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Disease Incidence and Severity of Spot Blotch in Different Dates of Sowing of Wheat Crop (*Triticum aestivum* L.)

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Abstract

Spot blotch disease, *Bipolaris sorokiniana,* has become a very enduring disease of wheat crops in Nepal and elsewhere. The study aimed to identify the severity of spot blotch disease and its consequence in two different showing dates (timely sowing and late sowing) of wheat crop. A field experiment was conducted in Bhatkepati, Kirtipur, Middle Hill, Nepal and the experiment plots with the size of 10 x 22 m were laid out with three replications. Five plots of 1 m^2 were set from each experiment plot for data collection. The study result showed a significant impact of spot blotch on the area under the disease progress curve yield, thousand kernel weight, spike length, grains per spike and plant height. The disease severity and area under the disease progress curve on the timely sowing wheat crop were 31.3% and 878.9, respectively, whereas the values of disease severity and area under the disease progress curve on the late sowing crop were 44.9% and 1321.1 respectively. The yields of timely sowing and late sowing wheat crops were 415.7 gm and 328.7 gm/m^2, respectively, whereas the thousand kernel weight was 48.7 gm and 45.0 gm, respectively. Similarly, spike length, plant height and grains per spike were significantly high in the timely sowing wheat crop. The late sowing date can increase the disease severity in the wheat crop, thereby significantly affecting yield and productivity.

Keywords: *Bipolaris sorokiniana*, Crops, Late sowing, Spot blotch disease, Timely sowing

Introduction

Wheat (*Triticum aestivum* L.) is the top three cereal crops in terms of global production, along with maize and rice. Wheat alone can provide over 20 % of the required calories and protein (Bhatta, 2012). Globally, wheat production exceeded 734 million tons from 214 million ha of land (Food and Agriculture Organization of the United Nations [FAO], 2021). In 2018, China, India, Russia, the USA and France were the largest wheat producer, accounting more than 50 % of the world's production (FAO, 2021). It is the major staple food of South Asian countries as well. In terms of production and cultivated area, wheat is the third major staple food crop in Nepal after rice and maize (Bhatta, 2012). In 2020, Nepal produced 2.13 million ton wheat grain from 711,067 hector land with an average productivity of 2.99 metric tons/ha (Ministry of Agriculture & Livestock Development [MOALD], 2022).Wheat exhibits extensive adaptability, spanning across all agro-ecological zones of Nepal, encompassing elevations from sea level to high mountain region (Upadhaya, 2017).

There are many constraints in wheat production in Nepal and elsewhere; among them, some important ones are biotic stress -spot blotch, yellow and leaf rusts, stem rust, loose smut, and hill bunt- as well as some other climatic factors *i.e*. changing climate, weather and rainfall patterns, and soil fertility degradation (Tripathi, 2011). South Asia is the hotspot for spot blotch (SB) disease (Sultan et al., 2018). One of the major reported diseases of the wheat crop in Nepal is spot blotch (Bhandari, 2012), which is caused by *Bipolaris sorokiniana* (Sacc.) Shoem. (syn. *Helminthosporium sativum* Pammel, King & Bakke, *H. sorokinianum* Sacc). It is also known as *Helminthosporium* leaf blight, HLB (Sharma et al., 1997), or foliar blight. Symptoms of spot blotch appear as brown lesions surrounded by yellow halos, which progressively expand to encompass large sections of the leaf. Lesions may change an olive-brown color, particularly in humid conditions that encourage sporulation of the fungus (Gupta et al., 2018).

In Nepal, approximately two-thirds of the total wheat growing area is under the pressure of spot blotch disease in January and February, where the mean temperature is 16-18^{o}C, respectively, and the relative humidity (RH) is more than 90% (National Agricultural Research Centre [NARC], 1998). Spot blotch is the most important disease in the warm lowlands of Nepal (Shrestha et al., 1998) and South Asia (Kumar et al., 2002; Saari, 1998). At present, spot blotch of wheat is a major pathogen across the wheat-growing region in Nepal; it has been reported that sowing period is also a major cause of disease severity. Spot blotch disease is a serious pathogen, not only due to its substantial impact on crop yield, but also its ability to target various parts of the wheat plant. Spot blotch, the predominant wheat disease, has intensified in the plains and foothills of Nepal and is now starting to appear in the mid hills and higher elevations (Basnet et al., 2022).

Cultivation date or times vary in middle mountain region of Nepal. Cultural practices and date of sowing are crucial for the sound management of plant diseases, which helps to determine the effect of spot blotch on wheat grain production and productivity. Timely sowing is important components of integrated crop management for spot blotch (Basnet et al., 2022). Therefore, this study aimed to identify the severity of spot blotch disease and its consequence in two different showing time of wheat crop.

Materials and Methods

Experimental site

The experiment was conducted in Bhatkepati area of Kirtipur Municipality (27° 38’ N and 27° 41’ N & 85° 13’ E and 85° 19’ E), at the altitudes of about 1300 m asl. The recorded maximum temperature in summer was 33°C and the minimum temperature in winter was 3 to -3°C. The average annual rainfall is 1200 mm. The temperature and rainfall data were obtained from the Department of Hydrology and Meteorology, Government of Nepal.

In the crop field, two different treatments (experiment) were established in wheat season. In the first treatment, the seed was sown in November 10 (described as timely sowing [TS]) and in the second treatment, the seed was sown in December 10 (described as late sowing [LS]). For each treatment (experiment), plot was laid out in a randomized manner (plot size was 10 m × 22 m) with three replications. Land preparation was done by plowing with a tractor. The seed (WK 1204 obtained from NARC, Khumaltar) was sown (120 kg/ha) uniformly in the field. The soil was fertigated with farmyard manure at 6 tons/ha and urea and DAP at 120:60 kg/ha, respectively. The crops were irrigated once at the seedling stage. Five plots (size of 1m^2) were set within the each treatment (experiment) plot for disease sampling and data collection.

Data collection

Disease incidence and assessment: After one month of seed showing, the experimented plots (1 m^2) were started to observe the disease incidence and followed every week to monitor the disease incidence. After the appearance of the disease, the numbers of infected plants per m^2 plot, as well as the total number of plants per m^2 plot were counted based on the symptoms developed by the disease. The disease incidence was calculated using the following formula:

Disease incidence % = Number of infected plants/ m^2 plot / Total number (healthy+infected) plants/ m^2 plot × 100

A double-digit (00-99) method was applied for disease severity by visual estimation. Spot blotch severity were visually scored for each plot using double digit scale described by Saari & Prescott (1975). The percent disease severity was calculated by the following formula:

Severity (%) = ((D1/9) * (D2/9) *100)

Where, D1 = First digit (height of infection) and D2 = Second digit (severity of infection), Scale for height of infection:1 = lowest leaf; 2 = second leaf from base; 3-4 = second leaf up to below middle plant; 5= up to middle of plant; 6-8= from center of plant to below the flag leaf; 9= up to flag leaf.

Estimation of area under disease progress curve

The area under disease progress curve (AUDPC) was calculated by summarizing the progress of disease severity. AUDPC values from double digit were calculated by using the following formula (Das et al., 1992).

$$\text{AUDPC} = \sum_{i=0}^{n} (Y_i + Y_{i+1}) 0.5 (T_{i+1} - T_i)$$

Where,
Yi = disease severity on first date,
Ti = date on which the disease was scored,
N= number of dates on which disease was scored.

Measurement of yield and other attributing characters

Crops of different treatments were harvested manually. Harvested plants were sun-dried in the field, weighed, and manually threshed separately. Wheat plants were taken from each plot and were manually threshed separately and the grains of each plot were properly cleaned, sun-dried, and kept in jute bags. The yield was determined by weighing the grains separately from each plot. The grain weight of each plot was recorded in gm/m^2. Randomly counted 1000 grains were weighed on a digital balance. Spike lengths and the number of grains per spike were measured from the five randomly selected and tagged wheat plants. The plant height of five randomly selected tillers was measured just before crop harvesting. The diseases were identified by using the protocol of Mathur and Olga (2003). The cultured samples were taken to the NARC laboratory and further confirmation was also obtained.

Statistical analysis

The data were analyzed using Microsoft Excel 2007 and SPSS version 16.0. An analysis of t-test was performed to determine the level of significance between the means of two different yield-attributing characters of variables. Pearson's correlations coefficients were analyzed between variables.

Results and Discussion

Spot blotch (SB) percentage and area under the disease progress curve (AUDPC) are presented in Table 1. All the plants were found to be infected (100 %) by spot blotch at the time of disease severity observation. However, the study showed that the mean disease severity percentage of spot blotch for TS and LS wheat crops was 31.3% and 44.9%, respectively. Spot blotch disease has become a significant issue for wheat-farming regions. The disease results in substantial yield reductions, ranging from 22 percent to complete crop failure during severe outbreaks (Chowdhury et al., 2013). The disease severity percentage was significantly high ($P<0.05$) in the LS crop. The disease severity was observed to be lower in TS wheat crop as compared to LS wheat crop. Similar results were also reported by Nepal et al. (2020) & Singh et al. (1998) who have reported the low disease severity in timely sowing crops. While, the AUDPC of spot blotch disease in TS and LS was calculated based on disease severity percent. In this study, the AUDPC was highly significant (P<0.001) between the TL and LS. The mean AUDPC for the LS wheat crop (1321.1) was higher than that of the TS wheat crop (878.9). The increase in AUDPC value in the LS condition might be due to the combined effect of cold stress and easily available spore inoculums from the first-date sowing plots. Our result was corroborated with the result of Neupane et al. (2013), in which AUDPC was higher in the late sowing condition in comparison with the normal sowing condition. Similar to our findings, Kandel et al. (2007) observed

Table 1: Spot blotch percentage and AUDPC attributing in TS and LS wheat crops

Disease Attributing Character	Type of showing	Mean	F	*p* Value
Spot blotch (SB) (%)	TS	31.3±1.7b	54.50	P< 0.001
	LS	44.9±0.8a		
Area Under Disease Progress Curve (AUDPC)	TS	878.9±35.2b	115.99	P<0.001
	LS	1321.1±21.1a		

Note: TS = Timely sowing; LS = Late sowing ; ± Standard error of mean; mean value with name letter non-significant different letters are significantly different (P<0.05) that the seed sowing date had a significant impact on AUDPC and disease severity. Moreover, the epidemiological condition might have favored the higher AUDPC on the second date of sowing (Duveiller et al., 2005). Spot blotch percentage is positively correlated with AUDPC in both crops (Tables 3 and 4).

The yield, grain per spike (GperS), thousand kernel weight (TKW) and total number of grains (GN) are presented in Table 2. The total yield of wheat in TS and LS crops was 415.7 gm and 328.7 gm per meter square plot (equivalent to 3.85 tons/ha and 3.03 tons/ha), respectively, which was significantly different ($P<0.05$) between the treatments. Present study showed that LS wheat crops have significantly slashed the crop yield. In both treatments, yield was negatively correlated with spot blotch percentage and AUDPC (Tables 3 and 4). A significantly higher ($P<0.05$) number of grains per spike (37.38) was observed in TS than in grains (35.68) in the LS crop. Kandel et al. (2007) had also reported that the seed-sowing date showed a significant effect on grain yield, thousand-kernel weight and plant height. The lower the disease severity, the higher the grain per spike observed. Similarly, grain per spike is negatively correlated with the AUDPC value in both treatments (Tables 3 and 4). Result from the present study is corroborated with the findings of Tewari et al. (2016). Present study observed that the weight per thousand kernel of TS and LS crops was 48.66 gm and 44.93 gm, respectively. The weight per thousand kernels was significantly high ($P<0.05$) in TS. Similar type of result was also reported by Sharma & Duveiller (2004) in which gross reduction in grain yield and thousand-kernel weight under late sowing conditions. Their finding was also compatible to the present study results as well.

The tiller number (TN), length of the spike (LoS) and plant height (PH) are presented in Table 2. The number of tillers per quadrate in the TS crop was 270.73 , however, the number of tillers per quadrate in the LS crop was 268.00. There is no significant difference in tiller number per quadrate, despite the different mean values between the treatments. The length of the spike was significantly higher ($P< 0.05$) in the TS treatment than in the LS treatment. The value of the length of spikes in the TS wheat crop was 11.94 cm, whereas the mean value of the length of spikes in the LS crop was 10.06 cm. A similar finding was also observed by Chaurasia & Duveiller (2006). The mean plant height for the TL wheat crop (77.3 cm) was greater than the mean plant height of the LS wheat crop (73.32cm), and this is highly significant ($P<0.01$) between the treatments. The disease incidence and severity may lead to low photosynthesis thereby impact on plant height. Plant height is negatively correlated with AUDPC (Table 3 and 4). In contrary, Pandey et al. (2018) found that there was a positive association between plant height and AUDPC. Overall, present findings showed that LS wheat crops have a great impact on significantly slashing the yield and plant height including some other plant attributes as well.

Table 2: Yield and other plant attributing characters of timely and late showing wheat crops

S.N.	Yield Attributing Character	Type of showing	Mean	F	P Value
1.	Yield(Y) (gm)	TS LS	415.7±14.8a 328.7±16.9b	15.06	P<0.001
2.	Grain Per Spike (number) (GPS)	TS LS	37.4±0.2a 35.9±0.2b	46.26	P<0.001
3.	Thousand Kernel Weight (gm) (TKW)	TS LS	48.7±0.4a 45.0±0.4b	49.24	P<0.001
4.	Length of Spike (cm) (LoS)	TS LS	11.9±0.07a 10.06±1.1b	237.08	P<0.001
5.	Tiller number (TN)	TS LS	270.7±3.4a 268.0±3.0a	0.36	0.55
6.	Plant Height (cm) (PH)	TS LS	77.4±1.03a 73.3±1.08b	7.38	0.01

Note: TS = Timely sowing; LS = Late sowing; ± Standard error of mean; the same letter are non-significant and different letters are significantly different ($P<0.05$).

Table 3: Pearson correlation for timely sowing (TL) wheat crop

	AUDPC	LoS	GperS	TKW	Yield	TN	PH	SB
AUDPC	1	-.983**	-.943**	-.974**	-.979**	-0.276	-.965**	.985**
LoS		1	.972**	.984**	.970**	0.274	.950**	-.966**
GperS			1	.964**	.927**	0.198	.912**	-.934**
TKW				1	.951**	0.283	.915**	-.954**
Yield					1	0.288	.972**	-.994**
TN						1	0.246	-0.269
PH							1	-.972**
SB								1

Note: **= Correlation is significant at the 0.01 level (2-tailed).

Table 4: Pearson Correlation for late sowing wheat crop

	SB	AUDPC	LoS	GperS	TKW	Yield	TN	PH
SB	1	.980**	-.974**	-.963**	-.958**	-.893**	-.965**	-.982**
AUDPC		1	-.980**	-.982**	-.961**	-.873**	-.975**	-.980**
LoS			1	.967**	.969**	.890**	.971**	.996**
GperS				1	.984**	.841**	.957**	.963**
TKW					1	.851**	.953**	.962**
Yield						1	.923**	.899**
TNL							1	.971**
PHL								1

Note: **= Correlation is significant at the 0.01 level (2-tailed).

Conclusion

Spot blotch disease of wheat is caused by the fungus *Bipolaris sorokiniana* and is one of the most destructive diseases of the wheat crop. It has been a longstanding problem in wheat-growing areas of Nepal. The experiment was conducted in two different treatments with disease severity observation. The study found that all the plants were infected by spot blotch during the experiment. The spot blotch disease can be observed on both timely and late sowing dates in wheat crops, but the late sowing condition showed a more severe condition. The late sowing date of the wheat crop intensifies the incidence of disease severity, thereby affecting the overall growth and yield of the wheat crop. Thus from the present study it can be concluded that timely sowing (TS) the wheat crop in the middle hill area of Nepal could be the best way to achieve better yields.

Author Contributions

The research concept was developed by Y Pant and C P Pokhrel. The experiment was performed by Y Pant and supervised by C P Pokhrel. The manuscript was prepared by Y Pant and revised by C P Pokhrel.

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