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Management of Field Bean Anthracnose with Fungicides, Leaf Extracts and Bioagents under Field Conditions

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ABSTRACT

A field study was conducted at College of Horticulture, Venkataramannagudem from 2016 to 2018 to find out the efficacy of five fungicides, two leaf extracts and bioagents for the management of field bean anthracnose. Among the fungicides, propiconazole (@ 0.1%) was found with least mean disease index (21.22%) and maximum green pod yield (9.16 t ha^{-1}), with highest reduction in disease index (48.91%), per cent increase in yield (31.33%) over unsprayed control. Maximum incremental cost: benefit ratio (ICBR) was obtained with thiophanate methyl (19.66). With the bioagents, *B. subtilis* (2.0%) disease reduction of 39.37% was obtained while *T. viride* reduced upto 37.64%. The relative yield losses showed notable differences among treatments. Yield losses were highly reduced when fungicide was sprayed compared to bio-agents and botanicals. The lowest yield losses were recorded with thiophanate methyl (0.66%) followed by carbendazim+mancozeb (6.22%), captan+hexaconazole (7.86%) as compared to the untreated control (24.53%).

Key words: *Anthracnose, Bioagents, Field bean, Fungicides, Leaf extracts.*

Field bean (*Lablab purpureus* var. *lignosus*) anthracnose incited by *Colletotrichum lindemuthianum* (Sacc. and Magn.) is an important disease causing lossess up to 100 per cent, if contaminated seed is planted (Lakshmi Ramakrishnan, 1964; Zate *et al*., 1976; Sharma and Sugha 1995; Sharma *et al*., 2008). Adoption of control practices is not quite common in the farmers' fields but, it becomes obligatory to have spray schedules for the management of plant diseases, particularly in the absence of resistant cultivars. Hence, an attempt was made to know the efficacy of different fungicides, leaf extracts and bioagents formulation against field bean anthracnose.

MATERIAL AND METHODS

The field experiments were conducted at Instructional Farm, College of Horticulture, V.R. Gudem during 2016-17 and 2017-18 using field bean variety Arka Amogh. The experimental crop was raised as per the package of practices of Dr. YSR Horticultural University, Andhra Pradesh.

Eleven treatment *viz*., T_1-*Azadirachta indica* leaf extract (10.0%); T_2-Thiophanate methyl (0.1%); T_3-talc based formulation of *Trichoderma viride* (2.0%); T_4- talc based formulation of *Pseudomonas fluorescens* (2.0%); T_5- Captan (70%) +hexaconazole (0.15%); T_6- Propiconazole (0.1%); T_7- Azoxystrobin (0.1%); T_8- Carbendazim (12%) +mancozeb (0.1%); T_9- leaf extract of *Lantana camara* (10.0%); T_{10}- talc based formulation of *Bacillus subtilis* (2.0%) and T_{11}- control were imposed in randomized block design and replicated thrice in plots of 6.0 x 4.5 m^2. Three sprayings were taken up at an interval of 10 days starting from first appearance of disease symptoms. Observations on disease severity were recorded on five point scale as given by Mayee and Datar (1986). Fifteen plants from each plot were selected and labeled randomly for scoring the disease severity. Disease severity was recorded by observing three trifoliate leaves, one each from base, middle and upper portion of the selected plant and per cent disease index (PDI) was calculated by Wheeler's (1969) formula and per cent disease reduction over control (PDC) was calculated by the formula given by Lodha (1976). Green pods were harvested separately at regular intervals from each treatment after maturity and plot wise yield was recorded in terms of kg to derive yield per hectare. Further per cent yield increase over control and relative yield loss was estimated for each treatment. Economics of the each treatment was worked by incremental cost benefit ratio.

RESULTS AND DISCUSSION

Effect of fungicides, leaf extracts and bioagents on per cent disease index and per cent disease reduction over control

Anthracnose appeared at about 45-50 days after sowing and significant difference between sprayed and un-sprayed plots at three (50, 60 and 70 DAS) successive disease assessment periods was observed (Table 1 and Fig.1).

During 2016-17, all the treatment imposed to test against anthracnose were found significantly superior over control with reduction in per cent disease index. After first spraying *i.e.*, at 58 DAS the per cent disease index ranged from 10.61 to 17.92 with corresponding disease reduction of 26.89 to 56.71%, as against control (24.51%). The three treatments *viz*., propiconazole, thiophanate methyl and carbendazim + mancozeb were at par with each other with the PDI of 10.61, 12.19, 12.44 and per cent disease reduction over control was 56.71, 50.27, 49.25, respectively (Fig.1).

After 2nd spraying (two days before third spraying *i.e.* at 68 DAS), the PDI ranged from 17.59 to 26.12 with PDC of 23.47 to 48.46 and significant difference was noticed among the treatments. The lowest PDI and the highest PDC were observed with propiconazole, which was significantly superior over rest of the treatments.

At 10 days after third spray (Terminal PDI *i.e.*, at 78 DAS), PDI increased but lesser extent than that of second spraying and ranged from 20.71 to 28.04, as against untreated control (40.52). Among the treatments, propiconazole was superior over rest of the treatment and controlled the disease with PDI of 20.71 except thiophanate methyl (22.62). After 3rd spraying, the fungicide spraying schedules were at par with talc based formulation of *B. subtilis* and *T. viride* and *P. fluorescens*. The PDI in case of plant extracts were from 26.21 to 28.04 but both were at par with each other.

During 2017-18 disease appeared at about 40-45 days after sowing *i.e.*, 5 days earlier than in 2016-17 may be due to available inoculum that survived in plant debris.

After first spraying, the per cent disease index ranged from 12.67 to 19.95 in all treatments imposed as against 26.50 % in control and all the treatments were found superior over unsprayed control. Four of the chemical treatments *viz*., propiconazole, thiophanate methyl, carbendazim+mancozeb and captan+ hexaconazole were at par with each other with the PDI (12.67, 14.16, 14.54 and 14.88) and PDC (52.19, 46.57, 45.13 and 43.85), respectively. The highest PDI (19.95) and corresponding lowest disease reduction of disease (24.72%) was observed with spraying of leaf extract of *A. indica*, which was superior to control (26.50).

After 2nd spraying, the PDI ranged from 19.46 to 36.81 including the untreated control and PDC was ranged from 23.72 to 47.13. At second spraying also significant difference was noticed among the treatments. In Propiconazole sprayed plots significantly the lowest PDI (19.46) and the highest PDC (47.13%) was recorded and was found superior over rest of the treatments (Fig. 2).

After third spraying, PDI ranged from 21.72 to 30.07 per cent, as against PDI of 42.59 % in untreated control. Among the treatments, propiconazole was significantly superior over rest of the treatments with a PDC of 29.40 (Fig.1).

The pooled data (Table 1) indicated, propiconazole very effective and superior over rest of the treatments in managing anthacnose with the lowest PDI of 11.64, 18.53 and 21.22 in 1st, 2nd and 3rd sprayings, respectively, and significant over the other treatments except thiophanate methyl after 1st spray

Therefore, fungicides were more found effective with the lowest PDI and the highest PDC followed by bio-agents (*B. subtilis*) and leaf extracts. These results were in accordance with the findings of Pastor Corrales and Tu (1989) who reported the fungicide spray on foliage prior to flowering initiation, late flowering and pod fill could satisfactorily control bean anthracnose disease.

With respect to different spray schedules, spraying at initial stages with fungicides was more effective in controling disease and as the crop growth period advanced bioagents, particularly *B. subtilis* was equally effective with azoxystrobin. This may be due to development of micro climate for fast multiplication of bioagents and also availability of sufficient food material *i.e.*, litter and production of endospores by *B. subtilis*.

Effect on fungicides, leaf extracts and bioagents on green pod yield and economics

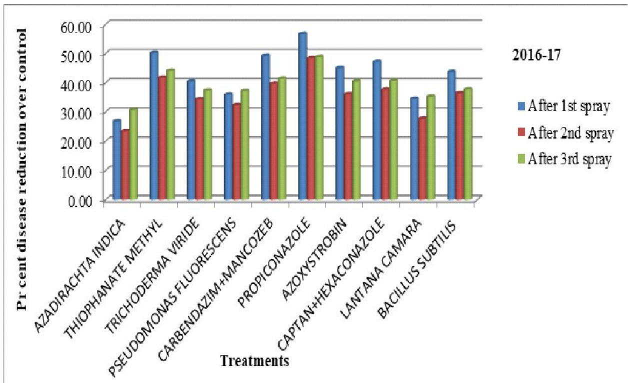
Green pod yield

All the treatments significantly reduced the disease severity and there by increased the green pod yield and profit compared to untreated check.

During 2016-17, it was observed that different treatments had significant impact on green pod yield (Table 2) and it ranged from 7.42 to 9.68, as against only 6.72 in control. Propiconazole sprayed plots were recorded with significantly high grain pod yield (9.68 t ha^{-1}) with corresponding increase in yield over control to an extent of 30.58%, which was at par with plots sprayed with thiophanate methyl (9.62 t ha^{-1}). These were followed by treatments of other fungicides and *B. subtilis* and *T. viride* with green pod yield in the range of 8.28 to 8.82 t ha^{-1} and all were at par.

Similarly during 2017-18, green pod yield (t ha^{-1}) ranged from 7.11 to 8.65, as against 5.87 in untreated control. Among the different treatments the highest green pod yield was obtained by spraying propiconazole (8.65 t ha^{-1}) with corresponding increase in yield over the control of 32.14%. The per cent increase in yield over the control ranged from 17.44 to 32.14 with the highest noticed in propiconazole and lowest with leaf extracts of *A. indica* (Fig.2).

The pooled data (Table 2) revealed the highest green pod yield to be in propiconazole (9.16 t ha^{-1})



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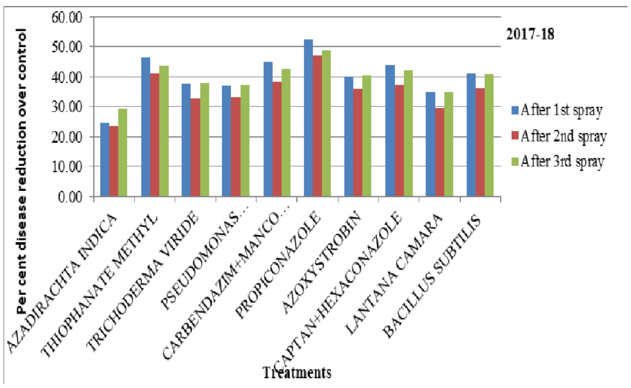

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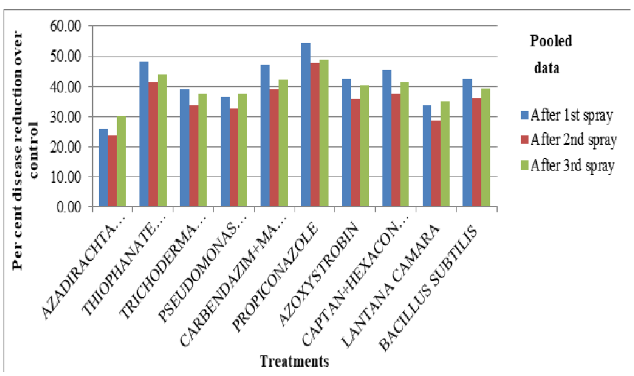

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Fig 1. Effect of fungicides, leaf extracts and bio-agents on per cent disease reduction over control of field bean anthracnose a) 2016-17; b) 2017-18; c) Pooled data

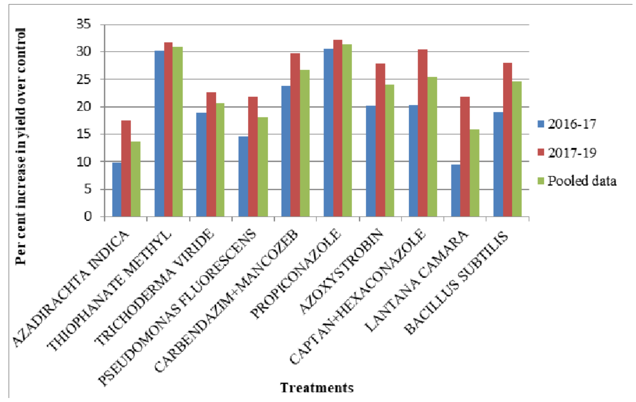

Fig 2. Efficacy of different treatments on per cent increase in yield over control

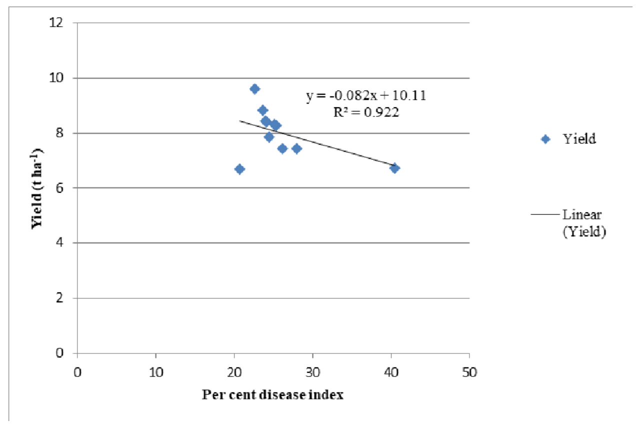

Fig 3. Correlation between PDI and green pod yield as affected by the different treatments during 2016-17.

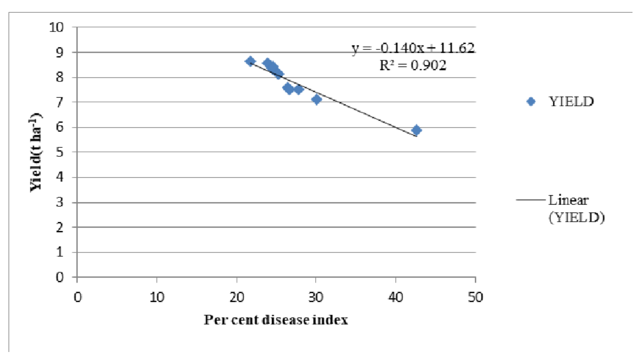

Fig 4. Correlation between PDI and green pod yield as affected by the different treatments during 2017-18.

followed by thiophanate methyl (9.10 t ha^{-1}) and both were on par with each other with the per cent increase in yield over control of 31.33 and 30.88, respectively.

The computed relative yield losses showed notable differences among treatments. Yield losses were highly reduced by fungicide spraying as compared to the bioagents and leaf extracts. Relative yield loss over propiconazole revealed that the lowest yield losses were recorded with thiophanate methyl (0.66%) followed by carbendazim+mancozeb (6.22%), captan+hexaconazole (7.86%) as compared to the untreated control (24.53%). Among the bioagents, *B. subtilis* resulted in the least relative yield loss (8.84%), whereas both *T. viride* and *P. fluorescens* showed a relative yield loss of 13.43 and 16.16 per cent, respectively, (Table 2).

Efficacy of fungicides in controlling anthracnose and increasing the yields were supported by the findings of Amrish *et al*. (2006) and Khalequzzaman (2015). Similar studies on plant

Table 1. Effect of fungicides, leaf extracts and bio-agents on per cent disease index of field bean anthracnose.

Treatments	Conc.	2016-17			2017-18			Pooled data		
		After 1st spray *	After 2nd spray *	After 3rd spray*	After 1st spray *	After 2nd spray *	After 3rd spray*	After 1st spray *	After 2nd spray *	After 3rd spray*
Azadirachta indica	10.00%	17.92 (25.05)**	26.12 (30.72)**	28.04 (31.96)**	19.95 (26.52)**	28.08 (31.98)**	30.07 (33.24)**	18.94 (25.78)**	27.1 (31.36)**	29.05 (32.61)**
Thiophanate methyl	0.10%	12.19 (20.43)	19.89 (26.48)	22.62 (28.39)	14.16 (22.09)	21.61 (27.69)	23.97 (29.30)	13.18 (21.28)	20.76 (27.09)	23.30 (28.85)
Trichoderma viride	2.00%	14.58 (22.40)	22.38 (28.21)	25.34 (30.21)	16.52 (23.94)	24.74 (29.80)	26.05 (30.93)	15.55 (23.18)	23.56 (29.02)	25.90 (30.57)
Pseudomonas fluorescens	2.00%	15.69 (23.33)	23.07 (28.70)	25.41 (30.25)	16.70 (24.11)	24.64 (29.75)	26.65 (31.01)	16.20 (23.72)	23.86 (29.23)	25.98 (30.63)
Carbendazim + mancozeb	0.10%	12.44 (20.64)	20.57 (26.96)	23.71 (29.12)	14.54 (22.40)	22.66 (28.41)	24.46 (29.62)	13.49 (21.54)	21.62 (27.70)	24.08 (29.38)
Propiconazole	0.10%	10.61 (19.00)	17.59 (24.79)	20.71 (27.06)	12.67 (20.81)	19.46 (26.17)	21.72 (27.76)	11.64 (19.93)	18.53 (25.48)	21.22 (27.41)
Azoxystrobin	0.10%	13.45 (21.50)	21.80 (27.81)	24.08 (29.38)	15.91 (23.45)	23.55 (29.00)	25.32 (30.19)	14.68 (22.51)	22.79 (28.48)	24.71 (29.79)
Captan+ hexaconazole	0.15%	12.93 (21.06)	21.24 (27.43)	24.01 (29.33)	14.88 (22.68)	23.12 (28.73)	24.65 (29.77)	13.91 (21.89)	22.18 (28.09)	24.35 (29.56)
Lantana camara	10.00%	16.03 (23.60)	24.65 (29.76)	26.21 (30.78)	17.23 (24.88)	25.98 (30.61)	27.78 (31.80)	16.88 (24.25)	25.30 (30.19)	27.00 (31.29)
Bacillus subtilis	2.00%	13.79 (21.74)	21.68 (27.74)	25.20 (30.11)	15.56 (23.22)	23.51 (28.98)	25.15 (30.09)	14.68 (22.51)	22.59 (28.37)	25.19 (30.04)
Control		24.51 (29.66)	34.13 (35.73)	40.52 (39.52)	26.50 (30.97)	36.81 (37.34)	42.59 (40.72)	25.50 (30.32)	35.47 (36.54)	41.56 (40.12)
CD at 5%		1.70	1.35	1.52	1.90	1.27	1.31	1.45	1.29	1.21
SEm (±)		0.57	0.46	0.51	0.64	0.43	0.44	0.49	0.43	0.41
CV (%)		4.39	2.76	2.90	4.60	2.47	2.44	3.61	2.57	2.28

* Mean of three replications **Figures in parentheses are transformed (angular) values

Table 2. Green pod yield (t ha⁻¹) of field bean as influenced by fungicides, leaf extract and bio-agents on the management of anthracnose.

Treatments	Concentration	2016-17*	2017-18*	2016-18 (Pooled data)*	Relative yield loss (%)	ICBR
Azadirachta indica	10.00%	7.45	7.11	7.28	20.52	7.82
Thiophanate methyl	0.10%	9.62	8.58	9.1	0.66	19.66
Trichoderma viride	2.00%	8.28	7.58	7.93	13.43	8.28
Pseudomonas fluorescens	2.00%	7.87	7.5	7.68	16.16	8.07
Carbendazim + mancozeb	0.10%	8.82	8.36	8.59	6.22	17.94
Propiconazole	0.10%	9.68	8.65	9.16	0	17.45
Azoxystrobin	0.10%	8.41	8.15	8.28	9.61	6.79
Captan+ hexaconazole	0.15%	8.44	8.44	8.44	7.86	8.75
Lantana camara	10.00%	7.42	7.51	7.47	18.45	9.53
Bacillus subtilis	2.00%	8.31	8.16	8.35	8.84	4.17
Control		6.72	5.87	6.29	24.53	-
CD at 5%		0.68	0.86	0.56		
SEm (±)		0.23	0.29	0.19		
CV (%)		4.79	6.43	4.08		

* Mean of three replications

Table 3. Correlation matrix between Per cent Disease Index (PDI), Area under disease progress curve (AUDPC) and rate of infection with yield under field conditions during 2016-17 and 2017-18.

Parameters	2016-2017				2017-2018			
	YIELD	PDI	AUDPC	r	YIELD	PDI	AUDPC	r
PDI	(-) 0.479	1			(-) 0.950**	1		
AUDPC	(-) 0.494	0.986**	1		(-) 0.965**	0.996**	1	
r	(-) 0.463	0.991**	0.980**	1	(-) 0.975**	0.984**	0.993**	1

**. Correlation is significant at the 0.01 level (2-tailed).

extracts and bioagents effective against *C. lindemuthianum* were reported by Gupta *et al*. (2005) and Amin *et al*. (2014). These results were further supported by Gillard *et al*. (2012) who reported that three sequential timings of fungicidal application [(5th trifoliate (A) + full flower (C), 1st flower (B)+full flower (C) and 1st flower (B) +10 days after full flower (D)] provide not only greater control of anthracnose but also improved yield and seed quality, compared with four single application timings of azoxystrobin and pyraclostrobin.

Incremental Cost Benefit Ratio

All spraying treatments gave significantly maximum gross return and additional income with better incremental cost: benefit ratio over unsprayed control (Table 3).

The pooled data suggested that, the highest ICBR in thiophanate methyl (19.66) and followed by carbendazim+mancozeb (17.94) and propiconazole (17.45) (Table 2). The present study emphasizes that the treatment cost involved in use of fungicides must be taken into consideration, while selecting the fungicides for the effective and economical control because of all the treatments were equally effective in reducing the field bean anthracnose disease thereby produced the higher yield.

Correlation between yield and disease parameters

Correlation and linear regression analysis were worked-out to know the relationship between yield and disease parameters and results were presented in Table 3 and Fig 3 & 4. There was significant negative correlation between yield and PDI (0.479), AUDPC

(0.494) and rate of infection (r) (0.463) during 2016-17 as well as with PDI (0.950), AUDPC (0.965) and rate of infection (0.975) during 2017-18. The results suggest that reliable yield loss estimates could be made on the basis of the severity level by employing regression equations.

Obviously the yield was decreased with the increase in per cent disease index. A linear negative correlation between yield and PDI was observed representing the best fit equation having R^2=92.9% during 2016-17 (Fig. 3) and R^2=90.2% during 2017-18 (Fig.4). The negative correlation between yield and per cent disease index showed that for every 1% increment in the disease severity, in the range of 16.30 to 33.06 of PDI, 0.082 unit of green pod yield will be lost during 2016-17 and 0.14 units during 2017-18 with PDI in the range of 17.95 to 35.20.

CONCLUSION

The field bean anthracnose can be using propiconazole @0.1 % or with thiophanate methyl @ 0.17 % (Table 1) as the yield increase due to fungicides varied from 24.03 to 31.33 per cent with relative yield loss of 24.53 per cent in control. Foliar application of bioagents also play a role in prevention of disease severity of field bean anthracnose caused by *C. lindemuthianum*. However, it is known that in a biological system more than one mechanism may operate to suppress a pathogen and the relative importance of a particular organism may vary with the physical or chemical condition in a given situation.

Therefore, control should be based not only on the application of fungicides but also in the integration of other management practices, such as the use of bioagents and plant products and also use of good quality seeds, in order to obtain an added or synergetic effect in the management of anthracnose of field bean.

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