The Pharma Innovation Journal 2021; 10(11): 1967-1970

www.ThePharmaJournal.com

The Pharma Innovation

ISSN (E): 2277- 7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2021; 10(11): 1967-1970

www.thepharmajournal.com
Received: 03-08-2021
Accepted: 30-09-2021

Dheeraj Kumar Singh
Ph.D., P.G. Department of Plant Pathology, College Ghazipur, Uttar Pradesh, India

Satyendra Nath Singh
Associate Professor and Head, Department of Plant Pathology, P.G. College Ghazipur, Uttar Pradesh, India

Corresponding Author:
Dheeraj Kumar Singh
Ph.D., P.G. Department of Plant Pathology, College Ghazipur, Uttar Pradesh, India

Impact of different fungicides and bio-agents on management of spot blotch of wheat caused by *Bipolaris sorokiniana* (Sacc.) Shoemaker

Dheeraj Kumar Singh and Satyendra Nath Singh

Abstract
Field experiment was conducted at Research Farm of PG college Gazipur For the management of spot blotch disease of wheat. One bio-agent, one bioenhancer and seven fungicides were used. Plant disease intensity decreased with the application of different treatment over untreated control. Minimum plant disease intensity was recorded (21.00% first year and 20.70% second year) under T_9 (Seed treatment with Raxil @ 2.5 gm/kg seed + 2 foliar sprays of propiconazole @ 0.1%, first at boot leaf stage second after 20 days), Maximum plant disease intensity was recorded (71.80% first year and 74.00% second year) under T_{11} (Control), Which has highly significant compared to all the treatments. Maximum grain yield was recorded (39.05 q/ha and 39.25 q/ha first and second year) and maximum thousand seed weight was recorded (42.05g and 42.40g first and second year) under T9 (Seed treatment with Raxil @ 2.5 gm/kg seed + 2 foliar sprays of propiconazole @ 0.1%, first at boot leaf stage second after 20 days), Minimum grain yield was recorded (31.25q/ha and 31.04q/ha during the both year) and least thousand seed weight was recorded(36.30g and 36.18g during 2018-19 and 2019-20) under T_{11} (Control).

Keywords: Fungicides, bio-agents, spot, *Bipolaris sorokiniana*

Introduction
Cereals serve a critical role in meeting the world's rising population's food needs, particularly in developing countries where cereal-based manufacturing is the norm system is the only predominant source of nutrition and calorie intake. The nutrient-rich cereal is grown in diversified environments; and globally wheat occupies around 216.95 million hectares (mha) holding the position of highest acreage among all crops with an annual production covering around 764.11 metric tonnes (mt) last year (Feldman, 2001) [4]. Moreover, it provides almost half of all calories in the region of North Africa and West and Central Asia Wheat, along with rice, is one of the most important sources of protein in least developed and middle-income countries, both in terms of calories and dietary intake. The crop is cultivated mostly in winter and spring seasons around the world; it being grown in winter in cold countries like Europe, USA, Australia, Russian Federation, etc., while in spring in countries of Asia and in some parts of the USA.

In India, production of Wheat during 2019-20 is estimated at record 107.18 million tonnes. It is higher by 3.58 million tonnes as compared to wheat production during 2018-19 and is higher by 11.02 million tonnes than the average wheat production of 96.16 million tones as per the recent 3th Advance Estimates from Directorate of Economics and Statistics (DES), Ministry of Agriculture and Farmers Welfare (MoA&FW), India (2020). The production of wheat has also showed an increasing trend, from 99.9 to 103.6 million tonnes from 2018-2019 to 2019-2020 with a magnitude of 3.7 million tones. The major source of this increase in production is mainly attributed to expansion in area followed by marginal increase in productivity. Uttar Pradesh still holds the position of largest producer in the country accounting for about 28 million tonnes which is roughly 30% of the total production. Around 85 million tonnes (90%) of wheat has been produced from traditional wheat-growing regions such as Uttar Pradesh, Punjab, Haryana, Madhya Pradesh, Bihar and Rajasthan. Wheat provides nearly 55% of carbohydrate and 20% of the food calories. It contains carbohydrate 78.10%, protein 14.70%, fat 2.10%, minerals 2.10% and considerable proportions of vitamins (thiamine and vitamin-B) and minerals (zinc, iron) calcium (37 mg/100g), iron (4.1 mg/100g), thiamine (0.45mg/100g), riboflavin (0.13mg/100g) and nicotinic acid (5.4mg/100mg). 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.

Globally, an estimated 25 million hectares of wheat cultivated land is affected by spot blotch disease (van Ginkel and Rajaram, 1998) [18]. Due to drastic changes in climatic conditions in the last two or three decades, spot blotch has emerged as a major threat to wheat production in India. Spot blotch is affecting nearly 9 mha of the warm North-Eastern Plain Zone where millions of resource-poor farmers grow wheat after rice (Joshi *et al.*, 2004) [6]. The disease is gradually extending towards the North-West, the major wheat growing areas in the country (Chand *et al.*, 2003) [3].

Materials and Methods

This experiment was conducted during *Rabi* season 2018-19 and 2019-20 MES, P.G. College Ghazipur, Uttar Pradesh. Eleven treatment *viz* T_1 Seed treatment with Thiram @ 3g/kg seed, T_2Seed treatment with Tebuconazole @ 2.5g/kg seed, T_3 Seed treatment with *Trichoderma viride* @ 4 g/kg seed, T_4 Two foliar spray of Tebuconazole 50% + Trifloxystorobin 25% @ 0.4% T_5 Two foliar spray of Jeevamrit @ 5%, 7.5% and 10% concentration T_6 Two foliar spray of Copper oxychloride @ 0.1% T_7 Two foliar spray of Hexaconazole @ 2.5% T_8 T_1 + Two foliar spray of Tebuconazole 50% + Trifloxystorobin 25% @ 0.4% T_9 T_2 + Two foliar spray of Propiconazole @ 0.1% T_{10} T_3 + Two foliar spray of Tebuconazole @ 0.1% and T_{11} Untreated (unsprayed) were tested for management of spot blotch disease in randomized block design with three replications observations on different traits were recorded and the results thus obtained are discussed under results and discussion.

Results and Discussion

During 2018-19 for the management of foliar blight disease of wheat seed dresser fungicides and bioagents *viz*. Thirum 50 WP @ 2.5g/kg of seeds, Tubuconazole @ 2.5g/kg of seeds and *Trichoderma viride*, foliar spray fungicides Propiconazole @ 0.4%, Tubuconazole 50%+Trifloxistorob in 25% @ 0.4%/lit., Hexaconazole @ 0.1%, Copper oxichloride @ 0.1% and one bio-enhancer Jeevamrit @ 2.5ml were used singly or in combination of seed treatment plus foliar spray. The minimum per cent disease intensity was recorded with T_9 (21.00%) which was non-significantly followed by T_{10} (22.50%), T_8 (23.60%) and T_4 (24.40%) and significantly followed by T_7 (25.70%) T_6 (31.40%), T_5 (32.80%), T_2 (35.60%), T_1 (31.10%) and T_3 (36.80%). Maximum per cent disease intensity (71.80%) was recorded under T_{11} untreated (control plot) (Table-1). Lowest per cent disease intensity, highest numbers of tillers, highest numbers of productive tillers per plant, highest 1000 test weight, highest yield q/ha, per cent increase yield and highest avoidable yield loss was recorded under the T_9 (seed treatment Tubuconazole 2.5g/kg of seed + two spray of Propiconazole @ 0.1%) during 2018-19. Table-1 clearly indicates that the minimum per cent disease intensity was found in T_9 (20.70%) (Seed treatment with Tebuconazole @ 2.5g/kg seed + 2 foliar spray of Tilt @ 0.1 per cent) which was non-significantly followed by T_{10} (22.40%), T_8 (23.20%), and T_7 (25.60%) and significantly followed by T_6 (30.90%), T_5 (32.30%), T_2 (35.80%), T_1 (30.70%) and T_3 (38.20%). Maximum per cent disease intensity (74.00%) was recorded under T_{11} untreated (control plot) observed during second year (2019-20) of study. Earlier also Propiconazole 25 have been reported effective against spot blotch of wheat by many other workers (Rashid *et al*., 2001; Hossain *et al*., 2001; Patil *et al*., 2002; Singh *et al*., 2005; Sharma *et al*., 2005; Shahidullah, 2006; Ahmed *et al*., 2007; Zamal, 2007; Malaker and Mian, 2009; Rahman *et al*., 2013) [12, 5, 11, 14, 13, 1, 19, 8, 5, 16]. Lapis (1985) [7] reported that three sprays of Propiconazole gave the best control of spot blotch and increased grain yield by 65 per cent. Mondol *et al.* (1994) [9] found that Propiconazole 25 EC (0.05 per cent) was the effective and profitable one, which controlled the disease significantly producing the high yield with maximum gross margin. Murray *et al*. (1998) [10] reported that fungicides groups like Mancozeb, Propiconazole and Tebuconazole were effective in controlling the spot blotch disease and reducing inoculum pressure. Singh and Gupta (2000) [17] have also reported that Tilt and Folicur were most effective. Singh and Singh (2007) also reported loss by this disease in the tarai region of district Balrampur is eastern Uttar Pradesh. Significant variation was found on the number of tillers per plants as a result of treatments Table-2. The maximum number of tillers per plant (10.40) was recorded in case of T_9 followed by rest treatments. Minimum number of tillers was found (6.30) on T_{11} control plot which was statistically at par with T_4, T_6, and T_7 during first year (2018-19).Similar result were found during 2019-20.

Significant variation was found on the number of productive tillers per plants as a result of treatments (Table-2). Maximum number of productive tillers per plant (9.70) was recorded in case of T_9 which was at par with that of T_{10} (9.40), T_8 (8.85) and T_2 (8.20). Minimum number of productive tillers was found (5.50) with T_{11} control plot which was statistically least than rest treatments during the first year (2018-19), similar result were also noted in second year ie 2019-20.

Maximum thousand seed weight was found in T_9 (40.05 g) which was non-significantly followed by T_{10} (41.70 g), T_8 (39.38 g), T_4 (40.05 g), T_7 (39.38 g), T_6 (39.00g) and T_5 (38.56 g) and significantly followed by T_2 (37.00 g), T_1 (36.90 g) and T_3 (36.30g). Minimum thousand seed weight was recorded under T_{11} (36.12 g) during the first year (2018-19). Similar findings were also noted during second year (2019-20)

It evident from Table-3 maximum yield of (39.05 q/ha) was recorded under treatment T_9 which was non-significantly followed by T_{10} (38.70 q/ha), T_8 (38.55 q/ha), T_4 (37.90 q/ha) and T_7 (37.45 q/ha) and significantly followed by T_6 (34.85 q/ha), T5 (34.70 q/ha), T2 (33.55 q/ha), T1 (34.30 q/ha) and T3 (33.90 q/ha) Least grain yield q/ha recorded under T_{11} control plot (31.85 q/ha) during 2018-19. Similar trend was noted during 2019-20 also.

Maximum per cent increase yield was found in T_9 (22.61%) which was non-significantly followed by T_{10} (21.51%) and T_8 (21.04%) and significantly followed by T_4 (19.00%), T_7 (17.58%), T_6 (9.42%), T_5 (8.95%), T_2 (8.48%), T_1 (7.69%), and T_3 (6.44%). Minimum percent increase yield was recorded under T_{11} (0.00%) control, during the first year and maximum per cent increase yield was found in T_9 (24.01%) which was non-significantly followed by T_{10} (22.91%) and T_8 (22.43%) and significantly followed by T_4 (20.06%), T_7 (18.48%), T_6 (10.43%), T_5 (9.95%), T_2 (9.48%), T_1 (8.69%), and T_3 (7.40%). Minimum percent increase yield was recorded under T_{11} (0.00%) control, during the second year (2019-20). During 2001-02 crop season also the treatment with Propiconazole (5.36 ton/ha) and Tebuconazole (5.26 ton/ha) provided higher yield than untreated check (Singh *et al*., 2011).

Maximum avoidable losses was found in T_9 (18.44%) which was non-significantly followed by T_{10} (17.58%) and T_8 (17.28%) and significantly followed by T_4 (15.96%), T_7

(14.95%), T_6 (8.61%), T_5 (8.21%), T_2 (7.81%), T_1 (7.14%), and T_3 (5.98%). Minimum avoidable loss was recorded under T_{11} (0.00%) control, during the first year (2018-19). Maximum avoidable losses was found in T_9 (19.36%) which was non- significantly followed by T_{10} (18.64%) and T_8 (18.32%) and significantly followed by T_4 (16.71%), T_7 (15.60%), T_6 (9.44%), T_5 (9.05%), T_2 (8.66%), T_1 (7.99%), and T_3 (6.91%). Minimum avoidable loss was recorded under T_{11} (0.00%) control, during the second year (2019-20). Result of a multi-locational test conducted nation wise during 1997-98 and 1998-99 reveal highest yield losses of 50.6 per cent, at Dharwad, 40.9 per cent at Faizabad and 27.0 per cent at Gordaspur during 1998-99 (Singh *et al.*, 2002) [15]. In Nepal, it was shown that spot blotch induced grain yield losses of 52% under soil nutrient stress comrade with 26% under optimum fertilization and spot blotch continues to causes substantial grain yield reductions under resource-limited farming conditions (Sharma and Duveillar 2006) [14]. In farmers' fields in Bangladesh, the average losses due to these foliar blights were estimated to be 15 per cent (Alam *et al*., 1997) [2].

Table 1: Impact of different fungicides and bio-agent against foliar blight disease of wheat 2018-19 and 2019-20

S.N.	Treatment	Date of Disease appearance	PDI 2018-19			Date of Disease appearance	PDI 2019-20		
			Before spray	After I spray	After II spray		Before spray	After I spray	After II spray
T_1	Thiram	04/02/19	14.30(6.10)	31.82(27.80)	37.52(31.10)	04/0220	13.31(5.30)	31.88(27.90)	37.29(30.70)
T_2	Raxil	03/02-19	11.24(3.80)	30.79(26.20)	36.63(35.60)	04/02/20	10.94(3.60)	30.98(26.50)	36.75 (35.80)
T_3	*T. virde*	03/02/19	15.45(7.10)	33.21(30.00)	38.41(36.80)	05/02/20	15.34(7.00)	33.15(29.90)	38.17 (38.20)
T_4	Nativo	30/01/19	20.09(11.80)	25.77 (18.90)	29.60(24.40)	29/01/20	20.00(11.70)	25.70(18.80)	36.03(34.60)
T_5	Jeevamrit	31/01/19	18.24(9.80)	29.53 (24.30)	34.94 (32.80)	01/02/20	18.24(9.80)	28.79 (23.20)	34.63 (32.30)
T_6	Copper oxychloride	26/01/19	21.72(13.70)	30.46 (25.70)	34.08 (31.40)	27/01/20	21.56 (13.50)	30.33 (25.50)	33.77(30.90)
T_7	Hexaconazole	01/02/19	20.96(5.80)	26.57 (20.00)	30.46 (25.70)	31/01/20	20.62 (12.40)	26.42(19.80)	30.40 (25.60)
T_8	T_1+ T_4	04/02/19	13.94(5.80)	24.35(17.00)	29.06 (23.60)	05/02/20	13.69(5.60)	24.04 (16.60)	28.79(23.20)
T_9	T_2 + Tilt	05/02/19	10.63(3.40)	22.46(14.60)	27.27 (21.00)	05/02/20	10.30(3.20)	21.56(13.50)	27.06 (20.70)
T10	T_3+ Folicur	02/02/19	15.12(6.80)	23.18 (15.50)	28.32 (22.50)	04/02/20	14.65(6.40)	23.03(15.30)	28.25 (22.40)
T11	Control	20/01/19	22.54 (14.70)	45.46 (50.80)	57.92(71.80)	18/01/20	23.03 (15.30)	46.61(52.80)	59.34 (74.00)
	S.Em±		0.86	1.30	1.55		081	1.18	1.74
	CD (p=0.05)		2.54	3.86	4.59		2.40	3.51	5.16

Table 2: Impact of different fungicides and bio-agent on Numbers of tillers per plant and number of productive tillers per plant

S.N.	Treatment	2018-19		2019-20	
		No. of Tillers per plant	No. of productive tillers per plant	No. of Tillers per plant	No. of productive tillers per plant
T_1	Thiram	8.20	7.60	8.30	7.70
T_2	Raxil	9.00	8.20	9.10	8.30
T_3	*T. virde*	8.00	7.40	8.15	7.55
T_4	Nativo	7.20	6.80	7.30	6.90
T_5	Jeevamrit	7.30	6.76	7.45	6.85
T_6	Copper oxychloride	6.90	6.25	7.00	6.35
T_7	Hexaconazole	7.00	6.55	7.20	6.60
T_8	T_1+ T_4	9.60	8.85	9.80	9.00
T_9	T_2 + Tilt	10.40	9.70	10.50	9.80
T10	T_3+ Folicur	10.10	9.40	10.25	9.50
T11	Control	6.30	5.50	6.40	5.56
	S.Em±	0.36	0.35	0.34	0.33
	CD (p=0.05)	1.06	1.05	1.01	0.98

Table 3: Impact of different fungicides and bio-agent on test weight, grain yield,% increase yield over control and avoidable losses on wheat

S.N.	Treatment								
		Test weight	Grain yield (q/ha)	% increase yield	Avoidable losses	Test weight	Grain yield (q/ha)	% increase yield	Avoidable losses
T_1	Thiram	36.90	34.30	7.69	7.14	36.95	34.40	8.69	7.99
T_2	Raxil	37.00	34.55	8.48	7.81	37.30	34.65	9.48	8.66
T_3	*T. virde*	36.30	33.90	6.44	6.05	37.15	34.00	7.42	6.91
T_4	Nativo	40.05	37.90	19.00	15.96	40.25	38.00	20.06	16.71
T_5	Jeevamrit	38.56	34.70	8.95	8.21	38.80	34.80	9.95	9.05
T_6	Copper oxychloride	39.00	34.85	9.42	8.61	39.20	34.95	10.43	9.44
T_7	Hexaconazole	39.38	37.45	17.58	14.95	39.70	37.50	18.48	15.60
T_8	T_1+ T_4	40.95	38.55	21.04	17.38	41.20	38.75	22.43	18.32
T_9	T_2 + Tilt	42.05	39.05	22.61	18.44	42.40	39.25	24.01	19.36
T10	T_3+ Folicur	41.70	38.70	21.51	17.70	41.75	38.90	22.91	18.64
T11	Control	36.12	31.85	0.00	0.00	36.18	31.65	0.00	0.00
	S.Em±	1.43	1.61	0.55	0.62	1.98	1.55	0.72	0.64
	CD (p=0.05)	4.26	4.79	1.63	1.84	5.89	4.60	2.14	1.90

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