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Application of fungicides and *Trichoderma viride* in management of soybean pod blight complex

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Abstract
Two year (2016 & 2017) field trial was carried out to determine which combination of fungicides and *Trichoderma viride* either for seed treatment or foliar application are most effective in minimizing the pod blight caused by *Colletotrichum truncatum.* Amongst, Seed treatment with carboxin 37.5 % + thiram 37.5 % @ 2 g/kg seed plus spray with thiophanate methyl 70 % WP @ 0.1 % at 55 and 75 DAS was found to be superior as recorded lowest pod infection followed by seed treatment with carbendazim 12 % + mancozeb 63 % @ 2 g/kg seed plus spray with thiophanate methyl 70 % WP @ 0.1 % at 55 and 75 DAS and seed treatment with *Trichoderma viridae* @ 5 g/kg seed plus spray with thiophanate methyl @ 0.1 % at 55 and 75 DAS, respectively. These combinations were also found impressive in improving seed germination as well as yield in comparison with untreated check. All the treatments were found effective in reducing pod blight infection and recorded 11.9 to 71.1 and 13.1 to 67.2 per cent disease control during 2016 and 2017, respectively.

Keywords: fungicides, *Trichoderma viride*, pod blight, management, soybean

Introduction
Soybean is a leguminous oil seed crop and grown worldwide as an excellent source of major nutrients i.e. protein (40 per cent) and fat (20 per cent). In India, it is cultivated as rainfed kharif crop and occupied area of 10.97 million ha with total production of 10.99 million tons and productivity of 1002 kg/ha during 2016-17 (SOPA) [1]. Madhya Pradesh is the leading state in area and production of soybean in India and grown in 54.01 lakh ha with average productivity of 1020 kg/ha and total production is 55.06 lakh ton during 2016-17 (SOPA) [1]. Soybean is extremely sensitive to biotic and abiotic stresses and especially plant pathogens can infect at different stages of crop starting from seed germination to physiological maturity. It is reported that more than 100 pathogens can affect soybean, of which 35 are of economically important (Sinclair and Backman, 1989) [2]. The diseases reduce yield, on an average of 10 to 30% in most production area (Sinclair, 1994) [3]. Amongst, anthracnose (Pod blight) caused by *Colletotrichum truncatum* (*C. dematium*) appeared during later stage of crop is also an economically important disease. An Outbreak of pod blight was observed on pods and seeds whereas other parts were free from infection and pathogen identified as *Colletotrichum dematium* (Gaikwad *et al.*, 1993) [4]. In M.P., low to moderate severity of *Colletotrichum* pod blight was recorded by Verma *et al*. (2009) [5]. Disease can be recognized by minute black fruiting bodies (acervulli) on affected stem and pods. Apart from *C. truncatum* (Pod blight and Anthrancose) another pathogen *Diaporthe phaseolorum var. sojae* can also caused pod and stem blight (Sinclair, 1982) [6]. Management strategies for pod blight disease includes use of disease free seeds, grow resistant varieties, Seed treatment, and fungicidal sprays. Hence keeping in the view to minimize the incidence caused by pod blight complex, the bio efficacy of new molecules along with biological control agent (BCA) were evaluated in different combination for seed treatment and foliage application.

Materials and Methods
Two year (2016 and 2017) field experiment was conducted to evaluate efficacy of various fungicides and their combo product along with biological control agent namely *Trichoderma viride* in controlling pod blight of soybean in research field of J.N.K.V.V., Jabalpur, Madhya Pradesh. A variety JS 335 was sown during last week of June in randomized block designed in a Plot size of 4 m x 1.5 m^2 (five rows) with three replication. Seeds from previous year infected plot were used in trial and in each plot four hundreds seeds were sown.

Fungicides and *Trichoderma virid* are applied as singly for seed treatment or in combination of seed treatment and foliar spray as mentions below.

Treatments

T1- Seed Treatment (ST) with carboxin 37.5 % + thiram 37.5 % (combo product) @ 2 g/kg seed
T2- Seed treatment (ST) with carbendazim 12 % + mancozeb 63 % (combo product) @ 2 g/kg seed
T3- Seed treatment with *Trichoderma viride* @ 5 g/kg seed
T4- T1 + spray with thiophanate methyl 70 % WP @0.1% at 55 and 75 DAS (Days after sowing)
T5- T2 + spray with thiophanate methyl 70 % WP @ 0.1% at 55 and 75 DAS
T6- T3 + spray with thiophanate methyl 70 % WP @0.1% at 55 and 75 DAS
T7- Spray with thiophanate methyl 70 % WP @0.1% at 55 and 75 DAS
T8- Spray with *Trichoderma viride* @ 5 g/ l
T9- Control

Crop was cared as per the recommended package and practices and watched regularly for appearance of disease on stem and pods. Replication wise per cent pod infected, yield and weight of 100 seeds were recorded at the time of harvesting. Per cent disease control (PDC) was calculated over the control and data was statistically analyzed and summarized in table 1.

Table 1: Effect of different treatments on incidence of soybean pod blight during 2016 and 2017

S. N	Treatments	2016					2017				
		Per cent Germin-ation	Per cent Pod Infected	Per cent disease control	100 Seed Weight (g)	Yield (Kg/ha)	Per cent Germin-ation	Per cent Pod Infected	Per cent disease control	100 Seed Weight (g)	Yield (Kg/ha)
1	T1- ST with carboxin + thiram @ 2 g/kg seed	62.50	8.73	42.5	9.87	950.0	63.53	10.57	39.2	9.29	716.3
2	T2 – ST with carbendazim + mancozeb @ 2 g/kg seed	61.50	9.63	36.5	10.17	983.3	62.83	11.54	33.6	8.72	713.6
3	T3 - ST with *Trichoderma viridae* @ 5 g/kg seed	54.0	13.37	11.9	8.57	779.0	55.66	15.12	13.1	8.1	670.0
4	T4 -T_1 + spray with thiophanate methyl @ 0.1 % at 55 and 75 DAS	63.33	4.39	71.1	10.23	1183.3	64.57	5.70	67.2	9.74	811.6
5	T5 -T_2 + spray with Thiophanate methyl @ 0.1 % at 55 and 75 DAS	64.11	5.59	63.2	10.12	1080.0	64.87	6.10	64.9	9.70	798.3
6	T6 -T_3 + spray with Thiophanate methyl @ 0.1 % at 55 and 75 DAS	52.50	6.61	56.4	8.81	823.0	53.23	6.70	61.5	8.27	776.6
7	T7 - Spray with Thiophanate methyl @ 0.1 % at 55 and 75 DAS	49.50	6.85	54.8	8.43	966.0	51.90	6.97	59.9	8.14	746.6
8	T8 - Spray with *Trichoderma viride* @ 5 g/L 55 and 75 DAS	51.50	12.31	18.9	8.74	812.5	52.66	15.23	12.4	8.24	690.0
9	T9=Control	50.23	15.17	-	8.51	721.0	53.07	17.39	-	8.17	656.6
	CD at 5 per cent	1.27	0.79	-	0.63	273.13	1.78	2.00	-	NS	39.2

Results and Discussion

Results revealed that all the treatments were found to be effective in minimizing the incidence of soybean pod blight. Per cent seed germination was significantly higher in seed treated plot with different treatments over control. Seed treatment with both the fungicides i.e. carbendazim + mancozeb @ 2 g/kg seed and carboxin + thiram @ 2 g/kg seed were found to be highly and equally effective in seed germination whereas *Trichoderma viridae* @ 5 g/kg seed was also gave good germination over control during 2016 and 2017. The germination of soybean varied from 49.50 to 64.11 per cent and 51.90 to 64.87 per cent in each year, respectively. Disease was appeared in the later stage of crop growth. All the treatments either of seed treatment or combination of seed treatment and foliar application were found to be significantly effective in controlling pod blight. T-4 (ST with carboxin 37.5 % + thiram 37.5 % @ 2 g/kg seed and spray with thiophanate methyl @ 0.1 % at 55 DAS and 75 DAS) was found to be superior as recorded lowest per cent pod infection followed by T – 5 (ST with carbendazim + mancozeb @ 2 g/kg seed and spray with thiophanate methyl @ 0.1 % at 55 DAS and 75 DAS) and T-6 (ST with *Trichoderma viridae* @ 5 g/kg seed and spray with thiophanate methyl @ 0.1 % at 55 DAS and 75 DAS). Per cent disease control due to different treatments was ranging from 11.9 to 71.1 and 13.1 to 67.2 in 2016 and 2017, respectively. The maximum weight of 100 seeds was obtained from T- 4 which is significantly differed from control in 2016 whereas results were non-significant in 2017. Similarly T- 4 recorded the highest yield of 1183.3 and 811.6 kg/ha followed by T-5 of 1080.0 and 798.3 kg/ha during 2016 and 2017, respectively.

Previous works are also showed similar trends as Dhurwey (2015) [7] recorded higher germination in soybean seed treated with carbendazim + mancozeb and carboxin + thiram as compared to untreated in blotter paper and also tested efficacy of carbendazim and other fungicides in minimizing pod blight under Madhya Pradesh conditions. Nagaraj (2013) [8] observed that seed treatment with carboxin+ thiram or captan along with foliar spray of trifloxystrobin + tebuconazole at 55 DAS was found very effective in reducing the soybean anthracnose. Jagtap *et al.* (2012) [9] recorded 75.73 per cent reduction in pod infection over unsprayed control by application of carbendazim (@ 0.1 per cent. Chaudhary *et al.*

(2005) [10] found lowest incidence of pod blight caused by *Colletotrichum truncatum* by application of thiophanate – methyl.

Conclusion

Seed treatment with carboxin 37.5 % + thiram 37.5 % @ 2 g/kg seed and spray with thiophanate methyl @ 0.1 % at 55 DAS and 75 DAS was found to be superior in minimizing the pod blight infection as well as in yield criteria. Whereas seed treatment by carbendazim 12 % + mancozeb 63 % @ 2 g/kg seed or *Trichoderma viridae* @ 5 g/kg along with foliar application of thiophanate methyl @ 0.1 % at 55 DAS and 75 DAS can be the other alternative combinations.

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