Plant Archives Vol. 25, No. 2, 2025 pp. 1078-1082 e-ISSN:2581-6063 (online), ISSN:0972-5210

Plant Archives

Journal homepage: http://www.plantarchives.org
DOI Url : https://doi.org/10.51470/PLANTARCHIVES.2025.v25.no.2.155

INTEGRATED SOLUTIONS FOR MANAGEMENT OF LEAF BLIGHT (*EXSEROHILUM TURCICUM*) IN SORGHUM

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(Date of Receiving-30-06-2025; Date of Acceptance-10-09-2025)

ABSTRACT

Leaf blight (*Exserohilum turcicum*) is one of the most devastating diseases in sorghum. The innovative idea to manage crop diseases is the integrated method (chemical and bio-control agents), as it involves the least fungicidal load in the environment. Thus, in the present study, the main objective was to investigate the effect of various effective fungicides, botanicals and bio-agents against leaf blight disease under field conditions. Among various treatments, two sprays of hexaconazole 5% EC at 0.1 per cent was best with lowest PDI -16.90 % and AUDPC – 339.61 followed by, tebuconazole 250 EC @ 1 ml/l (PDI - 19.86 %, AUDPC – 403.32) and hexaconazole 5% EC @ 1 ml/l - liquid *Pseudomonas fluorescens* @10 ml/l (PDI –21.52 %, AUDPC – 444.65) which were on par with each other and significantly superior over the control (57.20 %). In context to integrated management maximum grain yield (30.57 q/ha) and fodder yield (6.42 t/ha) were seen in the spray schedule of hexaconazole 5% EC@ 0.1 % - liquid *Pseudomonas fluorescens* @10 ml/l significantly superior over control. The highest B:C ratio was obtained in two sprays of hexaconazole 5% EC @ 0.1% (1:2.40).

***Key words*:** leaf blight, sorghum, integrated management, bio-agents, fungicides

Introduction

Sorghum (*Sorghum bicolor*) is a significant cereal crop, ranking as the fifth most important crop globally, following wheat, rice, maize, and barley. It is indigenous to northeastern Africa, commonly referred to as guinea corn or "great millet." This crop is susceptible to various fungal diseases, among which leaf blight, caused by *Exserohilum turcicum* (Pass.) Leonard and Suggs [Telomorph = *Setosphaeria turcica*], is particularly noteworthy. This disease adversely impacts photosynthesis and can lead to a substantial reduction in grain yield, with losses reaching up to 50 percent in susceptible genotypes, as reported by Mittal and Boora (2005), Ogliari *et al*., (2007)and Ramathani *et al.*, (2011). Leaf blight is a significant fungal disease affecting sorghum worldwide, particularly in warm and humid environments. Previously regarded as a minor disease, it has now escalated to a major concern in India.

The efficacy of several systemic and combi-fungicides, along with contact fungicides and bio-agents, in strive against leaf blight in sorghum was evaluated utilizing the poisoned food technique under *in-vitro* conditions. The combination of Carbendazim (12%) + Mancozeb (63%) exhibited the highest level of effectiveness, closely succeeded by Propiconazole (99.19%), Mancozeb (93.39%), and *Trichoderma harzianum*(98.34%), all of which significantly diminished the incidence of leaf blight in sorghum (Vinay and Sataraddi, 2019). Praveen Kumar *et al*., (2010) reported that the synergistic application of mancozeb (0.25%),

Table 1: Treatment details for integrated management of leaf blight of sorghum.

Treatments	First spray	Second spray
T_1	Hexaconazole 5% EC @ 1 ml/L	Hexaconazole 5% EC @ 1 ml/L
T_2	Tebuconazole 250 EC @ 1 ml/L	Tebuconazole 250 EC @ 1 ml/L
T_3	Liquid *Pseudomonas fluorescens* @10 ml/L	Liquid *Pseudomonas fluorescens* @10 ml/L
T_4	Formulation of *Bacillus subtilis* @ 10g/L	Formulation of *Bacillus subtilis* @ 10g/L
T_5	Azadirachtin 1500 ppm @ 5ml/L	Azadirachtin 1500 ppm @ 5ml/L
T_6	Hexaconazole 5% EC @ 1 ml/L	Liquid *Pseudomonas fluorescens* @10 ml/L
T_7	Hexaconazole 5% EC @ 1 ml/L	Formulation of *Bacillus subtilis* @ 10g/L
T_8	Hexaconazole 5% EC @ 1 ml/L	Azadirachtin 1500 ppm @ 5ml/L
T_9	Tebuconazole 250 EC @ 1 ml/L	Liquid *Pseudomonas fluorescens* @10 ml/L
T_{10}	Tebuconazole 250 EC @ 1 ml/L	Formulation of Bacillus subtilis @ 10g/L
T_{11}	Tebuconazole 250 EC @ 1 ml/L	Azadirachtin 1500 ppm @ 5ml/L
T_{12}	Mancozeb @ 2g/L	Mancozeb @ 2g/L
T_{13}	Control (without spray)	Control (without spray)

Trichoderma viride (0.4%), monopotassium phosphate (1%)and potassium silicate (1%) proved effective in reducing leaf blight in maize. Numerous studies have demonstrated the efficacy of *Pseudomonas* in managing diseases induced by various foliar pathogens (Rao, 2006; Anand, 2013). Additionally, Hexaconazole at 0.1 percent has been reported to effectively control leaf blight in sweet sorghum, contributing to increase in net returns (Kiran and Patil, 2019). A comprehensive study was initiated to evaluate the effectiveness of fungicides, botanicals, and bio-agents in reducing leaf blight caused by *E. turcicum*under field conditions. This investigation aimed to identify reliable solutions to mitigate this significant threat to crop health, productivity and also provide evidence-based recommendations to farmers for improving disease management strategies and promoting sustainable agricultural practices.

Materials and Methods

Various effective fungicides, botanicals, and bio-agents from the University of Agricultural Sciences, Dharwadand Institute of Organic Farming were evaluated on M 35-1 against leaf blight in a randomized block design with two replications and thirteen treatments during *Rabi* 2023 at AICRP-Sorghum, Main Agricultural Research Station, Dharwad. The treatment details for the experiment are mentioned in Table 1.

A recommended package of practice was followed to raise the crop. Two sprays were applied with 15 days interval, starting at onset of disease. *E. turcicum* inoculum was sprayed on 21-day-old crops in the evening and mass-multiplied *E. turcicum* sorghum seeds (2-3) in the whorl to create high humidity and disease pressure, except in control.

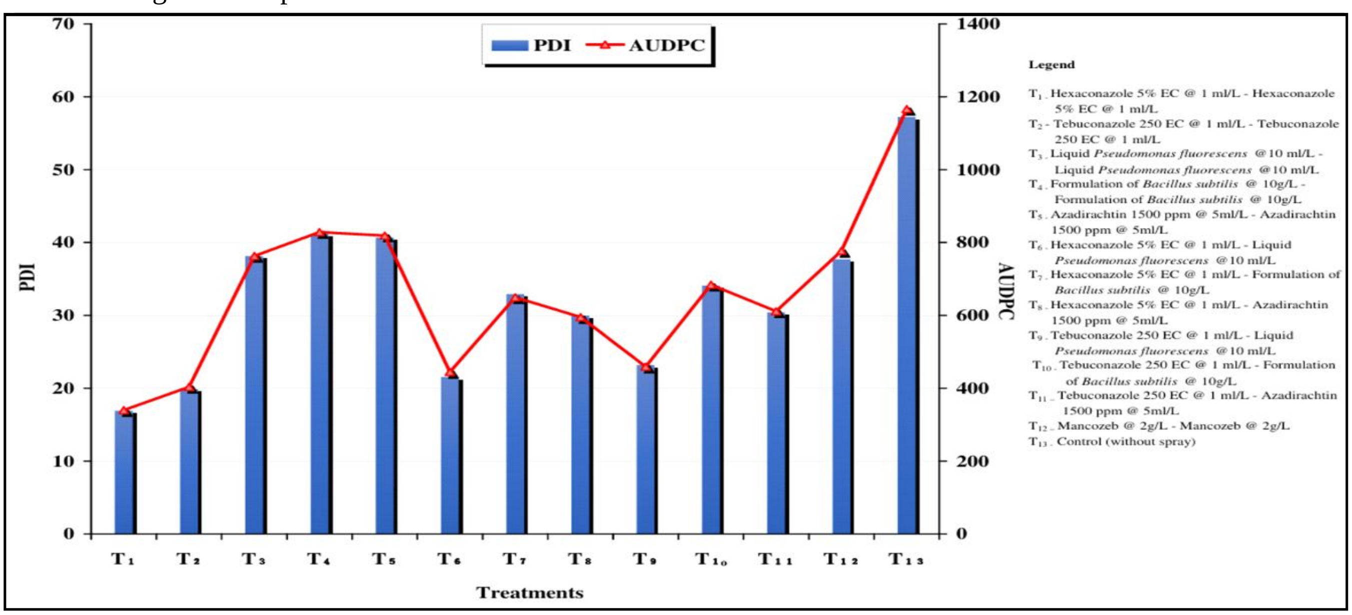

Fig. 1: Leaf blight severity involving effective fungicides, commercially available botanicals and bio-agents for sorghum during *Rabi* 2023-24.

Table 2: Evaluation of spray schedule involving effective fungicides, commercially available botanicals and bio-agents on leaf blight of Sorghum during *Rabi* 2023-24.

T. no.	Spray schedule		PDI	PIOC	AUDPC	GY	FY	SW	BC
	First spray	**Second spray**							
T_1	Hexaconazole 5% EC @ 1 ml/L	Hexaconazole 5% EC @ 1 ml/L	16.90(24.28)*	70.45	339.61	32.84	6.90	4.29	2.40
T_2	Tebuconazole 250 EC @ 1 ml/L	Tebuconazole 250 EC @ 1 ml/L	19.86(26.47)	65.27	403.32	31.45	6.60	3.79	2.17
T_3	Liquid *Pseudomonas fluorescens* @10 ml/L	Liquid *Pseudomonas fluorescens* @10 ml/L	38.12(39.30)	33.35	762.90	23.50	4.94	2.88	1.68
T_4	Formulation of *Bacillus subtilis* @ 10g/L	Formulation of *Bacillus subtilis* @ 10g/L	41.21(41.68)	27.95	828.56	21.25	4.67	2.84	1.52
T_5	Azadirachtin 1500 ppm @ 5ml/L	Azadirachtin 1500 ppm @ 5ml/L	40.68(40.21)	28.81	819.07	22.95	4.90	2.86	1.53
T_6	Hexaconazole 5% EC @ 1 ml/L	Liquid *Pseudomonas fluorescens* @10 ml/L	21.52(27.64)	62.37	444.65	30.57	6.42	3.31	2.21
T_7	Hexaconazole 5% EC @ 1 ml/L	Formulation of *Bacillus subtilis* @ 10g/L	32.90(35.01)	42.48	649.62	28.10	5.90	3.12	1.95
T_8	Hexaconazole 5% EC @ 1 ml/L	Azadirachtin 1500 ppm @ 5ml/L	29.98(33.21)	47.58	595.15	29.83	6.26	3.19	2.08
T_9	Tebuconazole 250 EC @ 1 ml/L	Liquid *Pseudomonas fluorescens* @10 ml/L	23.19(28.79)	59.45	459.02	30.49	6.40	3.22	2.14
T_{10}	Tebuconazole 250 EC @ 1 ml/L	Formulation of *Bacillus subtilis* @ 10g/L	34.07(35.71)	40.43	683.97	26.73	5.61	3.10	1.87
T_{11}	Tebuconazole 250 EC @ 1 ml/L	Azadirachtin 1500 ppm @ 5ml/L	30.39(33.46)	45.92	611.30	28.89	6.07	3.13	2.03
T_{12}	Mancozeb @ 2g/L	Mancozeb @ 2g/L	37.68(39.04)	34.12	776.75	25.52	5.36	2.89	1.86
T_{13}	Control (without spray)		57.20(49.14)	-	1166.37	18.28	4.26	2.63	-
S.Em±			1.98			1.68	0.30	0.26	
CD at 5%			6.12			5.19	0.87	0.78	
CV			8.45			7.59	7.40	11.93	

T: Treatment; **PDI:** Per cent disease index; **PIOC:** Per cent increase over control; **GY:** Grain yield (q ha^{-1}); **FY:** Fodder yield (t ha^{-1}); **SW:** 100 seed weight (g); **BC:** B:C ratio

Leaf blight severity was assessed one day before each spray and just before harvest using a 1-9 scale (Anon, 2023). Post-harvest data included grain yield (q/ha), fodder yield (t/ha), and 100 seed weight (g). The Percent Disease Index (PDI) was calculated by using Wheeler(1969) formula, and these PDI values were then used to compute the Area Under the Disease Progressive Curve (AUDPC), based on Wilcoxen *et al.*, (1975).

Results

In the present investigation results of *in vitro* studies revealed that among the thirteen spray schedules evaluated during *Rabi* 2023, spray schedule involving hexaconazole 5% EC @ 0.1% - hexaconazole 5% EC @ 0.1% recorded least PDI (16.90 %) and AUDPC – 339.61 followed by, tebuconazole 250 EC @ 1 ml/l - tebuconazole 250 EC @ 1 ml/l (PDI - 19.86 %, AUDPC – 403.32) and hexaconazole 5% EC @ 1 ml/l - liquid *Pseudomonas fluorescens* @10 ml/l (PDI –21.52 %, AUDPC – 444.65) which were on par with each other and significantly superior over the control (57.20%) as mentioned in Fig. 1. Estimating the cost-benefit ratio is essential for the economic management of plant diseases. The highest B:C ratio was obtained in two sprays of hexaconazole 5% EC @ 0.1%(1:2.40). Among the various treatments evaluated, the highest grain yield of 32.84 q ha^{-1} was achieved with treatment T_1, which involved the application of hexaconazole 5% EC at 1 ml/l. In contrast, the lowest grain yield of 18.28 q ha^{-1} was recorded for treatment T_4, while the unsprayed control treatment yielded 21.25 q ha^{-1} (Table 2). All treatments that received foliar sprays exhibited significantly higher grain yields in comparison to the control group. A similar trend was observed in relation to fodder yield (t/ha) and 100 seed weight (g).The results of this study are in close alignment with the research conducted by Kiran and Patil (2019), who experimented to evaluate the effects of fungicides,

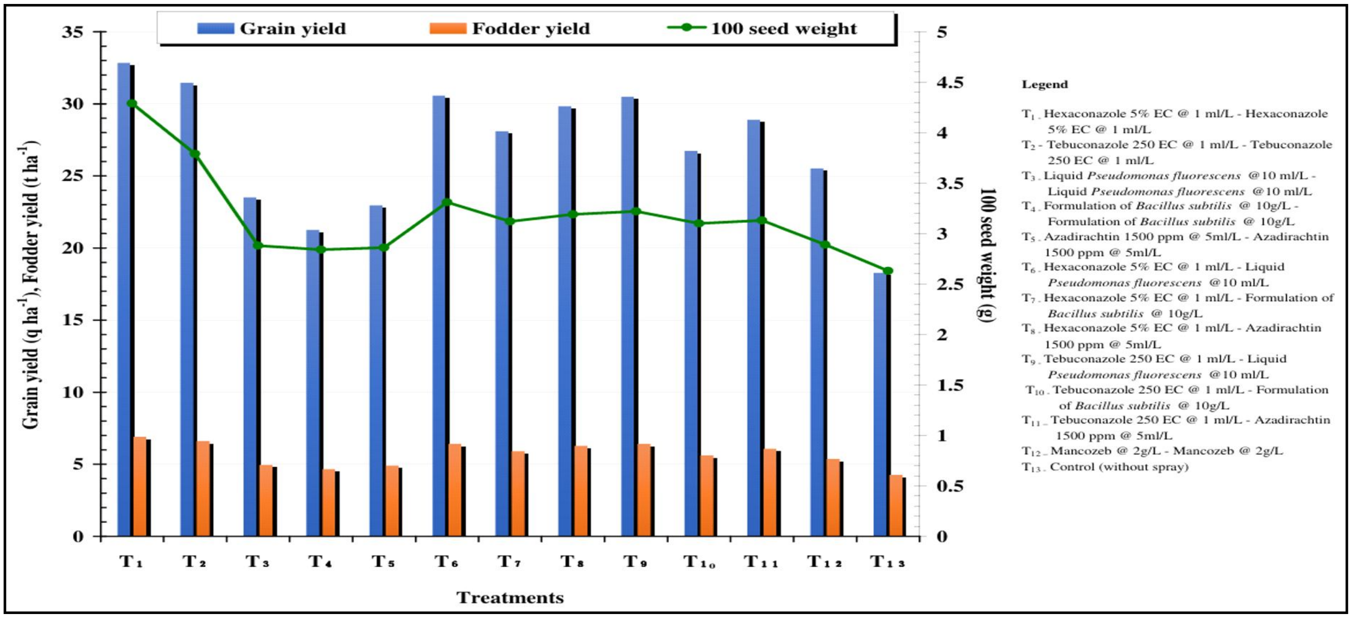

Fig. 2: Yield parameters in different spray schedules for the management of leaf blight of sorghum.

bioagents, and botanicals on severity of leaf blight, as well as on fodder yield and brix value of sweet sorghum. Their findings revealed that administering three applications of hexaconazole at a concentration of 0.1% during the physiological maturity stage was particularly effective in mitigating disease levels and also revealed the increased yield parameters.The current study's findings are consistent with Wani *et al*., (2017), who found that seed treatment with 0.25% mancozeb and two foliar applications of 0.1% propiconazole minimized disease intensity to 3.57 per cent. This approach achieved maximum grain yield of 56.95 qha^{-1} and stover yield of 15.57 tons per hectare as shown in Fig. 2, echoing results from Yadav *et al*., (2015) and Sartori *et al*., (2017). The effectiveness of these chemicals is mainly because they belong to the broad spectrum systemic triazole fungicide with a protective, curative and eradicant activity whose primary mode of action is inhibition of fungal ergo sterol biosynthesis as stated by Hewitt, 1998. Ergo sterol, an essential membrane constituent is responsible for maintaining membrane integrity and activity. Interference in its biosynthesis and insufficiency of ergo sterol in fungal membranes severely disturbs membrane functions. Activity of membrane bound enzymes in the plasmalemma was also get disturbed to the greater extent. Hence, these chemicals treated plot resulted minimum disease severity. The bio-agent *Pseudomonas fluorescens* has similar ant-fungal activity towards the mycelial growth of the fungus.

The increased returns from these treated plots mainly attributed to decrease in reduction of photosynthetic area, increased grain yield, increased fodder yield and 100 seed weight. Minimum returns from control plot compared to all treatments imposed due to decreased grain yield and

a) T_1: Hexaconazole 5% EC @1 ml/L-Hexaconazole 5% EC @1 ml/L

b) T_6: Hexaconazole 5% EC @ 1 ml/L - Liquid *Pseudomonas fluorescens* @10 ml/L

c) T_{13}: Control (without spray)

Fig. 3: Integrated management of leaf blight of sorghum.

fodder yield, loss is due to low fodder yield because of maximum disease pressure with no management practices. Given that no single management practice can completely eradicate foliar fungal diseases, the implementation of integrated management strategies with precise timing is crucial. These strategies minimize reliance on fungicides, thereby promoting environmentally sustainable, cost-effective and efficient management against leaf blight of sorghum. In a similar way, Ali *et al*., (2015) undertook an experimental investigation to examine the management of turcicum leaf blight in maize through an integrated approach that combined fungicides, botanicals and bio-agents. The findings of this study indicated that two applications of hexaconazole5% EC @ 0.1 % at 15-day intervals, was the most effective method for reducing the incidence of the disease over years of the study. This was closely followed by application of hexaconazole 5% EC and liquid *Pseudomonas fluorescens*. It is also observed that per cent increase over control was maximum in spray schedule hexaconazole 5% EC - hexaconazole 5% EC as seen in Fig. 3.

Conclusion

Results from this study revealed that, the fungicide hexaconazole 5% EC@ 1 ml/L andbio-agent liquid *Pseudomonas fluorescens*@10 ml/Loffer substantial economic benefits compared to other treatments by providing the highest return on investment though the differences were not statistically significant (P = 0.05).

Acknowledgments

The authors are thankful to both UASD and AICRP for funding my project. Authors' contribution: Butty Lakshmi Shivani: Concept ualization, design, material preparation, data collection as a part of PG thesis; Samina Anjum Syeda: Major advisor to Butty Lakshmi Shivani and helped in fund acquisition; Shalini N. Huilgol: Helped in review and editing; N. G. Hanamaratti: Proofreading; Samina Anjum Syeda: Manuscript preparation. The funding for the research was received from the Department of Plant Pathology, University of Agricultural Sciences, Dharwad and AICRP- Sorghum, Main Agricultural Research Station, Dharwad entitled "Variability in *Exserohilum turcicum* and integrated management of leaf blight of sorghum".

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