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Research Article

Management of Foliar Fungal Diseases of Soybean through Chemicals and Its Impact on Yield

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ABSTRACT

The efficacy of some combination fungicides like pyraclostrobin 13.3% + epoxiconazole 5% SE, carbendazim 12% + mancozeb 63% WP along with commonly used systemic fungicides viz., hexaconazole 5% EC, difenoconazole 25% EC, propiconazole 25% EC, pyraclostrobin 20% WG and kresoxim-methyl 44.3% SC were tested against foliar fungal diseases in soybean using susceptible cv. NRC-37 at Agricultural Research Station, Ladol, Gujarat. All the fungicide treatments reduce the disease intensity significantly as compared to untreated check. Observations on PDI of both the diseases (Alternaria leaf spot and Cercospora leaf spot) of soybean were recorded periodically at 60, 75 and 90 days after sowing with consecutive three sprays of fungicides at 15 days interval (before and after seven days of spray) and was found low to moderate in range (9.70 - 36.53 per cent). In case of Alternaria leaf spot, the minimum per cent disease intensity (PDI, 23.11%) was recorded (after seven days of third spray) in the treatment T_6 (pyraclostrobin 13.3% + epoxiconazole 5% SE @ 0.01%) and it was at par with the treatment T_1 (hexaconazole 5% EC @ 0.005%) and T_5 (kresoxim-methyl 44.3% SC @ 0.05%) with its PDI 23.75 and 24.78 per cent, respectively. Whereas, in case of Cercospora leaf spot, the minimum per cent disease intensity (PDI, 24.75%) was also recorded (after seven days of third spray) in the treatment T_6 and it was at par with the treatment of T_1 with its PDI 26.55 per cent as compared to untreated check. Similarly, the highest yield of soybean grains was recorded in T_6 against foliar fungal diseases (ALF & FLS) with 1640 kg/ha followed by T_1 and T_5 with its yield 1494 kg/ha and 1417 kg/ha, respectively. Thus, it can be said that combination of such systemic, protective fungicides may be effectively had suppression of pre as well as post-infection activity with its unique mode of action (block the energy supply of the fungus & stop the development of cell membrane) and inhibited sporulation and/or restricted lesion expansion of foliar fungal pathogens. Also found not only to manage leaf spots but increase in the grain yield of soybean as well.

Keywords: *Soybean, Alternaria leaf spot, Cercospora brown leaf spot or Frog-eye leaf spot, Fungicides, pyraclostrobin 13.3% + epoxiconazole 5% SE, Percent Disease Intensity and management.*

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INTRODUCTION

Soybean (*Glycine max* L.) is the unique grain legume globally known for its dual purpose use as pulse and oilseed containing 38-44% protein and 18-22% oil. Soybean also finds place as the key component in a diverse range of industrial products like solvents, adhesives, inks, lubricants and insulating foams etc. In a large section of vegetarian people in country like India, soybean plays an important role as a rich source of protein. Occupying an area of 12.03 million ha with total production of 12.98 metric tonne and productivity 1264 kg ha^{-1} (Anonymous, 2018). In India, soybean is mainly grown in the states of Madhya Pradesh, Maharashtra, Rajasthan, Karnataka, Andhra Pradesh, Chattisgarh, Nagaland and Gujarat as a rainfed crop during the rainy (Kharif) season. Over the years, cultivation of the crop has been instrumental in improving the socioeconomic conditions of large numbers of small and marginal farmers in the rainfed agro-ecosystems of central and peninsular India. In Gujarat, it has 0.930 lakh ha area with 0.977 million tone of production (Anonymous, 2020). In India, so many foliar fungal diseases have been reported on soybean like soybean rust, sclerotium blight, coller rot, charcoal rot, rhozoctonia root rot, aerial blight, anthracnose, myrothecium leaf spot, alternaria leaf spot, brown spot, frog eye leaf spot etc. with enormous losses. Among them, alternaria and cercospora leaf spots are commonly found in Gujarat.

In Gujarat, the disease occurs every year in not epidemic form but contributing to yield loss up to 15 per cent in unsprayed crop (Sharma et al., 2014). Among the new fungicides, spraying of pyraclostrobin 13.3% + epoxiconaxole 5% SE and hexaconazole 5% EC have been evaluated as highly effective against Alternaria and Cercospora leaf spots in soybean. Both the fungicides have already been used in different parts of the country for management of foliar leaf spots in soybean. However, it is quite essential to evaluate their efficacy against the disease for a particular climatic condition. Therefore, an experiment has been carried out to investigate the performances of some fungicides *viz.*, hexaconazole 5% EC, difenoconazole 25% EC, propiconazole 25% EC, pyraclostrobin 20% WG, kresoxim-methyl 44.3% SC, pyraclostrobin 13.3% + epoxiconaxole 5% SE and carbendazim 12% + mancozeb 63% WP under North Gujarat agro climatic field conditions.

MATERIALS AND METHODS

The experiment was conducted at Agricultural Research Station, S. D. Agricultural University, Ladol, Gujarat during the year 2020-21 in kharif season with susceptible cv. NRC-37 for the management of foliar leaf spots in soybean. The soil of the experimental field was sandy loam. The experiment was laid out in a randomized block design with three replications. All recommended agronomic practices were followed. The soybean seeds were sown in the first week of July at a distance of 35 cm X 10 cm spacing by using 100 kg ha^{-1} seed with the gross area of 5.0 m X 3.5 m = 17.5 m^2 and a net plot size of 4.0 m X 2.8 m = 11.2 m^2. Efficacies of seven fungicides with their prefixed concentrations (as per treatments) were compared with untreated control. Three sprays of each fungicide with their prefixed concentration were applied at an interval of 15 days when the disease initiation was started. All the treatments each being comprised of three sprays were imposed after the appearance of the disease starting from 60 DAS till 90 DAS at 15 days interval. Observations of disease intensity were recorded from the appearance of the disease at 15 days interval (before and after seven days of spray) till 90 DAS as per the 0-5 point standard scale for assessment of foliar leaf spots of soybean.

Treatment details:

Sr.	Treatments	Dosage/ha	
		a.i. (g)	Formulation g or ml/1 litre of water
1	Hexaconazole 5% EC	0.005	1.0 ml
2	Difenoconazole 25% EC	0.025	1.0 ml
3	Propiconazole 25% EC	0.05	2.0 ml
4	Pyraclostrobin 20% WG	0.01	0.5 ml
5	Kresoxim-methyl 44.3% SC	0.055	1.25 ml
6	Pyraclostrobin 13.3% + Epoxiconaxole 5% SE	0.01	0.5 g
7	Carbendazim 12% + Mancozeb 63% WP	0.2	2.7 g
8	Untreated Control	-	-

The per cent disease intensity was recorded as per three consecutive sprays of fungicides at 60 75 and 90 days after sowing. On the basis of symptoms (Figure A and Figure B) and microscopic studies, the fungus was identified as *Alternaria alternata* (Fries) Keissler and *Cercospora sojina* Hara, the causative agents of leaf spots in soybean.

Alternaria leaf spot (*Alternaria* sp.)

A brown necrotic spots with concentric rings appears on foliage which coalesces and form large necrotic areas. Infected seeds appear small and shriveled. A dark irregular spreading sunken area occurs on seeds. The symptoms was in conformity as described by Kumar et al. 2015; Bhosale et al. 2014.

Cercospora leaf spot (*Cercospora* sp.)

Leaf spots sub-orbicular to angular, small, 0.5-1 mm wide, often confluent and become irregular patches, up to 10 mm wide, later covering the whole leave surface, pale brown to tan or grey center with a reddish brown to purple margin. Similar observations were reported by Grau et al., 2004 and Philips, 1999. Symptoms often appear during reproductive stages as light purple areas on leaves later on expanded and turn a darker purple to almost leathery brown, and finally necrotic leaves dropped prematurely.

The observations on the intensity of alternaria leaf spot (ALS) and cercospora/frog-eye leaf spot (FLS) were recorded from 5 plants randomly selected from each plot using 0-5 scale as detailed below.

Disease Score	:	Disease Intensity
0	:	Leaves free from infection.
1	:	Small irregular spots covering < 5% leaf area.
2	:	Small irregular brown spots with concentric rings covering 5.1-10% leaf area.
3	:	Lesions enlarge, irregular brown with concentric rings covering 10.1-25% leaf area.
4	:	Lesions coalesce to form irregular and appear as a typical blight symptom covering 25.1-50% leaf area.
5	:	Lesions coalesce to form irregular and appears as a typical blight symptom covering >50% leaf area.

The per cent disease intensity (PDI) was computed as per the formula suggested by Horsfall and Heuberger (1942).

$$PDI = \frac{\text{Sum of all numerical ratings}}{\text{No. of leaves examined X maximum disease severity grade}} \times 100$$

Based on these observations, percent disease intensity (PDI) of two different types of leaf spots of soybean was recorded. The per cent disease intensity data was arcsine transformed before analysis of variance (ANOVA). Statistical analysis was done with using the standard procedure described by Gomez and Gomez (1986).

RESULTS AND DISCUSSION

The experiment was conducted successfully at ARS, SDAU, Ladol farm with susceptible variety NRC-37 of soybean. We visually observed two different types of leaf spots in the experiment. It was Alternaria leaf spot caused by *Alternaria alternata* (Fries) Keissler and the other was cercospora or frog-eye leaf spot caused by *Cercospora sojina* Hara. The data on PDI of leaf spots (Alternaria & Cercospora) of soybean was recorded periodically at 60, 75 and 90 days after the sowing with consecutive three spray of fungicides (before and after seven days of spray) at 15 days interval and was found low to moderate in range. In Alternaria Leaf Spot (ALS) it was observed in 9.70-34.43 per cent range. Whereas, in case of Frog-eye Leaf Spot (FLS) it was observed with the range of 11.49-

36.53 per cent. It has also been found that in all treatments PDI increased with the age of the plants. The data on disease intensity revealed that all fungicides tested reduced the disease intensity significantly as compared to control. Table 1 revealed that in case of Alternaria Leaf Spot (ALS) the minimum PDI was recorded after 7 days of first spray at 60 DAS in the treatment T_6 *i.e.* spraying of pyraclostrobin 13.3% + epoxiconaxole 5% SE @ 0.01% (13.34%) followed by T_1 *i.e.* hexaconazole 5% EC @ 0.005% (14.33%) which was found at par with T_6 also then T_5 kresoxim-methyl 44.3% SC @ 0.05% with its PDI 14.95 per cent. After 7 days of second spray at 75 DAS and third spray at 90 DAS the minimum PDI was recorded in the same trends. At 7 days after third spray, the minimum PDI was found in T_6 (23.11%) followed by T_1 and T_5 which was found at par with their values 23.75, 34.78 per cent, respectively. (Table 1) Whereas, in case of Frog-eye Leaf Spot (FLS) or Cercospora Brown Leaf Spot, the minimum PDI was recorded after 7 days of first spray at 60 DAS in the treatment T_6 *i.e.* spraying of pyraclostrobin 13.3% + epoxiconaxole 5% SE @ 0.01% (14.33%) followed by T_1 *i.e.* hexaconazole 5% EC @ 0.005% (15.85%) and T_5 *i.e.* kresoxim-methyl 44.3% SC @ 0.05% with its PDI 16.42 per cent. After 7 days of second spray at 75 DAS and third spray at 90 DAS the minimum PDI was recorded in the same trends. The minimum PDI, It was found in T_6 (24.75%) with highest grain yield 1640 kg ha^{-1} followed by T_1 and T_5 which was found at par with their values 26.55, 27.49 per cent, respectively. The present study on efficacy of different fungicides with their doses against foliar fungal diseases of soybean revealed that the combination of two different group of fungicides *i.e.* pyraclostrobin 13.3% + epoxiconaxole 5% SE @ 0.01% was found very effective against Alternaria leaf spot & Frog-eye Leaf Spot of soybean and increasing the grain and haulm yield as compared to control. (Table 1).

For the management of frog-eye leaf spot in soybean, evaluation of resistant varieties is considered to be the most feasible and durable solution. Das et al. (2017) were screened out 26 varieties including one susceptible check against FLS under natural condition. Percent Disease Index was worked out and it varied from 4.00 % to 31.00 %. No variety was found Immune (Disease severity 0%). Fifteen varieties *i.e*., RKS 18, PK 564, PS 1241, PK 1092, Indira Soya 9, PS 1029, NRC 37, PS 1347, MAUS 71, PK 1024, PK 472,PK 416, Alankar, Ankur, JS 335 were observed to be resistant (Disease severity 1% to 10%). Eight varieties (NRC 37, PS 19, PK 327, RAUS 5, PK 1042, JS 9752, Shilajeet, JS -20-29) were categorized as moderately resistant (Disease severity 10% to 20%) and two varieties (Kalitur & Bragg) were showed under moderately susceptible (Disease severity 20% to 30%). Only one variety *i. e*., PK 262 was found susceptible (Disease severity 30% to 50%). None of the varieties was found highly susceptible (Disease severity above 50.1%). These resistant and moderately resistant varieties can be used as good donor for evolving resistant varieties against Frogeye leaf spot disease in soybean. Similar type of observation was done by Chandra, 2012.

In the year 2003, Prasad et al. conducted an experiment at ICAR Research Complex, Barapani for the management of two commonly occurring diseases like frog eye leaf spot and rust with different fungicides viz., propineb (antracol) @ 0.3%, tricyclazole (beam) @ 0.1 %, hexaconazole 5% EC (contaf 5E) @ 1%, tebuconazole (folicur) @ 0.2%, chlorothalonil 75% WP (kavach 75 WP) @ 0.2%, mancozeb 75% WP (indofil M-45) @ 0.25%, propiconazole 25% EC (tilt 25 EC) @ 0.1 %, benomyl (benlate) @ 0.2% and a neem product azardichtin (nimbicidin) @ 0.3% were evaluated against frog eye leaf spot and rust. They found that all the chemicals were effective against frog-eye leaf spot. Benomyl (12.2 PDI) was found best in reducing the frog eye leaf spot followed by chlorothalonil (13.6), mancozeb (15.4), tebuconazole (15.8), propicanazole and tricyclazole (17) however, these were at par with each other.

An experiment was conducted at AAU, Assam for identification of soybean diseases in assam region by Borah, M. (2019). Among foliar diseases, Alternaria leaf spot appeared during first week of September

vegetative growth stage of the crop whereas, Cercospora leaf spot (CLS) and Pod Blight[PB (Ct)] were noticed at flowering and pod formation stage viz. September 25th onward where intermittent rainfall was experienced by the crop. Whereas, in our experimental farm both the diseases were noticed at flowering and pod formation stage *viz.* September 25th onward.

Shivaprasad et al. (2021) studied on effect of fungicides on severity of coffee leaf rust and influence on yield of coffee. They found pyraclostrobin 133 g/l + epoxiconazole 50 g/l SE @ 1.5-4.5 ml/l recorded minimum severity of CLR diseases and maximum yield. Therefore, pyraclostrobin 133 g/l + epoxiconazole 50 g/l SE @ 1.5 ml/l can well be adopted as one of the component in developing integrated disease management strategies for minimizing the losses due to leaf rust (CLR) in Coffee.

Ribeiro et al. (2014) evaluated eight group of fungicides applied as seed treatment and aerial part of the soybean plants. They found that pyraclostrobin + methyl thiophanate favored root development on plantlets, plant height and grain yield, when it was applied on the soybean seeds. Fungicides applied on the plant aerial parts showed positive effects on control of foliar diseases in soybean.

Result of the present study showed that among the eight different fungicide treatments, one combination fungicides *viz*., pyraclostrobin 13.3% + epoxiconaxole 5% SE @ 0.01% and hexaconazole 5% EC @ 0.005% were found significantly superior for control the foliar fungal diseases (ALS & FLS) as compared to control. These fungicides acted as the best fungicides when applied as prophylactic as well as curative measures. Similar results were obtained by many scientists as per earlier discussed. All the treatments showed significantly better foliage controlled as well as increase in grain yield over non- treated control. The results of this study were consistent with previous studies and indicated that the application of protective fungicides could reduce foliar fungal leaf spots to acceptable levels. Thus, in the present study, it can be said that combination of protective fungicides (strobilurin group fungicide-pyraclostrobin and traizole group fungicide epoxyconazole) may be effectively had suppression of pre as well as post-infection activity with its unique mode of action (block the energy supply of the fungus & stop the development of cell membrane) and inhibited sporulation and/or restricted lesion expansion of foliar leaf spot pathogens. Also found not only to manage fungal leaf spots but increase in the yield of soybean as well.

Table 1: Efficacy of fungicides against leaf spots (Alternaria & Cercospora) of Soybean and its impact on yield

Tr	Treatment	Percent Disease Intensity												Yield (kg/ha)	
		Alternaria Leaf Spot (ALS)						Frog-eye Leaf Spot (FLS)							
		60 DAS		75 DAS		90 DAS		60 DAS		75 DAS		90 DAS			
		First Spray		Second Spray		Third Spray		First Spray		Second Spray		Third Spray			
		Before	After 7 days	Before	After 7 days	Before	After 7 days	Before	After 7 days	Before	After 7 days	Before	After 7 days	Grain	Haulm
T_1	Hexaconazole 5% EC @ 0.005%	10.25 (3.20)	14.33^{de} (6.13)	16.41^{e} (8.00)	20.25^{f} (12.00)	23.14^{e} (15.47)	23.75^{e} (16.27)	11.49 (4.00)	15.85^{d} (7.47)	18.03^{f} (9.60)	20.01^{f} (11.73)	24.59^{de} (17.33)	26.55^{ef} (20.00)	1494^{ab}	4845^{a}
T_2	Difenoconazole 25% EC @ 0.025%	9.84 (2.93)	15.26^{d} (6.93)	18.03^{d} (9.60)	23.76^{d} (16.27)	24.99^{cd} (17.87)	26.74^{cd} (20.27)	11.87 (4.27)	18.80^{c} (10.40)	19.51^{de} (11.20)	23.56^{d} (16.00)	27.35^{bcd} (21.13)	28.41^{cde} (22.67)	1330^{abc}	4640^{a}
T_3	Propiconazole 25% EC @ 0.05%	9.70 (2.93)	17.51^{c} (9.07)	19.77^{c} (11.47)	24.37^{d} (17.07)	26.17^{c} (19.47)	27.48^{c} (21.33)	12.28 (4.53)	19.04^{c} (10.67)	20.48^{cd} (12.27)	24.79^{c} (17.60)	28.23^{bc} (22.40)	29.14^{cd} (23.73)	1298^{bcd}	4366^{ab}
T_4	Pyraclostrobin 20% WG @ 0.01%	11.03 (3.73)	19.30^{b} (10.93)	21.18^{b} (13.07)	25.38^{c} (18.40)	28.60^{b} (22.93)	29.13^{bc} (23.73)	11.87 (4.27)	20.01^{bc} (11.73)	21.17^{c} (13.07)	25.39^{c} (18.40)	29.83^{b} (24.80)	29.85^{c} (24.80)	1199^{bcd}	3878^{bc}
T_5	Kresoxim-methyl 44.3% SC @0.05%	10.25 (3.20)	14.95^{d} (6.67)	17.24^{de} (8.80)	21.61^{e} (13.60)	23.97^{de} (16.53)	24.78^{de} (17.60)	11.84 (4.27)	16.42^{d} (8.00)	18.80^{ef} (10.40)	22.06^{e} (14.13)	25.97^{cde} (19.20)	27.49^{de} (21.33)	1417^{abc}	4839^{a}
T_6	Pyraclostrobin 13.3% + Epoxiconaxole 5% SE @ 0.01%	11.03 (3.73)	13.34^{e} (5.33)	14.95^{f} (6.67)	18.03^{g} (9.60)	20.48^{f} (12.27)	23.11^{e} (15.47)	12.62 (4.80)	14.33^{e} (6.13)	15.85^{g} (7.47)	18.03^{g} (9.60)	24.31^{e} (17.07)	24.75^{f} (17.60)	1640^{a}	4857^{a}
T_7	Carbendazim 12% + Mancozeb 63% WP @ 0.2%	11.03 (3.73)	20.24^{b} (12.00)	21.18^{b} (13.07)	26.36^{b} (19.73)	29.85^{b} (24.80)	31.08^{b} (26.67)	11.84 (4.27)	21.17^{b} (13.07)	22.71^{b} (14.93)	26.93^{b} (20.53)	29.10^{b} (23.67)	33.28^{b} (30.13)	1125^{cd}	3804^{bc}
T_8	Untreated Control	10.25 (3.20)	22.92^{a} (15.20)	24.79^{a} (17.60)	29.67^{a} (24.53)	32.44^{a} (28.80)	34.43^{a} (32.00)	12.21 (4.53)	24.17^{a} (16.80)	26.16^{a} (19.47)	28.23^{a} (22.40)	33.93^{a} (31.20)	36.53^{a} (35.47)	1006^{d}	3685^{c}
	S.Em (±)	0.99	0.43	0.35	0.30	0.48	0.83	0.86	0.49	0.37	0.32	0.89	0.66	96	202
	C.D at 5%	N/A	1.33	1.09	0.91	1.47	2.55	N/A	1.51	1.15	0.98	2.73	2.02	292	613
	C.V. (%)	16.46	4.36	3.20	2.18	3.17	5.23	12.38	4.56	3.19	2.35	5.52	3.88	12.71	8.02

Note 1: Figures in parenthesis are retransformed values of Arcsine transformation; 2. Treatment means with the letter (s) in common are not significant by DNMRT at 5% level of significance; 3. DAS- Day after sowing; 4. ALS- Alternaria leaf spot; 5- FLS- Frog-eye leaf spot

Figure A

Alternaria Leaf Spots on leaves

Figure B

Frog-eye Leaf Spots on leaves

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