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Efficacy of fungicides against spot blotch of wheat caused by *Bipolaris sorokiniana* Sacc. (Shoem.)

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Abstract: Spot blotch of wheat caused by *Bipolaris sorokiniana* has emerged an important disease of wheat in India and causing considerable yield losses. Experiments were conducted at Dharwad and Arabhavi with ten treatments including single and combi-products of different fungicides during 2013-14 and 2014-15 respectively. It was revealed that three sprays of Pyraclostrobin 13.3% + Epoxiconazole 5 % @ 0.1 per cent at an interval of 15 days from the date of appearance of typical symptoms was an effective fungicide with maximum reduction of disease severity (88.27 %) and black pointed grain. It exhibited considerable increase in yield attributing traits and higher net returns (Rs. 20608/ha.) with Incremental Benefit Cost ratio (IBCR) of 4.91. Next best fungicide was Propiconazole@ 0.1 per cent. The above combi-product can be used as an alternate fungicide to triazoles especially Propiconazole and can be an alternative to for management of this disease.

Key words: Spot blotch, Wheat, *Bipolaris sorokiniana*

Introduction

Wheat, the second most important food crop of the India and contributes one-third of the total food grain production. In India, it is grown an about 29.30 million hectare, with production of 95.91 million tones with an average productivity of 3140 kg per hectare (Anon., 2005). It is one of the important *rabi* cereals in Karnataka wherein all three cultivated species *viz., Triticum aestivum* (L), *Triticum durum* (Derf) and *Triticum dicoccum* (Schrank) Schubler are grown on an area of 1.70 lakh ha with a production of 1.73 lakh tones but the productivity is low (1010 kg/ha) as compared to the national average (3140 kg/ha) (Anon., 2015). Among all the diseases of wheat, spot blotch caused by *Bipolaris sorokiniana* Sacc.(Shoem.) is considered as one of the most important diseases in environments which are characterized by high temperature and high humidity. In the field, only the anamorph stage *B. sorokiniana* is found. Although different lesion types have been reported in relation to host resistance, lesions in the field progress and coalesce in much the same way irrespective of genotype. The disease symptoms associated with lesions on the leaves start as a few millimeter that extend as elongated dark brown spots greater than 1-2 cm (Chand *et al.,* 2002). Yellowing due to toxin production is sometimes observed extending from the lesion. Later such spots coalesce each other thus result blight on large leaf portion. As the disease progresses the spots join together forming large blotches that cover the leaves and eventually killing it (Bockus *et al*., 2010). Disease severity increases with crop growth stage and is generally devastating after flowering. There is a sharp increase in disease at the reproductive growth stage. In severe condition it affect ear head resulting in shriveling of kernels with black point appears as distinct dark brown or black discoloration of the whole germ and surrounding area. Black point has an adverse effect on seed weight, germination, and seedling emergence (Rahman and Islam, 1998).

Grain yield reductions due to spot blotch are variable but are of great significance in warmer areas of South Asia (Saari, 1998; Sharma and Duveiller, 2004). On an average, South Asian country looses 20 per cent of crop yield through leaf blight disease (Saari, 1998). In Karnataka, about 60 per cent of area is under tetraploid wheat which comprises *T. durum* and *T. dicoccum*. The later one is very susceptible to spot blotch disease. Natural resistance of wheat towards this pathogen is found to be low (Agarwal *et al.,* 2004). Use of fungicides has proven useful and economical in the control of spot blotch. Foliar spray with fungicide can control *B. sorokiniana* infection on foliage and reduce leaf blight severity of wheat (Rashid *et al.,* 2001). The use of fungicides under environmental conditions with high disease pressure is not economical. The likelihood of receiving a yield benefit from applying fungicide or risk of yield loss by not applying fungicides needs to be considered with the associated costs in mind. Hence, the present study was undertaken to find out best performing fungicides against spot blotch under two different environmental conditions.

Materials and Methods

Experimental design and treatments: Field experiments were conducted at two different location *viz.* AICRP on Wheat and Barley, University of Agricultural Sciences, Dharwad and Agricultural Research Station, Arabhavi, UAS, Dharwad during *rabi* 2013-14 and 2014-15 respectively. The highly susceptible tetraploid wheat variety, Bijaga Yellow was used in a randomized block design of three replications planted 20 cm apart in a plot size of 5m X 1.20 m (6.0 m^2). The crop was raised as per recommended agronomic practices. The spore suspension was prepared from 15 days old culture of *B. sorokiniana* multiplied on sorghum seeds (Joshi *et al.,* 1969). Fifteen-day-old cultures were used to prepare aqueous suspension containing 8-10 spores per microscopic field under 10x (Prasad *et al.,* 2003).

Spore suspension was sprayed on the experimental plots by using high volume knapsack sprayer at an age of one month to create disease pressure. The experiment comprised of ten treatments *viz.* T1= Chlorothanil 75 WP @ 0.2 per cent; T2= Triademefon 25 WP @ 0.1 per cent; T3= Propiconazole 25 EC @ 0.1 per cent; T4= Tebuconazole 250 EC@ 0.1 per cent; T5= Hexaconazole 5 EC@ 0.1 per cent; T6= Captan 70%+ Hexaconazole 5% (75WP) @ 0.2 per cent; T7= Pyraclostrobin 13.3% + Epoxiconazole 5% (18.3 SE) @ 0.1 per cent; T8= Tebuconazole 50% + Trifloxystrobin 25% (75 WG) @ 0.1 per cent; T9= Mancozeb 80 WP@ 0.2 per cent; T10= untreated control (Water spray). The spray concentration was taken according to recommended dosage. Water sprayed plots served as control. Chemical spray was imposed immediately after first appearance of typical symptoms and subsequent two sprays at an interval of 15 days.

Disease assessment and economic analysis: Efficacy of the treatments in managing the disease was assessed by recording spot botch rating and there after calculating percent disease severity. Observations on disease rating was recorded a week after each spray by using the double digit scale (00-99) developed as modifications of Saari and Prescott's (1975) severity scale. Five plants in each plot were selected randomly to record disease rating and the mean of them was considered. For each score, disease severity percentage was calculated based on the following formula (Sharma and Duveiller, 2007).

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

The first digit (D_1) gives the relative height of the disease using the original 0-9 Saari-Prescott scale as a measure and the second digit (D_2) shows the disease severity as a percentage of diseased leaves but in terms of 0-9. The data were analyzed statistically using analysis of variance (ANOVA). Grain yield, fodder yield, thousand grain weight and Incremental Benefit Cost ratio (IBCR) was calculated. Overall, efficacy and economics of these treatments, in managing spot blotch disease was worked out by means of spot blotch disease severity, grain yield and fodder yield of two years. Average of two years (2013 & 2014) market price of wheat grain (Rs. 1450/q) and fodder (Rs. 1000/t) was considered for the purpose of working crop production economics. For spraying 2125 liters of water (for three sprays) in one hectare area, three man days were considered. Labour and spray charges were taken into account to compute IBCR. Cost of labour @ 200 per man day and average market price of Chlorothanil 75 WP @ Rs. 1040/kg; Triademefon 25 WP @ Rs. 3150/kg; Propiconazole 25 EC @ Rs. 1300/lt; Tebuconazole 250 EC @ Rs. 1710/lt; Hexaconazole 5 EC @ Rs. 550/lt; Captan 70%+ Hexaconazole 5% (75WP) @ Rs. 1264/kg; Pyraclostrobin 13.3% + Epoxiconazole 5% (18.3 SE) @ Rs. 2200/lt; Tebuconazole 50% + Trifloxystrobin 25% (75 WG) @ Rs. 5850/kg; Mancozeb 80 WP @ Rs. 350/kg were taken to assess the net returns and IBCR for different combination of treatments used in the investigation (Kumar, 2013).

Results and Discussion

A study was undertaken to know the effect of recommended dose of fungicides as foliar sprays against severity of spot blotch disease, yield attributing parameters and economic analysis on yield advantage. Fungicides used for field evaluation as described in materials and methods. Totally, 10 treatments including single and combi-products of different fungicides were composed to manage spot blotch. The considerable reduction in vertical spread of spot blotch and per cent leaf area blighted was observed in plots sprayed with fungicides as compared to unsprayed control. The results showed that all the treatments significantly reduced the disease severity as evident from the double digit score (Table 1 and Plate 1). The two years data over the location of all the parameters showed differential reaction significantly may be due to different environmental conditions. So, all the recorded parameters of two years data have been presented separately.

Effect on disease rating: The lowest spot blotch score (23) was in case of T7 and T8 (24) as compared to 85 score in case of untreated plots during 2013-14 at Dharwad. In case of Arabhavi (2014-15), these treatments along with T3 also reduced the disease score from 97-34 (Table 1). On an average of two location over the years maximum reduction in spot blotch rating was recorded in case of plots sprayed with Pyraclostrobin 13.3% + Epoxiconazole 5% (18.3 SE) (disease score 33), this was on par with Propiconazole 25 EC and Tebuconazole 50% + Trifloxystrobin 25% (75 WG) (disease score 34) followed by Tebuconazole 250 EC (disease score 44). The reduction in the rating of spot blotch was comparatively less in case of Chlorothanil 75 WP (disease score 67) followed by Mancozeb 80 WP (disease score 66) and Triademefon 25 WP (disease score 65) were on par with each other. The highest rating of spot blotch was noticed in unsprayed control (disease score 96) (Table 1).

Effect on disease severity: The disease severity data are given in Table 1 reveals, during first year, on an average, in different category of fungicide treatments, disease severity was least in the T7 (7.82 %) followed by T3 (10.29%). These were statistically on par with each other and followed by T8 (12.07%) and there after T4 (13.99 %) were on par with each other. T3 and T8 were statistically similar. The highest average disease severity was observed in T10 of 52.54 per cent followed by T1 (40.88 %). During second year, maximum mean disease severity was noticed in T10 (68.45 %) next to this was T1 (54.32 %). T7, T8 and T3 recorded minimum disease severity of 11.11, 11.93 and 12.89 per cent respectively and were statistically similar (Table 1). The two year pooled mean showed that the minimum disease severity of 9.47 percent was recorded in the crop which was sprayed with 0.1 percent Pyraclostobin 13.3%+ Epoxiconazole 5 % (9.47 %) followed by Propiconazole 25 EC (0.1%) of disease severity 11.59 per cent and 0.1 per cent Tebuconazole 50% + Trifloxystrobin 25% (75 WG) (12.00 %) (Table 1).

All treatments revealed to be better in reduction of spot blotch severity over control. The results of chemical management

Table-1: Effect of fungicides on disease severity of spot blotch

Treat-ment	Spot blotch rating (double digit 0-9) (Days After Sowing-DAS) Dharwad, 2013-14 47	62	77	Mean*	Arabhavi, 2014-15 47	62	77	Mean*	Grand mean*	Disease severity (%) (Days After Sowing-DAS) Dharwad, 2013-14 47	62	77	Mean	Arabhavi, 2014-15 47	62	77	Mean	Grand mean*	% reduction in disease severity over control Dha-rwad, 2013-14	Arab-havi 2014-15	Mean
T1	46**	56	68	57	48	85	97	77	67	32.10**	34.57	55.97	40.88	44.44	44.44	74.07	54.32	47.60	31.31	25.93	28.62
										(34.51)	(36.01)	(48.43)	(39.74)	(41.81)	(41.81)	(59.39)	(47.48)	(43.62)			
T2	44	54	56	55	46	73	74	64	65	18.11	26.75	36.63	27.16	25.51	23.05	34.57	27.71	27.43	55.05	65.43	60.24
										(25.18)	(31.14)	(37.24)	(31.41)	(30.34)	(28.69)	(36.01)	(31.76)	(31.59)			
T3	23	33	33	33	24	34	34	34	34	7.41	12.35	11.11	10.29	10.29	14.81	13.58	12.89	11.59	86.36	86.42	86.39
										(15.79)	(20.57)	(19.47)	(18.71)	(18.71)	(22.64)	(21.62)	(21.04)	(19.90)			
T4	24	34	35	34	34	44	45	44	44	11.52	13.17	17.28	13.99	14.81	21.40	26.34	20.85	17.42	78.79	73.66	76.23
										(19.84)	(21.28)	(24.57)	(21.97)	(22.64)	(27.55)	(30.88)	(27.17)	(24.67)			
T5	34	46	55	45	36	74	85	65	55	16.46	27.98	30.86	25.10	20.99	31.69	44.44	32.37	28.74	62.12	55.56	58.84
										(23.94)	(31.94)	(33.75)	(30.07)	(27.27)	(34.26)	(41.81)	(34.68)	(32.42)			
T6	34	46	56	45	37	73	74	65	55	16.46	25.93	34.98	25.79	24.69	28.81	30.04	27.85	26.82	57.07	69.96	63.51
										(23.94)	(30.61)	(36.26)	(30.52)	(29.80)	(32.46)	(33.24)	(31.85)	(31.19)			
T7	23	23	24	23	23	33	33	33	33	8.23	6.17	9.05	7.82	8.64	12.35	12.35	11.11	9.47	88.89	87.65	88.27
										(16.67)	(14.39)	(17.51)	(16.24)	(17.10)	(20.57)	(20.57)	(19.47)	(17.92)			
T8	24	24	34	24	24	33	34	34	34	11.52	11.52	13.17	12.07	11.11	9.88	14.81	11.93	12.00	83.84	85.19	84.51
										(19.84)	(19.84)	(21.28)	(20.33)	(19.47)	(18.32)	(22.64)	(20.21)	(20.27)			
T9	44	56	66	55	46	85	96	76	66	18.11	34.57	44.44	32.37	25.51	44.44	62.96	44.31	38.34	45.45	37.04	41.25
										(25.18)	(36.01)	(41.81)	(34.68)	(30.34)	(41.81)	(52.51)	(41.73)	(38.26)			
T10	74	85	97	85	85	96	99	97	96	31.69	44.44	81.48	52.54	44.44	60.91	100.00	68.45	60.49	-	-	-
										(34.26)	(41.81)	(64.51)	(46.45)	(41.81)	(51.30)	(90.00)	(55.83)	(51.06)			
SEm+										1.36	1.67	1.70	2.81	1.55	1.34	2.02	4.47	1.62			
CD@5%										4.03	4.95	5.05	8.35	4.61	3.99	6.00	13.29	5.19			

* Mean of each digit was calculated separately, **Mean of three replications, Figures given in parenthesis are arcsine transformed value

Table-2: Effect of fungicides on yield attributing parameters and black point incidence

Treat-ment	Grain yield (q/ha) 2013-14	2014-15	Pooled	Fodder yield (t/ha) 2013-14	2014-15	Pooled	1000-grain weight (g) 2013-14	2014-15	Pooled	Black pointed grain (%) 2013-14	2014-15	Pooled	Yield increase over control (%) 2013-14	2014-15	Pooled
T_1	11.30	7.27	9.28	7.42	11.67	9.54	38.57	34.65	36.61	53.33 (46.91)	60.67 (51.16)	57.00 (49.02)	106.58	3.56	55.07
T_2	14.15	12.09	13.12	11.08	13.33	12.21	40.46	39.35	39.90	21.00 (27.27)	20.17 (26.68)	20.58 (26.98)	158.68	72.33	115.51
T_3	18.58	16.38	17.48	11.83	15.83	13.83	41.70	41.20	41.45	12.83 (20.99)	14.17 (22.11)	13.50 (21.56)	239.73	133.37	186.55
T_4	16.85	15.48	16.17	11.42	14.58	13.00	41.60	37.37	39.49	17.83 (24.98)	22.50 (28.32)	20.17 (26.68)	208.04	120.67	164.35
T_5	15.80	16.53	16.16	11.25	13.33	12.29	41.15	36.38	38.77	20.50 (26.92)	25.17 (30.11)	22.83 (28.54)	188.85	135.51	162.18
T_6	11.43	11.95	11.69	10.33	12.50	11.42	38.90	39.85	39.38	18.33 (25.35)	23.33 (28.88)	20.83 (27.16)	109.02	70.31	89.66
T_7	19.88	20.78	20.33	13.67	15.83	14.75	42.49	40.85	41.67	12.33 (20.56)	13.00 (21.13)	12.67 (20.85)	263.50	196.08	229.79
T_8	18.70	19.09	18.90	13.67	15.83	14.75	40.01	38.93	39.47	18.00 (25.10)	18.17 (25.23)	18.08 (25.17)	241.86	172.09	206.98
T_9	11.30	11.78	11.54	9.33	11.67	10.50	39.59	32.60	36.10	31.33 (34.04)	46.67 (43.09)	39.00 (38.65)	106.58	67.93	87.26
T_{10}	5.47	7.02	6.24	7.33	11.25	9.29	36.81	28.93	32.87	57.83 (49.51)	64.83 (53.63)	61.33 (51.55)	-	-	-
SEm+	0.91	2.28	0.90	0.62	0.72	0.45	1.15	1.55	1.45	1.38 4.53	1.40				
CD @ 5%		2.70	6.77	2.87	1.84	2.14	1.42	3.41	4.59	4.65 4.09	13.46	4.47			

In Table 1 and 2: Figures given in parenthesis are arcsine transformed value. T1= Chlorothanil 75 WP @ 0.2%, T2= Triademefon 25 WP @ 0.1%, T3= Propiconazole 25 EC @ 0.1%, T4= Tebuconazole 250 EC@ 0.1%, T5= Hexaconazole 5 EC@ 0.1%, T6= Captan 70%+ Hexaconazole 5% (75WP) @ 0.2%, T7= Pyraclostrobin 13.3% + Epoxiconazole 5% (18.3 SE) @ 0.1%, T8= Tebuconazole 50% + Trifloxystrobin 25% (75 WG) @ 0.1%, T9= Mancozeb 80 WP@ 0.2%, T10= Control (Water spray)

Plate 1: Effect of fungicide sprays depicting reduction of disease severity over control

over two years showed that T7 (Pyraclostobin 13.3% + Epoxiconazole 5 % (Opera 18.3 SE)) with 88.27 per cent reduction of disease severity over control was the best treatment in suppressing spot blotch disease followed by T3 (Propiconazole 25 EC (Tilt)) and T8 (Tebuconazole 50% + Trifloxystrobin 25% (Nativo 75 WG)) with 86.39 and 84.51 per cent reduction of disease severity respectively. Least reduction of disease severity was shown by T1 (28.62%) proceeded by T9 (41.25%) (Table 1). The causal pathogen of spot blotch is a necrotroph and possibly the reduced severity that was observed can be attributed to the nutrients increasing plant cell resistance to infection (Yadav *et al.,* 2015). Chen *et al.,* (2012) reported single use of Pyraclostrobin or Epoxiconazole applied at 150 and 225 g a.i./ha provided over 70 and 80 per cent control efficacy while integrated use of Pyraclostrobin + Epoxiconazole applied at 150 + 150 g a.i./ha provided over 85 per cent control efficacy against *Fusarium* Head Blight of wheat where as widely used Carbendazim (a benzimadazole fungicide, MBC) applied at 562.5 g a.i./ha provided only less than 67 per cent control efficacy. Strobilurins are systemic fungicides and these exert their fungicidal action by blocking electron transport in the mitochondrial respiratory chain in fungi (Balba, 2007). With this unique mode of action the strobilurin is an important addition to the existing fungicides, in which recent broad-spectrum fungicide products have been largely based on sterol biosynthesis inhibitors (SBI) *viz.,* Triazoles.

Table-3: Efficacy of fungicides against spot blotch; its impact on yield and Incremental Benefit Cost ratio of different treatments (mean of 2 years)

Treat.	Disease severity (%)	Grain yield (q/ha)	Fodder yield (t/ha)	Gross Income (Rs./ha)	Additional grain yield (q/ha)	Additional fodder yield (t/ha)	Additional cost (Rs./ha)	Additional return (Rs./ha)	Net return (Rs./ha)	Incremental B:C ratio
T_1	47.60 (43.62)*	9.28	9.54	23003	3.04	0.25	5022	4658	-364	0.93
T_2	27.43 (31.59)	13.12	12.21	31234	6.88	2.92	7294	12889	5595	1.77
T_3	11.59 (19.90)	17.48	13.83	39178	11.24	4.54	3363	20834	17471	6.20
T_4	17.42 (24.67)	16.17	13.00	36442	9.93	3.71	4234	18097	13863	4.27
T_5	28.74 (32.42)	16.16	12.29	35727	9.92	3.00	1769	17383	15614	9.83
T_6	26.82 (31.19)	11.69	11.42	28370	5.45	2.13	5970	10025	4055	1.68
T_7	9.47 (17.92)	20.33	14.75	44227	14.09	5.46	5275	25883	20608	4.91
T_8	12.00 (20.27)	18.90	14.75	42149	12.66	5.46	13031	23804	10773	1.83
T_9	38.34 (38.26)	11.54	10.50	27235	5.30	1.21	2088	8891	6803	4.26
T_{10}	60.49 (51.06)	6.24	9.29	18345	-	-	-	-	-	-
SEm+	1.62	0.90	0.45							
CD@5%	5.19	2.87	1.42							

* Figures given in parenthesis are arcsine transformed value. T1= Chlorothanil 75 WP @ 0.2%, T2= Triademefon 25 WP @ 0.1%, T3= Propiconazole 25 EC @ 0.1%, T4= Tebuconazole 250 EC@ 0.1%, T5= Hexaconazole 5 EC@ 0.1%, T6= Captan 70%+ Hexaconazole 5% (75WP) @ 0.2%, T7= Pyraclostrobin 13.3% + Epoxiconazole 5% (18.3 SE) @ 0.1%, T8= Tebuconazole 50% + Trifloxystrobin 25% (75 WG) @ 0.1%, T9= Mancozeb 80 WP@ 0.2%, T10= Control (Water spray).

Effect on Yield attributing traits: The parameters like grain yield, fodder yield and 1000-grain weight were recorded to know the outcome of these fungicide treatments over untreated control. The data on effect of spot blotch and different treatments on grain yield, fodder yield and 1000-grain weight are presented in the Table 2. A significant increase in the yield attributing parameters was observed in fungicide treated plots as compared to water sprayed plots. During first year, highest yield (19.88 q/ha) with yield increase of 263.50 per cent over control was observed in T7 followed by other treatments. Lowest yield (11.30 q/ha) with yield increase of 106.58 was recorded in T1 and T9. In consequent year T7 recorded maximum yield (20.78 q/ha) with yield increase of 196.08 per cent over control. Least yield (7.27 q/ha) with yield increase of 3.56 per cent was recorded in T1 (Table 2).

The two year pooled mean over the location showed that highest fodder yield was recorded in T7 and T8 (14.75 t/ha) followed by T3 (13.83 t/ha). With respect to 1000-grain weight excluding T1 (36.61g) and T9 (36.10g) showed significantly higher 1000-grain weight over T10 (32.87g) *viz.* unsprayed control (Table 2).In both the years the maximum grain yield, fodder yield and 1000-grain weight were harvested in T7 followed by T8 and T3. Besides fungicidal activity of Opera 18.3 SE, its foliar application enhances physiological parameters like, biomass and yield in wheat plants compared to untreated control plants as evident in the results. In wheat plants strobilurins are reported to enhance the net rate of photosynthesis in the treated leaves (Kohle *et al.,* 1997). These observations on photosynthesis indicate a higher amount of fixation of carbon by the application of strobilurin. They have shown some effects in boosting yields in wheat and corn, (Nelson and Meinhardt, 2011), Wheat grain yields were higher in a study by Ruske *et al.,* (2003). These reports gives evidence for present findings as strobilurin is a one of the component in combi-products Opera18.3 SE and Nativo 75 WG. This result are in agreement with the work of Butkute *et al.,* (2008) reported highest winter wheat yield increase was obtained from the plots treated with the Pyraclostrobin+ Epoxiconazole, while the least increase was recorded for the plots applied with triazole Propiconazole. The plots sprayed with the other fungicides containing Strobilurines and Triazole Epoxiconazole gave a similar average grain yield increase. Singh *et al.,* (2008) proposed that three foliar application of Propiconazole @ 0.1% after appearance of the disease significantly reduce the spot blotch disease and increase yield tested over several locations of India. The results are in accordance with Kalappanavar *et al.,* (2008) reported fungicide Propiconazole performed best followed by Triadimefon and Hexaconazole against leaf rust disease in wheat with respect to reduction of disease and significant increase in grain yield and 1000-grain weight. Chandrashekara *et al.,* (2013) showed Hexaconazole found to be best followed by Propiconazole against spot blotch of barley. Earlier to this Ramchandra and Kalappanavar (2006) reported Hexaconazole @ 0.1 per cent or Mancozeb @ 0.25 per cent found to be better in managing leaf blight of wheat and The C: B ratio of Hexaconazole was high compared to all other treatments.

Black point incidence: There was considerable decrease in per cent black pointed grains in fungicide treated plots as compared with water sprayed plot are presented in Table 2. The two year pooled mean over the locations ranged between 12.67-61.33 per cent of black pointed grain. It revealed least occurrence of black pointed grain in T7 (12.67%), T3 (13.50%) and T8 (18.80%) were statistically similar (Table 2). Foliar fungicide applications to reduce spot blotch severity, and thus decrease the inoculum load of the pathogen, might have little impact on kernel infection. Durum wheat was reported to be more susceptible to black point than common wheat, especially under conditions favoring the development of kernel discolouration (Wang *et al.,* 2003). Shriveled durum wheat seed caused by heavy black point infections under field conditions resulted in a decrease in kernel weight (Fernandez *et al.,* 2000). Hudec and Muchova, (2008) reported *B. sorokiniana* causes seed black point, which inhibits seed germination and causes seedling root rots.

The result showed that spraying of fungicides at dough stage was found best for controlling black point during humid climatic conditions (Couture and Sutton, 1978). Maximum disease was recorded in control, suggested that using pathogen free seed is best option to control this disease (Panna *et al.,* 2009). Application of fungicides at or after head emergence could reduce the incidence of black point (Wang *et al.,* 2003). These results were also in accordance to researchers who suggested that use of late fungicide application targeted to control black point disease of wheat (Ellis *et al.,* 1996). However foliar application of fungicides effect on this disease (Paradeshi *et al.,* 2008). The results are in accordance with Malaker and Mian (2009) reported foliar sprays with Tilt 250EC spraying at 30, 40, 50, 60, 70, 80 and 90 DAS appeared to be most effective, which was similar to spraying at 30, 45, 60, 75 and 90 DAS in reducing black point incidence and increasing grain yield.

These results were contradictory to scientists reported early fungicide application, which could lead to increased kernel infection resulting from an increase in grain size (Wang *et al.,* 2002). Conner and Kuzyk (1988) showed that fungicides were not consistently effective in reducing black point incidence.

Economic analysis: The economic analysis on yield advantage obtained from foliar sprays of fungicides that in turn results in higher net returns in all treatments except T1 (Chlorothanil 75 WP) are presented in Table 3. The economic analysis was carried out by method as followed by Kumar, (2013). Fungicidal sprays were found economical with Incremental Benefit Cost ratio (IBCR) varied from 0.93 to 9.83. From the data analyzed, the highest variable cost (input and labor cost) was computed for Tebuconazole 50% + Trifloxystrobin 25% (Rs. 13031/ha). Highest net return of Rs. 20608/ha was calculated in the treatment Pyraclostobin 13.3% + Epoxiconazole 5 % (IBCR-4.91) followed by Propiconazole (IBCR-6.20) and Hexaconazole (IBCR-9.83). Spray of Hexaconazole which indicated its economic advantage, by indicating higher IBCR of 9.83 followed by propiconazole (IBCR-6.20). Results from assessment of economic returns in this study indicate that fungicide application for spot blotch disease control in wheat can be profitable. Fungicidal sprays results in higher yield that in turn adds economic advantage. T7 results in higher net returns followed by T3 but T5 revealed greater IBCR which indicated its economic advantage especially for the resource poor farmers.

The market price of wheat can markedly influence the profitability of applying fungicides to control foliar fungal diseases in wheat. Wegulo *et al.* (2011) reported the net returns ($"101 to $294 ha$^{"1}$) from fungicide application to winter wheat. Iqbal *et al.,* (2014) revealed maximum economic return was recorded in Metiram (Rs. 20425/ha) followed by Difenaconazol (Rs. 16520/ha), Propiconazole (Rs. 13200/ha) and Propineb (Rs. 9550/ha). At the end they concluded that all the fungicides were involved for controlling disease but Metiram gave maximum control against black point followed by difenaconazole and propiconazole.

Despite the harmful effect of fungicides to human and environment, it has proved useful and economical in the control of spot blotch. Non systemic and systemic foliar fungicides belonging to the dithiocarbamates (*viz*; Mancozeb) and Triazoles (*viz*. Propiconazole, Tebuconazole, Flutriazol, Procloraz, and Triadimenol) and dicarboxymides (*viz.* Iprodione) are known to be effective. Foliar applications especially with systemic fungicides such as Tebuconazole, Epoxiconazole, Flutriazol, Cyproconazole, Flusilazole, Epoxiconazole and Metaconazole applied between heading and grain filing stages, have been proved to be cost effective (Chowdhury *et al.,* 2013). The use of fungicide Opus (Epoxiconazole) reduced disease severity to below 10 per cent, which suggest its value in controlling spot blotch (Duveiller *et al.,* 2005; Sharma *et al.,* 2005). The fungicide combination Pyraclostrobin 13.3% + Epoxiconazole 5% (Opera 18.3% SE) @ 0.1 per cent three sprays at 40, 55 and 70 DAS is the best alternate fungicide to triazoles especially Propiconazole.

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