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Assessment of yield losses in dolichos bean due to anthracnose caused by *Colletotrichum lindemuthianum*

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Abstract
An investigation on yield loss assessment in dolichos bean due to anthracnose (*Colletotrichum lindemuthianum*) was conducted under field conditions using different spray schedules of thiophanate methyl (0.1%). Field experiments revealed maximum disease severity and low yields in control plots. The disease drastically affected yield causing significant reduction in yield. Three sprays of recommended fungicide, thiopahante methyl, at 10 days interval starting from 45 days after sowing recorded in lowest per cent disease index (PDI) and area under disease progress curve (AUPDC), which resulted in highest green pod yield and cost benefit ratio.. Highest avoidable losses of green pod yield due to the anthracnose infection were noticed in two sprays. The results indicated that three sprays of thiophanate methyl (0.1%) resulted in minimum disease severity and maximum profit.

Keywords: Anthracnose, dolichos bean, losses and thiophanate methyl

Introduction
Plant diseases are one of the major constraints in the crop production, causing enormous losses by reducing the yield, quantitatively and qualitatively. Estimation of yield losses is of utmost significance for crop production inventories, crop insurance policies, quarantines, variety and gene deployment (Campbell and Madden, 1990, Teng and Johnson, 1988) [1, 2]. The estimation of crop loss is an important parameter in determining the economic importance of the disease and in order to develop threshold for determining, when the exact cost effective management practices should be deployed.

Dolichos bean (*Lablab purpureus* var. *lignosus*) is a grain legume species and is known by several common names across the world (Aleksandar and Vesna, 2016) [3]. It is one of the most ancient crops among cultivated plants and is presently grown throughout the tropics, especially in South Asia and African countries (Devaraj, 2016) [4]. Though, an important vegetable crop grown worldwide, variable weather conditions, poor soil fertility, diseases and insect pests appear to be amongst the important constraints contributing to decrease bean production, causing significant reduction in yield (Rheenen *et al*., 1981) [5]. Schwartz and Gálvez (1980) [6] reported that more than 50% of the major diseases are seed borne in bean among which anthracnose of dolichos bean caused by *Colletotrichum lindemuthianum* (Sacc. & Magnus) Briosi & Cavara is a major problem throughout the world though present in more severe form in the temperate regions than in the tropics.

Crop losses due to pests and pathogens are direct, as well as indirect; they have a number of facets, some with short and others with long term consequences (Zadoks, 1967) [7]. The phrase "losses between 20 and 40%" therefore inadequately reflects the true costs of crop losses to consumers, public health, societies, environments, economic fabrics and farmers. Hence, the present study was undertaken to estimate the losses in the field under different levels of disease severity and number of sprays of thiophanate methyl (0.1%) required to make different level of inoculum pressure of anthracnose pathogen.

Materials and Methods
Field experiments were conducted for two consecutive seasons to find out the number of sprays of recommended fungicide, thiophanate methyl (0.1%), required to manage anthracnose of dolichos bean and to assess the influence of thiophanate methyl sprays on green pod yield

of dolichos bean. Three schedules of thiophanate methyl (0.1%) were sprayed as treatments and one negative control *i.e.* un-protected was maintained.

Treatment details

	Treatment
T_1	Thiophanate methyl (0.1%) - one spray (at 45 days after sowing)
T_2	Thiophanate methyl (0.1%) - two sprays (at 45 and 55 DAS)
T_3	Thiophanate methyl (0.1%) - three sprays at 45, 55 and 65 DAS
T_4	No spray (without fungicide application)

The sprays under T_1, T_2 and T_3 were initiated from 45 days after sowing (DAS) irrespective of disease appearance and subsequent applications at an interval of 10 days due to the assumed appearance of disease every year.

Fifteen plants were selected randomly from each replication for taking various disease measurements and yield for assessment of losses. Disease severity was recorded by scoring all the pre tagged selected plants in each treatment using five point scale of Mayee and Datar (1986) [8] at seven days interval following first appearance of the anthracnose symptoms till the final harvest of the crop.

Disease rating scale for recording the severity of bean anthracnose

Scale	Description
0	No disease on leaves and pods
1	Small round spots, less than 1% leaf area (minute flecks on pod)
3	Brown sunken spots, 1 -10% leaf area (1% pod area)
5	Brown spots, 11 - 25% leaf area (1 - 10% pod area)
7	Circular brown sunken spots, 26 - 50% leaf area (11 - 25% pod area)
9	Circular to irregular, more than 50% leaf area (>25% pod area)

The disease severity was recorded at different time intervals *viz*., 45, 52, 59, 66, 73, 80, 87, 94, 101, 108, 115, 112 and 129 DAS. Further, the PDI was calculated with the above scales using the formula given by Wheeler (1969) [9].

$$\text{PDI} = \frac{\text{Sum of individual disease ratings}}{\text{No. of units assessed} \times \text{Maximum disease rating}} \times 100$$

A total of thirteen observations of PDI were taken to calculate the AUDPC by following the formula of Wilcoxon *et al.* (1975) [10] as follows:

$$\text{AUPDC} = \sum_{i=1}^{k} \tfrac{1}{2}(S_i + S_{i-1})(T_{i-1} - T_i)$$

Where,

S = Severity of anthracnose at the end of time i

K = Number of successive evaluation of anthracnose

T_{i-1}-T_i = Time interval between two evaluations i-1 and i of the disease

Overall efficiency and economics of these treatments in managing disease were worked out by comparing their mean disease severity as AUDPC, green pod yield, additional net income and cost-benefit (C:B) ratio.

The yield loss (YL) due to this disease was calculated using green pod yield data from the fungicidal spraying plots by using following formula:

$$\text{Per cent yield loss} = \frac{(Y_P - Y_x)}{Y_P} \times 100$$

Where, Y_P is the potential yield, Yx = yield when per cent disease index is x Per cent yield increase over control

$$\text{Per cent yield increase over control} = \frac{\text{Yield in treatment plot - Yield in control plot}}{\text{Yield in control plot}} \times 100$$

Benefit cost (B: C) ratio was calculated using formula:

B: C ratio = Additional income from protection/cost of protection.

Results and Discussion

Efficacy of spraying schedules of thiophanate methyl in management of anthracnose

Since foliar application of thiophanate methyl @ 0.1% gives good control of dolichos bean anthracnose, its different sprays intervals were evaluated against the disease. Anthracnose symptoms first appeared at 45 DAS.

Per cent disease index (PDI)

Anthracnose severity values were higher in unsprayed plots throughout the assessment period than the plots received the foliar fungicide spray till 129 DAS. Significant differences among fungicide intervals with reduced disease severity were observed at all dates of assessment except at 45 DAS. Fungicide sprays were at par up to 73 DAS; thereafter significant difference was noticed in among fungicide treatments. At 80 DAS, plots receiving the two and three sprays were at par and significantly superior over the single sprayed plots. Significant difference among the fungicide application was observed from 87 DAS to 129 DAS. At 87 DAS lowest PDI (14.08) was recorded in plots received three sprays and highest was noticed with the control (25.80) during 2016-17 (Table 1). The lowest terminal PDI (29.58) with highest reduction (45.82%) of disease index was observed in plots sprayed thrice with thiophanate methyl which was significantly superior over the other treatments and highest PDI was recorded in control (54.60%). The reduction of disease index in two sprays and single spray was 40.02 per cent and 19.72, respectively (Fig 1a).

The data pertaining to the year 2017-18 presented in Table 2 reveal that all the treatments were similar at 45 DAS and fungicide sprays were no significant up to 66 DAS, thereafter significant difference was noticed among the fungicide treatments. Up to 94 DAS, plots received two and three sprays were at par and significantly superior over once sprayed plots. Significant difference among the fungicide application was observed from 101 DAS to 129 DAS. At 101 DAS lowest PDI (21.00) was recorded in plots received three sprays and highest was noticed in the control (36.17%). The lowest terminal PDI (31.33) with highest per cent reduction (43.81) of disease index observed in plots sprayed thrice with thiophanate methyl which was significantly superior over the other treatments and highest PDI was recorded in control (55.77). The reduction of disease index in twice and once sprayed plots were 34.55 per cent and 18.71 per cent, respectively (Fig 1b).

Table 1: Effect of thiophanate methyl spraying schedule on per cent disease index of dolichos bean anthracnose during 2016-17

Treatments	45 DAS	52 DAS	59 DAS	66 DAS	73 DAS	80 DAS	87 DAS	94 DAS	101 DAS	108 DAS	115 DAS	122 DAS	129 DAS	Per cent reduction over control
Control	2.00* (8.13)**	3.83* (11.29)	7.92* (16.35)**	11.33* (19.68)**	16.67* (24.11)**	22.03* (28.01)**	25.80* (30.54)**	30.17* (33.33)**	35.13* (36.37)**	40.57* (39.58)**	45.87* (42.65)**	50.20* (45.15)**	54.60* (47.66)**	0.00* (0.00)**
One spray	1.17 (6.21)	3.17 (10.26)	5.00 (12.93)	7.08 (15.44)	10.58 (18.99)	14.83 (22.66)	19.75 (26.40)	25.17 (30.13)	29.58 (32.96)	32.75 (34.93)	35.42 (36.54)	39.58 (39.01)	43.83 (41.48)	19.72 (26.38)
Two sprays	2.00 (8.13)	2.75 (9.55)	4.83 (12.70)	6.75 (15.07)	9.33 (17.79)	11.67 (19.99)	15.95 (23.55)	20.50 (26.94)	23.50 (29.01)	25.58 (30.40)	27.58 (31.70)	29.83 (33.12)	32.75 (34.93)	40.02 (39.26)
Three sprays	1.43 (6.87)	2.67 (9.41)	4.25 (11.90)	6.08 (14.28)	8.92 (17.39)	11.25 (19.61)	14.08 (22.05)	16.33 (23.85)	19.33 (26.10)	22.58 (28.39)	25.00 (30.02)	27.17 (31.43)	29.58 (32.96)	45.82 (42.62)
C.D.	N/A	0.731	1.071	0.97	1.893	1.643	1.579	2.015	2.172	1.802	1.518	1.27	1.789	
SE(m)±	0.244	0.24	0.352	0.319	0.622	0.54	0.519	0.663	0.714	0.592	0.499	0.417	0.588	
C.V.	36.15	18.964	15.687	10.001	13.399	8.851	6.731	7.043	6.504	4.778	3.652	2.786	3.584	

DAS = Days After Sowing *Mean of six replications **Figures in parenthesis are transformed values

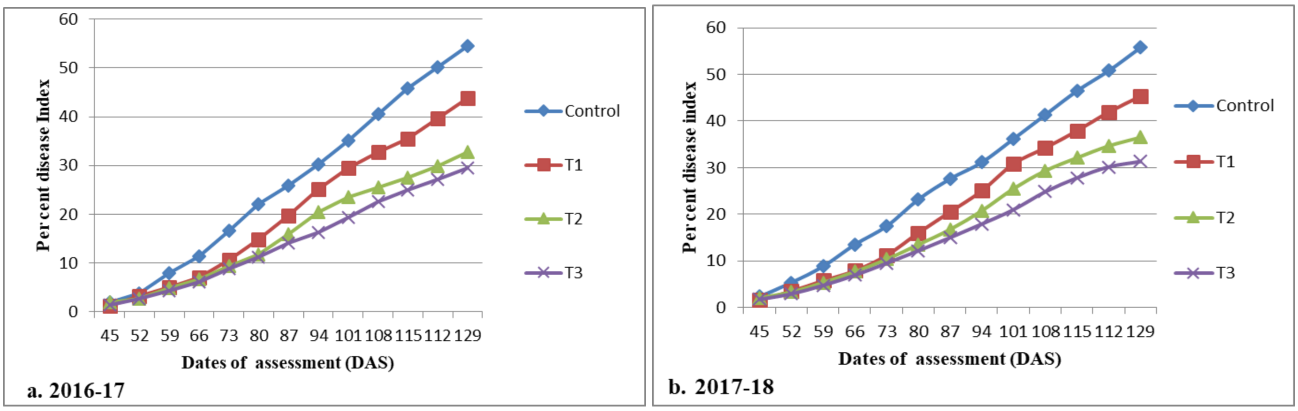

Fig 1: Effect of spraying schedules of thiophanate methyl on per cent disease index of dolichos bean anthracnose

Table 2: Effect of thiophanate methyl spraying schedule on per cent disease index of dolichos bean anthracnose during 2017-18

Treatments	45 DAS	52 DAS	59 DAS	66 DAS	73 DAS	80 DAS	87 DAS	94 DAS	101 DAS	108 DAS	115 DAS	122 DAS	129 DAS	Per cent reduction over control
Control	2.33* (8.78)**	5.33* (13.35)**	8.83* (17.30)**	13.50* (21.57)**	17.43* (24.69)**	23.17* (28.79)**	27.60* (31.71)**	31.13* (33.93)**	36.17* (36.99)**	41.33* (40.03)**	46.47* (43.00)**	50.80* (45.48)**	55.77* (48.34)**	0.00* (0.00)**
One spray	1.58 (7.22)	3.50 (10.79)	5.75 (13.88)	7.88 (16.31)	11.17 (19.53)	16.00 (23.59)	20.50 (26.94)	25.03 (30.04)	30.83 (33.74)	34.25 (35.84)	37.92 (38.03)	41.92 (40.37)	45.33 (42.34)	18.71 (25.64)
Two sprays	2.08 (8.30)	3.33 (10.52)	5.33 (13.35)	7.67 (16.09)	10.33 (18.76)	13.50 (21.57)	16.75 (24.17)	20.75 (27.11)	25.50 (30.35)	29.33 (32.81)	32.12 (34.54)	34.67 (36.09)	36.50 (37.19)	34.55 (36.02)
Three sprays	1.75 (7.61)	2.92 (9.84)	4.75 (12.59)	6.92 (15.26)	9.50 (17.96)	12.17 (20.43)	15.00 (22.80)	17.92 (25.06)	21.00 (27.29)	24.83 (29.90)	27.83 (31.86)	30.17 (33.33)	31.33 (34.05)	43.81 (41.47)
C.D.	N/A	0.838	0.999	1.603	1.326	1.802	2.343	3.273	3.325	1.977	1.878	1.942	1.727	
SE(m)±	0.212	0.275	0.328	0.527	0.436	0.592	0.77	1.076	1.093	0.65	0.617	0.638	0.568	
C.V.	26.757	17.886	13.046	14.355	8.82	8.951	9.453	11.118	9.437	4.908	4.191	3.97	3.293	

DAS = Days After Sowing *Mean of six replications **Figures in parenthesis are transformed values

Pooled data of two years (Table 3) indicated that, all the treatments significantly differed from each other from 45 DAS to 129 DAS. All the fungicide treatments were at par up to 66 DAS and plots sprayed with twice and thrice were at par up to 87 DAS and thereafter all the fungicide sprays significantly differed from each other in controlling dolichos bean anthracnose. The terminal PDI in plots sprayed thrice (30.46%) with thiophanate methyl was significantly superior over other treatments and highest was recorded in control (55.18%). The reduction of disease index was higher (44.81%) in treatment with three sprays followed by 37.25 per cent and 19.21 per cent with two sprays and one spray, respectively.

The number of sprays were positively correlated with reduction of disease (0.952, 0.989 and 0.973) and an increase in one number of spray caused 13.05, 12.55 and 12.8 units control of the disease with the relation holds good fit for 90.6, 97.7 and 94.7 (R2 values = 0.906, 0.977 and 0.947), respectively, during 2016-17, 2017-18 and pooled data (Fig. 2).

The progress of disease severity values were higher side from 45 DAS onwards in unsprayed and plots those received single spray, while the progress of disease was still low in plots received twice and thrice application of fungicide. This might be due to the spray of foliar fungicide at an early stage (vegetative stage), in which severity progressed was delayed. Therefore, the pathogen developed secondary inocula and severely affected the crop. The per cent disease index reached peak (55.18%) at the final assessment date on plots that were not protected from foliar fungicide (Table 3).

The above study indicated that, anthracnose progress in all the spraying schedules was significantly different except at 45 DAS and further fungicide thiophanate methyl effectively controlled anthracnose disease in plots received three rounds of spraying. Further the spray schedules/intervals showed the period of effectiveness of thiophanate methyl. Based on above data, effective period thiophanate methyl in controlling the anthracnose varied from 10-20 days after spraying. First spraying was initiated at 45 DAS irrespective of treatments and experimental period.

Table 3: Effect of thiophanate methyl spraying schedule on Per cent Disease index pooled data of 2016-2018

Treatments	45 DAS	52 DAS	59 DAS	66 DAS	73 DAS	80 DAS	87 DAS	94 DAS	101 DAS	108 DAS	115 DAS	122 DAS	129 DAS	Per cent reduction over control
Control	2.17* (9.16)**	4.58* (12.25)**	8.38* (16.74)**	12.42* (20.65)**	17.05* (24.35)**	22.60* (28.45)**	26.70* (31.11)**	30.65* (33.60)**	35.65* (36.65)**	40.95* (39.78)**	46.17* (42.80)**	50.50* (45.29)**	55.18* (47.94)	0.00* (0.00) **
One spray	1.38 (6.68)	3.33 (10.50)	5.38 (13.31)	7.48 (15.86)	10.88 (19.19)	15.42 (23.11)	20.13 (26.66)	25.10 (30.07)	30.21 (33.35)	33.50 (35.37)	36.67 (37.28)	40.75 (39.66)	44.58 (41.86)	19.21 (26.01)
Two sprays	2.04 (8.15)	3.04 (10.01)	5.08 (12.98)	7.21 (15.59)	9.83 (18.28)	12.58 (20.72)	16.35 (23.84)	20.63 (27.01)	24.50 (29.67)	27.46 (31.58)	29.85 (33.04)	32.25 (34.58)	34.63 (36.05)	37.25 (37.61)
Three sprays	1.59 (7.25)	2.79 (9.51)	4.50 (12.25)	6.50 (14.77)	9.21 (17.52)	11.71 (20.01)	14.54 (22.40)	17.13 (24.45)	20.17 (26.66)	23.71 (29.14)	26.42 (30.93)	28.67 (32.35)	30.46 (33.48)	44.81 (42.03)
C.D.	0.551	0.509	0.814	1.005	1.393	1.507	1.85	2.516	2.616	1.748	1.275	1.11	1.202	
SE(m)±	0.181	0.167	0.267	0.33	0.458	0.495	0.608	0.827	0.86	0.575	0.419	0.365	0.395	
C.V.	24.724	11.926	11.23	9.632	9.557	7.791	7.669	8.669	7.625	4.482	2.953	2.35	2.349	

DAS = Days After Sowing *Mean of six replications **Figures in parenthesis are transformed values

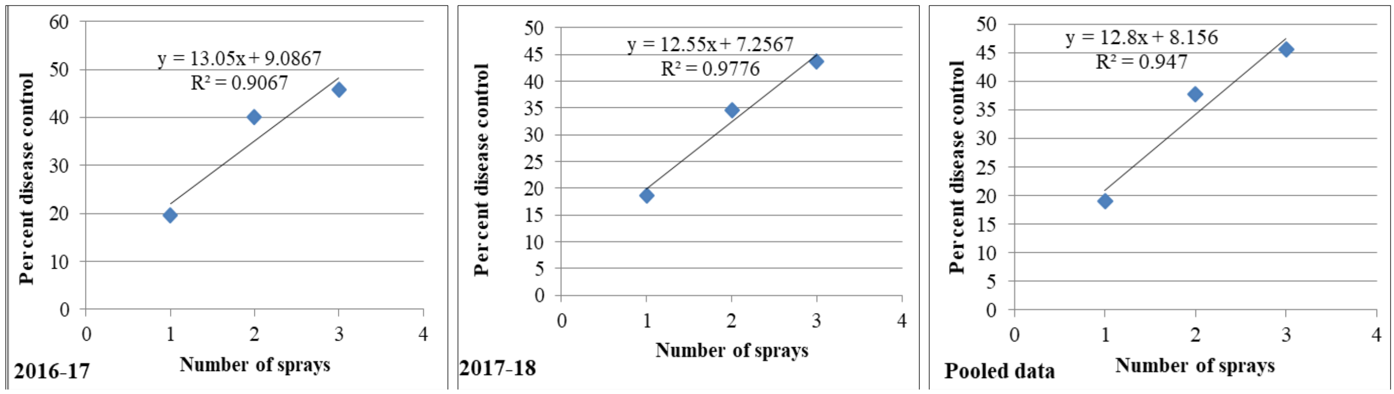

Fig 2: Control of dolichos bean anthracnose in relation to the number of sprays

During the 2016-17, plots sprayed once recorded the PDI of 5.00 which was at par with twice (4.83) and thrice (4.25) sprayed plots up to 59 DAS and similarly plots sprayed twice (11.67) were at par with thrice sprayed (11.25) up to 80 DAS. These observations on the onset of bean anthracnose are in agreement with the findings of Amin *et al.* (2014) [11] who reported the onset of bean anthracnose from 52 DAS onwards. During the 2017-18, plots sprayed once recorded the PDI of 7.88 which was at par with twice (7.67) and thrice (6.92) sprayed plots up to 66 DAS and similarly plots sprayed twice (20.75) were at par with thrice sprayed (17.92) up to 94 DAS. Pooled data of two years also indicated that, spraying once (7.48) was at par with twice (7.21) and thrice (6.50) up to 66 DAS and similarly spraying twice (16.35) were at par with thrice (14.54) up to 87 DAS.

Per cent disease index increased at linear rate at different dates of assessment periods in both the years. This could be due to the accumulation of secondary inocula, susceptibility of the crop's stage and or the occurrence of favorable environmental conditions. These results are supported by the findings of Tesfaye (1997) [12] where a mean severity of 59.3 at the podding stage of haricot bean was reported.

The comparative account of disease progression in terms of area under disease progress curve (AUDPC) for different spray schedules were worked out and presented in Table 4.

Area under diseases progress curve (AUDPC)

The AUDPC analysis showed the overall disease development was significantly affected by the number of spraying schedules imposed. The increase in disease throughout the assessment days indicated the spread of the disease in space. The data showed highly significant differences among treatments. The results revealed (Table 4) that disease severity (AUDPC) was higher in control plots (unsprayed) as compared with fungicide sprayed plots in both the years.

The difference in AUPDC with number of fungicide application was statistically significant. Highest AUDPC value was obtained in control plots with value of 2224.72 and 2315.72 during 2016-17 and 2017-18, respectively (Table 4). The lowest AUPDC values were obtained with three sprays of fungicide with highest per cent decrease of AUPDC values (45.51% and 42.71%) over control, during 2016-17 and 2017-18, respectively. Similar trend was also noticed with respect to AUPDC value and per cent decrease of AUPDC value over control in pooled data. The study showed that the pathogen *C. lindemuthianum* grew faster in unsprayed plots than the protected plots. The results of the experiment clearly indicated that three applications of fungicide are sufficient to reduce the disease levels.

Significantly different AUDPC results were obtained, indicating that anthracnose progressed differently among spray schedules. These findings are in accordance with reports of Patil (1997) [13] where reduction in AUDPC values of sunflower rust occurred with increase in number of mancozeb sprays and Amaresh and Nargund (2004) [14] where AUDPC values of *Alternaria* leaf blight (ALB) and rust of sunflower were less in higher number of sprays of chlorothalonil, but low for ALB by Iprodion treatment. These are results were further supported by earlier studies of Bassanezi *et al*. (2001) [16] and Lopes and Berger, (2001) [17].

Table 4: Effect of spraying schedules of thiophanate methyl on AUPDC in dolichos bean anthracnose

Treatments	AUPDC	Per cent reduction of AUPDC valve over control	AUPDC	Per cent reduction of AUPDC valve over control	AUPDC	Per cent reduction of AUPDC valve over control
	2016-17		2017-18		Mean	
Control	2224.72	0	2315.72	0	2270.22	0
One spray	1702.18	23.49	1807.46	21.94	1762.69	22.35
Two sprays	1,375.80	38.16	1530.38	33.92	1449.82	36.14
Three sprays	1,212.27	45.51	1326.79	42.71	1269.5	44.08
C.D.	75.35		97.54		78.92	
SE(m)±	24.77		32.06		25.95	
CV (%)	3.73		4.50		3.77	

*Mean of six replications

Efficacy of spraying schedules of thiophanate methyl on yield of dolichos bean anthracnose

A Green pod yield

The results of field experiment on loss assessment revealed that, all the fungicide spraying intervals with thiophanate methyl were found significantly effective in reducing the disease severity and there by increased the green pod yield and profit compared to untreated check. With an increase in the number of sprays, corresponding increase in the per cent disease control and crop yield were recorded in dolichos bean for both the years (2016-17 and 2017-18).

During 2016-17, significant difference was found between the treatments regarding to the efficacy of spraying intervals/schedules on green pod yield and results were furnished in Table 5. The green pod yield (t/ha) ranged from 5.52 to 7.38, as against 4.34 t/ha in untreated control. Plots received three applications recorded significantly highest green pod yield (7.38 t/ha) and the next best treatment was two applications of thiophanate methyl (6.73 t/ha). Maximum yields were obtained with three sprays followed by two sprays and their differences were statistically significant.

Sprays of thiophanate methyl gave significantly good control of disease with appreciable increase in crop yield compared to unprotected crop. Even a single spray of thiophanate methyl resulted in 19.72 and 18.71% control of disease during 2016-17 and 2017-18 crop seasons, respectively, with 27.06% and 28.71% increase in crop yield.

During 2017-18, same trend was recorded but yields were comparatively less than the year 2016-17 and yields ranged from 4.04 to 7.24 t/ha. As per the pooled data, highest yield were recorded in three applications of thiophanate methyl (7.31 t/ha) and lowest were noticed in control (4.19 t/ha). Highest green pod yields were obtained from the plots sprayed thrice followed by twice which were attributed to the lower disease severity (PDI, AUDPC) of anthracnose in these treatments. Accordingly, the differences in PDI, AUPDC values explain the observed differences in yield loss among the spray schedules. Lower yields in case of single spray than two and three sprays may be due to early pod infection leading to pod death and drop causing reduction in green pod yield. This corroborates the findings of Selamawit (2004) [18] who indicated spray interval of 5 days increased yield over unsprayed one. Conner *et al*. (2001) [19] also observed that application of foliar fungicide could reduce losses in seed yield and quality from bean anthracnose disease.

Loss in green pod yield

The losses in green pod yield over maximum number of sprayings (three) were different in two different years' data and also in pooled mean. In both years, the loss was maximum in untreated control (no fungicidal spray) and minimum in the plots receiving two numbers of sprays. The loss in green pod yield due to anthracnose was to the tune of 41.13 per cent and 44.21 per cent in control plot, whereas it was least (8.71% and 9.32%), during 2016-17 and 2017-18, respectively. in plots received two sprays (Table 5). Based on the pooled data the per cent increase in yield over the control was more (74.46) in plots received three sprays and followed by two sprays (58.71). The green pod yield loss was high in the absence of control measures of the disease. So, by minimizing the anthracnose disease severity by increased number of foliar application of fungicide, the yield loss could be reduced considerably. These findings are in accordance with the reports of Bharadwaj and Thakur (1991) [20] and Deeksha and Tripathi (2002) [21] who recorded least yield loss in protected plots as compared to unprotected. Shukla *et al.* (2014) [22] also reported losses in yield up to 24-36% due to pod blight in mungbean and yield losses were proportional to disease severity and very remarkably depending on the stage of infection, genotype and environmental conditions.

Benefit: Cost ratio (BCR)

General cost of cultivation remained the same for all other treatments. The difference in cost of cultivation in different treatments was due to increased number of sprayings and harvesting. Maximum BCR of 21.23 and 28.42 was obtained from plots which have received two sprays of fungicides during 2016-17 and 2017-18, respectively (Table 6). The mean BCR of both the years revealed the similar benefit from the treatments which received two sprays (24.74) followed by one spray (22.93) and three sprays (20.94). It may thus be inferred that three sprays of thiophanate methyl (0.1%) are essential to obtain maximum yield when disease pressure is moderate or less. These results are in accordance with Hirpa and Thangavel (2016) [23] who reported that fungicide (Folpan) application at weekly intervals reduced anthracnose disease severity, AUPDC, increased seed yield, yield components and accrued higher net return.

Conclusion

It may thus be inferred that three sprays thiophanate methyl (0.1%) in dolichos bean were essential to obtain maximum yield when disease pressure is moderate or less. Two sprays of thiophanate (0.1%) are enough to get maximum profit.

Table 5: Crop loss assessment due to anthracnose of dolichos bean caused by *Colletotrichum lindemuthianum*

Treatments (Spraying schedules)	2016-17				2017-18				Mean (Pooled data)			
	Terminal PDI	Green pod yield (t ha^{-1})	Per cent yield increase over control	Per cent yield loss	Terminal PDI	Green pod yield (t ha^{-1})	Per cent yield increase over control	Per cent yield loss	Terminal PDI	Green pod yield (t ha^{-1})	Per cent yield increase over control	Per cent yield loss
No spray (control)	54.60* (47.66)**	4.34* (12.03)**	0.00* (0.00)**	41.13* (39.91)**	55.77* (48.34)**	4.04* (11.60)	0.00* (0.00)	44.21* (41.70)**	55.18* (47.95)	4.19* (11.82)**	0.00* (0.00)**	42.68* (40.81)**
One spray	43.83 (41.48)	5.52 (13.60)	27.06 (31.36)	25.19 (30.14)	45.33 (42.34)	5.20 (13.19)	28.71 (32.42)	28.20 (32.09)	44.58 (41.86)	5.36 (13.39)	27.92 (31.91)	26.68 (31.12)
Two sprays	32.75 (34.93)	6.73 (15.04)	55.07 (47.93)	8.71 (17.17)	36.50 (37.19)	6.57 (14.86)	62.55 (52.29)	9.32 (17.78)	34.63 (36.06)	6.65 (14.95)	58.71 (50.04)	9.03 (17.50)
Three sprays	29.85 (33.13)	7.38 (15.77)	69.85 (56.72)	0.00 (0.00)	31.33 (34.05)	7.24 (15.62)	79.26 (62.94)	0.00 (0.00)	30.46 (33.47)	7.31 (15.69)	74.46 (59.67)	0.00 (0.00)
C.D.	1.789	0.359			1.727	0.236			0.202	0.183		
SE(m)±	0.588	0.118			0.568	0.078			0.395	0.06		
C.V.	3.584	4.819			3.213	3.297			2.349	2.504		

*Mean of six replications **Figures in parenthesis are arc sine transformed values

Table 6: Economics in loss estimation due to dolichos bean anthracnose

Treatment	Yield (t/ha)*	Avoidable Yield over control (t/ha)	Additional income/ ha	Yield (t/ha)*	Avoidable Yield over control (t/ha)	Additional income/ ha	Additional cost on spraying and harvesting: Cost of fungicides	Cost for spraying	Additional wages for harvesting	Cost of each treatment (Rs.)	Net profit (Rs.)		B:C Ratio		
	2016-17			2017-18							2016-17	2017-18	2016-17	2017-18	Mean
Control	**4.34**			**4.04**			**0**	**0**	**0**	**0**					
One spray	5.52	1.18	23600	5.20	1.16	29000	450	500	150	1100	22500	27900	20.45	25.36	22.93
Two sprays	6.73	2.39	47800	6.57	2.53	63250	900	1000	250	2150	45650	61100	21.23	28.42	24.74
Three sprays	7.38	3.04	60800	7.24	3.20	80000	1350	1500	350	3200	57600	76800	18.01	24.00	20.94

*Mean of six replications Average fresh bean cost during 2017-18 Rs.25/- Kg
Average fresh bean cost during 2016-17 Rs.20/- Kg, Thiophanate methyl, Rs.900/-kg
Skill labour, Rs.300/- day, Quantity of spray solution used per hectare: 500 lit
Unskilled labour, Rs. 200/-/ day

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