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Integrated Management of Wheat Spot Blotch caused by *Bipolaris sorokiniana* (Sacc.) Shoem.

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ABSTRACT: Wheat the versatile cereal crop has attained a premier position in the world for its unique consumable protein *i.e.,* gluten, which is vital for bread making properties of wheat flour, along with the straw which is a major source of nutritious feed for cattles. Wheat spot blotch caused by *Bipolaris sorokiniana* is an important disease. In recent days, triazole group of fungicides are used for managing the spot blotch disease of wheat but continuous use of triazole compounds may lead to development of resistance by the pathogen. Hence an integrated approaches using effective fungicide, commercially available botanical, bioagent and ITK will reduce risk of resistance development. Results of field experiment revealed that among the nine treatments imposed, treatment involving hexaconazole @ 0.1% –*hexaconazole@0.1% has recorded lowest percent disease* index (13.40%) and highest grain yield (13.33 q ha^{-1}), 1000 grain weight (40.65 g), biomass (8.33 t ha^{-1}) and highest benefit: cost ratio(1:1.94). The next best treatment was hexaconazole 5 % EC at 0.1 % - multineemore at 0.5 % (T_5) with per cent disease index of 28.93 per cent, grain yield (12.50 q ha^{-1}) and benefit: cost ratio (1:1.70) while the control treatment (T_9) recorded significantly highest per cent disease index of 46.41 and it was followed by the spray schedule *T. harzianum* + *B. subtilis*+ *P. fluorescens* at 3.3 g each/l - *T. harzianum* + *B. subtilis*+ *P. fluorescens* at 3.3 g each/l (T_3) which recorded highest disease severity of 45.34 per cent.

Keywords: Wheat, spot blotch, *Bipolaris sorokiniana*, fungicides, bioagents, botanicals, ITKs, spray schedules.

INTRODUCTION

Wheat (*Triticum* spp.) the versatile cereal crop is also described as "the shuffle of life" or "king of cereals**.** In India, wheat is the second most important food crop, it contributes to around 25 percent to the total food grain production. The total estimated area under wheat cultivation in India during 2017 was 30.59 m ha, with a production of 93.80 mt and average productivity of 3261 kg/ha (Anon., 2017). In Karnataka, the area under wheat is about 1.74 lakh ha with an annual production of 1.56 mt having productivity of 897 kg/ha (www.indiastat.com, 2017). During the wheat growing season due to rise in temperature and humidity coupled with winter rains, *Bipolaris sorokiniana* is getting favourable conditions to develop aggressively and caused amage to wheat cropat larger scale by causing significant yield loss up to 18-50 per cent under favourable conditions (Duvellier *et al.,* 2005). In recent days, triazole group of fungicides are used for managing the spot blotch disease of wheat but continuous use of triazole compounds may lead to development of resistance by the pathogen (Yadav *et al*., 2015). So integrated approaches using effective fungicide, commercially available botanical, bioagent and ITK will reduce risk of resistance development. Further, little information is available with regard to the evaluation of fungicides, commercially available botanicals, bioagents, ITKs against *Bipolaris sorokiniana* and integrated management of wheat spot blotch, so an effort was made to evaluate fungicides, commercially available botanicals, bio agents, ITK sand to develop cost effective integrated spray schedule involving fungicide, commercially available botanical, bioagents andITK.

MATERIALS AND METHOD

Development of integrated spray schedule for the management spot blotch of wheat

For this initially *in vitro* study was conducted at Department of Plant Pathology, College of Agriculture, Dharwad during 2017–18. Effectiveness of several fungicides, bioagents, botanicals and ITKs were tested under *in vitro* condition against *B. sorokiniana. The fungicides* bio agents, botanicals and ITKs which were found effective under in vitro conditions were further tested for their efficacy under field conditions. A field experiment was laid out in a randomized complete block design with three replication sand nine treatments at Main Agricultural Research Station, UAS, Dharwad during *rabi* 2017-18 with the following details

Design : Randomized Block Design (RBD)
Replications : 3
Treatments : 9
Plot size: Gross plot : 2.4 × 3.0 m
Net plot : 2.0 × 3.0 m
Variety : Bijaga yellow
Date of sowing : 09-12-2017
Spacing : 20 cm
Soil type: Medium black

Treatments	Spraying schedule	
	1st Spray	2nd Spray
T_1	Hexaconazole 5 % EC @ 0.1 %	Hexaconazole 5 % EC @ 0.1 %
T_2	Multineemore @ 0.5 %	Multineemore @ 0.5 %
T_3	*T. harzianum* + *P. fluorescens* + *B. subtilis* @ 3.3g each/l	*T. harzianum* + *P. fluorescens* + *B. subtilis* @ 3.3g each/l
T_4	Panchagavya @ 10 %	Panchagavya @ 10 %
T_5	Hexaconazole 5 % EC @ 0.1 %	Multineemore @ 0.5 %
T_6	Hexaconazole 5 % EC @ 0.1 %	*T. harzianum* + *P. fluorescens* + *B. subtilis* @ 3.3g each/l
T_7	Hexaconazole 5 % EC @ 0.1 %	Panchagavya @ 10 %
T_8	Hexaconazole 5 % EC @ 0.1 %	Water spray
T_9	Control (unsprayed)	

Number of sprays: Two sprays at 15 days interval starting from the onset of disease was given.

Treatment details: Following nine spray schedule treatments developed based on the effectiveness under *in vitro* condition and considering the cost of different fungicide, bioagents, commercially available botanical and ITK are given here under.

Recommended package of practices was followed to raise the crop. The inoculum of *B. sorokiniana* was sprayed uniformly in the evening hours on all the treatments at 30 days after sowing to create high disease pressure and frequent irrigations were given for facilitating disease establishment and development. Two sprays were given in each treatment at 15 days interval starting from the onset of disease. Ten plants in each plot were selected randomly to record disease rating and disease rating was done using the double-digit scale (00-99) developed as a modification of Saari and Prescott`s severity scale.

Descriptions of severity levels (0-9) to assess spot blotch of wheat (Saari and Prescott 1975; Eyal *et al.*, 1987).

Scale	Descriptions of severity levels
0	Free from infection.
1	A few isolated lesions on only the lowest leaves.
2	Scattered lesions on the second set of leaves with first leaves lightly infected.
3	Light infection of lower third of plant; lowermost leaves infected at moderate to severe levels.
4	Moderate infection of lower leaves with scattered to light infection extending immediately below the middle of the plant.
5	Severe infection of lower leaves; moderate to light infection extending only to the middle of the plant.
6	Severe infection on lower third of plant moderate on middle leaves and scattered lesions beyond the middle of the plant.
7	Lesions severe on lower and middle leaves with infection extending to the leaf below the flag leaf, or with trace infection on the flag leaf.
8	Lesions severe on lower and middle leaves; moderate to severe infection of upper third of plant; flag leaf infected in amounts more than a trace.
9	Severe infection on all leaves; spike also infected to some degree.

For each score, disease severity percentage was calculated based on the following formula (Sharma and Duveiller, 2007).

Disease severity (%) = $(D_1/9) \times (D_2/9) \times 100$

The first digit (D1) indicated vertical disease progress (relative height of the disease) on the plant using the original 0-9 Saari-Prescott scale as a measure and the second digit (D_2) refers to severity measured as diseased leaf area but in terms of 0-9. Disease severity of all the ten plants per plot was calculated and mean disease severity of ten plants was considered.

Following observations were recorded in each plot as given below

1. Disease severity: Disease severity was recorded one day before both the sprays and 15 days after the second spray (total three observations) using double digit scale (00-99) developed as a modification of Sarri and Prescott's (1975) severity scale.

2. Grain yield per hectare: The individual plots were harvested separately and grain yield was recorded and it was further converted into quintals per hectare (q/ha).

3. 1,000 grain weight: A total of 1,000 grains were counted randomly from each plot and weighed in grams (g).

4. Biomass: The straw weight from each plot weighed in kilo grams and then converted into tons per hectare (t/ha).

Statistical analysis

Statistical analysis was carried out as per the procedures given by Panse and Sukhatme (1978). Actual data in percentage were converted to angular transformed values, before analysis according to the table given by Walter, (1967). Fischer's method of analysis of variance was used for analysis and interpretation of the data as outlined by Gomez and Gomez (1984). The level of significance used in 'F' and 'T' tests was p = 0.05. Critical differences were calculated wherever 'F' test was significant.

RESULTS AND DISCUSSION

An integrated spray schedule was developed using *in vitro* effective fungicide (hexaconazole 5% EC), commercially available botanical (multineemore), bio agents (*T. harzianum* + *B. subtilis* + *P. fluroscence*) and ITK (panchagavya) and evaluated under field condition during *rabi* 2017-18 at Main Agricultural Research Station, Dharwad and the data is presented in Table 1 and Plate 1.

Table 1: Integrated spray schedule for the management of wheat spot blotch.

Treatments	Per cent disease index	Grain yield (q/ha)	1000 grain weight (g)	Biomass (t/ha)	B:C ratio
T1: Hexaconazole 5 % EC @ 0.1 % - Hexaconazole 5 % EC @ 0.1 %	13.40 (21.47) *	13.33	40.65	8.33	1: 1.94
T2: Multineemore @ 0.5 %- Multineemore @ 0.5 %	31.36 (34.06)	11.55	36.26	7.77	1: 1.56
T3: *T. harzianum*+ *B. subtilis* + *P. fluorescens*@ 3.3 g each/l - *T. harzianum*+ *B. subtilis* + *P. fluorescens*@ 3.3 g each/l	45.34 (42.33)	9.83	36.15	6.94	1: 1.42
T4: Panchagavya @ 10 %- Panchagavya @ 10 %	35.03 (36.29)	9.55	34.75	6.66	1: 1.39
T5: Hexaconazole 5 % EC @ 0.1 %- Multineemore @ 0.5 %	28.93 (32.54)	12.50	38.50	8.05	1: 1.70
T6: Hexaconazole 5 % EC @ 0.1 % - *T. harzianum*+ *B. subtilis* + *P. fluorescens*@ 3.3 g each/l	31.64 (34.23	10.00	37.31	7.50	1: 1.50
T7: Hexaconazole 5 % EC @ 0.1 %- Panchagavya @ 10 %	32.67 (34.86)	10.27	36.30	7.22	1: 1.51
T8: Hexaconazole 5 % EC @ 0.1 %- Water spray	35.39 (36.51)	11.22	37.11	7.95	1: 1.66
T9: Unsprayed control	46.41 (42.94)	8.38	34.00	6.12	1:1.35
S.Em. ±	0.37	0.38	0.61	0.56	
C.D. at 5 %	1.11	1.15	1.82	1.68	

* Angular transformed values

Cost of grain @ Rs. 2500 /q, Biomass cost: Rs. 1000/t, Cost of fungicides/botanicals/bioagents/ITK's in Rs. /kg or l: hexaconazole 5EC (528), multineemore (500),

Trichoderma harzianum(130), *Bacillus subtilis* (220), *Pseudomonas fluorescens* (150) and panchgavya (10), Labour charges for two sprays per hectare: Rs.1000.

Effect of spray schedule on spot blotch severity among the eight different spray schedules involving fungicide, botanical, bioagent and ITK, the spray schedule hexaconazole 5 % EC at 0.1 % - hexaconazole5 % EC at 0.1 % (T_1) recorded the least per cent disease index of 13.40 and was significantly superior to other spray schedule combinations. The next best treatment was hexaconazole 5 % EC at 0.1 % - multineemore at 0.5 % (T_5) with per cent disease index of 28.93 and multineemore at 0.5 % - multineemore at 0.5 % (T_2) with 31.36 per cent disease index.

The spray schedule combinations hexaconazole 5 % EC at 0.1 % - *T. harzianum* + *B. subtilis*+ *P. fluorescens* at 3.3 g each/l (T_6), hexaconazole 5 % EC at 0.1 % - panchagavya at 10 % (T_7), panchagavya at 10 % - panchagavya at 10 % (T_4), hexaconazole 5 % EC at 0.1 % - water spray (T_8) were recorded 31.64, 32.67, 35.03 and 35.39 per cent disease index, respectively. The control treatment (T_9) recorded significantly highest per cent disease index of 46.41 and it was followed by the spray schedule *T. harzianum* + *B. subtilis*+ *P. fluorescens* at 3.3 g each/l - *T. harzianum* + *B. subtilis*+ *P. fluorescens* at 3.3 g each/l (T_3) with 45.34 per cent disease index (Fig. 1).

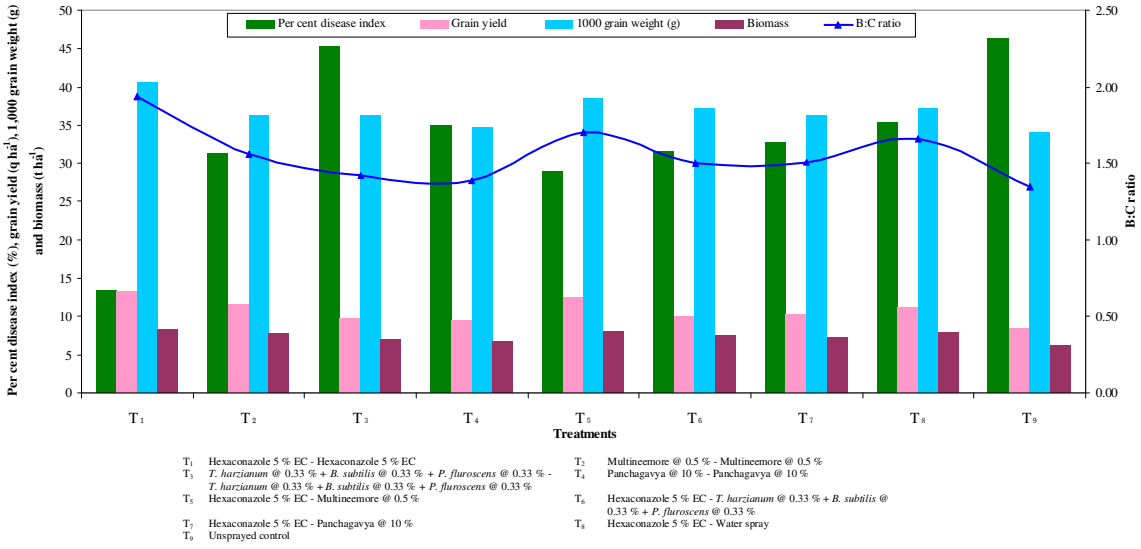

Fig. 1. Evaluation of integrated spray schedule for the management of spot blotch of wheat.

Effect of spray schedule on grain yield, 1,000 grain weight and biomass: The grain yield, 1,000 grain weight and biomass were recorded after harvest of the crop (Table 1). The spray schedule hexaconazole 5 % EC at 0.1 % - hexaconazole 5 % EC at 0.1 % (T_1) recorded highest grain yield of 13.33 q/ha and it was statistically on par with T_5 (12.50 q/ha). Next best spray schedule was hexaconazole 5 % EC at 0.1 % - water spray (T_8) and multineemore at 0.5 % - multineemore at 0.5 % (T_2) which have recorded the grain yield of 11.22 q/ha and 11.55 q/ha, respectively. Grain yield performance of hexaconazole 5 % EC at 0.1 % - panchagavya at 10 % (T_7) (10.27 q/ha), hexaconazole 5 % EC at 0.1 % - *T. harzianum* + *B. subtilis*+ *P. fluorescens* at 3.3 g each/l (T_6) (10.00 q/ha), *T. harzianum* + *B. subtilis*+ *P. fluorescens* at 3.3 g each/l -

T. harzianum + *B. subtilis*+ *P. fluorescens* at 3.3 g each/l (T_3) (9.83 q/ha) and panchagavya at 10 % - panchagavya at 10 % (T_4) (9.55 q/ha) were found superior over unsprayed control which recorded grain yield of 8.38 q/ha.

In case of 1,000 grain weight, the spray schedule hexaconazole 5 % EC at 0.1 % - hexaconazole 5 % EC at 0.1 % (T_1) recorded highest grain weight of 40.65 g followed by the treatment T_5 (38.50 g). Treatments hexaconazole 5 % EC at 0.1 % - *T. harzianum* + *B. subtilis*+ *P. fluorescens* at 3.3 g each/l (T_6) (37.31 g), hexaconazole 5 % EC at 0.1 % - water spray (T_8) (37.11 g), *T. harzianum* + *B. subtilis*+ *P. fluorescens* at 3.3 g each/l - *T. harzianum* + *B. subtilis*+ *P. fluorescens* at 3.3 g each/l (T_3) (36.15 g), multineemore at 0.5 % - multineemore at 0.5 % (T_2) (36.26 g), hexaconazole 5 % EC at 0.1 % - panchagavya at 10 % (T_7) (36.30 g) were on par with each other. Lowest grain yield was recorded in unsprayed control (T_9) (34.00 g) followed by treatment T_4 *i.e.,* panchagavya at 10 % - panchagavya at 10 % (34.75 g).

The spray schedule hexaconazole 5 % EC at 0.1 % - hexaconazole5 % EC at 0.1 % (T_1) recorded highest biomass of 8.33 t/ha and it was statistically on par with treatments T_5 hexaconazole 5 % EC at 0.1 % - multineemore at 0.5 % (8.05t/ha), hexaconazole 5 % EC at 0.1 % - water spray (T_8) (7.95t/ha), multineemore at 0.5 % - multineemore at 0.5 % (T_2) (7.77t/ha), hexaconazole 5 % EC at 0.1 % - *T. harzianum* + *B. subtilis*+ *P. fluorescens* at 3.3 g each/l (T_6) (7.50t/ha) and *T. harzianum* + *B. subtilis*+ *P. fluorescens* at 3.3 g each/l - *T. harzianum* + *B. subtilis*+ *P. fluorescens* at 3.3 g each/l (T_3) (6.94t/ha). Lowest biomass was recorded in unsprayed control (T_9) (6.12t/ha) followed by treatment T_4 *i.e.*, panchagavya at 10 % - panchagavya at 10 % (6.66t/ha).

(a) Field view of the experiment.

(b) T_1:Hexaconazole 5% EC @0.1% - Hexaconazole 5 % EC @ 0.1%

(c) T_5: Hexaconazole 5% EC @0.1% - Multineemore @ 0.5 %.

(d) Unsprayed control

PLATE-1. Evaluation of integrated spray schedule for the management of spot blotch of wheat.

Benefit Cost ratio. The estimation of benefit cost ratio is an important aspect in the economic management of plant disease. The benefit cost ratio has been worked out for different spray schedule and presented in Table 11. The highest BC ratio was obtained with spray schedule hexaconazole 5 % EC at 0.1 % - hexaconazole5 % EC at 0.1 % (T_1) (1:1.94) followed by treatment T_5 *i.e.,* hexaconazole 5 % EC at 0.1 % - multineemore at 0.5 % (1:1.70) and treatment T_8 hexaconazole 5 % EC at 0.1 % - water spray (1:1.66). The lowest BC ratio was observed in unsprayed control (T_9) (1:1.35) and it was followed by treatment T_4 *i.e.*, panchagavya at 10 % - panchagavya at 10 % (1:1.39) and treatment T_3 *i.e., T. harzianum* + *B. subtilis*+ *P. fluorescens* at 3.3 g each/l -*T. harzianum* + *B. subtilis*+ *P. fluorescens* at 3.3 g each/l (1:1.42), respectively (Fig. 1).

These results were in agreement with most of the earlier workers, where they highlighted the efficacy of triazole fungicides in spot blotch management. Singh *et al.* (2008) proposed that three foliar applications of propiconazole 25 % EC @ 0.1 % after appearance of the disease significantly reduced the spot blotch severity and increased grain yield tested over several locations of India. Similarily, Ramchandra and Kalappanavar (2006) reported that hexaconazole 5 %

EC @ 0.10 per cent or mancozeb 75 % WP @ 0.25 per cent were effective in reducing wheat spot blotch severity and the B:C ratio of hexaconazole 5 % EC was maximum compared to all other treatments. Similarly, Yadav *et al.,* (2015) reported the effectiveness of systemic fungicides (propiconazole, carbendazim and hexaconazole), bioagents and botanicals in reducing the severity of spot blotch and increasing grain yield of wheat. They reported that two sprays of carbendazim at 0.10 per cent concentration followed by two applications of propiconazole 25 % EC at tillering and boot leaf stage resulted in the maximum reduction in spot blotch incidence and severity. Foliar spray of *P. fluorescens* followed by *T. harzianum* resulted in the highest reduction in disease severity and two applications of aqueous eucalyptus leaf extract at tillering and boot leaf stage resulted in the highest wheat yield as compared to other botanical extracts.

Conflicts of Interest. Nil.

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