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Management of Cercospora Leaf Spot of Mungbean [*Vigna radiata* (L.) Wilczek] using Fungicides and Host Resistance in Bundelkhand Region of Uttar Pradesh, India

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ABSTRACT

Background: The pulses are important crop of Bundelkhand region of Uttar Pradesh. Among the pulses, mungbean is an important. Despite the multifaceted importance of this crop, its production could not be stabilized in the Uttar Pradesh as well as in the country due to several biotic constraints like diseases and insect-pests leading to considerable yield losses. Among several diseases affecting mungbean, cercospora leaf spot (CLS) caused by *Cercospora canescens* Ellis and Martin is one of the most important fungal diseases occurring regularly in the mungbean growing areas during the warm and humid weather.

Methods: Experiments were conducted during two cropping seasons *i.e. Kharif* 2019 and 2020 to find out an efficient management strategy for this disease. In first experiment, 9 fungicides were assessed against CLS during both the seasons. In second experiment, 200 germplasm of mungbean were evaluated for resistance against cercospora leaf spot.

Result: Among nine different fungicide treatments evaluated individually and as well as in combinations, spraying Carbendazim twice after first appearance of symptoms and second at 15 days' interval, gave maximum reduction in the incidence and severity of Cercospora leaf spot *i.e.* 45.57% and 58.45%, respectively along with significant enhancement (53.39%) in grain yield over the unprotected crop followed by treatment with Carbendazim + Mancozeb which resulted in 35.44% and 52.65% reduction in incidence and severity respectively and 44.88% enhancement in yield. Treatment with Captan + Hexaconazole was found to be least effective to reduce the disease incidence/ severity as well as to increase the crop yield. In second field experiment out of 200 mungbean genotypes evaluated against cercospora leaf spot during two consecutive crop seasons, four genotypes *viz.*, PDM 04-123, PDM 54, EC520034-1 and EC 520022 were found to be resistant against cercospora leaf spot disease.

Key words: *Cercospora canescens*, Cercospora leaf spot, Greengram, Host resistance, Mungbean.

INTRODUCTION

Mungbean [*Vigna radiata* (L.) Wilczek] is an important short duration summer legume in the tropical and subtropical countries of the world. In India, this crop is cultivated in three different seasons *viz.*, *Kharif* (July-Oct.), *Rabi* (Sept.-Dec.) and *Zaid* or summer (March-June). In India, mungbean is one of the thirteen food legumes and is also considered 3rd important pulse crop after chickpea and pigeonpea. Despite its multifaceted importance, the mungbean production could not be stabilized in the country. Mungbean is attacked by several pathogens, especially cercospora leaf spot (*C. canescens, C. cruenta*), powdery mildew (*Erysiphe polygoni*), anthracnose (*Colletotrichum capsici*), charcoal rot (*Macrophomina phaseoli*), web blight (*Rhizoctonia solani*), Alternaria leaf spot (*Alternaria alternata*), Aschochyta blight (*Ascochyta phaseolorum*), root disease complex (*Pythium* spp., *Rhizoctonia solani*, *Fusarium* spp.), reniform nematode (*Rotylenchulus reniformis*), root knot (*Meloidogyne* spp.) nematodes and yellow mosaic virus. Among all these diseases, cercospora leaf spot and yellow mosaic virus have been found to be most destructive in causing qualitative and quantitative losses worldwide (Nair *et al.,* 2019).

CLS occurs regularly in the most of the mungbean growing areas. It is very wide spread and has been reported from many countries. The leaf spot caused by *Cercospora canescens* was declared as a threat to mungbean cultivation in several countries for its devastating appearance in crop stands. CLS causing yield loss ranging from 50-70% has been observed in mungbean (Chand *et al.,* 2012). The yield losses vary depending upon how early the crop is infected in the season, crop variety and prevailing weather. Although scientific recommendations for management of a particular disease are more or less similar in different parts of the world, the management strategies in a particular region prove better when devised out of local scientific studies and according to socio-economic conditions because nature of the host and pathogen may vary according to local climate and weather

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conditions. Actual determinant of amount and spread of any disease may be variable according to local ecology and environment. Therefore, the biotic stresses experienced by this crop in Bundelkhand region need to be addressed. Until now very few varieties of mungbean have been found resistant or moderately resistant to *C. canescens*, although several improved varieties have been developed through selection, hybridization and mutation (Hasan *et al.,* 2017). Use of chemicals in disease management programmes is inevitable at some point of time for the management of plant diseases especially those involving polycyclic pathogens. It was an established fact that although ecofriendly and economical strategies are available, but these were not as effective as chemical management. Keeping the importance of mungbean as well as the associated disease in view, the present study was, therefore, intended to find host resistance and chemical molecules for management of CLS understanding crop conditions.

MATERIALS AND METHODS

Evaluation of fungicides against CLS under natural epiphytotic conditions

Field experiments were carried out during the two successive crop seasons *viz*, *Kharif* 2019 and 2020 to study the efficacy of different fungicides on CLS. 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. Sowing was done manually in 10 rows plots. The mean of maximum and 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 during the year 2020. In the experiment 9 fungicides *viz*., 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 Cercospora leaf spot 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 and a total of two sprays were given at the time of initial disease symptoms appearance and later at fifteen days after first spray. The spray operation was done during the evening with the help of Knap sack sprayer. The crop was sprayed till run off and in check plot only plain water was sprayed.

Data was collected regarding per cent incidence of CLS at 60 days of sowing. The severity of CLS was recorded with the help of randomly selected five plants in a plot having 4 m × 3 m size. CLS severity was recorded with the help of standard scale of All India Coordinated Research Project on MULLaRP (Alice and Nadarajan, 2007) and PDI was calculated. Observations of yield attributes *viz*., number of primary branches/ plant, number of pod/ plant, seed yield/ plant (g) were recorded with the help of randomly selected five plants in a plot. Number of seed/ pod was counted on the basis of five pods randomly selected from each plot just prior to harvesting of crop. Pod yield/ plot (kg) was recorded prior to threshing of harvested pods. One hundred seed weight (g) and yield (q/ha) were recorded after threshing and cleaning of seeds. The data of each observation/ experiment recorded in above investigations were statistically analyzed and calculations were made after applying the test of significance for the treatment means. Analysis of data is carried out using angular transformation at 5% level of significance with the help of OPSTAT software.

The observations recorded for CLS and yield parameters were calculated by using appropriate formula as given under:

Per cent disease incidence:

$$\text{Per cent disease incidence} = \frac{\text{Number of plants infected in a microplot}}{\text{Total number of plants in a microplot}} \times 100$$

Per cent disease severity (Wheeler, 1969):

$$\text{PDI} = \frac{\text{Sum of all numerical rating}}{\text{Total number of rating} \times \text{Maximum grade}} \times 100$$

Per cent disease control:

$$\text{Percent disease control} = \frac{\text{PDI in control - PDI in treated}}{\text{PDI in control}} \times 100$$

Per cent yield increase:

$$\text{Per cent yield Increase} = \frac{\text{Yield under protected - Yield under unprotected}}{\text{Yield under protected}} \times 100$$

Reaction of mungbean genotypes against cercospora leaf spot

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 200 germplasm of mungbean for identification of resistance against CLS under natural epiphytotic conditions. Each genotype was sown in 3 m × 0.6 m plots (2 rows) with inter-row and inter-plant spacing of 30 cm and 10 cm, 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 presence of abundant and uniform inoculum in the field. Land preparation, fertilizer application and sowing was done as described in earlier experiment. The genotypes were categorized on the basis of an established scale and observation for disease severity was recorded at 60 days of sowing using 1-9 scale for which a random sample of 5 plants

was taken in each plot (Singh *et al.,* 1995). The calculations for disease incidence/ severity and yield attributes were done with the help of above formulae.

RESULTS AND DISCUSSION

Effect of fungicides on CLS and yield parameters

The findings of both crop seasons (*Kharif* 2019 and 2020) indicated that among all treatments of fungicidal sprays given twice at 15 days interval after symptom appearance, carbendazim gave the maximum reduction (45.57%) in CLS incidence over the unprotected crop and it was followed by 35.44% and 30.74% reduction in incidence with treatments Carbendazim + Mancozeb and Azoxystrobin, respectively. Similar trend of results were found with CLS severity, where both treatment with Carbendazim and combination of Carbendazim + Mancozeb, were found equally effective which were statistically at par to each other with disease severities of *i.e.* 58.45% and 52.65%, respectively followed by Azoxystrobin which resulted in 41.11% reduction in severity. In the investigation, it was observed that impact of fungicides on number of primary branches per plant or number of seed per pod was non-significant (Table 2). However, twice application of fungicides enhanced the other yield parameters like number of pod/ plant, pod yield/ plot, seed yield/ plant, hundred seed weight and seed yield/ hectare over the unprotected control (Table 2 and 3). Maximum enhancement in seed yield (53.39%) as well as in yield parameters were recorded due to application of Carbendazim followed by 44.88% and 38.82% enhancement in seed yield due to Carbendazim + Mancozeb and Azoxystrobin, respectively. Among all nine treatments of fungicides, treatment with Captan + Hexaconazole was found to be least effective in reducing disease incidence (7.59%) and severity (6.12%) as well as to increase the yield and its components in comparison to unprotected crop. There was a noticeable point that the yield components like pod yield per plot (kg/12 m^2), seed yield per plant (g) and 100 seed weight (g) obtained in treatments with Carbendazim or combination of Carbendazim + Mancozeb were statistically at par with each other. But with respect to overall seed yield (q/ha), carbendazim gave the highest yield (10.63 quintal/ha) as compared to treatment with Carbendazim + Mancozeb. The maximum seed yield was recorded with Carbendazim because of highest number of pods per plant recorded which were significantly higher compared to carbendazim + Mancozeb (Table 1, 2 and 3).

The findings of present investigation are quite in conformity with the reports of earlier workers. Bhat *et al.,* (2015) reported that foliar spray of Carbendazim (0.1%) was effective in reducing the disease severity of CLS of mungbean. Palakshappa *et al.* (2012) evaluated different fungicides against Cercospora leaf spot of sesame and found carbendazim (0.1%) as most effective in controlling the disease. Muhammad and Garba (2015) evaluated the efficacy of three fungicides against cercospora leaf spot and

Table 1: Effect of fungicides on incidence and severity of Cercospora leaf spot disease of mungbean under natural epiphytotic.

Treatments	Per cent disease incidence			Per cent reduction in disease incidence	Per cent disease severity			Per cent reduction in disease severity
	2019	2020	Pooled		2019	2020	Pooled	
T_1- Propiconazole 25% EC @ 0.10%	75.00 (60.07)*	86.00 (68.77)	80.5 (64.42)	12.66	37.04 (37.37)	44.33 (41.73)	40.68 (39.55)	22.89
T_2- Carbendazim 50% WP @ 0.15%	42.66 (40.76)	57.66 (49.41)	50.16 (45.08)	45.57	19.26 (25.99)	24.59 (29.69)	21.92 (27.84)	58.45
T_3- Copper oxychloride 50% WP @ 0.25%	69.00 (56.22)	81.00 (64.22)	75.00 (60.22)	18.62	36.29 (37.01)	42.48 (40.64)	39.38 (38.83)	25.36
T_4- Captan 70%+Hexaconazole 5% WP @ 0.20%	81.00 (64.22)	89.33 (71.34)	85.16 (67.78)	7.59	46.07 (42.71)	52.99 (46.74)	49.53 (44.73)	6.12
T_5-Hexaconazole 5% EC @ 0.25%	67.33 (55.22)	75.00 (60.07)	71.16 (57.64)	22.78	33.33 (35.24)	41.66 (40.18)	37.49 (37.71)	28.94
T_6- Mancozeb 75% WP @ 0.25%	77.66 (62.01)	87.00 (69.70)	82.33 (65.85)	10.67	40.11 (39.28)	47.25 (43.42)	43.68 (41.35)	17.21
T_7- Tebuconazole 25.9% EC @ 0.10%	64.33 (53.40)	70.66 (57.28)	67.50 (55.34)	26.76	28.75 (32.39)	39.29 (38.8)	34.02 (35.59)	35.51
T_8- Carbendazim12%WP + Mancozeb 63% WP @ 0.20%	54.33 (47.49)	64.66 (53.56)	59.5 (50.52)	35.44	21.81 (27.84)	28.15 (32.02)	24.98 (29.93)	52.65
T_9- Azoxistrobin 23% SC @ 0.10%	60.00 (50.78)	67.66 (55.44)	63.83 (53.11)	30.74	26.28 (30.84)	35.86 (36.65)	31.07 (33.74)	41.11
T_{10}- Untreated control	90.00 (74.80)	94.33 (79.69)	92.16 (77.25)	0.00	48.89 (44.36)	56.63 (48.85)	52.76 (46.6)	0.00
SEM±	1.82	1.99	1.45	-	0.99	1.17	0.79	-
C.D. (0.05)	5.41	5.93	4.31	-	2.93	3.48	2.36	-

*Figures given in parentheses are angular transformed values.

Table 2: Effect of fungicides on number of primary branches, pod per plant and seed per pod of mungbean.

Treatments	Number of primary branches			Number of pod per plant				Number of seed per pod		
	2019	2020	Pooled	2019	2020	Pooled	Per cent increase in number of pods	2019	2020	Pooled
T_1- Propiconazole 25% EC @ 0.10%	2.60	2.70	2.65	15.80	13.01	14.40	8.43	10.05	9.38	9.72
T_2- Carbendazim 50% WP @ 0.15%	2.73	2.87	2.80	21.60	21.17	21.38	60.99	10.60	10.17	10.38
T_3- Copper oxychloride 50% WP @ 0.25%	2.67	2.57	2.62	15.13	14.88	15.00	12.95	10.11	9.41	9.76
T_4- Captan 70%+Hexaconazole 5% WP @ 0.20%	2.53	2.70	2.62	14.53	12.57	13.55	2.03	9.76	9.36	9.56
T_5- Hexaconazole 5% EC @0.25%	2.57	2.50	2.53	15.80	14.06	14.93	12.42	10.11	9.62	9.87
T_6- Mancozeb 75% WP @ 0.25%	2.60	2.60	2.60	15.13	13.89	14.51	9.26	9.79	9.41	9.60
T_7- Tebuconazole 25.9% EC @ 0.10%	2.57	2.73	2.65	16.93	15.46	16.19	21.91	10.39	9.58	9.99
T_8- Carbendazim12%WP+Mancozeb 63% WP @ 0.20%	2.73	2.80	2.77	19.46	19.18	19.32	45.48	10.47	10.10	10.28
T_9- Azoxistrobin 23% SC @ 0.10%	2.70	2.80	2.75	19.20	17.15	18.17	36.82	10.42	9.98	10.20
T_{10}-Untreated control	2.60	2.63	2.62	15.20	11.37	13.28	0.00	9.94	9.25	9.60
SEM±	0.05	0.08	0.05	0.44	0.43	0.30	-	0.19	0.16	0.14
C.D. (0.05)	N/S	N/S	N/S	1.30	1.26	0.88	-	N/S	N/S	N/S

Table 3: Effect of fungicides on pod yield, seed yield per plant, 100 seed weight and seed yield of mungbean.

Treatments	Pod yield per plot (kg/12m^2)				Seed yield per plant (g)				100 seed weight (g)				Seed yield (Quintal/ha)			
	2019	2020	Pooled	Per cent increase in pod yield	2019	2020	Pooled	Per cent increase in seed yield	2019	2020	Pooled	Per cent increase in seed weight	2019	2020	Pooled	Per cent increase in seed weight
T_1- Propiconazole 25% EC @ 0.10%	1.10	1.00	1.05	23.41	2.02	1.99	2.00	17.65	3.12	2.99	3.05	5.54	8.30	8.00	8.15	17.60
T_2- Carbendazim 50% WP @ 0.15%	1.72	1.63	1.67	96.47	3.24	3.07	3.15	85.29	3.65	3.57	3.61	24.91	10.76	10.51	10.63	53.39
T_3- Copper oxychloride 50% WP @ 0.25%	1.15	1.11	1.13	32.94	2.13	2.10	2.11	24.12	3.16	3.13	3.14	8.65	8.43	8.13	8.28	19.48
T_4- Captan 70% +Hexaconazole 5% WP @ 0.20%	0.99	0.90	0.94	10.59	1.85	1.77	1.80	5.88	2.94	2.86	2.90	0.35	8.17	7.50	7.83	12.99
T_5- Hexaconazole 5% EC @0.25%	1.24	1.14	1.18	38.82	2.31	2.13	2.22	30.59	3.33	3.21	3.26	12.80	8.47	8.37	8.42	21.50
T_6- Mancozeb 75% WP @ 0.25%	1.08	0.93	1.00	17.65	1.90	1.87	1.88	10.59	3.06	3.00	3.03	4.84	8.23	7.80	8.01	15.58
T_7- Tebuconazole 25.9% EC @ 0.10%	1.34	1.32	1.33	56.47	2.49	2.37	2.43	42.94	3.33	3.25	3.28	13.49	8.84	8.44	8.64	24.68
T_8- Carbendazim12% WP+Mancozeb 63% WP@ 0.20%	1.64	1.53	1.58	85.88	3.08	2.97	3.02	77.65	3.60	3.51	3.55	22.84	10.09	10.01	10.04	44.88
T_9- Azoxistrobin 23% SC @ 0.10%	1.57	1.36	1.46	71.76	2.80	2.60	2.70	58.82	3.37	3.37	3.37	16.61	9.62	9.63	9.62	38.82
T_{10}- Untreated Control	0.87	0.83	0.85	0.00	1.70	1.70	1.70	0.00	2.93	2.85	2.89	0.00	7.17	6.70	6.93	0.00
SEM±	0.09	0.08	0.08	-	0.08	0.08	0.08	-	0.07	0.05	0.05	-	0.26	0.2	0.18	-
C.D. (0.05)	0.27	0.24	0.24	-	0.23	0.25	0.23	-	0.22	0.16	0.14	-	0.78	0.60	0.54	-

found that least disease incidence, disease severity, highest number of pods per stand, pod weight and 100 seed weight were recorded with Carbendazim 12% + Mancozeb 63%. Yadav *et al.,* (2014) reported that combination of Carbendazim + Mancozeb was found superior against Cercospora leaf spot of greengram. Shrawan *et al.* (2015) evaluated 13 fungicides against cercospora leaf spot of okra and found that Tebuconazole (0.1%), Propiconazole (0.1%) and Bavistin (0.1%) gave minimum disease incidence and maximum fruit yield. Khunti *et al.* (2005) recorded minimum intensity of CLS and highest yield with the application of triazoles fungicides. Hence, the findings of earlier workers are quite supportive to the results of present investigation.

Screening of mungbean genotypes for resistance against CLS

Several workers have made efforts to identify resistant sources; 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. In this connection a set of 200 mungbean genotypes were evaluated for resistance against Cercospora leaf spot during *Kharif* 2019 and 2020 crop seasons under natural epiphytotic conditions.

Out of 200 mungbean genotypes, only four genotypes *viz.*, PDM 04-123, PDM 54, EC520034-1 and EC 520022 were found to be resistant against CLS during both the *Kharif* seasons, however, none of the genotype were found with immune reaction to *Cercospora canescens.* There is a need for intensive screening of available genotypes against the disease so as to indentify the genotypes with high degree of resistance which can be used as resistant donor. Raje and Rao (2002) were also identified 35 genotypes of mungbean possessing resistance against Cercospora leaf spot.

CONCLUSION

Foliar spray of carbendazim at the first appearance of symptoms and 15-day intervals gave the maximum reduction in the incidence and severity of Cercospora leaf spot (CLS) disease *i.e.* 45.57% and 58.45%, respectively along with significant enhancement in grain yield (53.39%) over the unprotected crop, it was followed by treatment in which the crop was sprayed twice with carbendazim + mancozeb. Out of 200 mungbean genotypes evaluated against CLS, four genotypes *viz.*, PDM 04-123, PDM 54, EC520034-1 and EC 520022 were found to be resistant to CLS and they may be used as donors for developing the varieties resistant to CLS. Hence, spraying crops either with carbendazim or with the combination of carbendazim + mancozeb can be recommended to farmers for effective management of CLS in standing crop conditions.

Conflict of interest

The authors declare that they have no conflict of interest.

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