academicJournals

Vol. 10(25), pp. 2494-2500, 18 June, 2015
DOI: 10.5897/AJAR2013.8196
Article Number: 733EC0F53506
ISSN 1991-637X

http://www.academicjournals.org/AJAR

African Journal of Agricultural Research

Full Length Research Paper

Management of spot blotch of wheat using Fungicides, Bio-agents and Botanicals

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Received 4 November, 2013; Accepted 20 May, 2015

Experiments were conducted to know the effect of recommended dose of fungicides (Propiconazole, Carbendazim and Hexaconazole), bio-agents and botanicals on incidence and severity of spot blotch disease and seed yield of wheat. Two sprays of Carbendazim at 0.1% at tillering and boot leaf stage resulted in the maximum reduction in spot blotch incidence and severity followed by two applications of Propiconazole at tillering and boot leaf stage. Propiconazole was also found to be quite effective in reducing the level of disease and enhancing crop yield followed by Carbendazim and Hexaconazole. However, Carbendazim, Propiconazole and Hexaconazole were almost equally effective against spot blotch of wheat and may be used as an alternative to each other for management of disease. Two applications of Carbendazim at tillering and boot leaf stages resulted in highest grain yield. Out of the two bio-agents tested against spot blotch of wheat under field conditions, *Pseudomonas fluorescence* followed by *Trichoderma harzianum* resulted in the highest reduction in disease incidence. However, both of these bio-agents were comparatively less effective in minimizing the disease as compared to chemical fungicides. Out of four plant extracts 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.

Key words: Fungicides, bio-agents, *Pseudomonas fluorescence*, botanicals, *Bipolaris sorokiniana*, spot blotch, *Triticum aestivum*.

INTRODUCTION

The world's population is increasing by one billion in every 11 years and at the present rate, it is expected to be 8.5 billion by the year 2025. The demand for wheat will grow faster than any other major crop as it is estimated that around 1,050 mt. of wheat will be required globally for ever growing population by 2020 (Kronstad, 1998), while Indian demand will be between 105 to 109 million tonnes (Shoran et al., 2005). To fulfill the demand of wheat for rapidly increasing population, emphasis should be given to minimize the crop losses due to several diseases, insect pests and terminal heat at the time of anthesis. 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, a South Asian country looses 20% of crop yield through leaf blight disease (Saari, 1998).

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Among all the diseases, spot blotch of wheat is considered as one of the most important disease in environments which are characterized by high temperature (coolest month greater than 17°C) and high humidity (van Ginkel and Rajaram 1993). However, it is also gradually instigating serious concerns among places with irrigated, low rainfall and temperate growing conditions (van Ginkel and Rajaram, 1993; CIMMYT, 1995). Globally, an estimated 25 million hectares of wheat cultivated land is affected by spot blotch disease (van Ginkel and Rajaram, 1998). Indian subcontinent has 10 million ha of affected land, out of which India alone has 9 million ha, most of which is in the rice-wheat cropping system (Nagarajan and Kumar, 1998). The widely applied rice-wheat cropping system of South Asia provides favourable environment for the survival and multiplication of foliar blight pathogens because rice serves as a host for the spot blotch fungi and rice stubble plays its role as a substrate for the fungi after rice harvest (Saari, 1998). Nowaday, the peasants are moving towards organic farming to reduce the hazards due to chemical residues present in the end product due to massive use of chemical pesticides for controlling the spot blotch of wheat. Natural resistance of wheat towards this pathogen is found to be low (Agarwal et al., 2004). However, there is a possibility of biological control of this disease (Mandal et al., 1999). Use of fungicides has proven useful and economical in the control of spot blotch (Viedma and Kohli, 1998). The Triazole group Propinazole especially have proven to be very effective against spot blotch disease. Keeping in view these facts an experiment was conducted for two crop season i.e. in 2008-2009 and 2009-2010 to test the efficacy of certain potential fungicides, botanicals and bio-agents against spot blotch disease of wheat so that to come up with a suitable integrated management practice for this disease.

MATERIALS AND METHODS

Experimental design

The experiments were carried out on crop research centre (CRC) of Sardar Vallabhbhai Patel University of Agriculture and Technology, Modipuram, Meerut, during the crop season 2008–2009 and 2009–2010. Bread wheat (*Triticum aestivum* L.) was sown in November of 2008 and 2009 at a seed rate of 100 kg ha^{-1} with a commercial seeder. Ten treatments were used, which included untreated control as water spray (check), foliar application with fungicides viz. Propiconazole, Carbendazim, Hexaconazole at 0.1%, bio-agents *Trichoderma harzianum* and *Pseudomonas fluorescence* at 10 g/L water and botanicals *Eucalyptus* leaf extract, Garlic clove extract, Neem leaf extract and Neem cake extract at 0.5% of aqueous solution were used.

Preparation of aqueous solution

Preparation of aqueous Garlic extract (AGE)

Two hundred gram fresh raw garlic clove were chopped and ground to prepare fine paste. This paste was soaked overnight in 200 ml distilled water. This was filtered using fine muslin cloth. The filtrate obtained served as aqueous solution for further use at desired concentration.

Preparation of aqueous Neem cake extract (ANCE)

Freshly collected 200 gram neem cakes were crushed into fine powder with help of mortar and pestle. The fine cake was soaked overnight in 200 ml of water. This was filtered using fine muslin cloth. The filtrate obtained served as aqueous solution for further use at desired concentration.

Preparation of aqueous Eucalyptus leaf extract (AELE)

Two hundred gram freshly collected eucalyptus leaves were crushed with the help of mortar and pestel to prepare fine paste .The paste was soaked overnight in 200 ml distilled water. This was filtered using fine muslin cloth. The filtrate obtained surved as aqueous solution for further use at desired concentration.

Preparation of aqueous Neem leaf extract (ANLE)

Method of aqueous extract of Neem leaf was similar as in case of eucalyptus leaf extract. Experiments were conducted in randomized block design with 3 replications per treatment, with plots size 5 × 4 m^2. The foliar application was done with a knapsack sprayer, and spraying pressure was maintained at 300 kPa and the rate was 1000 l water ha^{-1}. The foliar applications were applied at tillering and boot leaf stages during evening time.

Disease assessments

Disease was allowed to develop from natural inoculums and epiphytotic. During the assessment of disease severity, 50 flag leaves per plot were randomly collected and were removed from the centre rows of each plot. During first and second disease rating was done by taking the per cent blighted area on flag leaf (F) and flag-1 (F-1) leaf using the rating scale as: 0 = No infection, 1 = up to 10%, 2 = 11-20%, 3 = 21-30%, 4 = 31-40%, 5 = 41-50%, 6 = 51-60%, 7 = 61-70%, 8 = 71-80%, and 9: > 80% leaf area blighted according to Singh et al. (2003) and Singh and Kumar (2005). Disease severity was assessed by determining the number of lesions per cm^2 (Table 1).

First and second value respectively represent percent blighted area on the top (flag) and second top leafs. Value 1, 2, 3, 4, 5, 6, 7, 8, and 9, respectively correspond to 10, 20, 30, 40, 50, 60, 70, 80, and 9: > 80% blighted area. The percent disease index (PDI) was calculated as per following formula:

$$PDI = \frac{\text{Sum of all disease ratings}}{\text{Total number of rating} \times \text{maximum grade}} \times 100$$

On the basis of above observation, the percent disease control (PDC) was calculated with the help of following formula:

$$PDC = \frac{\text{PDI in control -- PDI in treated}}{\text{PDI in control}} \times 100$$

Statistical analysis

Analysis of variance was performed for all the data using the

statistical procedure and calculations were made after applying the test of significance for the treatment means. The data taken into percentage were first transformed into angular value and then analyzed for test of significance (Chandel, 2002; Gomez, 1996).

RESULTS

Experiments were conducted for two consecutive crop season, that is, Rabi 2008-2009 and 2009-2010, using the susceptible cultivar, PBW-343 under field conditions, to know the effect of different doses and recommended doses of fungicides, bio-agents, and botanicals on incidence and severity of spot blotch disease and crop yield. In this experiment, efficacy was tested as two spraying at different crop growth stages viz. tillering and boot leaf stage. In control (Check) plot, there was no application of any fungicides, bio-agents, and botanicals. The data is presented in Tables 1, 2 and 3.

Effect on disease incidence

During first year, the results exhibited that in check plot, disease incidence was 31.11% which was significantly higher than incidence recorded in remaining other treatments. Two applications of Propiconazole at tillering and boot leaf stage resulted in least incidence 12.06% with 68.35% reduction in the incidence. The incidence recorded due to Propiconazole was at par with the incidence recorded due to Propiconazole and Carbendazim as well. Among the botanicals and bio-agents, Eucalyptus leaf extract (27.21% incidence with 28.61% reduction) was superior over the other botanicals and bio-agents applied, but significantly there effect were non significant to each other.

During second year, the results exhibited that in unprotected crop, there was 12.40% disease incidence which was significantly higher than incidence recorded in remaining other treatments. In case of twice application of Carbendazim, that is, at tillering and boot leaf stage it resulted in least incidence 4.82% with 61.12% reduction in incidence). The incidence recorded due to Carbendazim was at par with the incidence recorded due to Hexaconazole and Propiconazole as well. Among the botanicals and bio-agents Eucalyptus leaf extract resulted in 7.96% disease incidence with 16.38% reduction. Effect of Eucalyptus leaf extract on disease incidence of spot blotch was superior among the botanicals and bio-agents but significantly, it was at par with the effect exhibited by other botanicals and bio-agents used during the course of investigation.

As per average of two years data, first year 2008-2009 and second year 2009-2010; it was observed that minimum disease incidence was recorded in crop which was twice sprayed with Propiconazole followed by two applications of Carbendazim Hexaconazole at tillering and boot leaf stages of crop. Application of bio-agents and plant based extracts were found to be comparatively little less effective in minimizing the disease incidence (Table 1).

Effect on disease severity

During first year, the results exhibited that that in unprotected crop, that is, check there was 49.62% disease severity which was significantly higher than the severity recorded in remaining other treatments. Twice application of Propiconazole, that is, at tillering and boot leaf stage resulted in least severity, that is, 27.58% with 44.42% reduction which was significantly less than the severity (30.32% with 38.90% reduction) due to two application of Hexaconazole at tillering and boot leaf stages of wheat crop, which was at par with severity (32.07% with 33.37% reduction) recorded in the crop which was twice sprayed at tillering and boot leaf stages, with Carbendazim. Two application of 5.0% Garlic clove extract at tillering and boot leaf stages resulted in 35.30% disease severity with 28.66% reduction in severity and it was significantly different than the severity recorded in the crop, which was twice sprayed with 5% Neem leaf extract where 38.65% disease severity and 22.11% reduction in severity was recorded. Two application of 1.0% *P. fluorescence* at tillering and boot leaf stages resulted in 39.05% disease severity with 21.30% reduction in severity, the effect of *P. fluorescence* on disease severity was at par with the effect of Neem leaf extract on spot blotch severity.

During second year the results exhibited that in unprotected crop, that is, check there was 20.26% disease severity which was significantly higher than the severity recorded in remaining other treatments. A two application of 0.1% Carbendazim at two stages of crop tillering and boot leaf stages resulted in 7.73% severity with 61.84% reduction in disease severity which was at par with severity, that is, 8.93% with 55.92% reduction in severity recorded in the crop where 0.1% Propiconazole was applied twice at tillering and boot leaf stages, it was again at par with severity, that is, 10.13% with 50 reduction in severity recorded in the crop which was twice sprayed at tillering and boot leaf stages with 0.1% Hexaconazole. Application of 5% Neem cake extract at tillering and boot leaf stages resulted in 12.66% disease severity with 37.51% reduction in severity and it was at par with the severity recorded due to two application of 1.0% *T. harzianum* where 12.80% diseases severity with 36.82% reduction in severity was recorded and also with the severity recorded due to two application of 0.1% *P. fluorescence* where 13.86% severity with 31.85% reduction in severity were recorded. However, disease severity recorded due to application of Eucalyptus leaf extract, Garlic clove extract and neem leaf extract were at par to each other and also were at par with the effect of bio-agents.

Table 1. Effect of different fungicides, bio-agents and botanicals on percent disease incidence of spot blotch.

Treatment and method of applications	Percent disease incidence			Percent reduction in disease incidence		
	2008-2009	2009-2010	AV.	2008-2009	2009-2010	AV.
T_{1}- Propiconazole	* 12.06 **(20.19)	5.49 (13.43)	8.77	68.35	55.72	62.03
T_{2}- Carbendazim	13.17 (21.24)	4.82 (12.66)	8.99	35.56	61.12	57.78
T_{3}- Hexaconazole	12.52 (20.66)	5.48 (13.52)	9.00	67.14	55.80	61.47
T_{4}-*Trichoderma harzianum*	34.61 (35.86)	9.75 (18.16)	22.18	09.18	21.37	15.27
T_{5}- *Pseudomonas fluorescence*	28.92 (32.31)	9.05 (17.44)	18.98	24.11	27.01	25.56
T_{6}- Eucalyptus leaf extract	27.21 (31.02)	7.96 (16.38)	17.58	28.61	35.80	32.20
T_{7}- Garlic clove extract	35.64 (36.35)	8.94 (17.36)	22.29	64.81	27.90	17.19
T_{8}- Neem leaf extract	29.51 (32.23)	8.22 (16.64)	18.66	22.56	33.70	18.13
T_{9}- Neem cake extract	35.30 (36.25)	8.80 (17.24)	22.05	7.73	29.03	18.38
T_{10}- Control	38.11 (38.09)	12.40 (20.63)	25.25	-	-	--
SE (m)	2.823	0.694				
CD at 5%	8.454	2.078				

*Average of three replications. **Figures given in parenthesis are angular transformed value.

Table 2. Effect of different fungicides, bio-agents and botanicals on percent disease severity of spot blotch.

Treatment and method of applications	Percent disease severity			Percent reduction in disease severity		
	2008-2009	2009-2010	AV.	2008-09	2009-10	AV.
T_{1}- Propiconazole	*27.58 **(31.65)	8.93 (17.37)	18.25	44.42	55.92	50.17
T_{2}- Carbendazim	32.07 (34.47)	7.73 (15.97)	19.90	35.37	61.84	48.60
T_{3}- Hexaconazole	30.32 (33.39)	10.13 (17.95)	20.22	38.90	50.00	44.45
T_{4}- *Trichoderma harzianum*	41.27 (39.94)	12.80 (20.80)	27.03	16.83	36.82	26.82
T_{5}- *Pseudomonasfluorescence*	39.05 (38.65)	13.86 (21.24)	26.43	21.30	31.58	26.44
T_{6}- Eucalyptus leaf extract	40.93 (39.75)	16.43 (24.20)	28.68	17.51	18.90	18.20
T_{7}- Garlic clove extract	35.30 (36.43)	14.13 (21.89)	33.71	28.86	30.25	29.55
T_{8}- Neem leaf extract	38.65 (38.42)	15.41 (23.04)	27.03	22.11	23.93	22.52
T_{9}- Neem cake extract	39.88 (39.14)	12.66 (20.64)	26.27	19.63	37.51	28.57
T_{10}- Control	49.62 (44.76)	20.26 (26.73)	34.94	-		--
SE (m)	0.633	1.533				
CD at 5%	1.896	4.590				

*Average of three replications. **Figures given in parenthesis are angular transformed values.

Table 3. Effect of different fungicides, bio-agents and botanicals on percent yield increase.

Treatment and method of applications	Percent average (q/ha)			Percent yield increase		
	2008-2009	2009-2010	AV.	2008-2009	2009-2010	AV.
T_{1-} Propiconazole	* 51.00	41.67	46.33	56.58	68.90	62.74
T_{2-} Carbendazim	44.17	36.67	40.42	35.61	48.64	42.12
T_{3-} Hexaconazole	42.17	37.83	40.00	29.47	53.34	41.40
T_{4-}*Trichoderma harzianum*	38.17	27.33	32.75	17.19	10.78	13.98
T_{5-}*Pseudomonasfluorescence*	34.50	27.67	31.08	5.92	12.20	9.06
T_{6-} Eucalyptus leaf extract	37.77	31.67	34.72	15.96	28.41	22.18
T_{7-} Garlic clove extract	33.50	27.50	30.50	2.85	11.47	7.16
T_{8-} Neem leaf extract	34.66	29.83	32.25	6.66	20.91	13.78
T_{9-} Neem cake extract	33.73	28.83	31.28	3.56	16.86	20.42
T_{10-} Control	32.57	24.67	28.62	--	--	--
SE (m)	3.110	2.676	----	----		
CD at 5%	9.311	8.012				

*Average of three replications.

During both the crop seasons, that is, 2008-2009 and 2009-2010; it was observed that minimum disease severity was recorded in the crop which was twice sprayed with 0.1% Propiconazole followed by twice application of Carbendazim at tillering and boot leaf stages of crop followed by Hexaconazole. After these two treatments, next minimum disease severity was recorded when crop was sprayed with a bio-agents and botanical, that is, *P. fluorescence* and Neem cake at tillering and boot leaf stages. When we compared among fungicides, bio-agents and botanicals on the basis of disease severity; the lower disease severity was recorded with fungicidal spray.

Effect on yield

During Rabi crop season 2008-2009 highest yield (51.00 q/ha) with yield increase 56.58% was obtained where Propiconazole was applied at tillering and boot leaf stages. It was significantly higher than the yield obtained in the remaining other treatments. Second highest yield, that is, 44.17 q/ha with 35.61% yield increase was obtained where Carbendazim was applied and it was significantly higher than the yield obtained due to application of *T. harzianum* (38.17 q/ha) followed due to application of eucalyptus leaf extract, there was 37.77 q/ha yield and 15.96% yield increase was obtained, which was at par with the yield recorded due to T_5, T_7, T_8 and T_9, respectively.

During Rabi crop season 2009-2010 highest yield 41.67 q/ha with yield increase 68.90% was obtained when Propiconazole was applied followed by Hexaconazole, that is, 37.83 q/ha yield and 53.34% increase in yield. In case of botanicals eucalyptus leaf extract when applied at tillering and boot leaf stages resulted in a yield of (31.67 q/ha and 28.41% yield increase) followed by bio-agents *P. fluorescence* with 27.67 q/ha yield and 12.20% yield increase was obtained.

As per average of both seasons, it was observed that the highest yield was obtained in crop where Propiconazole was applied twice at tillering and boot leaf stages followed by yield obtained in crop where Carbendazim was applied twice, that is, at tillering and boot leaf stages. Overall best result during the year 2008-2009 and 2009-2010 was in Propiconazole where Propiconazole was applied and the average yield obtained was 46.33 q/ha (Table 3).

DISCUSSION

The present study showed that foliar application of fungicides, bio-agent and botanicals can be effective in reducing the severity of spot blotch in wheat. 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. Result indicated that two applications of Propiconazole at tillering and boot leaf stages which is already in practice for management of spot blotch disease, gave the maximum reduction in incidence and severity. Propiconazole was found superior at 0.1% concentration in suppressing the spot blotch disease of wheat than any other chemical, bio-agent and botanicals tested. Kalappanavar and Patil (1998) reported that propiconazole, tridimefon and Hexaconazole were the most effective fungicides for management of leaf rust of wheat. Agrawat et al. (1980) found that Carbendazim and Benlate were highly effective against A. helianthi on sunflower. Rao (2006) reported Bayleton as effective fungicide against leaf blight of sunflower which increased yield up to 63%.

Mesta et al. (2003) reported Propiconazole (0.1%) was effective fungicide against Alternaria blight of sunflower. Higher efficacy of Carbendazim and Propiconazole may be due to same dose of Carbendazim and Propiconazole present in crop system for longer time as it was applied for two times. When two applications of Carbendazim and Propiconazole at tillering and boot leaf stages were compared, the Carbendazim seem to be more effective and economic as well. Comparatively higher reduction in incidence and severity of spot blotch was observed due to T. harzianum which was significantly higher than P. fluorescence. Hamdy et al. (2001), reported that under field conditions guard (T. harzianum) reduce 64.29% disease in case of spot blotch of wheat. The P. fluorescence was evaluated under field conditions. Two sprays were applied at tillering and boot leaf stages of wheat and experimental results showed that P. fluorescence minimized the incidence and severity of spot blotch of wheat. Singh et al. (2009) reported that either twice application of Carbendazim, or four application of T. harzianum and P. fluorescence (1:1 ratio) at seed, seedling, tillering and symptoms initiation stage or two application of antagonists at seedling and symptoms initiation stage were almost equally effective in reducing the disease severity of sheath blight in rice. Vidhyasekaran et al. (1997) developed the powder formulation of P. fluorescence and applied in the form of seed treatment and foliar spray.

Shafique et al. (2007) studied effect of aqueous leaf extract of 8 allelopathic tree species including Eucalyptus citridora on germination and seed borne mycoflora of wheat (T. aestivum), they found that aqueous extract of all allelopathic tree species including E. citridora significantly reduced the frequency of occurrence of two most frequent seed borne fungi viz A. alternata and F. solani. Through this finding, it is clear that Eucalyptus leaf, certainly posses some fungicidal activities and due to this reason, application of aqueous extract as foliar spray might have resulted in reducing disease severity of spot blotch caused by B. sorokiniana. Foliar application of aqueous extract garlic clove to the wheat plants, at tillering and boot leaf stages also reduced the spot blotch incidence and severity. Through the findings of Hason et al. (2005), antifungal activity of Allium sativa (Garlic) against B. sorokiniana in wheat is well proven; during present investigation foliar application of aqueous garlic clove extract resulted in reduction of spot blotch severity which is well in accordance with the findings of earlier workers. Aqueous extract of Azadirachta indica (Neem) has been reported to cause significant growth inhibition of certain fungi such as Rhizoctonia solani, Botrytis cinera and Fusarium oxysporum (Alkhail, 2005).

During present investigation, aqueous extract of Neem leaf at 5% was applied as foliar spray at tillering and boot leaf stages, which showed reduction of disease severity. Twice application of Neem cake aqueous extract at 5% to the wheat plants, at tillering and boot leaf stages resulted in reduction of disease severity and incidence. Mohammad and Aman (2001) reported that A. indica controlled 56.96% leaf rust of wheat. Sajid et al. (1995) studied the comparative effects of Neem products and baytan against leaf rust of wheat in the laboratory. Neem oil and Baytan (Triadimenol) completely inhibited germination of P. recondita f.sp. tritici uredospores. In the field, Neem oil at 4% concentration checked leaf rust on wheat after four applications but Baytan at 0.1% showed excellent rust control and best improvement in yield. These reports showed that application of Neem based products as foliar spray reduced the foliar diseases which also support the present findings.

Conclusion

For efficient management of B. sorokiniana causing spot blotch of wheat, use of efficient strains of biological controlling agents botanicals and fungicides needs to be sincerely incorporated in the cultivation package of important crops. The findings from this study suggest that foliar application of fungicides, bio-agents and botanicals can be used to reduce the severity of spot blotch on wheat. Present investigation concluded that the fungicides (Propiconazole, Carbendazim and Hexaconazole) bio-agents (T. harzianum and P. fluoresce) and botanicals (Eucalyptus leaf extract, Garlic clove extract, Neem leaf extract and Neem cake extract) in two season experiments were found to be effective in reducing the disease incidence, severity and increasing grain yield in wheat.

Conflict of Interest

The authors have not declared any conflict of interest.

ACKNOWLEDGEMENT

Authors are thankful to the Department of Plant

Pathology and University authority for providing facilities to conduct the experiment. Sources of literatures are also dully acknowledged.

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