lindemuthianum.* In the present study few attempts were made to identify anthracnose resistance in mungbean. For example, accessions ML 1486, 1464, 1194, and 1349 have been reported as anthracnose-resistant (Kaur et al., 2011). It implies that only limited sources of anthracnose resistance have been reported and the present study focused on searching for new sources that could be used in the breeding programs. Even though anthracnose resistance breeding has been in progress for the last two decades, little success has been achieved in this direction, mostly due to the absence of resistant sources and high complexity of the causal pathogen (Chongo and Bernier, 1999). Yadav and Pandey (2014) screened sixty five mungbean genotypes for resistance to anthracnose disease under natural epiphytotic conditions. Among the 65 genotypes, two (LGG-460 and TMV-37), one (GM-9926) and twenty five genotypes were found resistant, moderately resistant and moderately susceptible respectively to the anthracnose disease, while rests of the genotypes were found susceptible to highly susceptible. In the investigation, only four genotypes of mungbean had shown the moderately resistant reaction to *Colletotrichum lindemuthianum* sofar, although several improved varieties have been developed through selection, hybridization and mutation. There is a need for rigorous screening of available mungbean germplasm against the anthracnose disease so that the identified genotypes can be used in breeding program for development of varieties possessing resistance to anthracnose disease.

4. CONCLUSION

The present investigation was conducted to find out suitable fungicide molecule and host resistance to manage the anthracnose disease. Of 9 fungicides evaluated against anthracnose, twice sprays of Carbendazim gave the maximum reduction in disease intensity and the highest enhancement in seed yield and yield components as well followed by twice sprays of combination of Carbendazim+Mancozeb. Four genotypes viz., Pairy Mung, PMG-991, MGG-295 and Kopargaon were found to be moderately resistant to anthracnose while none of the genotype was resistant.

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