

Comparative evaluation of different fungicides and bio-agents for management of spot blotch of barley caused by *Bipolaris sorokiniana* (Sacc. Ex Sorok)

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Barley (*Hordeum vulgare* L) is one of the first domesticated cereal crop after maize, rice and wheat, which contributes 5.5-6.0% of the global cereals and 11.5-12 per cent of the coarse cereals production (Pal *et al.* 2012, Kumar *et al.* 2013b, Kumar *et al.* 2014). Barley is used as food crop in many countries of Africa, Middle East, South America and Asia. During 2019-20 in India, the area under the crop was 0.62 million hectare, productivity 25.73 q/ha with a production of 1.59 million metric tonnes (Anonymous 2019-20). In India, barley is an important coarse cereal crop being grown in Rabi (winter) season in Northern plains. Barley occupies area in 10 states viz. Himanchal Pradesh, Jammu & Kashmir, Bihar, Maharashtra, West Bengal, Punjab, Haryana, Madhya Pradesh, Uttar Pradesh and Rajasthan (Randhir Singh *et al.* 2014). Malt is the second largest use of barley and among cereals, barley is preferred for Kernel and its enzymatic activity (α and β amylase mainly) (Shaveta *et al.* 2019). The utilization of barley for malting and brewing industry has increased recently with the increase in consumption of beer, health drinks and other malt based products in India (Randhir Singh *et al.* 2014). Currently it has received attention of research workers to boost its production through the adoption of new technology and high yielding varieties.

Like other cereals, barley is also exposed to various diseases which are ultimately responsible for significant yield reduction and poor grain quality. Barley is exposed to several biotic stresses, however, some of these are rust, spot blotch, net blotch, powdery mildew, loose smut and covered smut (Gangwar *et al.* 2018). Among these, spot blotch caused by *Bipolaris sorokiniana* is an important fungal disease causing severe losses up to 25-30 per cent reduction in grain yield and also reduces the grain quality (Randhir Singh *et al.* 2014). Keeping in view, the importance of disease, especially with reference to the state of Uttar Pradesh, it is better to have management well in advance. The management of disease can be done through cultural practices and use of resistant genotype, but there is need for efficient management of disease with eco-friendly means.

In vitro, six systemic fungicides against *Bipolaris sorokiniana* viz; Propiconazole, Tebuconazole, Azoxystrobin, Difenconazole, Azoxystrobin + Difenconazole and Mancozeb and five bio-agents viz. *T. viride-1*, *T. viride-2*, *T. harzianum-1*, *T. harzianum-2* and *Pseudomonas fluorescens* were tested against the pathogen to find out their relative efficacy in inhibiting the growth of fungus in culture in four dilutions (25 ppm, 50 ppm, 100 ppm and 200 ppm) using



poisoned food technique proposed by Nene and Thapliyal, (1993). The desired concentrations were obtained by adding appropriate amount of stock solution of fungicides to potato dextrose agar (PDA) medium in petri dishes. PDA without fungicides served as control. Each plate was inoculated with a 5mm mycelial disc of the pathogen i.e. fungus taken from 7-days old culture. The inoculated plates were incubated at $25\pm 1^{\circ}\text{C}$ till the fungus covered the whole plate in control. For antagonistic activities of five bio-control agents, dual culture technique was used (Rahman 2009). Five mm diameter disc of actively growing pathogen (*B. sorokiniana*) taken from the margin of 10-days old culture was placed at one end of petri dish containing solidified PDA medium. The inoculation of mycelia disc (5mm) of antagonist at opposite end of petri dish was done 3-days after the placement of pathogen in order to adjust the slow growth rate of pathogen. The disc of pathogen and antagonist were placed at equal distance from the periphery of petri dish. In case of bacterial antagonist, culture disc (5mm diameter) of the pathogen was placed at one end of the petri dishes containing PDA medium and after three days the bacterial antagonist was streaked on opposite side of the growing pathogen colony. The plate containing PDA medium inoculated with pathogen only, served as control. The both experiments were conducted under Complete Randomized Design with four replications for each treatment. The inoculated plates were incubated at $25\pm 1^{\circ}\text{C}$.

The radial growth of colony was recorded and per cent inhibition of each treatment was calculated by using formula given by Vincent (1927).

$$\text{Growth inhibition(I)} = \frac{\text{Radial growth in control (C)} - \text{radial growth in treatment (T)}}{\text{Radial growth in control (C)}} \times 100$$

Where,

I = Per cent growth inhibition

C = Growth of pathogen (mm) in control

T = Growth of pathogen (mm) in treatment

All the six fungicides significantly inhibited the mycelial growth of *B. sorokiniana* at all doses (25, 50, 100 and 200 ppm). There was a significant decrease in the respective mycelial growth and accordingly more inhibition was observed at higher concentration (200 ppm) than lower concentrations. A significant interaction between pathogen and concentration of fungicides was observed (Table-1). Among the fungicides viz. Propiconazole,

Azoxystrobin, Azoxystrobin + Difencnazole and Tebuconazole were most effective. Propiconazole showed 91.51, 97.67, 100.00 and 100.00 per cent inhibition, while Tebuconazole exhibited 87.20, 95.11, 100.00 and 100.00 per cent mycelial inhibition at 25, 50, 100 and 200 ppm concentration respectively and followed by Azoxystrobin exhibiting 87.20, 94.18, 100 and 100 per cent mycelial inhibition at 25, 50, 100 and 200 ppm, respectively. Next to these fungicidal treatment against the *B. sorokiniana* was Azoxystrobin + Difencnazole which showed inhibition of 87.20, 94.18, 95.34 and 100 per cent followed by Difencnazole recording mycelial growth inhibition of 85.34, 87.20, 90.69 and 96.27 per cent. Mancozeb was least effective fungicide exhibiting 27.90, 31.39, 48.83 and 89.18 per cent inhibition respectively. Fungicides Propiconazole, Tebuconazole, Azoxystrobin and Azoxystrobin + Difencnazole were found most effective exhibiting 100 per cent inhibition at 200ppm followed by Difencnazole (96.27) and Mancozeb (89.18) per cent. The similar findings were reported by Mahapatra and Das, 2013. Padha (2008) reported that Propiconazole and Tebuconazole completely inhibited mycelial growth of *B. sorokiniana* at 25 ppm and higher concentration. No growth of *Drechslera sorokiniana* had been reported when fungicide Mancozeb was used (Chattannavar *et al.* 1985). Hasan *et al.* (2012) reported that systemic fungicides completely inhibited the growth of pathogen at lower concentration under laboratory condition. Bio-agents viz; *T. viridi-1*, *T. viridi-2*, *T. harzianum-2*, *T. harzianum-1* and *Pseudomonas fluorescens* were evaluated against *B. sorokiniana* and showed highly significant inhibiting effect on mycelial growth. Data presented in Table-2 showed that *T. harzianum-1* was most effective exhibiting 77.90 per cent mycelial inhibition of the pathogen followed by *T. harzianum-2* (74.80 per cent) and *T. viride-1* (74.41 per cent). These three were at par with each other. Bacterial bio-agent *P. fluorescens* was least effective reducing 47.22 per cent mycelia growth of pathogen. Hasan *et al.* (2008) found that species of *Trichoderma* inhibited the mycelia growth of *F. moniliformae* in the range of 32.50 to 45.00 per cent. Hasan (2013) reported that *T.harzianum* isolates RVT-103 effectively reduced radial growth of *B. sorokiniana* (45.45 %). According to Harman (2006), *Trichoderma spp.* sensed the presence of target fungi and appeared to grow towards them.



Table 1: *In vitro* evaluation of different fungicides against *B. sorokiniana*.

Treatment	Mean radial growth (mm) at different concentration (ppm)							
	25		50		100		200	
	Growth (mm)	Inhibition (%)	Growth (mm)	Inhibition (%)	Growth (mm)	Inhibition (%)	Growth (mm)	Inhibition (%)
Propiconazole	7.30**	91.51	2.00**	97.67	0.00**	100.00	0.00**	100.00
Tebuconazole	11.00**	87.20	4.20**	95.11	0.00**	100.00	0.00**	100.00
Azoxystrobin	51.60**	40.00	12.00**	86.04	4.80**	94.41	0.00**	100.00
Difenconazole	12.60**	85.34	11.00**	87.20	8.00**	90.69	3.20**	96.27
Azoxystrobin + Difenconazole	11.00**	87.20	5.00**	94.18	4.00**	95.34	0.00**	100.00
Mancozeb	62.00**	27.90	59.00**	31.39	44.00**	48.83	9.30**	89.18
Control	86.00	-	86.00	-	86.00	-	86.00	-
SE (d)	1.32	-	1.31	-	0.70	-	0.57	-
CV (%)	4.68	-	6.30	-	4.33	-	4.96	-
S.E.m±	0.93	-	0.93	-	0.50	-	0.40	-
CD (1%)	2.83	-	2.82	-	1.51	-	1.22	-

** Significant at 1 % level

Table 2: Effect of antagonists on the growth of *B. sorokiniana* by dual culture method:

Antagonist	Mycelial growth (mm)	Growth inhibition (%)
Trichoderma viride-1	22.00**	74.41
T. viride-2	26.33**	69.37
T. harzianum-1	19.00**	77.90
T. harzianum-2	21.66**	74.80
Pseudomonas fluorescens	45.33**	47.22
Control	86.00	-
SE (d)	1.53	-
CV (%)	5.13	-
S.E.m±	1.08	-
CD (1%)	3.33	-

** Significant at 1 % level

Conclusion

Among the fungicides Propiconazole, Tebuconazole, Azoxystrobin and Azoxystrobin + Difenconazole completely inhibited the mycelia growth of pathogen at 200 ppm concentration under *in-vitro* condition. Among bio control agents, *T. harzianum-1* (77.90 per cent) was found most effective antagonist against pathogen followed by *T. harzianum-2* (74.80 per cent) and *T. viride-1* (74.41 per cent).

Compliance with ethical standards

NA

Conflict of Interest

Authors declare that they have no conflict of interest

Authors' contribution

The compliance of referee comments has been made. The manuscript Comparative Evaluation of Different Fungicides and Bio-agents for Management of Spot Blotch of Barley Caused by *Bipolaris sorokiniana* (Sacc. Ex Sorok) is a part of M. Sc. Ag. Thesis of Mr. Sugam Katiyar submitted in C S A Univ. of Agri. and Tech., Kanpur.



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