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Field evaluation of fungicides against pod blight complex disease of soybean *Glycine max* (L.) Merrill

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Abstract
Experiment on soybean (Glycine max L. Merrill) were carried out aiming to control pod blight caused by fungus, *Colletotrichum truncatum* (Schew.) Andus and Moore, *Colletotrichum gloeosporoides* (Penz.) Penz. and Sac. and *Rhizoctonia bataticola* (Taub.) Butler with seven treatments represented by different seed treatments and fungicidal sprays against disease. Whereas, control receiving no spray with three replications of each under field conditions during two consecutive years from 2016 to 2017. In 2016, the least Per cent Disease Index (PDI), per cent pod infection and increase in yield were estimated in plot treated with seed treatment with Carboxin 37.5% + Thiram 37.5% (Vitavax Power) @ 2 g/Kg of seed + Foliar Spray with Trifloxystrobin 25% + Tebuconazole 50% (Nativo 75WG) (0.7 g/l) followed by seed treatment with Mancozeb 50% + Carbendazim 25% (Sprint 75 WP) at 2 g/Kg of seed + Spray with Carbendazim 12% + Mancozeb 63% (SAAF 75 WP) fungicides. The mean Pod Disease Index (PDI) was highest in plots treated with Seed treatment with Carboxin 37.5% + Thiram 37.5% (Vitavax Power) @ 2 g/Kg of seed + Foliar Spray with Hexaconazole 5 EC (0.1%) followed by Seed treatment with Carboxin 37.5% + Thiram 37.5% (Vitavax Power) @ 2 g/Kg of seed + Foliar Spray with Propiconazole 25 EC (0.1%). Almost similar trends of disease control were observed in 2017. The treatment with Carboxin 37.5% + Thiram 37.5% (Vitavax Power) @ 2 g/Kg of seed + Foliar Spray with Trifloxystrobin 25% + Tebuconazole 50% (Nativo 75WG) (0.7 g/l) recorded least per cent disease Index, per cent pod infection and better yield productions against pod blight disease in soybean.

Keywords: Soybean, pod blight, fungicide, per cent disease index (PDI)

Introduction
Soybean [*Glycine max* (L.) Merill] is a species of legume native to East Asia. The plant is classed as an oilseed rather than a pulse. The genus Glycine is wild and divided into two subgenera, Glycine and Soja. It is cultivated over an area of 0.27 million hectare with a production of 0.17 million tonnes and productivity of about 639 kg/ha in Karnataka (Directors report, 2018) [1]. The state productivity (639 kg/ha) and national productivity (803 kg/ha) are low in comparison with world average (2735 kg/ha). The major soybean growing states in the country are Madhya Pradesh, Maharashtra, Karnataka, Andhra Pradesh, etc.

Soybean is a major oilseed and pulse crop and its plant parts easily succumb to different biotic stresses. Among them major constrains for soybean cultivation is the pod blight disease. Even though many seed and soil borne diseases do occur in the crop, pod blight has more important due to severe crop losses. Pod blight is a complex disease in which more than one pathogens are involved and also nature of damage and symptoms are decided by pathogens association. The disease is usually caused by fungal spp.

Among the fungal diseases infecting soybean crop, pod blight complex disease caused by *Colletotrichum truncatum, Colletotrichum gloeosporoides and Rhizoctonia bataticola* is one of the most important and destructive disease causing lower production and productivity and higher yield losses in soybean., has been reported as the major constraint in the successful cultivation of soybean (Khan and Backman, 1989 and Sinclair, 1974) [7, 8].

Material Methods
Field experiment was conducted during crop season of the year 2016-2017 at Ugar Research and Development Unit, Ugarkhurdh, Belagavi. The efficacy of fungicides by seed treatment and foliar spray and alone against the pathogen were tested in field during 2016 and 17.

The susceptible genotype JS 335 by 10 cm × 30 cm spacing was sown in plots size 4 m × 2 m size and the experiments were laid down in Randomized Block Design (RBD) by incorporating with seven treatments with three replication including untreated control. The soil of experimental plot was black in nature, well drained with low C: N ratio.

Prior to sowing, the seeds were treated with fungicides at the rate of 2 g / kg with combiproducts *viz.*, Vitavax Power and Sprint 75 WP. For this purpose required quantity of each fungicide were suspended in 5ml of tap water in a container, slurry was prepared and poured on seeds in plastic tray. They were vigorously shaken in order to coat the fungicidal slurry uniformly on the seed surface. The seeds were then dried overnight on papers and later used for sowing. The observations on severity of the disease and per cent pod infection were recorded at 70 and 90 days after sowing at pod maturation and pod formation stage and later the data was statistically analysed.

Table 1: Treatments details included for management of pod blight complex of Soybean

Treatments	Treatment details
T_1	Seed treatment with Carboxin 37.5% + Thiram 37.5% (Vitavax Power) @ 2 g/Kg of seeds + Foliar Spray with Hexaconazole 5 EC (0.1%) at 50 and 70 DAS
T_2	Seed treatment with Carboxin 37.5% + Thiram 37.5% (Vitavax Power) @ 2 g/Kg of seed + Foliar Spray with Propiconazole 25 EC (0.1%) at 50 and 70 DAS
T_3	Seed treatment with Carboxin 37.5% + Thiram 37.5% (Vitavax Power) @ 2 g/Kg of seed + Foliar Spray with Trifloxystrobin 25% + Tebuconazole 50% (Nativo 75WG) (0.07 %) at 50 and 70 DAS
T_4	Seed treatment with Mancozeb 50% + Carbendazim 25% (Sprint 75 WP) at 2 g/Kg of seed + Spray with Carbendazim 12% + Mancozeb 63% (SAAF 75 WP) (0.2%) at 50 and 70 DAS
T_5	Seed treatment with Mancozeb 50% + Carbendazim 25% (Sprint 75 WP) at 2 g/Kg of seed + Spray with Zineb 68% + Hexaconazole 4% (Avatar 72 WP) (0.2%) at 50 and 70 DAS
T_6	Seed treatment with Mancozeb 50% + Carbendazim 25% (Sprint 75 WP) at 2 g/Kg of seed + Spray with Mancozeb 75 WP (0.2%) at 50 and 70 DAS
T_7	Untreated control

Table 2: The severity of pod blight was using a disease rating scale 0 to 9 given by Mayee and Datar (1986).

Category	Reactions	Description
0	Immune	No lesions / discolouration
1	Resistant	1% area covered with lesions/spots/discolouration
3	Moderately resistant	1.1-10% area covered with lesions/spots/discolouration
5	Moderately susceptible	10.1-25% area covered with lesions/spots/discolouration
7	Susceptible	25.1-50% area covered with lesions/spots/discolouration
9	Highly susceptible	>50% area covered with lesions/spots/discolouration

Further, these scales were converted into Per cent Disease Index (PDI) by using the formula given by Wheeler (1969) [9].

$$\text{Per cent Disease Index} = \frac{\text{Summation of numerical ratings}}{\text{No. of pods observed} \times \text{Max. Rating}} \times 100$$

$$\text{Per cent pod infection} = \frac{\text{No. of infected pods}}{\text{Total no. of pods}} \times 100$$

$$\text{Per cent disease control} = \frac{\text{Control} - \text{Treatment}}{\text{Control}} \times 100$$

Results and Discussion

During the year *Kharif* 2016 results indicated that all the treatments were significantly superior over untreated control. From the data, it is clear that the least per cent disease index (13.57 PDI) and per cent pod infection of 10.79 was found in T3 (Seed treatment with Carboxin 37.5% + Thiram 37.5% (Vitavax Power) @ 2 g/Kg of seed + Foliar Spray with Trifloxystrobin 25% + Tebuconazole 50% (Nativo 75WG) (0.7 g/l)) followed by T4 (Seed treatment with Mancozeb 50% + Carbendazim 25% (Sprint 75 WP) at 2 g/Kg of seed + Spray with Carbendazim 12% + Mancozeb 63% (SAAF 75 WP) (0.2%)) with PDI of 18.51 and per cent pod infection of 15.38 and they are on par with each other.

Next to T4 the treatment T6 (Seed treatment with + Mancozeb 50% + Carbendazim 25% (Sprint 75 WP) at 2 g/Kg of seed + Spray with Mancozeb 75 WP (0.2%)) recorded least PDI of 23.45 and per cent pod infection of 20.00 followed by T5 (Seed treatment with + Mancozeb 50% + Carbendazim 25% (Sprint 75 WP) at 2 g/Kg of seed + Spray with Zineb 68% + Hexaconazole 4% (Avatar 72 WP)) with PDI of 29.22 and per cent pod infection of 36.29 were these two treatments i.e. T6 and T5 are on par with each other.

During the year *Kharif* 2017 similar trends of results were obtained that all the treatments were significantly superior over untreated control. From the data, it is clear that the least per cent disease index (18.49 PDI) and per cent pod infection of 15.73 was found in T3 (Seed treatment with Carboxin 37.5% + Thiram 37.5% (Vitavax Power) @ 2 g/Kg of seed + Foliar Spray with Trifloxystrobin 25% + Tebuconazole 50% (Nativo 75WG) (0.7 g/l)) followed by T4 (Seed treatment with Mancozeb 50% + Carbendazim 25% (Sprint 75 WP) at 2 g/Kg of seed + Spray with Carbendazim 12% + Mancozeb 63% (SAAF 75 WP) (0.2%)) with PDI of 21.45 and per cent pod infection of 18.64 and they are on par with each other.

While, coming to yield parameters in both the seasons of *Kharif* 2016 and 2017 among the thirteen treatments T3 (T3 (Seed treatment with Carboxin 37.5% + Thiram 37.5% (Vitavax Power) @ 2 g/Kg of seed + Foliar Spray with Trifloxystrobin 25% + Tebuconazole 50% (Nativo 75WG) (0.7 g/l))) recorded highest yield of 2666.66 kg/ha, test weight of 13.90 gms and 1847.22 kg/ha, test weight of 14.11 gms respectively which is on par with the next best treatment T4 (Seed treatment with Mancozeb 50% + Carbendazim 25% (Sprint 75 WP) at 2 g/Kg of seed + Spray with Carbendazim 12% + Mancozeb 63% (SAAF 75 WP) (0.2%)) with yield of 2533.33 kg/ha, test weight of 13.69 gms and 1750 kg/ha, test

weight of 13.63 gms in test weight and yield parameters and all the treatments that were significantly superior over untreated control (T13) with yield of 1516.66 kg/ha, test weight of 13.04 gms and 694.44 kg/ha, test weight of 12.07 gms during both the years of *Kharif* 2016 and 2017 respectively.

Similar observations were obtained by Picinini and Fernandes (1996) indicated that seed treatment with captan, carboxin + thiram (WP and EC in soybean helped to eradicate different levels of *Colletotrichum truncatum* infection. Billore *et al.* (2004) and Kulkarni (2009) showed propiconazole @1ml was the effective one followed by hexaconazole@1ml. Jagtap *et al.* (2013) studied that was conducted during 2009 to 2010 to control *Colletotrichum truncatum* causing anthracnose/pod blight of soybean with fungicides. Results indicated that Spray of SAAF 75 WP (Carbendazim 12% + Mancozeb 63%) emerged as the best chemical in managing pod blight disease.

Conclusion

In conclusion, pod blight of soybean is caused by one or association of various pathogens. Hence, the effort was made to manage the pathogens that are associated with causing pod blight disease in soybean under the epiphytotic field conditions. In the experiment the better management strategies against the disease the treatment T_3 (Seed treatment with Carboxin 37.5% + Thiram 37.5% (Vitavax Power) @ 2 g/Kg of seed + Foliar Spray with Trifloxystrobin 25% + Tebuconazole 50% (Nativo 75WG) (0.07 g/l)) emerged as the best chemical in controlling the disease with least disease severity, per cent pod infection and higher yield production.

Table 3: Per cent disease index due to pod blight disease of soybean during *Kharif* –2016

Sl. no	Treatments	PDI at 70 DAS	PDC	PDI at 90 DAS	PDC
1.	T_1	35.80 (36.73)*	43.12	34.17 (35.75) *	54.62
2.	T_2	34.56 (35.96)	45.09	33.33 (35.26)	55.73
3.	T_3	17.28 (24.36)	72.54	13.57 (21.49)	81.97
4.	T_4	22.21 (28.07)	64.71	18.51 (25.19)	75.41
5.	T_5	30.85 (33.74)	50.99	29.62 (32.95)	60.66
6.	T_6	25.92 (30.57)	58.82	23.45 (28.90)	68.85
7.	T_7	62.95 (50.33)	0.00	75.30 (60.58)	0.00
	S.EM 1.968 CD (5%) 5.745 CV 9.261			S.EM 2.433 CD (5%) 7.102 CV 11.654	

* Indicates arc sine transformed values

Table 4: Per cent pod infection by pod blight disease in soybean during *Kharif* 2016.

Sl. no	Treatments	PI at 70 DAS	PDC	PI at 90 DAS	PDC
1.	T_1	38.45 (38.32)*	34.22	35.38 (36.46)	49.26
2.	T_2	33.84 (35.47)	42.01	31.27 (33.95)	55.16
3.	T_3	15.38 (23.07)	73.68	10.79 (19.15)	84.92
4.	T_4	19.50 (26.17)	66.78	15.38 (23.02)	77.94
5.	T_5	30.73 (33.65)	47.41	29.22 (32.72)	58.10
6.	T_6	21.01 (27.22)	64.04	20.00 (26.55)	71.33
7.	T_7	58.44 (49.87)	0.00	69.74 (56.64)	0.00
	S.EM 1.451 CD (5%) 4.236 CV 6.930			S.EM 1.582 CD (5%) 4.619 CV 7.730	

* Indicates arc sine transformed values

Table 5: Per cent disease index of pod blight disease in soybean during *Kharif* -2017

Sl. no	Treatments	PDI at 70 DAS	PDC	PDI at 90 DAS	PDC
1.	T_1	40.74 (39.64)*	43.29	38.51 (38.32)	51.40
2.	T_2	38.51 (38.27)	46.40	37.77 (37.87)	57.00
3.	T_3	21.48 (27.56)	70.10	18.49 (25.31)	76.66
4.	T_4	25.92 (30.53)	63.92	21.45 (27.54)	72.93
5.	T_5	34.07 (35.64)	52.58	36.29 (36.98)	54.20
6.	T_6	28.14 (31.89)	60.83	28.88 (32.47)	63.55
7.	T_7	71.85 (57.97)	0.00	79.25 (63.12)	0.00
	S.EM 2.203 CD (5%) 6.430 CV 9.789			S.EM 2.313 CD (5%) 6.792 CV 10.343	

* Indicates arc sine transformed values

Table 6: Per cent pod infection by pod blight disease in soybean during *Kharif* -2017

Sl. no	Treatments	PI at 70 DAS	PDC	PI at 90 DAS	PDC
1.	T_1	40.88 (39.71)*	35.58	39.52 (38.94)	48.25
2.	T_2	36.01 (36.86)	43.25	35.97 (36.85)	52.90
3.	T_3	18.38 (25.26)	71.03	15.73 (23.30)	74.40
4.	T_4	20.64 (26.95)	67.47	18.64 (25.47)	75.59
5.	T_5	36.60 (37.19)	42.32	33.47 (35.29)	56.18
6.	T_6	42.52 (40.68)	32.99	21.02 (27.27)	72.48
7.	T_7	63.46 (52.96)	0.00	76.38 (61.09)	0.00
	S.EM 2.407 CD (5%) 7.026 CV 10.523			S.EM 1.678 CD (5%) 4.898 CV 7.677	

* Indicates arc sine transformed values

Table 7: Seed yield of soybean during *Kharif* 2016 in IDM experiment under field experiment

Sl. no	Treatments	Mean seed yield of plots (kg/plot)	Seed yield (kg/ha)	Test weight.100 seeds (g)
1.	T_1	1.29	2150.00	13.46 (21.52)*
2.	T_2	1.32	2183.33	13.24 (21.34)
3.	T_3	1.61	2666.66	13.90 (21.89)
4.	T_4	1.53	2533.33	13.69 (21.72)
5.	T_5	1.41	2333.33	13.40 (21.48)
6.	T_6	1.44	2400.00	13.38 (21.45)
7.	T_7	0.92	1516.66	13.04 (21.17)
	S.EM 117.430 CD (5%) 517.882 CV 14.095			S.EM 0.151 CD (5%) 0.440 CV 1.220

* Indicates arc sine transformed values

Table 8: Seed yield of soybean during *Kharif* 2017 in IDM experiment under field experiment

Sl. no	Treatments	Mean seed yield of plots (kg/plot)	Seed yield (kg/ha)	Test weight.100 seeds (gms)
1.	T_1	0.98	1361.11	13.41 (21.48)*
2.	T_2	1.10	1527.77	13.23 (21.32)
3.	T_3	1.33	1847.22	14.11 (22.07)
4.	T_4	1.26	1750.00	13.63 (21.66)
5.	T_5	1.21	1680.55	13.22 (21.32)
6.	T_6	1.16	1611.11	13.35 (21.43)
7.	T_7	0.50	694.44	12.07 (20.32)
	S.EM 113.064 CD (5%) 330.010 CV 13.848			S.EM 0.259 CD (5%) 0.756 CV 2.099

* Indicates arc sine transformed values

Fig 1: Overall view of experimental plot Ugarkhurdh, Belagavi

T_3 - Seed treatment with carboxin+ thiram + foliar spray of trifloxystrobin + tebuconazole (Nativo)

T_{13} - (Untreated control)

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