Efficacy of fungicides against *Bipolaris sorokiniana* under *in vitro* and *in vivo* conditions

Abstract

Spot blotch of wheat caused by *Bipolaris sorokiniana* could be effectively and economically controlled by two foliar sprays of either Propiconazole or Hexaconazole @ 0.1 per cent at fifteen days interval but on the basis of cost- benefit ratio Hexaconazole had an edge over Propiconazole. The harmful effects of fungicides to human and environment, there have been proved useful and economical in the control of spot blotch. Non systemic and systemic foliar fungicides belonging to the dithiocarbamate and Triazoles are found to be effective. Foliar applications of systemic fungicides between heading and grain filling stages, are cost effective. Propiconazole, Hexaconazole and Difenaconazole + Propiconazole at 250 ppm completely inhibited the mycelial growth of *B. sorokiniana*. Carbendazim and Copper oxychloride also causes and complete inhibition but at 500 and 1000 ppm, respectively but Mancozeb could not give complete inhibition even at 1000 ppm.

Key words-*Bipolaris, sorokiniana*,blotch,wheat

INTRODUCTION

Wheat (*Triticum aestivum* L.) belonging to the family Graminae, is one of the oldest and most important cereal crops.). In India, three species of wheat are cultivated, *Triticum aestivum, T. duram*, and *T. dicoccum* (Gupta, 2004). Wheat in the warmer parts of the world is mainly affected by many diseases and among these diseases, spot blotch or foliar blight caused by *Bipolaris sorokiniana* (Sacc.) Shoem. is one of the most important diseases in warm and humid regions of India and other South Asian countries due to its wide spread prevalence and increasing severity (Joshi *et al*., 2002). In India, the spot blotch pathogen is prevalent throughout the wheat-growing regions of the country, more frequently in the North-eastern plains zone where it has assumed an epidemic proportion (Singh *et al*., 2002). Later on Shamim *et al.*, (2010) estimated that about 10 million hectares of wheat growing belt in the Indian subcontinent is affected by the disease, out of which 9 million hectares belonged to Indo-Gangetic plains predominantly with rice-wheat cropping system. Rattu *et al*., (2011) reported that in the year 2009 four diseases, viz. spot blotch, powdery mildew, yellow and leaf rust were prevalent in Punjab, Pakistan. Spot blotch was the most prevalent disease on varieties cultivated at farmer fields and no variety was found free of it.

Spot blotch of wheat has emerged as a serious concern for wheat cultivation in warmer and humid regions of the world including South-East Asian countries such as

India, Nepal and Bangladesh (Acharya *et al.,* 2011; Chowdhary *et al*., 2013). Iftikhar *et al.,* (2009) reported that *Bipolaris sorokiniana* caused serious foliar disease in south Asian countries. Bahadar *et al*., (2016) concluded that spot blotch caused by *Bipolaris sorokiniana* is a major disease of wheat in warm and humid regions of the world including South-east Asian countries such as India, Nepal and Bangladesh and the disease is very significant**,** especially in North Eastern Plains Zone (NEPZ) of India. Spot blotch is considered to contribute significantly lowering the average yield of wheat crop under warm and humid conditions.

Malik *et al.,* (2008) tested the efficacy of foliar spray of different fungicides against spot bloch disease of wheat. Propiconazole and difenoconazole (0.1 and 0.2 per cent, respectively) were most effective and reduced the score of spot blotch up to 12 as compared to 79 score in unsprayed crop. The fungicidal sprays increased grain yield (40.1-46.3 per cent) and 1000-grain weight significantly as compared to the unsprayed check.

Sarkar *et al,*. (2010) reported the efficacy of some newly synthesized organotin compounds against *B. sorokiniana.*

Kumar *et al.,* (2014) suggested that a combination of seed treatment by Carboxin (37.5 per cent) + Thiram (37.5 per cent WS) @ 2.5 g/kg seed + two foliar sprays of Propiconazole 25 per cent EC @ 0.1per cent one at boot leaf stage and another 20 days after 1st spray gave best result in reducing the spot blotch of wheat as well as increasing the 1000-grain weight and grain yield of wheat.

Singh *et al.,* (2015) evaluated efficacy of fungicides against *Bipolaris sorokiniana.* They found minimum per cent disease intensity (37.28 per cent) with seed treatment with Vitavax @ 3g/kg of seed + foliar spray of Tilt @ 0.1 per cent at boot leaf or at the time of initiation of disease on flag-1 leaf. This was followed by seed treatment with Captof @ 3g/kg of seed + foliar spray of Folicur @ 0.1 per cent at boot leaf or at the time of initiation of disease on flag-1 leaf. Treatments were significantly superior over check in reducing the disease severity and increasing yield and yield contributing characters during a year.

Yadav *et al*., (2015) reported that two sprays of Carbendazim (0.1 per cent) 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. 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.

Mehboob *et al*., (2015) found that Score (Difenoconazole) and Topsin-M (Thiophanate methyl) exhibited the best performance in inhibiting the mycelial growth of *D. sorokiniana* followed by AmistarTop (Azoxystrobin + Difenoconazole), while Halonil (Chlorothalonil) and Curzate-M (Cymoxanil + Mancozeb) were least effective.

Pradeep and Kalappanavar (2016) on the basis of studies carried out during 2013-14 and 2014-15 reported that three sprays of Pyraclostrobin 13.3 per cent + Epoxiconazole 5 per cent @ 0.1 per cent, at an interval of 15 days from the date of appearance of typical symptoms gave maximum reduction of disease severity (88.27 per cent) with 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. They have advocated that above combi-product can be used as an alternate fungicide to triazoles especially Propiconazole for management of this disease.

Kavita *et al.,* (2017) evaluated efficacy of 15 fungicides at 0.5, 0.1 and 2 per cent for studying their inhibitory effect on the mycelia growth of *Bipolaris sorokiniana* by using food poison technique and recorded, the maximum mycelial growth inhibition (87.77 per cent) with Propiconazole (0.1 per cent) followed by Propiconazole (0.05 per cent) which showed 81.57 per cent inhibition. Hexaconazole (0.2 per cent) and Hexaconazole (0.1 per cent) showed 77.98 per cent and 70.37 per cent mycelial growth inhibition, respectively.

MATERIAL AND METHODS

Effect of fungicides on radial growth of *Bipolaris sorokiniana*

Six fungicides, namely Tilt, Contaf, Taspa, Bavistin, Blitox-50 and Indofil M-45 were evaluated against *B. sorokiniana in vitro* by the poison food technique. Their trade name, common name, formulation, chemical group and mode of action are given in Table 1.

Table 1. Trade name, common name, chemical group and mode of action of fungicides used against *B. sorokiniana*

Trade name	Common name	Formulation	Chemical group	Mode of action
Tilt 25% EC	Propiconazole	25 EC	Triazole	Systemic
Contaf 5EC	Hexaconazole	5 EC	Triazole	Systemic
Taspa	Difenaconazole + Propiconazole	Propiconazole 13.9% + Difenaconazole 13.9%	Triazole	Systemic
Bavistin 50WP	Carbendazim	50 WP	Benzimidazole	Systemic
Blitox-50	Copper oxychloride	50 WP	Copper compound	Contact
Indofil M-45	Mancozeb	75 WP	Dithiocarbamate	Contact

For poison food technique, potato dextrose agar medium was used as a basal medium and stock solution of 5000 ppm strength of each fungicide was prepared by dissolving 2.5 g or 2.5 ml in 500 ml sterilized distilled water. To obtain the desired concentration of fungicides in the medium, amount of stock solution to be added in potato dextrose agar was calculated by using following formula:

$$C_1V_1 = C_2V_2$$

Where,

C_1 = Concentration of stock solution (ppm)

C_2 = Required concentration of the fungicide (ppm) in plate

V_1 = Volume (ml) of the stock solution to be added

V_2 = Final volume (ml) of PDA after adding stock solution

Required amount of stock solution of various fungicides were poured in 100ml of sterilized melted PDA to get final concentration of 50, 100, 200, 250, 500 and 1000 ppm of each fungicide. PDA poisoned with each fungicide was poured into four sterilized Petri-plates @ 20 ml/plate and allowed to solidify. Plates containing PDA without fungicide served as check. After solidification, 5 mm disc of seven days old culture of *Bipolaris sorokiniana*were placed in the center of the Petri-plates and incubated at 28 ± 1°C. Observation on radial growth of test fungus was recorded after 5 and 7 days as per method described earlier. Recorded data on radial growth was converted into per cent growth inhibition by using following formula:

Per cent growth inhibition $I = \left(\frac{C - T}{C}\right) \times 100$

Where,

C = Colony diameter (mm) in check plate

T = Colony diameter (mm) in the treated plate

The per cent inhibition data was transformed into Arcsin √Percentage transformation and then analysed statistically using completely randomized design (CRD).

Effects of spraying of fungicides on spot blotch of wheat

To see the effects of foliar spray of fungicides on spot blotch of wheat, field trials were conducted during *Rabi* 2018-19 and 2019-20. The trial was laid out as per details given below:

Design	:	Randomized Block Design (RBD)
Treatments	:	Fungicides
T_1	:	2 spray of Tilt @ 0.1% at 15 days interval
T_2	:	2 spray of Contaf @ 0.1% at 15 days interval
T_3	:	2 spray of Taspa @ 0.1% at 15 days interval
T_4	:	2 spray of Bavistin @ 0.1% at 15 days interval
T_5	:	3 spray of Blitox-50 @ 0.25 % at 15 days interval
T_6	:	3 spray of Indofil M-45 @ 0.25 % at 15 days interval
T_7	:	Check (water spray)
Replication	:	4
Variety	:	HD-2733
Plot size	:	5 m × 2 m
Seed rate	:	120 kg/ha
Row to row distance	:	20 cm
Fertilizer	:	120 kg N : 60kg P_2O_5 : 40 kg K_2O per ha
Date of sowing	:	28thNovember 2018 and 25th November 2019

Observations on disease severity were recorded at dough stage following Saari-Prescot in 0-9 scale. The yield and 1000-grain weight were recorded after harvest of the crop. Data was analyzed statistically.

EXPERIMENTAL FINDING

Effect of fungicides on radial growth of *Bipolaris sorokiniana*

Six fungicides namely, Propiconazole (Tilt), Hexaconazole (Contaf), Difenaconazole + Propiconazole (Taspa), Carbendazim (Bavistin), Copper oxychloride (Blitox-50) and Mancozeb (Indofil M-45) were evaluated against *B. sorokiniana* by recording their effect on radial growth by poison food technique on potato dextrose agar medium. Fungicides were tested at 50, 100, 200, 250, 500 and 1000 ppm concentrations to find out the concentration of fungicides at which complete inhibition of radial growth *B. sorokiniana* can be achieved. Data on the effect of six concentrations of six fungicides on inhibition of radial growth of *B. sorokiniana* is presented in Table 2.

Data presented in Table 2 clearly indicates that all the fungicides, at all the six concentrations tested inhibited the growth of *B. sorokiniana in vitro.* After seven days of incubation, Propiconazole, Hexaconazole and Difenaconazole + Propiconazole completely inhibited the growth of *B. sorokiniana in vitro* at a concentration of 250 ppm or more. Carbendazim produced cent per cent inhibition at a concentration of 500 ppm or more whereas copper oxychloride produced it at 1000 ppm only. Mancozeb even at 1000 ppm concentration could not completely inhibit the growth of *B. sorokiniana in vitro.* Cent per cent inhibitions of mycelial growth of *B. sorokiniana* produced by Propiconazole, Hexaconazole and Difenaconazole + Propiconazole even at 250 ppm were significantly superior than their lower concentrations. Cent per cent inhibition produced by Carbendazim and Copper oxychloride, respectively at 500 and 1000 ppm which were also statistically superior than their lower concentrations.

Six fungicides were further evaluated against *B. sorokiniana* at selected concentrations of fungicides for confirmation. Systemic fungicides (Propiconazole, Hexaconazole, Difenaconazole + Propiconazole and Carbendazim) were tested at 50, 100, 200 and 250 ppm concentrations whereas; contact fungicides (Copper oxychloride and Mancozeb) were tested at 100, 200, 500 and 1000 ppm concentrations. Data on the effect of four concentrations of six fungicides on the radial growth of *B. sorokiniana* is presented in Table 2.

Data presented in Table 2 clearly indicates that all the fungicides, at all the four concentrations tested inhibited the radial growth of *B. sorokiniana in vitro.* After seven days of incubation, Propiconazole, Hexaconazole, and Difenaconazole + Propiconazole at 250 ppm and copper oxychloride at 1000 ppm concentration completely inhibited the growth of *B. sorokiniana in vitro* in this experiment.

Effect of foliar spraying of fungicides on spot blotch, yield and 1000-grain weight of wheat

The experiment was conducted in Randomized Block Design with four replications during *Rabi* 2018-19 and 2019-20 to find out the effect of foliar spraying of fungicides on disease, yield and 1000-grain weight of wheat. Six fungicides namely, Propiconazole, Hexaconazole, Difenaconazole + Propiconazole, Carbendazim, Copper oxychloride and Mancozeb were tested in field conditions. Propiconazole, Hexaconazole, Difenaconazole + Propiconazole and Carbendazim were sprayed @ 0.1% whereas Copper oxychloride and Mancozeb were sprayed @ 0.25 % in the field.

Effect on progress of spot blotch of wheat

Five observations on Per cent Disease Index (PDI) and leaf blotch score (dd) were taken at fifteen and seven days intervals during *Rabi* 2018-19 and 2019-20, respectively . Data obtained on the effect of foliar spraying of fungicides on disease progress of spot blotch of wheat is presented in Table 3.

Data presented in Table 3 clearly indicates that in both the years, initially there was not much difference in PDI observed in different fungicidal treatments. In *Rabi* 2018-19 and 2019-20, at initial stage PDI ranged from 8.39 to 12.80 and 8.06 to 10.88 per cent, respectively; however, at final stage PDI ranged from 29.12 to 80.40 and 25.80 to 82.19 per cent, respectively in different fungicidal treatments. In both the years maximum PDI was recorded in untreated check which ranged from 11.98 to 80.40 and 10.36 to 82.19 per cent in 2018-19 and 2019-20, respectively and minimum PDI was recorded in plots given sprays of Propiconazole and PDI ranged from 10.29 to 29.08 and 8.33 to 25.75 per cent in 2018-19 and 2019-20, respectively. In both the years, PDI was higher at final stage in all treatments including check in comparison to initial stage.

Similarly, in both the years at initial stage almost similar leaf blotch scores (dd) were observed in different treatments. In *Rabi* 2018-19 and 2019-20, at initial stage leaf blotch score (dd) ranged from 11 to 12 and 11 to 13, respectively. With the advancement of crop season it increased and at final stage, leaf blotch score (dd) ranged from 36 to 67 and 35 to 66 per cent in 2018-19 and 2019-20, respectively. During both the years maximum leaf blotch score (dd) was recorded in untreated check which ranged from 12 to 67 and 13 to 66 in 2018-19 and 2019-20, respectively and minimum leaf blotch score (dd) was recorded in plots given sprays of Propiconazole which ranged from 11 to 36 and 11 to 35 in 2018-19 and 2019-20, respectively. In both the year leaf blotch scores (dd) were higher at final stage in all treatments including check as compared to initial stage.

Data presented in Table 3 clearly indicates that initially in the both years, almost similar PDI and leaf blotch scores were observed in different fungicidal treatments but with advancement of season development of disease was different in different treatments and finally in both the years differences in PDI as well as leaf blotch score in different fungicidal treatments were prominent or visible.

Effect on yield and 1000-grain weight of wheat

Data on the effect of spraying of six fungicides, namely Propiconazole, Hexaconazole, Difenaconazole + Propiconazole, Carbendazim, copper oxychloride and Mancozeb on yield and 1000-grain weight along with Per cent Disease Index (PDI) and per cent disease control during Rabi 2018-19 and 2019-20 is presented in Table 4.

Data presented in Table 4 reveals that in both years all the fungicides tested significantly reduced the disease (PDI) when compared with untreated check. Propiconazole @ 0.1 per cent (two sprays) showed minimum PDI of 29.02 and 25.80 per cent and maximum disease control of 63.74 and 68.40 per cent over check during *Rabi* 2018-19 and 2019-20, respectively and was statistically superior than other treatments. Hexaconazole @ 0.1 per cent ranked second best in reducing the PDI and gave 54.20 and 54.20 per cent disease control over check in 2018-19 and 2019-20, respectively. Other fungicides could produce less than 50 per cent disease control over check. Minimum disease control of 12.20 and 7.80 per cent was observed during 2018-19 and 2019-20, respectively by two sprays of Mancozeb, indicating that Mancozeb was least effective in controlling spot blotch. Yield and 1000-grain weight observed in Propiconazole and Hexaconazole, two best fungicides, were statistically at par during both the years. Yield was 42.70 and 42.83 q/ha in case of Hexaconazole and Propiconazole in 2018-19 and 39.02 and 41.60 q/ha in 2019-20, respectively. Similarly 1000-grain weights were 45.01 and 46.02 g in 2018-19 and 44.01 and 45.20 g in 2019-20.

DISCUSSION

In vitro* screening of fungicides against radial growth of *Bipolarissorokiniana

In the present studies on effect of fungicides on radial growth of *Bipolarissorokiniana*,it was observed that after seven days of incubation, Propiconazole, Hexaconazole and Difenaconazole + Propiconazole completely inhibited the growth of *B. sorokinianain vitro* at a concentration of 250 ppm or more. Carbendazim produced cent per cent inhibition at a concentration of 500 ppm or more whereas copper oxychloride produced it at 1000 ppm only. Mancozeb even at 1000 ppm concentration could not completely inhibit the growth of *B. sorokiniana* in vitro. Possibilities of using these fungicides in the field for the management of spot blotch of wheat can be explored. Earlier, Singh and Chauhan (1995) studied the efficacy of Dithane M-45, Tilt and Topsin-M against *Helminthosporium* leaf blight of wheat *in-vitro*. Tilt (500 ppm) provided significant control of the pathogen *in-vitro.* Narayan (2004) has also observed complete inhibition of radial growth of *H. sativum in-vitro* by Tilt 25 EC (100 ppm), Blitox-50 (1000 ppm) and Saaf (50 ppm). Mehboob*et al.* (2015) found that Score (Difenoconazole) and Topsin-M (Thiophanate methyl) exhibited the best performance in inhibiting the mycelial growth of *D. sorokiniana*followed by AmistarTop (Azoxystrobin + Difenoconazole), while Halonil (Chlorothalonil) and Curzate-M (Cymoxanil + Mancozeb) were least effective. Kavita *et al.* (2017) evaluated efficacy of 15 fungicides at 0.5, 0.1 and 2 per cent for studying their inhibitory effect on the mycelia growth of *Bipolarissorokiniana* by using food poison technique and recorded, the maximum mycelial growth inhibition (87.77 per cent) with Propiconazole (0.1 per cent) followed by Propiconazole (0.05 per cent) which showed 81.57 per cent inhibition. Hexaconazole (0.2 per cent) and Hexaconazole (0.1 per cent) showed 77.98 per cent and 70.37 per cent mycelial growth inhibition, respectively.

Effect of foliar spraying of fungicides on spot blotch, yield and 1000-grain weight of wheat

Present finding clearly indicated that two sprays of Propiconazole at fifteen days interval @ 0.1 per cent was best for controlling spot blotch of wheat under field condition as it provided minimum PDI of 29.12 and 25.80 per cent and maximum disease control of 63.74 and 68.40 per cent over check during both years *i.e.* 2018-19 and 2019-20, respectively. Hexaconazole @ 0.1 per cent ranked second best in reducing the PDI and gave 54.20 and 54.25 per cent disease control over check in both years *i.e.* 2018-19 and 2019-20, respectively. Hence, present finding clearly indicates that both Propiconazole and Hexaconazole are equally effective in reducing disease and increasing yield but on the basis of cost- benefit ratio Hexaconazole has an edge over Propiconazole.

Earlier also Propiconazole (Tilt 25 EC) 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; Malakar and Milan, 2009; Rahman *et al*., 2013). Lapis (1985) 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) found that Tilt 250 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) 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) have also reported that Tilt and Folicur were most effective. Malik *et al.,* (2008) reported that propiconazole and difenoconazole (0.1 and 0.2 per cent) were most effective and reduced the score of spot blotch up to 12 as compared to 79 score in unsprayed crop. The fungicidal sprays increased grain yield (40.1-46.3 per cent) and 1000-grain weight significantly as compared to unsprayed check. Yadav *et al.,* (2015) reported that 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.

CONCLUSION

Propiconazole, Hexaconazole and Difenaconazole + Propiconazole at 250 ppm completely inhibited the mycelial growth of *B. sorokiniana*. Carbendazim and Copper oxychloride also produced cent per cent inhibition but at 500 and 1000 ppm, respectively.Mancozeb could not produce complete inhibition even at 1000 ppm.

Spot blotch of wheat could be effectively and economically controlled by two foliar sprays of either Propiconazole or Hexaconazole @ 0.1 per cent at fifteen days interval but on the basis of cost- benefit ratio Hexaconazole has an edge over Propiconazole.

Despite the harmful effects of fungicides to human and environment, there have been proved useful and economical in the control of spot blotch. Non systemic and systemic foliar fungicides belonging to the dithiocarbamate and Triazoles are found to be effective. Foliar applications especially with systemic fungicides are applied between heading and grain filling stages, have been proved to be cost effective.

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Table 2. Effect of fungicides on radial growth of *Bipolaris sorokiniana*

Fungicide	Concentration (ppm)	Colony diameter (mm)*		Growth inhibition over check (%)*	
		5 days	7days	5 days	7 days
Propiconazole (Tilt 25 EC)	50	15.02	20.70	76.98	74.08
	100	14.40	16.35	78.04	79.80
	200	7.84	11.70	88.04	85.46
	250	0	0	100.00	100.00
Hexaconazole (Contaf 5 EC)	50	23.60	27.60	63.65	65.40
	100	18.64	22.84	71.46	71.19
	200	14.40	16.70	78.14	79.20
	250	0	0	100.00	100
Difenaconazole + Propiconazole (Taspa)	50	21.70	27.02	66.94	65.9
	100	19.23	22.84	70.84	71.16
	200	17.04	20.35	73.94	74.40
	250	0	0	100.00	100.00
Carbendazim (Bavistin 50WP)	50	38.70	40.40	40.61	48.99
	100	33.35	38.30	48.70	51.60
	200	29.04	35.20	55.42	55.62
	250	10.60	11.85	83.85	85.46
Copper oxychloride (Blitox-50)	100	33.35	38.20	48.76	52.20
	200	28.80	30.80	55.56	61.04
	500	18.35	19.20	71.74	76.02
	1000	0	0	100.00	100.00
Mancozeb (Indofil M-45)	100	37.02	42.85	42.89	45.80
	200	30.85	35.20	52.69	55.78
	500	21.02	24.85	67.70	68.80
	1000	17.20	21.04	73.89	75.40
Check		65.15	79.20	0	0
CD 5%				3.82	2.72
SE(m)				1.34	0.97

*Average of 4 replications

Table 3. Effect of foliar spraying of fungicides on disease progress of spot blotch of wheat

Fungicides	Per cent Disease Index (PDI)*				Leaf blotch score (0-9dd)*			
	2018-19		2019-20		2018-19		2019-20	
	Initial	Final	Initial	Final	Initial	Final	Initial	Final
Propiconazole	10.30	29.08	8.39	25.80	11	36	11	35
Hexaconazole	12.80	37.72	10.71	37.70	12	44	12	46
Difenaconazole + Propiconazole	10.02	46.40	9.50	48.36	11	44	11	46
Carbendazim	8.80	50.90	10.76	52.80	12	46	12	56
Copper oxychloride	11.96	58.40	10.87	64.23	11	55	11	57
Mancozeb	8.50	70.64	8.08	75.80	12	57	12	56
Check	11.98	80.40	10.36	82.19	12	66	13	66
CD 5%	2.14	1.76	1.86	2.36				
SE(m)	0.74	0.57	0.65	0.76				

*Average of 4 replications

Table 4. Effect of foliar spraying of fungicides on Per cent Disease Index (PDI), yield and 1000-grain weight of wheat

Fungicides	Dose (%)	PDI (%)*		Disease control over check (%)*		Yield (q/ha)*		1000-grain weight (g)*	
		2018-19	2019-20	2018-19	2019-20	2018-19	2019-20	2018-19	2019-20
Propiconazole (Tilt 25 EC)	0.1	29.02	25.80	63.74	68.40	42.83	41.60	46.04	45.29
Hexaconazole (Contaf 5 EC)	0.1	37.60	37.89	54.20	54.20	42.70	39.02	45.01	44.01
Difenaconazole + Propiconazole (Taspa)	0.1	47.02	48.20	42.30	41.16	40.02	36.40	42.98	42.98
Carbendazim (Bavistin 50WP)	0.1	50.94	52.80	36.70	35.80	37.40	34.76	40.46	40.46
Copper oxychloride (Blitox-50)	0.25	58.20	63.34	26.80	23.00	36.40	33.60	40.20	40.30
Mancozeb (Indofil M-45)	0.25	70.54	75.80	12.20	7.80	32.80	32.20	38.50	38.50
Check		80.30	82.20	-	-	31.70	30.80	36.80	336.79
CD 5%		1.77	2.36	2.46	3.09	2.56	3.27	2.26	3.38
SE(m)		0.61	0.78	0.85	1.04	0.86	1.10	0.77	1.14

*Average of 4 replications