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Effect of chemicals on yield losses in soybean due to Rhizoctonia aerial blight

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Soybean is a major oilseed crop in India. It is an important pulse crop and is subjected to a number of diseases. Rhizoctonia aerial blight caused by *Rhizoctonia solani* Kuhn is one of themajor soybean disease in India and inflicts heavy loss in the production. Nearly 31–60% yield losses occur due to foliar blight disease of soybean. The present study was undertaken to estimate the avoidable yield losses in relation to the fungicides applied. Disease incidence (%), disease severity (%), yield (kg ha^{-1}) were also recorded. Treatment combinations were laid out in Split plot design with three replications. Among all the combinations that were under study, moderately resistant variety (JS 97 52) receiving four foliar spray of Tebuconazole recorded least disease incidence of 7.50% and minimum disease severity of 3.73%. Maximum (2326.67 kg ha^{-1}) and minimum (1073.33 kg ha^{-1}) yield was recorded from plots having moderately resistant variety (JS 97 52) with four foliar sprays and control plots with susceptible variety (JS 335), respectively. Minimum yield loss of 3.05% was observed from moderately resistant variety with four numbers of foliar sprays. Maximum avoidable yield loss of 37.96% was observed from moderately resistant plot receiving four numbers of foliar sprays.

Keywords: Aerial blight, avoidable yield loss, *Rhizoctonia solani*, soybean, Tebuconazole

INTRODUCTION

Soybean (*Glycine max* L.) is the *numero uno* oilseed crop in India (Agarwal *et al*. 2013) belonging to family Fabaceae. It contains about high quality protein (40 – 42%), oil (18 – 20%) and other nutrients like calcium, iron and glycine (Devi *etal*. 2012). In India, the area and production of soybean during 2018-19 was 10.83 million ha and 10.93 million ton (SOPA, 2020). In India, the major soybean growing states are Madhya Pradesh producing more than 50 percent of country's soybean followed by Maharashtra, Rajasthan, Karnataka and Telangana. Nearly ninety eight percent of area under soybean cultivation is rainfed (Dupare *et al*. 2014).

Soybean is economically an important pulse crop that suffers from a number of diseases caused by fungi, bacteria, viruses, nematodes and other physiological disorders. Among the various diseases, aerial blight caused by *Rhizoctonia solani* Kuhn, is a prominent soybean disease in India and causes heavy loss in soybean production.Yield losses due to foliar blight of soybean have been reported upto 31–60 percent by Fenille *et al*. (2002). The symptoms of aerial blight of soybean caused by *R. solani*, as leaf and pod spots, leaf blight, defoliation, stem and petiole lesions, cob web like mycelium and sclerotia developed over infected leaves were described previously.

Two fungicides *viz*., thiophanate methyl (seed treatment) and tebuconazole (foliar spray) was used to estimate the yield losses of the crop. Emphasis was given on the number of foliar sprays to estimate the yield losses.

Thiophanate methyl belongs to the member of benzimidazole and is a systemic fungicide with protective and curative activity against a broad spectrum of fungal diseases including leaf spots, blotches, blights, fruit spots, rots, sooty mould, scabs, bulb/corn/tuber decays, blossom blights,

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powdery mildews, certain rusts, and common soil borne crown and root rots. It is used on a variety of tree, vine, root crops, canola, and wheat, as well as on lawns and ornamentals. Thiophanate methyl is absorbed by the roots and leaves. Thiophanate-methyl has a low mammalian toxicity. But, it is an irritant and a skin sensitizer. It may also be mutagen. Moderate toxicity of thiophanate methyl is observed for aquatic organisms and earthworms. For application, Thiophanate-methyl is formulated into wettable powders containing 50 and 70% active ingredient (Lewis *et al*. 2016).

Tebuconazole is a broad-spectrum fungicide that belongs to the triazole group and additionally have plant growth regulating properties. However, tebuconazole is also likely to have phyto-toxicity and slows down plant growth when too much of the agent is applied during leaf or seed treatment. This is due to triazole fungicides effect on gibberellin phytohormone biosynthesis, thus, inhibiting the seed germination and plant growth. The fungicide tebuconazole can inhibit the synthesis of ergosterol. It has been used to prevent the development of fungal mycelium in several crops of fruits, vegetables, cereals, and nuts.

MATERIALS AND METHODS

Isolation and identification of the pathogen

Infected soybean plants were collected, isolated and identified based on its cultural and morphological characteristics.

Characteristics of the pathogen

Growth characteristics were observed in solid potato dextrose agar (PDA) medium. Morphological characters such as mycelial branching of the pathogen were also observed.

Experiment conducted under field conditions

The experiment was laid out in Split Plot design having twelve combinations of varieties and treatments and each replicated thrice. The net plot size was 2.25 m × 5 m. The experiment was conducted in *Kharif* season of 2021 at AICRP–Soybean farm, SASRD, Medziphema. Varieties *viz*. JS 335 (susceptible) and JS 97-52 (moderately resistant) were used as main plot factor and six treatments as sub plot factors for carrying out the experiment. Foliar spray was given @ 625 ml ha^{-1}. Seed treatment with Thiophanate methyl @ 2ml kg^{-1} and foliar spray of Tebuconazole @ 2.5 ml l^{-1} of water was administered at different days after sowing as given in Table 1. Twenty plants were selected randomly from each plot and labeled for scoring the disease intensity and percent disease incidence was also worked out. The selected plants were graded using 0–9 disease rating scale (Mayee and Datar, 1986) and are described as given in Table2. The percent disease intensity (PDI) and percent disease incidence was worked out applying formulae:-

$$\text{PDI} = \frac{\text{Sum of Individual rating}}{\text{No. of leaves examined}} \times \frac{100}{\text{Maximum disease rating}}$$

$$\text{Percent disease incidence} = \frac{\text{No. of infected plants in sample population}}{\text{Total no. of plants in sample population}} \times 100$$

At harvest, seed yield was recorded and data was computed on hectare basis. Further, AUDPC, avoidable yield loss and yield loss were also calculated by using the formulae;

$$\text{Avoidable yield loss} = \frac{YP - YU}{YP} \text{X}100$$

where, YP= yield under protected condition YU= yield under unprotected condition

$$\text{Yield loss} = \frac{EY - 0Y}{EY} \text{X}100$$

Where, EY= expected yield OY= observed yield

The area under disease progress curve (AUDPC) was computed from the PDI data recorded from each date of assessment as described by (Jeger, 2004).

$$\text{AUDPC} = \sum_{i=1}^{n-1} \left[\left(y_i + y_{i+1} \right) \div 2 \right] \left(t_{i+1} - t_i \right)$$

Where, y_i= percentage severity at ith observation,
t_i= time (days), and
n= total number of observations

The data was statistically analyzed using suitable transformation.

RESULTS AND DISCUSSION

Identification

The pathogen was responsible for causing aerial blight of soybean was identified as *Rhizoctonia solani* based on their morphological characteristics.

Characteristics of the pathogen

The isolate produced aerial mycelium with light gray coloration. Under the microscope, branching at right angle, septate mycelium and formation of septum in branch near the point of origin of vegetative hyphae were observed.

The present research findings are in accordance with Lal *et al*. (2014) who revealed that all the isolates of *R.solani* had hyphal branching at right angle, constriction at the point of branching of the mycelium and presence of a septum near the branching junction. Rahayu (2014) observed typical white mycelia, dark brown and irregular shaped sclerotia that were large and ranged from 1 mm to 4 mm in diameter. Rahman *et al*. (2020) observed light brown to brown colony color and compact to slightly fluffy colony structures, slight constriction at the point of hyphal branching and right angle branching. Babli *et al*. (2022) observed light brown hyphal growth and constriction at the point of branching and right angle branching in matured hyphae.

Per cent Disease Incidence

Results (Table 3) revealed all the data to be significantly superior over control plots. Disease incidence was observed to be minimum in moderately resistant plots with three numbers of foliar sprays (7.50 %) which was found to be at par with moderately resistant plots receiving four foliar sprays(7.66 %) followed by two sprays in moderately resistant plots(10.75 %) and four foliar sprays in susceptible plots (13.33 %) which was found to be statistically at par with susceptible plots with three foliar sprays (13.74 %), one foliar spray in moderately resistant plots (14.41 %) and susceptible plots receiving two foliar sprays (15.49 %) followed by treatments with water spray in moderately resistant plots (18.25 %) which was at par with susceptible plots receiving one foliar spray (18.50 %) followed by moderately resistant control plots (25.33 %) and susceptible plots with water spray (31.00 %) with highest disease incidence observed in susceptible unsprayed control plots with 39.16 percent.

The results obtained were somewhat similar to the ones reported by Bhuvaneswari and Raju (2012) who found least disease incidence of 9.36 percent and 16.43 percent with combination fungicide having Azoxystrobin (18.2 % SC) and Difenconazole (11.4 % SC) at 1.25 ml l^{-1} and 1.0 ml l^{-1} respectively. Meena *et al.* (2018) in their study reported Tebuconazole 50% + Trifloxystrobin 25% WG seed treatment (1.5 g/kg seed) and soil drenching (1.5 g/l water) was most effective in minimizing the web blight incidence at 10.76 percent in mungbean. Kashyap *et al.* (2019) reported maximum and minimum disease incidence of 69.55 percent and 6.67 percent respectively due to root rot of soybean. Borah (2019) observed 30–40% disease incidence in soybean due to *Rhizoctonia* aerial blight.

Per cent Disease Index

It can be observed from the data presented in (Table 3) that all the treatment combinations are superior in reducing the intensity of the disease over control. Minimum disease severity of 3.73 percent was observed from moderately resistant plots receiving four number of foliar sprays which was found to be statistically at par with three sprayings in moderately resistant plots (4.44 %), four sprays in susceptible plots (5.93 %), three number of spraying in susceptible plots (6.69 %), two foliar sprays in plots with moderately resistant variety (7.59 %), susceptible plots with two foliar sprays (8.85 %) and one foliar spray in moderately resistant plots (9.65 %) which was then followed by treatments with one spray in susceptible plots (12.71 %) which was found at par with water spray in moderately resistant plots (13.13 %) and water spray in susceptible plots (13.27 %). This was followed by treatments *viz.,* control moderately resistant plots with 15.50 percent and with maximum severity of 20.99 percent observed in susceptible control plots.

The findings corroborate with the findings of earlier workers. Kumar *et al*. (2008) found seed treatment and foliar sprays of Tilt at 15 days interval showing least disease severity (27.56 %) and Blitox-50 showing maximum disease severity of 48.23 %. Basandrai *et al.* (2016) observed that two foliar sprays of Hexaconazole 5 EC @ 0.1 %, Difenconazole 25 EC @ 0.05 %, Carbendazim 50 WP @ 0.1 % and Propiconazole 25 EC @ 0.1 % resulted in significant decline in disease severity i.e. 81.1, 80.6, 65.9 and 76 respectively. Kumar *et al.* (2019) concluded that Carbendazim showed minimum disease intensity at 45, 60 and 75 DAS (6.66, 11.33 and 22.66 %) respectively while conducting field experiment of different fungicides and neem oil on the growth of *R.solani*. Amrate *et al.* (2023) recorded minimum disease severity of 28.9 percent from cultivar JS 93-05 among different cultivars under investigation.

Yield (kg ha^{-1})

All the treatment combinations significantly enhanced seed yield over control (Table 3). Highest yield (2326.67 kg/ha) was obtained from moderately resistant plot with four spraysand was found significantly superior to other treatments. Next best treatment was with three foliar sprays in moderately resistant plot (2116.67 kg/ha) followed by two sprays in moderately resistant plot (1824.00 kg/ha) which was found at par with moderately resistant plot receiving one spray (1768.33 kg/ha) and susceptible plot receiving four sprays (1730 kg/ha). This was followed by treatments with water spray in moderately resistant plot (1586.33 kg/ha), control plot with moderately resistant variety (1568 kg/ha), three sprays (1560 kg/ha), and two sprays (1415.33 kg/ha) in susceptible plots respectively, all of which were statistically at par with each other. Other treatments *viz.*, one foliar spray (1282.33 kg/ha) and water spray (1176.67 kg/ha) in plots with susceptible variety were found at par with each other followed by susceptible control plots (1073.33 kg/ha) with the lowest seed yield.

Yadav and Khushwaha (2016) found increase in grain yield of 149.56 per cent over the check when seeds were treated with Carbendazim 50 WP (2g/kg seed) + foliar spray of Propiconazole 25 EC (0.1%). Meena *et al.* (2018) recorded highest seed yield of 14.20 q ha^{-1} with Tebuconazole 50% + Trifloxystrobin 25% WG seed treatment (1.5 g/kg seed) and soil drenching (1.5 g/l water).

Avoidable yield loss (%)

In the present investigation, it is evident from the data that with the increase in number of sprayings there was an increase in avoidable yield loss over untreated control. Maximum avoidable yield loss was recorded from plots having susceptible variety with four numbers of foliar sprays (37.96%). This was followed by moderately resistant plot receiving four sprays (32.60%) and three sprays in susceptible plot (31.20%) and was found statistically at par with each other. Treatments viz., three sprays in moderately resistant plot (25.92%) and two sprays in susceptible plot (24.16 %) were found at par with each other followed by one spray in susceptible plots(16.30 %), two sprays in moderately resistant plots (14.04%), one spray in moderately resistant plots (11.33%) and water spray in susceptible plot (8.78%). However, the least avoidable yield loss was observed from moderately resistant plots that received water spray (1.16%).

The findings are in support with the findings of earlier workers *viz.*, Yadav *et al.* (2013) conducted field experiment to find out efficacy of soil amendment on Frenchbean and reported maximum avoidable yield loss of 40.96% and 36.62 % in pod and seed respectively when the plots were treated with neem oil cake.

Yield loss (%)

The loss in yield varied with the number of sprayings. Maximum loss was observed in untreated control and gradually decreased with the increase in the number of sprayings. Minimum yield loss of 3.05 and 3.89% was recorded from moderately resistant plots with four sprays and susceptible plots with four sprays,respectively and were at par with each other. Other treatments *viz.*, three foliar sprays in moderately resistant plots and susceptible plotswere found significantly at par with each other with yield loss of 11.81 and 13.33 percent respectively. This was followed by two sprays in susceptible plots (21.37%), two sprays in moderately resistant plots (24.00%), one spray in moderately resistant plots (26.31%), and one spray in susceptible plots

Table 1 : Details of ChemicalTreatments applied

M_1T_1	Seed treatment with Thiophanate methyl @ 2ml/kg + one foliar spray of Tebuconazole @ 2.5 ml/l at 30 DAS
M_1T_2	Seed treatment with Thiophanate methyl @ 2ml/kg + two foliar sprays of Tebuconazole @ 2.5 ml/l at 30 and 45 DAS
M_1T_3	Seed treatment with Thiophanate methyl @ 2ml/kg + three foliar sprays of Tebuconazole @ 2.5 ml/l at 30, 45 and 60 DAS
M_1T_4	Seed treatment with Thiophanate methyl @ 2ml/kg + four foliar sprays of Tebuconazole @ 2.5 ml/l at 30, 45, 60 and 75 DAS
M_1T_5	Seed treatment with Thiophanate methyl @ 2ml/kg + water spray at 30, 45, 60 and 75 DAS
M_1T_6	Control
M_2T_1	Seed treatment with Thiophanate methyl @ 2ml/kg + one foliar spray of Tebuconazole @ 2.5 ml/l at 30 DAS
M_2T_2	Seed treatment with Thiophanate methyl @ 2ml/kg + two foliar sprays of Tebuconazole @ 2.5 ml/l at 30 and 45 DAS
M_2T_3	Seed treatment with Thiophanate methyl @ 2ml/kg + three foliar sprays of Tebuconazole @ 2.5 ml/l at 30, 45 and 60 DAS
M_2T_4	Seed treatment with Thiophanate methyl @ 2ml/kg + four foliar sprays of Tebuconazole @ 2.5 ml/l at 30, 45, 60 and 75 DAS
M_2T_5	Seed treatment with Thiophanate methyl @ 2ml/kg + water spray at 30, 45, 60 and 75 DAS
M_2T_6	Control

Table 2: Disease rating scale to determine the percent disease severity

Scale	Description
0	No lesions/spots.
1	1% leaf area covered with lesions/spots.
3	1.1 – 10% leaf area covered with lesions/spots, no spots on stem.
5	10.1 – 25% of the leaf area covered, no defoliation; little damage.
7	25.1 – 50% leaf area covered; some leaves drop; death of a few plants; damage conspicuous.
9	More than 50% area covered, lesions/spot very common on all plants, defoliation common; death of plants common; damage more than 50%.

(28.76%). Treatment with water spray in moderately resistant plot was found to be significantly at par with susceptible plots with water spray and moderately resistant control plots with yield loss of 33.90, 34.63 and 34.67 percent respectively. The highest yield loss to the tune of 40.37 percent was recorded from control susceptible plots.

Findings by Singh *et al.* (2012) recorded maximum yield loss (40.32%) in control plots of mungbean whereas one, two and three sprays of Carbendazim reduced yield loss of 21.93, 12.62 and 3.03% respectively. Sharma and Gupta (2003) reported 30 percent loss in yield due to web blight of urd bean caused by *R. solani*.

Area under disease progress curve (AUDPC)

Results revealed that the least AUDPC was observed from moderately resistant plots receiving four foliar sprays (33.54) followed by three sprays (39.08) in moderately resistant plots, susceptible plot with four sprays (53.32) and three sprays (60.50), two sprays in moderately resistant plots (63.34), susceptible plot with two foliar sprays (77.76), one foliar spray in moderately resistant plots(83.66), moderately resistant plots with water spray (108.01), one foliar spray in susceptible plots (114.23), water spray in susceptible plots (119.30), moderately resistant control plots(129.92) with highest AUDPC was recorded from control susceptible plots (176.38).

Table 3 : Effect of different chemical combinations on aerial blight disease of soybean caused by *Rhizoctonia solani*and yield losses

M × T Interaction	Disease Incidence (%)	Disease Index (%)	AUDPC	Yield (kg/ha)	Yield loss (%)	Avoidable yield loss (%)
M_1T_1	18.50 (25.22)*	12.71 (19.29)	114.23	1282.33	28.76	16.30
M_1T_2	15.49 (22.97)	8.85 (16.02)	77.76	1415.33	21.37	24.16
M_1T_3	13.74 (21.60)	6.69 (14.22)	60.50	1560.00	13.33	31.20
M_1T_4	13.33 (12.17)	5.93 (13.38)	53.32	1730.00	3.89	37.96
M_1T_5	31.00 (33.44)	13.27 (19.54)	119.30	1176.67	34.63	8.78
M_1T_6	39.16 (38.47)	20.99 (24.88)	176.38	1073.33	40.37	-
M_2T_1	14.41 (20.73)	9.65 (15.31)	83.66	1768.33	26.31	11.33
M_2T_2	10.75 (17.06)	7.59 (14.13)	63.34	1824.00	24.00	14.04
M_2T_3	7.50 (15.04)	4.44 (11.06)	39.08	2116.67	11.81	25.92
M_2T_4	7.66 (15.53)	3.73 (9.98)	33.54	2326.67	3.05	32.60
M_2T_5	18.25 (23.96)	13.13 (18.41)	108.01	1586.33	33.90	1.16
M_2T_6	25.33 (28.92)	15.50 (20.18)	129.92	1568.00	34.67	-
SEm±	1.20	1.01	-	32.03	0.70	-
CD (P=0.05)	3.52	2.95	-	93.50	2.05	-

* Figures in parenthesis are angular transformed values

Nainwal *et al*. (2020) reported minimum AUDPC for 38th meteorological week for all cultivars under investigation and after that it increased till 42th SMW (Standard meteorological week) and attained maximum value. It was recorded maximum for cultivar JS-58 (424.19) and minimum for cultivar PK-262 (160.99) for 10th-17th October. Amrate *et al*. (2021) observed that of all growing seasons *viz*. 2017, 2018 and 2019, the highest AUDPC (1183.00) and sclerotial count (187.20) were recorded in season 2018.

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DECLARATIONS

Conflict of Interest: Authors declare no conflict of interest.

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